STUDY ON WORKABILITY OF M60 GRADE CONCRETE USING ADMIXTURES AND THEIR STRENGTH PARAMETERS

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ABSTRACT: Self compacting concrete has been described as "the most revolutionary development in concrete construction for several decades". A self compacting concrete, which has excellent deformability and resistance to segregation and can be filled in heavily reinforced form work without vibrators was developed 20 years ago. SCC is defined as a concrete, which can be placed and compacted into every corner of formwork, purely by means of its self-weight by eliminating the need of either external input from vibrators or any other type of effort. Due to its specific properties, SCC may contribute a significant improvement in the quality of concrete structures and open up new fields for the application of concrete. In Civil Engineering the fibre reinforced technology has become advanced technique and over come some of the weaknesses in concrete. Fibres may be used to enhance the properties of SCC in the same way as for normal concrete. Steel fibres are used normally to enhance the mechanical characteristics of the concrete such as flexural strength and toughness.Hence in view of the above factors a study is made on strength behavior of steel fibre reinforced self-compacting concrete of M60Grade.The major steps in the production of SFRSCC are designing an appropriate mix proportion and evaluating the properties of the concrete obtained. In practice, SCC in its fresh state shows high fluidity, self-compacting ability and segregation resistance. The understanding of this value added construction material, forms the main theme of this dissertation.

I. INTRODUCTION

At present world is witnessing the construction of very challenging and difficult Civil Engineering structures. Quite often, concrete being the most important and widely used material is called upon to possess very high strength and sufficient workability properties. Efforts are being made in the field of concrete technology to develop such concrete with special characteristics. Researchers all over the world are attempting to develop high performance concrete by using various admixtures in concrete up to certain proportions. One of the most out standing advances in the concrete technology for the last decade is "Self Compacting Concrete (SCC)". Self Compacting Concrete (SCC) is defined as: "A Category of high-performance concrete that has excellent deformability in the fresh state and high resistance to segregation and can be placed and compacted under its self weightwith out applying vibration". SCC is also referred as self-leveling concrete, super workable concrete, self-consolidating concrete, highly flowable concrete, non-vibrating concrete etc.

Workability

A measure of the ease by which fresh concrete can be placed and compacted. It is a complex combination of aspects of fluidity, cohesiveness, transportability, compactability and stickiness.

Advantages of SCC

Self-compacting concrete originally developed to offset growing shortage of skilled labour, it has proved beneficial economically because of number of factor including.

- Faster construction
- Reduction in site man power
- Better surface finishes
- Easier placing
- Improved durability and reliability of concrete structures.
- Greater freedom in design
- Thinner concrete sections
- Reduced noise levels, absence of vibration
- Safer working environment
- Excellent bond to steel reinforcing
- Low permeability

II. ENGINEERING PROPERTIES OF SCC

compressive strength:

SCC with a similar water cement or cement binder ratio will usually have a slightly higher strength compared with traditional vibrated concrete, due to the lack of vibration giving an improved interface between the aggregate and hardened paste.

Tensile strength:

It may be safely assumed to be the same as the one for a normal concrete,as the volume of paste (cement +fines+water)has no significant effect on tensile strength.

Shrinkage:

Shrinkage is the sum of autogeneous and the drying shrinkage. Autogeneous shrinkage occurs during setting and is caused by the internal consumption of water during hydration .If the volume of the hydration products is less than the original volume of unhydrated cement and water, it results to tensional stresses.

Drying shrinkage is caused by the loss of water from the concrete, to the atmosphere. A decrease in maximum aggregate size, which results in a higher paste volume, increases drying shrinkage. With a low water\cement ratio drying shrinkage reduces and the autogeneous shrinkage can exceed it.

Fire resistance:
The fire resistance of SCC is similar to normal concrete. In general a low permeability concrete may be more prone to spalling but the severity depends upon aggregate type, concrete quality and moisture content. The use of polypropylene fibres in concrete has been shown to be effective improving resistance to spalling. The mechanism is believed to be due to fibres melting and being absorbed in the concrete mix. The fibre voids then provide expansion chambers for steam, thus reducing the risk of spalling.

Durability:
The durability of a concrete is closely associated to the permeability of the surface layer. The durability will depend upon the selection of materials and the effective water cement ratio\water binder ratio, concrete composition, as well as on degree of supervision during placing, impaction, finishing and curing. SCC with right properties will be free from lack of compaction of the surface layer, due to vibration difficulties in narrow space between the form work and the re-bars or other inserts (e.g. post-tensioning ducts) has been recognized as a key factor of poor durability .It offers less weak points for deleterious actions of the environment and, hence better durability.

Bond strength:
Reinforced concrete is based on an effective bond between concrete and the reinforcing bars. Poor bond often results from a failure of the concrete to fully encapsulate the bar during placing or bleed and segregation of the concrete before hardening which reduce the quality of contact on the bottom surface. SCC fluidity and cohesion minimize these negative effects.

III. FIBRE REINFORCED SCC

Fibre reinforced Self Compacting Concrete is considered as new technology for the construction industry. However this technology has found wide acceptance amongst the construction industry. The use of concrete as a structural material is limited to certain extent due to the deficiencies like brittleness, poor resistance to impact, fatigue and low durability. Its use is also very much limited when it is subjected to dynamic or fatigue loading. Commonly used types of fibres are steel or polymer in SCC. Fibres may be used to enhance the properties of SCC in the same way as for normal concrete. Steel fibres are used normally to enhance the mechanical characteristics of the concrete such as flexural strength and toughness. Polymer fibres may be used to reduce segregation and plastic shrinkage, or to increases the fire resistance.

