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Effect of Steel Fibers on Rheological Properties of Flyash and Alccofine based Self Compacting Concrete

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Abstract – *The aim of this study is to investigate the use of steel fiber with different percentage on structural concrete and to enhance the fresh as well as mechanical properties of self compacting concrete. The main objective of this study is to determine and do comparative study of the fresh properties of flyash and alccofine based self-compacting fibrous concrete containing no fibers and concrete with fibers, as well as comparison of different percentage of fibers on self-compacting concrete. Self-compacting concrete is a special concrete that is able to flow under its own weight without any vibrations. This investigation was carried out using several tests based on EFNARC guidelines. The tests include the Slump flow, V-funnel, L-box and U-box.*

Key Words: Self Compacting Fibrous Concrete, Aspect Ratio, Fly Ash, Alccofine, Workability.

1. INTRODUCTION

Self compacting concrete(SCC) is a concrete which flows to a virtually uniform level under the influence of its own weight without segregation and bleeding, during which it completely fills the form work and space between the reinforcement. It is used to ease and ensured proper filling of the heavily reinforced sections and good structural performance of restricted areas of heavily reinforced structural members. Development of SCC was first done in Japan in the late 1980s to be used in heavily reinforced sections in higher seismic regions. SCC also provides better environment for working by eliminating the noises from the vibrators. There are many advantages of using SCC, especially when the material cost is minimised. These include reducing the construction time and labour cost, eliminating the requirement of vibrating, minimising the noise pollution, improving the filing ability of highly congested structural members. Higher slump is the main requirement of such concrete which can be easily achieved by super plasticizer in addition to the concrete mixture. For enhancing the stability, a viscosity-modifying admixture is added. However chemical admixtures are costly and their use may increase the cost of concrete. Saving in labour may balance the increased cost, but the use of mineral admixtures such as fly ash and alccofine could increase the slump of concrete mixtures without increasing its cost. Concrete is known to be a relatively brittle material when subjected to stresses and loads, where tensile strength is only one tenth of its compressive strength. Due to these characteristics of concrete, concrete members could not support such stresses and loads that usually act on concrete beams and slabs. Conventionally concrete members reinforced with steel bars to tackle tensile stress and compensate for the lack of ductility and strength. Moreover, steel reinforcement adopted to overcome high potential tensile stresses and the shear stresses at the critical location in concrete. The addition of steel reinforcement notably enhances the strength of the concrete but to develop concrete with homogenous tensile properties, the development of micro cracks is a must to prevent. The introduction of fibres in the concrete was brought in as a solution to develop concrete view of enhancing its flexural and tensile strength. It is a new form of binder that could combine Portland cement in the bonding with cement matrices. Self compacting fibrous concrete (SCFC) is made up of cement, different sizes of aggregates, which incorporate with discrete, discontinuous fibre. The main goal of the study is to determine the effect of different percentage of fibre on the fresh properties of fly ash and alccofine based concrete. Even though, the suitability of using fly ash and alccofine needs much detailed investigations. This study covers only the rheological properties of the concrete developed. The self compacting concrete used in this research work is designed by Japanese method for ultra high strength. The w/c ratio is kept 0.2. The commercially available chemical admixture used in this study. The admixture used is polycarboxylic ether based.

2 METHEDOLOGY

The present research work is experimental and requires preliminary investigations in a methodological manner.

2.1 CEMENT

The cement used in this work is Ultratech Ordinary Portland Cement (grade-53). All the properties of cement is tested by referring to IS 12269-1987 specification for Ordinary Portland Cement (grade-53). The specific gravity of cement is 3.15. The initial setting time is 78 minutes. The final setting time is 440 minutes. The standard consistency of cement is 31.5%.

2.2 FINE AGGREGATE

Sand used for this experimental work is river sand. The specific gravity is 2.7 and fineness modulus is 2.76. The loose and compacted bulk density is1576kg/m³ and 1693kg/m³. The water absorption is 0.8%

2.3 COARSE AGGREGATE

Coarse aggregates of 10mm in size were used. The specific gravity of coarse aggregate is 2.68. The loose and compacted bulk density values are 1457 kg/m³ and 1553 kg/m³. The water absorption is 1%.

2.4 FLY ASH

Fly ash is available in dry powder form and is procured from nearby thermal power plant, Punjab. The fly ash produced by the company satisfies the requirements of the IS 3812:1981, BS 3892: Part I: 1987

2.5 ALCCOFINE

ALCCOFINE 1203 is a specially processed product based on slag of high glass content with high reactivity obtained through the process of controlled granulation. ALCCOFINE 1203 have used conforming to ASTM C989-99.

