EXPERIMENTAL INVESTIGATION OF THE FLEXURAL PROPERTIES OF SELF-COMPACTING STEEL FIBRE CONCRETE

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Abstract:

Conventional concrete frequently has issues with appropriate compaction in thin sections or regions of dense reinforcement, which results in a significant amount of trapped air the concrete's strength and longevity. Self-Compacting Concrete (SCC), which was created to compact under its own mass, can reduce this issue. Fresh concrete must have a high fluidity and good cohesion for this application. It is suggested to employ fine components in fresh concrete of grade M30, like fly ash (to replace 40% of the cement), superplasticizer (viscocrete), and viscosity modifying agent (stabiliser 4R), while also researching the characteristics of SCC concrete. In this study, slump flow tests, U-box tests, L-box tests, and V-funnel tests were used to determine the properties of self-compacting concrete with or without steel fibre. Flexural properties of regular concrete (M30) and self-compacting with various percentages of steel fibre (0%, 0.5%, 1%, and 1.5%) were also determined. The outcomes of the experiments were contrasted.

The compressive and flexural strengths of SCC with steel fibre were higher than those of M30 grade concrete with steel fibre. It has been determined that SCC with 1.5% steel fibre has compressive strength of 66.90 N/mm2, which is about 51% greater than M30 grade concrete with 1.5% steel fibre, and flexural strength of 27.57 N/mm2, which is approximately 4.43% greater than OCC with 1.5% steel fibre. Flexural strength increased by 1% more than other percentages of steel fibre in SCC. Deflection reduces as steel fibre percentage rises. With an increase in steel fibre percentage, strain lowers. Curvature falls as the percentage of steel fibre increases. Flexural rigidity was higher than other steel fibre percentages at 1% in SCC and OCC.

Keyword : steel fibre concrete, Self-Compacting Concrete , compressive and flexural strength ,

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1.INTRODUCTION:

The issue of concrete constructions' endurance has been a significant challenge for engineers for a number of years. Enough compaction is needed to create enduring concrete buildings. Vibrating is used to compact traditional concrete. Segregation is a simple result of excessive vibration. In conventional concrete, it might be challenging to guarantee material quality and good density in areas that have been severely reinforced. A concrete type that can compact into every corner of the form work and space between the steel just by virtue of its own weight and without the requirement for compaction can solve durability issues caused by improperly surrounding steel with concrete. This idea can be explained as the concrete that satisfies certain performance and uniformity standards that aren't always achievable when employing standard components, customary mixing techniques, and customary curing procedures.

A SCC is an engineered material made of cement, aggregates, water, and admixtures containing a number of novel ingredients, including colloidal silica, pozzolanic materials, potential Fly ash (PFA), ground granulated blast furnace slag (GGBS), and micro silica. Metakaolin, chemicals admixtures to address specific needs, such as high flowability, compressive strength, high workability, improved to chemical or mechanical stresses, lower permeability, durability, resistant to segregation, and possible under dense reinforcement settings. Concrete can be placed with minimal noise, labour, and equipment wear and tear thanks to qualities like fluidity and great resistance to segregation, which also make it possible to do so without experiencing any vibrations. While using SCC helps to abbreviate construction material and solves the issue of placing concrete in heavily reinforced portions, it has significant drawbacks such a low tensile strength to weight ratio and is prone to cracking. It is impossible to ignore how brittle ordinary concrete is, hence a method of making concrete a ductile material is required. In this perspective, steel is unquestionably a valuable material for concrete reinforcing.

No matter if it takes the shape of a steel or a reinforcing bar. Steel fibres can be added to concrete to increase its tensile strength and ductility while decreasing its workability. Since 1993, research has been carried out in Taiwan to enhance the workability of steel fibre reinforced concrete (SFRC). In Taiwan, a task force has been established to create high-performance concrete (HPC) and self-consolidating concrete (SCC) in order to address the issues of honeycombing brought on by poor concrete techniques. It is now well accepted that steel fibre reinforced concrete's (SRFC) exceptional resistance to cracking and fracture propagation is one of the material's most significant features. Fibre composites have enhanced extensibility and tensile strength due to their capacity to stop fractures, especially when subjected to flexural pressure. The fibres can also keep the matrix together even after significant breaking.