General Requirement of Fibres
The general form of fibre composites will be in the use of short discontinuous fibres in either two-dimensional planer orientations inthis section like shells, folded plates, or in th random three-direction as in thick section beam, slab etc., generally, economic consideration will dictate the choice and volume of percentage of fibres used. The basic requirenments of fibre for improving the properties of concrete are high tensile strength, elastic modules, impact resistance and durability etc. The properties of cement matrix are also important, since it is the matrix that the fibre reinforces. The fibres along with aggregate shell be fully embedded in the matrix because of this reason fibrous concrete require more volume of matrix than conventional matrix. Polymer dispersion (i.e. super plasticizers) can be use to improve the workability, ductility, cracking strain and strength of inter facial bond.
Factors influencing the fiber reinforced Self Compacting Concrete
The effect of fiber reinforced on the matrix and the efficient transfer of stress between the matrix and fiber depends on many factors. Many of these factors intimately inter depended and exercise a profound but complex influence on the properties of the composite, these innumerable factors can effectively be reduced to

- Aspect ratio
- Spacing of fibers
- Orientation of fibers
- Volume of fibers
- Size of course aggregate

Classification of fibers
Fibers can be classified basically into two categories.

- Based on the modulus of elasticity.
- Based on the material.

Based on the modulus of elasticity, fibers are classified as.
a) Hard intrusion fibers, fibers having higher elastic modulus than the cement
matrix can be termed as hard intrusion.
Soft intrusion fibers, having lower elastic modulus are called as Soft intrusion. Based on the material, fibers are classified as.

Steel Fibers:
Steel fibers are probably the only fibers that can be used for long-term load bearing applications. They are stable in cement matrix and need no longer to be a design or cost inhibiting factors. Fibers made from mild steel drawn wire have been practically used in India. Round steel fibers are produced by cutting or chopping the wire, flat sheet fibers are produced by slitting (shearing) flat sheets. Deformed fibers which are loosely bonded with water soluble glue in the form of a bundle are also available. Since individual fibers tend to cluster together, their uniform distribution in the matrix is often difficult. This may be avoided by adding fiber bundles, which separate during the mixing process. S.F.R.C. materials have been used for overlays and overslabbing roads, pavements, airfields, bridge decks, industrial and other flooring, particularly those subjected to wear and tear and chemical attack.

Fly Ash
According to IS: 3812 fly ash is defined as finely divided residue that results from the combustion of ground or pulverized coal and is transported from boilers by flue gases.
Industrial revolution through a prerequisite to prosperity has

brought with it the bane of environmental pollution. Large quantities of fly ash are spread out in enormous quantities by thermal power plants. This residue of pulverized coal dumped in the vicinity of power plant has become an industrial hazard. It constitutes 80% of the total ashes produced, and being higher than the remaining 20%, pollutes the air causing the serious problems or corrosion of structural surfaces and respiratory problems to those inhaling it quite often let out into streams and rivers. It also disturbs aquatic life cycle. The large quantities dumped on land occupy tracts of cultivable lands.

Characteristics of Fly Ash

The composition and properties of the pulverized fly ash depend both on the type of coal burnt and the efficiency of the combustion, degree of pulverization and the type of combustion equipment. In general the colour of fly ash is grayish and will become darker with increasing proportions of un-burnt carbon. The physico-chemical properties of fly ash determine its utilization potentiality in varies fields where as its chemical composition gives a broad based idea of it`s probable fields of utilization. Unburned carbon and SO3 in fly ash are undesirable as far as its use in cement making is concerned. Similarly high percentage of magnesia in fly ash is also undesirable in case of mortar, concrete and concrete products as these will tend to develop fine cracks on setting.

Chemical properties of fly ash.

s.no	Characteristics	Requirement as per IS-3812-1981.	Fly ash obtained from VTPS %BY mass
1	Silicon-di-oxide. ($Si0_2$)	35.00%	57.11%
2	Calcium oxide (Cao)	5.00%	1.61%
3	Alkalis of sodium oxide	1.50%	0.50%
4	Silicon-di-oxide ($Fe_2O_{3)}$ Aluminum oxide ($AL_2O_{3)}$	70.00%	95.80%
5	Loss on ignition	12.00%	0.99%

Physical properties of fly ash.

S.no	Properties	Test results
1	Bulk density	0.01079 N\mm3
2	Specific gravity	2.5
3	Fineness	2.0%

TEST METHODS FOR SELF-COMPACTIBILITY OF CONCRETE

Slump flow test (1) T $_{50cm}$test(2)

Introduction

The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. It was first developed in Japan [1] for use in assessment of underwater concrete. The test method is based on the test method for determining the slump. The diameter of the concrete circle is a measure for the filling ability of the concrete.

Procedure

About 6 liter of concrete is needed to perform the test, sampled normally. Moisten the base plate and inside of slump cone, Place base plate on level stable ground and the slump cone centrally on the base and hold down firmly.

Fill the cone with the scoop.

Do not tamp, simply strike off the concrete level with the top of the cone with the trowel.

Remove any surplus concrete from around the base of the cone.

Raise the cone vertically and allow the concrete to flow out freely.

Simultaneously, start the stopwatch and record the time taken for the concrete to reach the 500mm spread circle. (This is the T_{50} time).

Measure the final diameter of the concrete in two perpendicular directions.

Calculate the average of the two measured diameters. (This is the slump flow in mm).

Note any border of mortar or cement paste without coarse aggregate at the edge of the pool of concrete.

J Ring test

Introduction

The principle of the J Ring test may be Japanese, but no references are known. The test is used to determine the passing ability of the concrete. The equipment consists of a rectangular section (30mm x 25mm) open steel ring, drilled vertically with holes to accept threaded sections of reinforcement bar. These sections of bar can be of different diameters and spaced at different intervals: in accordance with normal reinforcement considerations, 3 times the maximum aggregate size might be appropriate. The diameter of the ring of vertical bars is 300mm, and the height 100mm.