2.6 FIBRES

The hooked ended steel fibres are used in this study. The fibres are used in four different percentages (0%, 0.5%, 1.0% and 1.5%). The length of the fibre is 30mm and the aspect ratio is 50. The shape of the fibre (hooked ended) helps in better bonding with the concrete.

2.6 SUPER PLASTICIZER

The super plasticizer used is BASF MasterGlenium Sky 8866. This is high-performance super plasticiser based on PCE (polycarboxylic ether) for concrete

2.7 MIXTURE PROPORTION

The very first step to satisfy the flow requirement of SCC is to determine the optimum dosage of fly ash, alccofine and super plasticizer. Various mixes were prepared and tested to satisfy the EFNARC guidelines. Finally a mix is chosen which gave satisfying fresh properties. The addition of different percentage of fibres would be done in this mix. The optimum dosage of fly ash is 21%, the optimum dosage of alccofine is 15% and the optimum dosage of super plasticizer is 1.2%.

2.8 TESTING OF FRESH PROPERTIES

For verifying the fresh properties following tests were conducted

1. Slump flow
2. V-Funnel
3. L-Box
4. U-Box

Viscosity and deformability of fresh concrete is evaluated by the measurement of slump flow time and diameter, L-Box test, U-Box test and V-Funnel test. The slump flow is related to horizontal free flow (deformability) of fresh concrete in the absence of obstructions. The method of testing of slump flow test and commonly used slump test are almost same. In the slump test the change in height between the cone and the spread concrete is measured, whereas in the slump flow test the diameter of the spread is measured. According to EFNARC, a slump flow diameter varies from 650 to 800mm is acceptable for SCC. In slump flow ability and segregation resistance can be also determined. Apart from slump flow L-Box test, U-Box test and V-Funnel test are also performed to evaluate flow ability, passing ability stability of SCC. The L-Box ratio is in range of 0.8-1.0. The V-Funnel time ranges from 8 to 12 seconds.

3 RESULT AND DISCUSSIONS

The results obtained from the experimentations are shown in the tables below

Table -1: Slump Cone Test

Sr. No.	Percentage of fiber (%)	Aspect ratio	Slump Flow by Abrams Cone (mm)	
			Horizontal Slump (mm)	T50-Time (sec)
1	0	50	770	2.98
2	0.5	50	755	3.18
3	1.0	50	718	3.9
3	1.5	50	680	4.44

Table 1 above shows the value of horizontal slump.

Table -2: V-funnel Test

Sr. No.	Percentage of fiber (%)	Aspect ratio	V-Funnel Test	
			Flow Time(sec)	T50-Time (sec)
1	0	50	7.44	8.10
2	0.5	50	7.90	9.15
3	1.0	50	8.72	10.11
3	1.5	50	9.57	10.98

Table 2 above shows the value of flow time.

Table -3: L-Box Test

Sr. No.	Percentage of fiber (%)	Aspect ratio	L-BOX TEST
			H2/H1
1	0	50	0.958
2	0.5	50	0.918
3	1.0	50	0.900
3	1.5	50	0.891

Table 3 above shows the value L-Box ratio.

Table -4: U-BOX TEST

Sr. No.	Percentage of fiber (%)	Aspect ratio	U-BOX TEST		
			H1 (mm)	H2 (mm)	H3 (mm)
1	0	50	309	299	10
2	0.5	50	315	304	11
3	1.0	50	321	308	13
3	1.5	50	323	309	14

Table 4 shows the value of U-Box

3. CONCLUSIONS

The study shows that it is possible to design self compacting fibrous concrete incorporating fly ash and alccofine with various proportions of steel fibers such as 0%, 0.5%, 1.0%, 1.5%. The result obtained from all the concrete mixtures satisfy the requirements suggested by EFNARC. All the mixtures have good flow ability and acquire self compaction characteristics. From the given tables it can be seen that the slump flow within the range of 680 to 770 and flow time ranging from 2.98 to 4.44 seconds. V-Funnel flow ranges from 7.44 to 9.57 and 8.10 to 10.98 seconds. L-Box ratio ranging from 0.958 to 891. All the results obtained from different mixes satisfy the lower and upper limits of EFNARC guidelines. All the mixes have good flow ability and self compaction characteristics. Also it is observed that the fibers improve resistance to segregation and bleeding. Also the addition of fly ash and alccofine in SCC improves microstructures of concrete that would be helpful in increasing mechanical properties of concrete developed. Use of fly ash and alccofine reduces the consumption of cement due to which CO^2 emulsion in manufacturing process is also reduced. By adding fly ash the issue of disposal is eradicated which reduces air pollution and land pollution.

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