2.MATERIAL AND METHODOLOGY:

2.1 Cement:

In concrete, cement acts as a binder, holding the other ingredients together to produce a solid mass. OPC is typically utilized for all engineering construction projects. All OPC grades have a 3.15 specific gravity. There are three grades of OPC 53 grades of OPC cement are employed in this project work for the experimental study.

The Cement typically has 350 to 450 Kg/m3 of volume. Cement weighing more over 500 Kg/m3 might be hazardous and cause more shrinkage.

Less than 350 Kg/m3 may only be suitable with the inclusion of other finer filler, such as fly ash, pozzolanic, etc.

2.2 Coarse aggregate:

Table

IS sieve size	Weightretainedi ng	Percentage weightretained	Cumulative %weightretained
20mm	-	-	0
12.5mm	858.5	85.85	85.85
10mm	141.5	14.15	100
4.75mm	0	0	100

1:SieveAnalysis resultsforCoarseAggregate (asper IS: 383-1970)

From Table 1 we come to know that coarse aggregate can only be as big as 20 mm. For constructions with crowded reinforcing, aggregate of size 12 to 20 mm is preferred. Aggregates that are well graded and cubical or rounded are preferred. Regarding shape and grading, aggregate quality should be uniform.

2.3 Fine aggregate:

Table 2:SieveAnalysisfor FineAggregate (asper IS: 383–1970)

IS Sievesize	Weight Retained ing	Percentagewei ghtretained	Cumulative % weightretained	PercentagePa ssing	Grading ZoneIIIfrom Table4ofIS:383-1970
10MM	0	0	0	100	100
4.75MM	37.5	3.75	3.75	96.25	90-100

2.36MM	33	3.3	7.05	92.95	85-100
1.18MM	112	11.2	18.25	81.75	75-100
600 micron	195	19.5	37.75	62.25	60-79
300 micron	484	48.4	86.15	13.85	12-40
150 micron	131.5	13.15	99.3	0.7	0-10
75micron	4	0.4	99.7	0.3	
Pan	3	0.3	100	0	

Sand that has rounded grains as opposed to angular grains can be used to create concrete that is of higher quality. Sand from rivers or pits should be utilised instead of sea sand, which includes salt and other contaminants. River sand has been used as the study's fine aggregate. Sand confirms to grading zone III according to Table 4 of IS 383-1970, according to the results of a sieve analysis and shown in Table 2.

2.4 Fly ash:

Fly ash, commonly referred to as pulverised fuel ash, is a cement-like, glassy-light grey powdered substance. Silica, alumina, iron, calcium, and magnesium oxides are among its key components. Burning pulverised coal or lignite that is rich in the aforementioned elements produces fly ash, which is categorised as class F.

Table 3: Physical properties of fly ash

COLOUR	WHITISHGRAY
Bulk density	1.2G/CC
Specific gravity	1.9- 2.0
Fineness	2000TO2200cm/g
Moisture	NILL

2.5 Steel fibre:

A fibre is a tiny piece of reinforcing material that has certain properties. They might be flat or spherical. A useful measure called aspect ratio is frequently used to describe fibre. The fibre's aspect ratio is the ratio of its length to its diameter. Aspect ratios often fall between 30 and 150. With an increase in "Aspect ratio," fibre efficiency rises.

The tensile strength, ductility, and crack resistance of plain concrete are all quite low. Internal microcracks are a feature of concrete by nature, and as these microcracks spread, the concrete becomes brittle and fractures. This results in poor tensile strength. In brittle materials like plain concrete, structural cracks (micro cracks) can appear even before the material is loaded, often as a result of drying shrinkage or another cause of volume change. These first crack width hardly ever go beyond a few microns, but their other two dimensions could be much larger.

The major properties of steel fibre are shown in Table 4

Table 4: Properties of steel fibre

Specific Gravity	7.86
Tensile strength (N/MM^2)	400-1200
Young's modulus (GN/M^2)	200
Elongation at failure %	3.5

3.MIX DESIGN FOR M30 GRADE CONCRETE:

3.1 Design data :

The general specification which has been used for the mix design and the materials test data has been shown in the Table 5

Grade of concrete	M30
CharacteristicCompressive Strengthin28daysin Mpa	30
MaximumSizeofAggregateinmm	20
DegreeofWorkability	0.9CF
DegreeofQualityControl	Good
Type of Exposure	Moderate
TestDataforMaterials:	
CementUsed	OPC53Grade
SpecificGravity of Cement	3.15g/cm^3
SpecificGravity of FineAggregate	2.6
SpecificGravity of CoarseAggregate	2.66
Water Absorption of CoarseAggregate in%	0.91