Procedure

About 6 liter of concrete is needed to perform the test, sampled normally. Moisten the base plate and inside of slump cone, Place base-plate on level stable ground. Place

the J Ring centrally on the base-plate and the slump-cone centrally inside it and hold down firmly.
Fill the cone with the scoop. Do not tamp, simply strike off the concrete level with the top of the cone with the trowel. Remove any surplus concrete from around the base of the cone. Raise the cone vertically and allow the concrete to flow out freely. Measure the final diameter of the concrete in two perpendicular directions. Calculate the average of the two measured diameters. (in mm). Measure the difference in height between the concrete just inside the bars and that just outside the bars. Calculate the average of the difference in height at four locations (in mm).
Note any border of mortar or cement paste without coarse aggregate at the edge of the pool of concrete.

V Funnel test and V funnel test
Introduction
The test was developed in Japan and used by Ozawa et al (5). The equipment consists of a V-shaped funnel, shown in Fig.2.5. An alternative type of V-funnel, with a circular section is also used in Japan. The described V-funnel test is used to determine the filling ability (flow ability) of the concrete with a maximum aggregate size of 10mm. The funnel is filled with about 12 litres of concrete and the time taken for it to flow through the apparatus measured. After this is funnel can be refilled concrete and left for 5 minutes to settle. If the concrete shows segregation then the flow time will increase significantly.

(a) (b)

Procedure
About 12 litres of concrete is needed to perform the test, sampled normally. Set the V-funnel on firm ground. Moisten the inside surfaces of the funnel. Keep the trap door open to allow any surplus water to drain. Close the trap door and place a bucket underneath. Fill the apparatus completely with concrete without compacting or tamping, simply strike off the concrete level with the top with the trowel. Open within 10 Sec after filling the trap door and allow the concrete to flow out under gravity. Start the stopwatch when the trap door is opened, and record the time for the discharge to complete (the flow time). This is taken to be when light is seen from above through the funnel. The whole test has to be performed within 5 minutes.box test method

Introduction
Peterson has described this test, based on a Japanese design for underwater concrete. The test assesses the flow of the concrete, and also the extent to which it is subject to blocking by reinforcement. The apparatus is shown in figure 2.6. The apparatus consists of a rectangular-section box in the shape of an ‘L’, with a vertical and horizontal section, separated by a moveable gate, in front of which vertical lengths of reinforcement bar are fitted. The vertical section is filled with concrete, then the gate lifted to let the concrete flow into the horizontal section. When the flow has stopped, the height of the concrete at the end of the horizontal section is expressed as a proportion of that remaining in the vertical section (H2/H1 in the diagram). It indicates the slope of the concrete when at rest. This is an indication passing ability, or the degree to which the passage of concrete through the bars is restricted. The horizontal section of the box can be marked at 200mm and 400mm from the gate and the times taken to reach these points measured. These are known as the T20 and T40 times and are an indication for the filling ability.
The sections of bar can be of different diameters and spaced at different intervals: in accordance with normal reinforcement considerations, 3x the maximum aggregate size might be appropriate. The bars can principally be set at any spacing to impose a more or less severe test of the passing ability of the concrete.
Procedure
About 14 litre of concrete is needed to perform the test, sampled normally. Set the apparatus level on form ground, ensure that the sliding gate can open freely and then close it. Moisten the inside surfaces of the apparatus, remove any surplus water Fill the vertical section of the apparatus with the concrete sample. Leave it to stand for 1 minute. Lift the sliding gate and allow the concrete to flow out into the horizontal section. Simultaneously, start the stopwatch and record the times taken for the concrete to reach the 200 and 400 mm marks. When the concrete stops flowing, the distances “H1” and “H2” are measured. Calculate H2/H1, the blocking ratio. The whole test has to be performed within 5 minutes.

Study of Hardened Concrete
The principle properties of concrete, which are of practical importance, are those concerning its strength, stress-strain characteristics, shrinkage and creep deformations, permeability and durability, of these the strength of concrete assumes a greater significance because the strength is related to the structure of hardened cement paste and gives an overall picture of the quality of concrete.

Compressive Strength.
Of the various strengths of concrete the determination of compressive strength has received a large amount of attention because the concrete is primarily meant to withstand compressive stresses. Generally cubes are used to determine the compressive strength. The cubes are usually of 100 x 100 x 100 mm or 150 x 150 x 150 mm size. In the present investigation the 150 x 150 x 150 mm size cubes are used.

In the compressive test, the cube while cleaned to wipe of the surface of water, is placed with the cast faces in contact with the platens of the test specimen, i.e., the position of the cube when tested is at right angles to that as cast, according to BIS 1881:part 116:1983,the load on the cube should be applied at a constant rate of stress equal to 0.2 to 0.4 Mpa/sec. Because of the non-linearity of the stress –strain relation of concrete at high stress, the rate of increase in strain must be increased progressively as failure is approached i.e, the speed of the movement of the head of the testing machine has to be increased.

Tensile strength
Tensile strength of concrete greatly affects the extent and size of cracking in concrete. It is of a great importance while designing liquid retaining structures and pre-stressed concrete structures. Tensile strength of concrete ranges from 10 to 18 percent of the compressive strength.

Measurement of tensile strength by subjecting the specimen to direct tension is extremely difficult therefore indirect measurements for tensile strength are made. The tensile strength of concrete can be measured by two methods.

- Split tensile strength.
- Flexural tension test.

Split tensile test
The concrete cylinder specimen may be tested at 28 days and shall be immersed in water for at least 24 hours before test. A concrete cylinder or size 150mm diameter and 300mm height is subjected to the action of a compressive force along two opposite edges by applying force in this manner the cylinder is subjected to compressive is acting for about 1/6 depth and the remaining 5/6 depth is subjected to uniform tensile stress.

The split tensile strength of specimen = 2P / ($_{11}$DL)
Where P = Applied ultimate load at failure
L = Length of cylinder
D = Diameter of the cylinder

Flexural tension test (modulus of rupture test)
The normal tensile stress in concrete when cracking occurs in a flexure test is known as its modules of rupture i.e. flexure strength. The flexural strength is calculated considering the material to be homogeneous. This gives

$f_{cr} = (M/I)*y$
Where fcr = flexural strength of concrete
M =Bending moment
Y = Distance of extreme fiber of concrete from neutral axis
I = Moment of inertia of the section

The standard test specimen is a beam of 150mmX150mmX700mm size.
However, if the largest nominal size of aggregate does not exceed 20mm, the Specimen of the size 100mmX100mmX500mm may be used. In the present Investigation the 100mmX100mmX500mm size beams are used.

The beam should be tested on a span of 600 mm or 400 mm for 150 mm and 100 mm specimen respectively by applying two equal loads placed at third points. The rate of loading shall be 4 KN/min.

Let ‘a’ be the distance between the line of fracture and the nearer support. Then, for finding modulus of rupture three cases should be considered.

Fine Aggregates

Sl.No:	Property	Result
1	Specific gravity	2.53
2	Fineness modulus	2.94
3	Bulk Density (loose state)	1.61 Gram/cc
4	Bulk Density	1.68 Gram/cc

Sieve Analysis for fine aggregates
Weight of Fine Aggregate sample taken = 1000Grams

S.no	I.S.Sieve	Weight retained (gm)	% Wt retained (gm)	Cumulative % of wt retained	Percentage passing (By weight)
1	10 mm	-	-	-	100
2	4.75 mm	13	1.30	1.30	98.70
3	2.36 mm	24	2.40	3.70	96.70
4	1.18 mm	142	14.20	17.90	82.10
5	600µ	564	56.40	74.30	25.70

6	300 µ	230	23.00	97.30	2.70
7	150 µ	20	2.70	100.00	0
8	Lower than 150 µ	7	-	-	-
Total		1000		294.00	

Fineness modulus of F.A = Total cumulative % retained\100 = 294.00/100 = 2.94.

Coarse Aggregate
The coarse Aggregate used in this experimental investigation is crushed granite of 12.5 mm maximum size, which was obtained from the local crushing plant. The laboratory tests on C.A. conducted in accordance with IS2386 and the values are shown in the Tables 5.5,

5.6 Properties of coarse aggregates

Sl.no	Property	Result
1	Specific gravity	2.64
2	Fineness modulus	6.28
3	Bulk density (Loose state)	1.37 gm/cc
4	Bulk density (compact state)	1.51 gm/cc

Sieve Analysis for Coarse Aggregates
C.A. Sample taken = 5000Grams

S.no	IS.sieve	Weight retained (gms)	% Wt retained (gms)	Cumulative % of wt retained	Percentage passing (by weight)
1	20 mm	0	-	0	100
2	10 mm	580	11.60	11.60	88.40
3	4.75 mm	4420	88.40	100	0
4	2.36 mm	0	0	100	0
5	1.18 mm	-	-	100	0
6	600µ	-	-	100	-
7	300 µ	-	-	100	-
8	150 µ	-	-	100	-
	Total	5000		611.60	

Fineness modulus of C.A=Total cumulative % retained/100
=611.60/100 =6.12

MIX DESIGN OF M_{60} GRADE (ERNTROY AND SHAKLOK METHOD)
Design parameters for M_{60} Grade:
Characteristic compressive strength
Required in the field at 28 days : 60 Mpa
a) Maximum size of aggregate :10mm (rounded)
b) Degree of workability : Medium
c) Degree of quality control : Good
d) Type of exposure : Mild
e) Compressive strength of cement : 54.00 N/mm^2 at 28 days

Test data for Materials:
Cement : OPC – 53 grade (IS12269-1987)
Specific gravity of cement : 2.95
Specific gravity of fine aggregate : 2.53
Specific gravity of coarse aggregate : 2.64
Fineness modulus of fine aggregate : 2.94
Fineness modulus of coarse aggregate : 6.12

Step – I Control factor
For very good degree of control
Control factor = 0.80
For high strength concrete mixes
Target mean strength = Characteristic strength / Control factor
= 60/0.80 = 75 Mpa

Step – II Reference Number

From fig 9.1 of Design of concrete mixes by N.K.RAJU for high strength concrete mixes Reference Number with respect to compressive strength of 75 Mpa are 30.00.

Step – III Selection of water, cement ratio
From fig 9.50 of Design of concrete mixes by N.K.RAJU for high strength concrete mixes 10 mm maximum size of aggregate with medium of workability water\cement ratio is 0.38.

Step – IV Selection of aggregate/cement ratio
From Table 9.10 of Design of concrete mixes by N.K.RAJU for high strength concrete mixes aggregate/cement ratio for desired workability is 2.50.

Step – V From fig. 9.6 of Design of concrete mixes by N.K.RAJU for high strength concrete mixes the aggregates are combined graphical method.
So that 30% of material passes through 4.75 mm I.S.Sieve
Ratio of fine to total aggregate = 30%]

Step – VI Mix proportions
Required proportion by weight of dry materials

Cement	Fine aggregate	Coarse aggregate	Water
1	30/100 x 2.50	70/100 x 2.50	0.38
1	0.75	1.75	0.38

If C = weight of cement required per cu.m. of concrete.
Then 1000 = C/2.95 + 0.75 C/2.53 + 1.75C/2.64 + 0.38C/1
= 0.34C + 0.30C + 0.68C + 0.38C
= 1.70C C = 588.30 kg
Fine aggregate = 0.75 C = 0.75x 588.30= 441.30 kg
Coarse aggregate = 1.75C = 1.75x 588.30= 1029.60 kg
Water = 0.30 C = 0.30 x 588.30= 223.60 liters

Cement	Fine aggregate	Coarse aggregate	Water
588.30	441.30	1029.60	223.60

Step – VII Fly ash based mixed design
Adopting 30% of replacement with Fly ash
Weight of cement = 0.70 x 588.30= 411.80
Weight of Fly ash = 0.30 x 588.30= 176.50

Cement Fly ash Fine aggregate Coarse aggregate Total aggregate Water
411.80 176.50 441.30 1029.60 1470.90 223.60

SCC Mix design as per EFNARC proposals
As per guidelines of EFNARC, FA/TA ratio must be in between (50% - 60%) on performing some trial mixes at last I got desirable results corresponding (EFNARC) limits for SCC, by adopting FA/TA ratio at 50% and the following all the materials.