Water Absorption of FineAggregate%	1.8
FreeSurfaceMoisture of CoarseAggregate	Nil
FreeSurfaceMoisture of FineAggregate	Zone- III

TEST	Unit	SCC	SCC(0.5%)	SCC(1%)	SCC(1.5%)	suggestedValues
Slumpflowtest	mm	735	690	675	680	650 to 800
T50cm slump flowtest	sec	3	4	4	2	2 to5
V–funneltest	Sec	9	8	8	10	6 to 12
V–funnel at 5mins	Sec	11	10	12	11	0to +3

Table 5:General data

- MIX PROPORTION: 1:1.02:2.57

4.RESULTS AND DISSCUSION:

4.1 Test on fresh concrete

The following tests were carried out to determine the qualities of self-compacting fresh concrete, and the findings are shown in the below Table 6.

i. Slump flow test ii. U box test iii. L box test iv. V funnel test

L–box test	(h1/h2)	0.95	0.82	0.82	0.8	0.8to 1
U –box test	(h1-h2)	12	14	15	18	0 to 30

Table 6: Qualities of self-compacting fresh concrete

4.2. Compressive strength:

The specimens were subjected to a compression test, and the results are listed in the Table 7 and graphed in fig.1and fig.2

Fc =P/A

Where, Fc = compressive strength (N/mm^2)

P = ultimate load (N)

A = loaded area (150 x 150mm)

Table 7: Compressive strength results

Steel fibre (%)	28dayscompressivestrength (N/mm^2)		% ofincrease
	OCC	SCC	
0%F	39.77	42.81	7.64
0.5%F	41.83	47.34	13.17
1%F	43.85	54.85	25.09
1.5%F	44.31	66.90	50.98

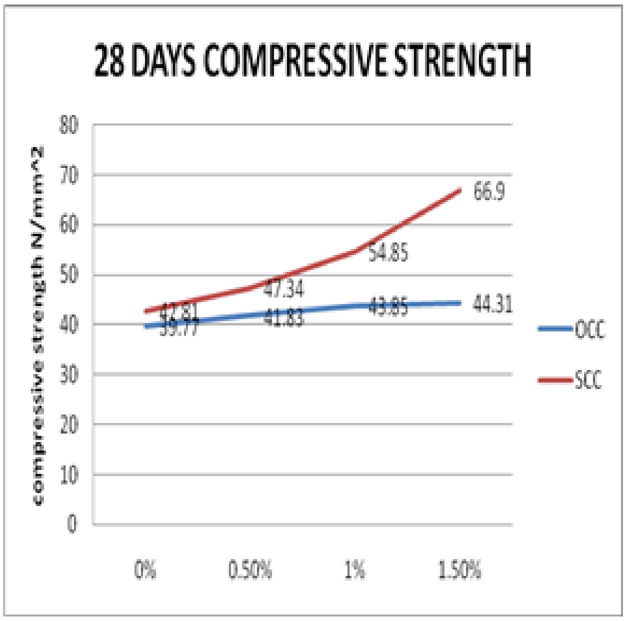


Figure 1:Variationof 28 days Compressive strengthresult forOCC&SCC

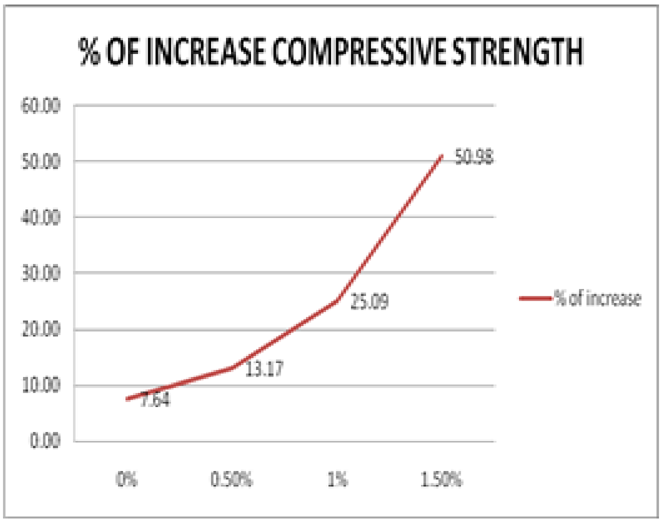


Figure 2:%ofincreasein28 Days Compressive strength resultfor OCC &SCC

4.3. Flexural strength:

A cylindrical specimen is placed horizontally between the loading surfaces of a compression testing equipment, and pressure is applied along the vertical diameter of the specimen until it fails. The results of the tensile strength test are listed in Table 8 and graph in fig 3 & fig 4