Material requirements for M_{60} Grade SCC

Sl. No:	Material required	Quantity in1 kg/m^3
1	Cement (C)	411.80
2	Fly ash	176.50
3	Fine aggregate (Fa)	735.45
4	Coarse aggregate (Ca)	735.45
5	Water (W)	223.60

The same proportion of mix was used throughout the tests.
Quantity of materials required for 1m^3 of concrete
Cement 411.80/1440 = 0.2859 m^3
Fly ash 176.50/1079 = 0.1635 m^3
Fine aggregate 735.45/1505 = 0.4886m^3
Coarse aggregate 735.45/1303.70 = 0.5641m^3
Water 223.60/1000 = 0.2236m^3
Total = 1.7257m^3
The materials required (Cement + Fly ash + Ca + Fa + Water) producing 1 m^3 of Cement concrete = 1.7257 m^3
1.7257 m^3 Materials produce → 1 m^3 of Cement concrete
1 m^3 Materials produce → 0.5795m^3 of Cement concrete

IV. TEST RESULTS

TABLE NO: 6.3 BACHING PROPORTIONS FOR M60 GRADE OF SCC PER CUBIC METER

Sl. No:	% Steel Fibres	Cement kg/cum	Fly ash kg/cum	F.A.	C.A.	Water ml/cum	Glenium B-233 ml/100kg of Cement +Fly ash	V.M.A. ml/cum	Steel Fibres kg/cum
1.	0.00	411.80	176.50	735.45	735.45	223.60	800	312.50	--
2.	0.25	411.80	176.50	735.45	735.45	223.60	900	375.00	19.625
3.	0.50	411.80	176.50	735.45	735.45	223.60	925	437.50	39.250
4.	0.75	411.80	176.50	735.45		223.60	975	468.75	58.875
5.	1.00	411.80	176.50	735.45	735.45	223.60	1050	531.75	78.500
6.	1.25	411.80	176.50	735.45	735.45	223.60	1075	593.75	98.125

EXPERIMENTAL RESULTS AND GRAPHS
WORKABILITY PARAMETERS OF STEEL FIBER REINFORCED SCC FOR M 60 GRADE

Sl. No:	Test method	property	unit	EFNARC Values		% of Fibres by volume of concrete (aspect ratio =50)						
				Min.	Max.	0	0.25	0.50	0.75	1.00	1.25	1.50
1.	Slump flow	filling	mm	650	800	780	720	715	700	690	680	650
2.	T 50 cm slump	viscosity	sec	2	5	2.30	2.90	2.70	3.30	3.40	3.68	4.78
3.	V – Funnel	filling	sec	6	12	6.00	7.00	8.00	9.20	9.60	10.00	11.20
4.	V – Funnel 5 min.	segregation	sec	11	15	11.00	12.10	12.90	13.10	13.90	14.30	15.00
5.	L - Box	passing	%	0.80	1.00	1.00	0.94	0.90	0.88	0.84	0.82	0.81
6.	T – 20 sec		sec	1.00	2.00	1.00	1.20	1.30	1.50	1.60	1.65	2.00

COMPRESSIVE STRENGTH OF M-60 GRADE OF STEEL FIBRE SELF COMPACTING CONCRETE AT 3 & 28 DAYS .

Subject: M.Tech Project
Sample Description: Concrete Cubes with Steel Fibres @3 days & 28 days
Date Of Casting:30.03.2017; Quantity: 6 Sets each
Test Required : Compressive Strength,
Date of receipt of sample : 23rd March,2017
Dt. of starting of testing : 25thMarch,2017
Dt. of completion of testing : 27th April,2017

TEST RESULTS

Sl.No	Description	Cross Sectional Area (Sq.mm)	Load (KN) in compression testing Machine in 3days		Compressive Strength (N/sq.mm) Compressive strength in 3days (MPa)			Load (KN) in compression testing Machine in 28days		Compressive strength in 28 days (MPa)		
			Cube no.1	Cube no.2	Cube no.1	Cube no.2		Cube no.1	Cube no.2	Cube no.1	Cube no.2	
I	Plain Concrete Cubes	150 x 150 = 22500	693.0	679.5	30.8	30.2	Average = 30.5	1487	1573	66.1	69.9	Average = 68.0
II	% 0.25 of steel Fibres Concrete Cubes	150 x 150 = 22500	742.5	657.0	33.0	29.2	Average = 31.1	1364	1809	60.6	80.4	Average = 70.5
III	0.50% of Steel Fiber Concrete Cubes	150 x 150 = 22500	798.8	657.0	35.5	29.2	Average = 32.4	1638	1649	72.8	73.3	Average = 73.1
IV	0.75 % Steel Fiber Concrete cubes	150 x 150 = 22500	785.3	681.8	34.9	30.3	Average = 32.6	1751	1649	77.8	73.3	Average = 75.6
V	1.0 % Steel Fiber Concrete Cubes	150 x 150 = 22500	776.3	717.8	34.5	31.9	Average = 33.2	1872	1737	83.2	77.2	Average = 80.2
VI	1.25 % Steel Fiber Concrete Cubes	150 x 150 = 22500	816.8	713.3	36.3	31.7	Average = 34.0	1987	1908	88.3	84.8	Average = 86.6
VIII	1.5% Steel Fiber Concrete Cubes	150 x 150 = 22500	515.3	726.8	22.9	32.3	Average = 27.6	1589	1559	70.6	69.3	Average = 70.0

FLEXURAL STRENGTH OF STEEL FIBRE SCC OF M_{60} GRADE CONCRETE AT 28 DAYS.
Sample Particulars: CONCRETE BEAM
Subject: M.Tech Project
Sample Description: Concrete Beam Steel Fibres @ 28days
Date Of Casting: 30.03.2017; Date of Testing : 27.04.2017
Quantity: 7 Sets.
Test Required: flexural strength of steel fibre scc of m60 grade concrete at 28 days.
Date of receipt of sample : 23rd March,2017
Dt. of starting of testing : 25th March,2017
Dt. of completion of testing : 27th April,2017

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TEST RESULTS

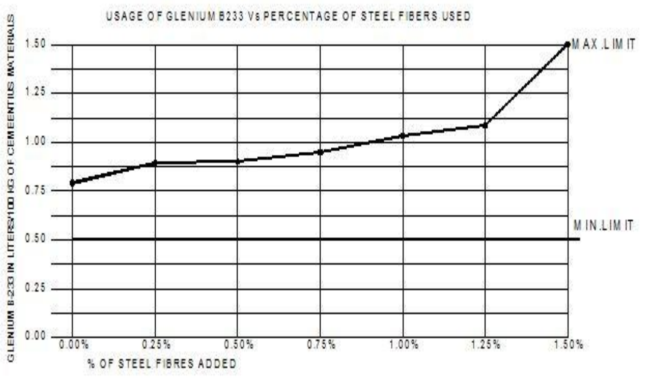
S.NO.	Specimen size In mm	% of steel fibers of aspect ratio 50.	SPAN. (mm)	Distance of Flexture in cm		Load in KN		Flexural Strength in N\mm²		Average strength. N\mm²
				B-1	B-2	B-1	B-2	B-1	B-2	
I	100*100*500mm.	0.00%	400	25.5	25.5	11.7	10.8	4.68	4.32	4.50
II	100*100*500mm.	0.25%	400	21.0	18.0	16.0	16.5	6.40	6.60	6.50
III	100*100*500mm.	0.50%.	400	20.0	22.0	16.5	17.0	6.60	6.80	6.70
VI	100*100*500mm.	0.75%	400	21.0	22.0	14.40	20.9	5.76	8.36	7.04
V	100*100*500mm.	1.00%	400	17.80	18.6	15.50	21.30	6.20	8.52	7.36
VI	100*100*500mm.	1.25%	400	18.4	18.8	17.10	21.45	6.84	8.58	7.71
VII	100*100*500mm.	1.50%	400	19.0	19.60	16.40	16.10	6.56	6.44	6.50

SPLIT TENSILE STRENGTH OF STEEL FIBRE SELF COMPACTED CONCRETE OF M-60 GRADE CONCRETE AT 28 DAYS.

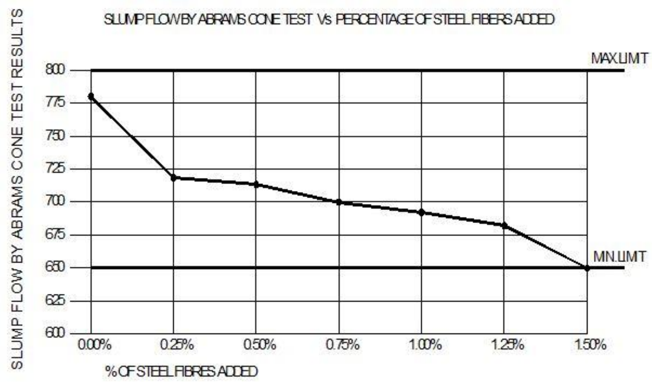
Sample Particulars: CONCRETE CYLINDER

Subject: M.Tech Project
Sample Description: Concrete Cylinder Steel Fibres @ 28days
Date Of Casting: 30.03.2017; Date of Testing : 27.04.2017
Quantity: 7 Sets.
Test Required: Split tensile strength of steel fibre self compacted concrete of m-60 grade concrete at 28 days.
Date of receipt of sample : 23rd March,2017
Dt. of starting of testing : 30th March,2017
Dt. of completion of testing : 27th April,2017

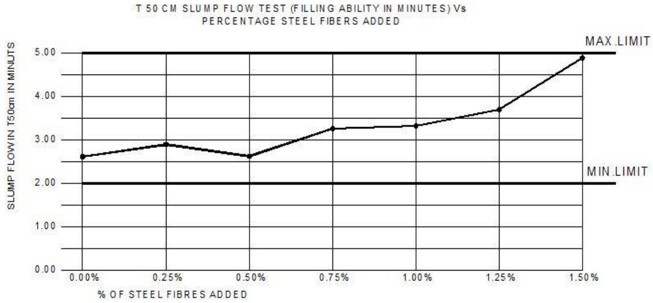
S.No.	Specimen size	% of steel Fibres of aspect ratio 50.	Load in kN		AVG. Load In KN	AVG Split tensile Strength in N\mm² (2P/πld)
I	150x150mm	0.00%	128.2	132.0	130.1	3.68
II	150x150mm	0.25%	139.1	137.4	138.3	3.91
III	150x150mm	0.50%	152.0	153.5	152.8	4.32
IV	150x150mm	0.75%	161.8	163.5	162.7	4.60
V	150x150mm	1.00%	186.1	188.0	187.1	5.29
VI	150x150mm	1.25%	220.1	218.3	219.2	6.20
VII	150x150mm	1.50%	187.2	186.2	186.7	5.28



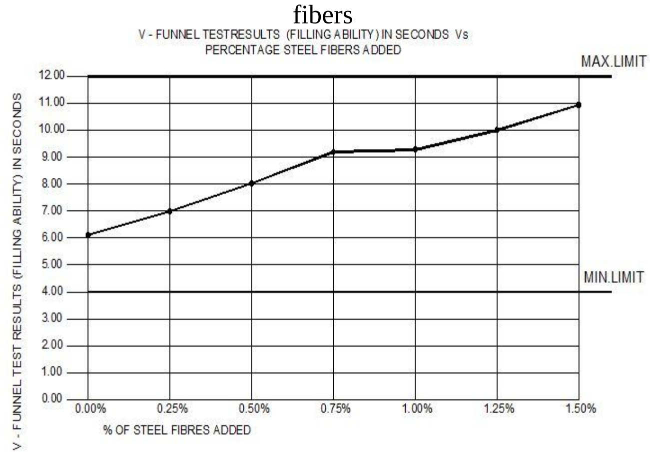
Usage Of Glenium B-233 Vs Percentage of Steel Fibers used.