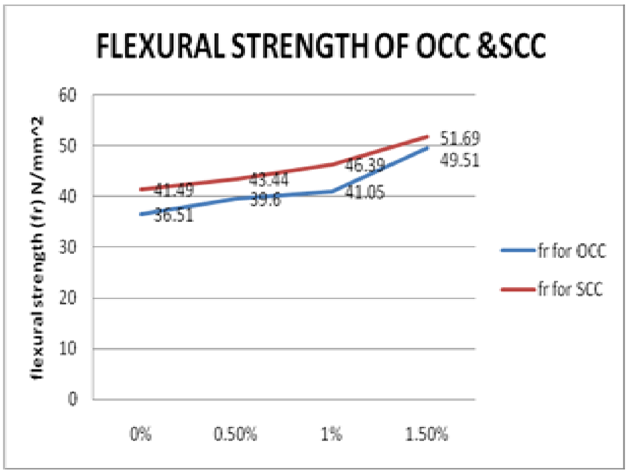
$Ft = 2P/\pi ld$

Where, P = compressive load on the cylinder

l = length of cylinder

Table8:Flexuralstrengthtestresult

% of Steel Fibre	Flexuralstrength(N/mm^2)		% ofincrease
	OCC	SCC	
0%F	19.47	22.13	13.66
0.5%F	21.12	23.17	9.71
1%F	21.89	24.74	13.02
1.5%F	26.40	27.57	4.43



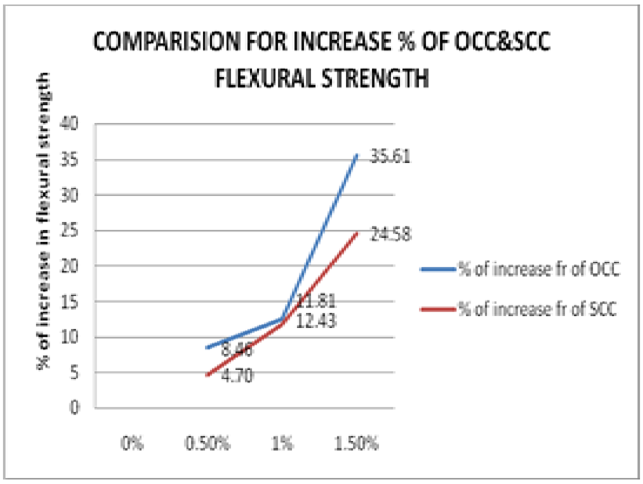


Figure3:Flexural strengthresult **Figure 4:%of increaseinFlexural strengthresult**

5. CONCLUSION:

In this project, The concrete mix design for M30 control concrete grade has been designed as 1: 0.98: 1.81. The SCC required have been arrived from the control concrete with addition of fly ash (225Kg), superplasticizer (1% of cement), and VMA (0.2% of cement).The addition of 0.5, 1.0, and 1.5 percentages of steel fibre was used to construct and evaluate compressive and flexural specimens. Following conclusions have been reached based on observations made and test findings. With a higher percentage of steel fibre, the fresh SCC flow reduces. In comparison to regular concrete with steel fibre, self-compacting concrete with steel fibre has a higher compressive strength. Compressive strength rises as the percentage of steel fibre content does. Self-compacting concrete with steel fibre has a higher flexural strength than regular concrete with steel fibre. Flexural strength rises as steel fibre content rises. With an increase in steel fibre percentage, Deflection reduces. SCC's deflection with steel fibre was less than OCC's deflection with steel fibre.

Increasing the percentage of steel fibre reduces strain. OCC and SCC with steel fibre strain were greater than those with no steel fibre. Moment grows as steel fibre increases by %. As seen in table 7.8, curvature decreases as the percentage of steel fibre increases. Initial crack size increases as steel fibre content rises.

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