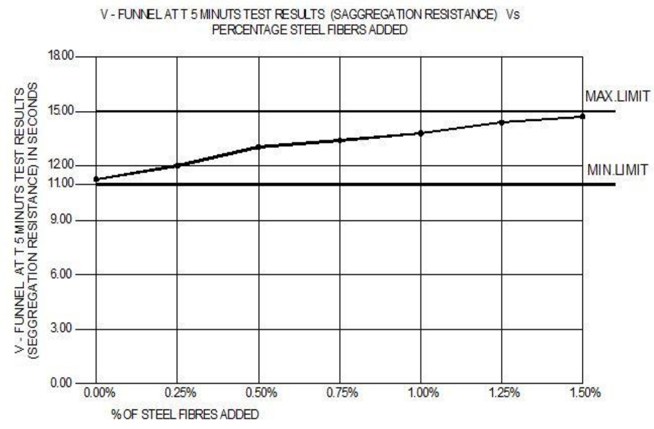
Slump flow by Abrams cone test(filling ability) vs Percentage of steel fibers added



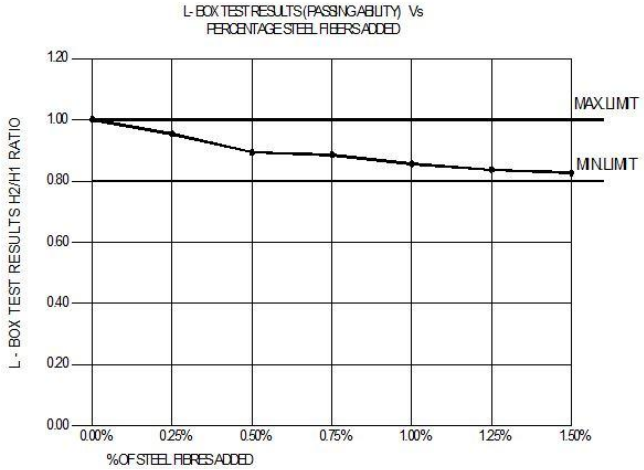
$T_{50\ CM}$ slump flow test (filling ability) Vs Percentage of steel fibers



V-Funnel test results (filling ability) Vs Percentage of steel fibers



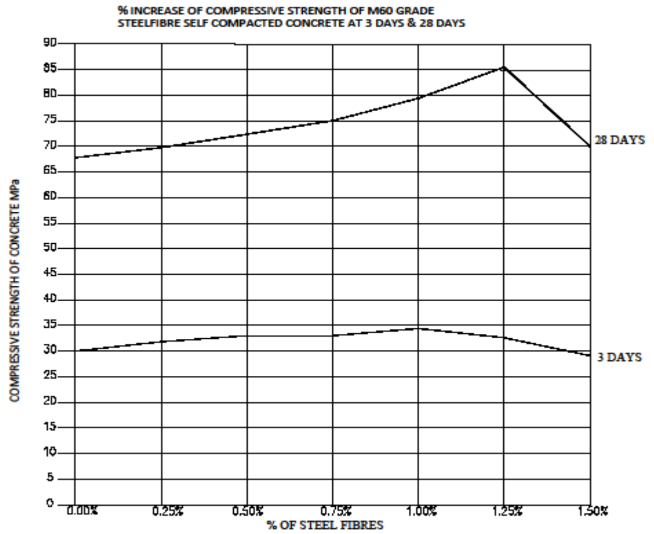
V – funnel at 5 minutes Vs Percentage of steel fibers



L – box test results Vs Percentage of steel fibers

L – box T – 20 sec. Vs Percentage of steel fibers

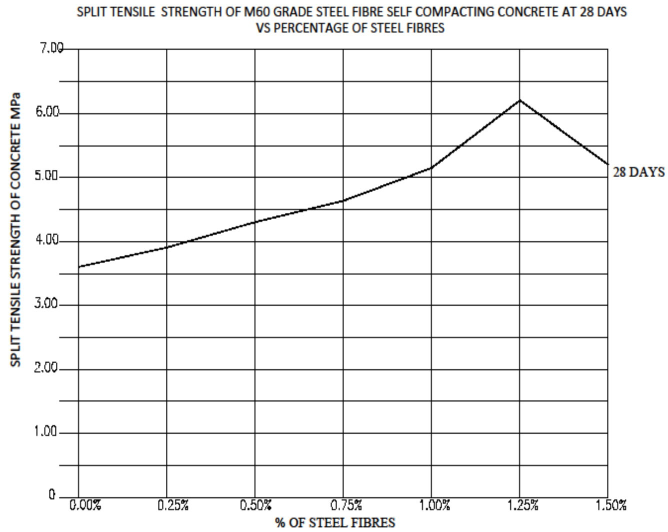
Compressive Strength Vs Percentage of steel



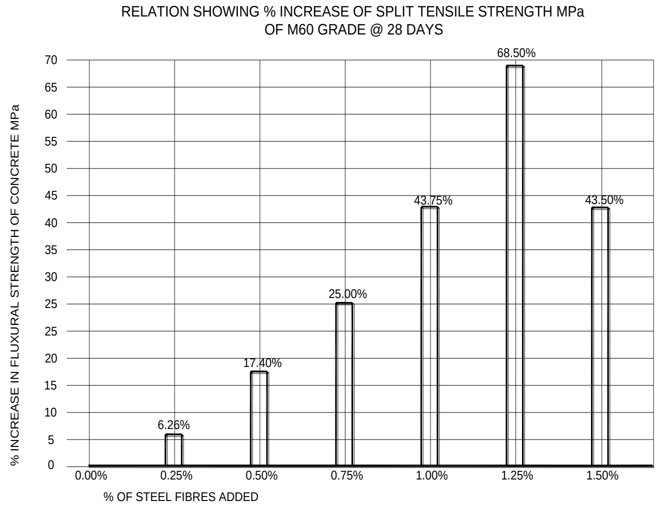
28 DAYS	68.0	70.5	73.1	75.6	80.2	86.6	70.0
3 DAYS	30.5	31.1	32.4	32.6	33.2	31.7	27.6

Compressive Strength Vs Percentage of steel

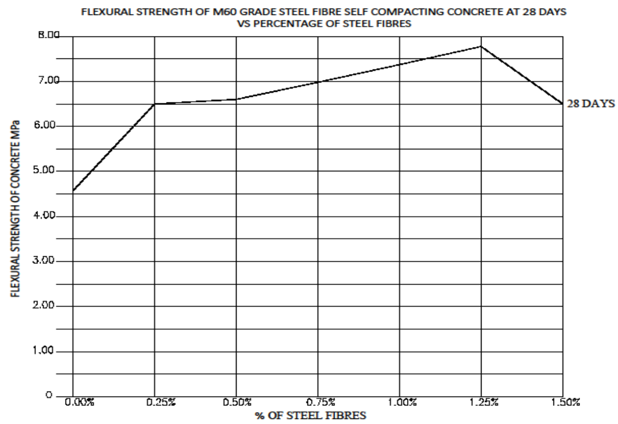
Compressive Strength (28 Days) Vs Percentage of Steel U



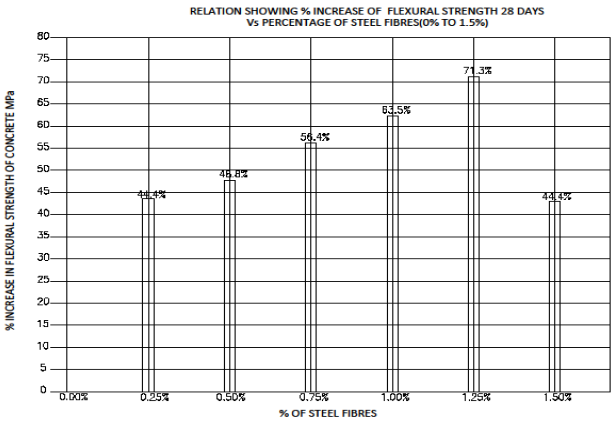
Split Tensile Strength (28 days) Vs Percentage of Steel Fibres used



Percentage of Split Tensile Strength Vs Percentage of Steel Fibres used



Flexural Strength (28 Days) Vs Percentage of Steel Used.



Percentage increase of Flexural Strength (28 days) Vs Percentage of Steel Fibres

V. CONCLUSIONS

Steel Fiber SCC mix requires high powder content, lesser quantity of coarse aggregate, high range super-plasticizer and viscosity modifying agent to give stability and fluidity to the concrete mix.

The improvement in Compressive strength of Steel fiber SCC for M_{60} at 28 days in comparison with ordinary SCC was found to be 5.08% for 0.25% Steel fiber, 18.70% for 0.50% Steel fiber, 19% for 0.75% Steel fiber, 19.70% for 1.00% Steel fiber, 13.21% for 1.25% Steel fiber, 9.56% for 1.50% Steel fiber with aspect ratio of 50.

The improvement in Split Tensile strength if Steel fiber SCC for M_{60} @ 28 days in comparison with ordinary SCC was found to be 6.26% for 0.25% Steel fiber , 17.40% for 0.50% Steel fiber, 25% for 0.75% Steel fiber, 43.75% for 1.00% Steel fiber, 68.50% for 1.25% Steel fiber, 43.50% for 1.50% Steel fiber with aspect ratio of 50.

The improvement in Flexural strength of Steel fiber SCC for M_{60} @ 28 days in comparison with ordinary SCC was found to be 39.60% for 0.25% Steel fiber, 41% for 0.50% Steel fiber, 42.80% for 0.75% Steel fiber, 57.50% for 1.00% Steel fiber, 71.70% for 1.25% Steel fiber, 40% for 1.50% Steel fiber content with aspect ratio of 50.

Scope for further work

The present investigation can be further carried out on other high strength concrete grades of M_{65}, M_{70}, M_{75}, M_{80} to study the Compressive strength, Flexural strength, and Split tensile strength of Steel fiber Self Compacting Concrete.

Durability of SCC is to be studied.

The effect of fresh properties of SCC, due to the usage of different sizes of aggregates in different proportions may be studies.

The remaining test methods for evaluating workability criteria of fresh SCC

(i.e. J.Ring, Fill box, GTM screen stability test, Orimet) may be studied.

The effect of using GGBFS, silica fume, Rice husk ach, surkhi and other pozzolanic materials may be studied.

The present investigation can be carried out at various grades to study the compressive strength, flexural strength and split strength of SCC with various types and using various percentages of fibers.

M_{60} GRADE SFRSCC CUBES, CYLINDERS

CUBE SPECIMENS STORED IN CURING TANK

COMPRESSION TESTINGMACHINE SPECIMENS TO BE TESTED

TESTEDCUBE SPECIMENTS AFTER FAILURE

WORKING IN LAB

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