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Waste Plastic Fibre Reinforced Self Compacting Concrete

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ABSTRACT
Self-compacting concrete is high performance concrete which is highly flowable, non-segregating, spread on its own weight and doesn't need any compaction. This paper deals with flow and strength characteristics such as compressive strength, split tensile strength, flexural strength and impact strength of Self-compacting concrete with various percentages of waste plastic fibres like 0%, 0.25%, 0.5%, 0.75%, 1.0%, 1.1%, 1.20%, 1.3% and 1.4% is added by weight of cement. The mix proportion for M_{40} grade of concrete was done by using Nan Su method (Cement: GGBS: Fine aggregate: Course aggregate 1: 0.705: 3.34: 2.62). Water powder (W/P) ratio 0.36, cement content 280kg/m^3, GGBS 220 kg/m^3 was calculated and maintained as constant throughout the experimental work for all eight mixes, only the superplastizers dosage was varied for different percentage of fibres. In this experimental investigation one control mix and eight (8) different mixes were considered. Totally 81 Cube, beam, Cylindrical specimens and square plates were casted, cured and tested as per IS specifications. For determining impact strength drop weight method was used. The results obtained indicate that fresh (workability) characteristics satisfy the lower and upper limit as suggested by EFNARC. The tests on hardened properties indicate that the compressive strength, split tensile strength, flexural strength was improved proportionally with the addition of waste plastic fibers upto 1.0% by weight of cement and then decreases. The impact strength improved proportionally with addition of fibres upto 1.2% by weight of cement and then decreases.
Keywords- Self-compacting concrete, Waste plastic fibres, Compressive strength, Split tensile strength, Flexural strength and Impact strength

I. INTRODUCTION

Self-compacting Concrete (SCC) is a new concrete technology that offers very powerful benefits. Self-Compacting Concrete was developed in Japan in the late 1980s to reduce the labour required to properly place concrete. The researchers are Okamura, Ozawa and Japanese contractors Kajima, Maeda, Taisei [5, 6]. This technology allows significant improvements compared to conventional slump concrete, in terms of workability or slump flow ability. No vibration is necessary, and better quality concrete can be produced. Some of the benefits for designers and clients are more innovative designs, more complex shapes, faster construction, improved durability, and better appearance [6, 7]. Self-compacting concrete is not affected by the skill of workers, shape and reinforcing bar arrangement of a structure. Due to high fluidity and resisting pavers of segregation of SCC, it can be pumped to longer distances. The use of SCC not only shortens the construction period, but also ensures quality and durability. Concrete has excellent deformation in the fresh state and high resistance to segregation and, can be placed and compacted under its self-weight without applying vibration. Self-compacting concrete is also known as *Self-Consolidating or Self-Leveling Concrete* [6, 7].

Basic Principle

The SCC is that which gets compacted due to its self weight and is de-aerated (no entrapped air) almost completely while flowing in the form work. In densely reinforced structural members, it fills completely all the voids and gaps and maintains nearly horizontal concrete level after it is placed. With regard to its composition, SCC consists of the same components as conventionally vibrated normal concrete, i.e., cement, aggregates, water, additives or admixtures [2, 6].

However, the high dosage of super-plasticizer used for reduction of the liquid limit and for better workability, the high powder content as 'lubricant' for the coarse aggregates, as well as the use of viscosity-agents to increase the viscosity of the concrete have to be taken into account[2, 9].

Super plasticizer enhances deformability and with the reduction of water/powder segregation resistance is increased. High deformability and high segregation resistance is obtained by limiting the amount of coarse aggregate. These two properties of mortar and concrete in turn lead to self compact ability limitation of coarse aggregate content [2, 7]. Figure 1 shows the basic principles for the production of SCC.

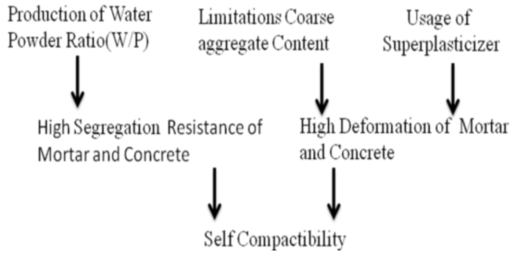

Fig.1: Basic principles for production of self-compacting concrete

The use of fibers might extend the possible fields of application of SCC. The addition of discrete fibres with adequate mechanical properties, in to concrete matrix improves several properties such as toughness, increase resistance to fatigue, impact and blast loading, reduce spalling of the reinforcement cover and improve abrasion resistance and flexural and shear strength[3,4]. The extent to which fibres contribute to each mechanical and durability characteristics depend on many factors including fibre type, configuration, length and volume, water-powder material ratio and other mixture parameters. Types of fibres like plastic or polymeric fibres, glass fibres, steel fibres, carbon fibres and natural fibres like bast or stem, leaf fibres, fruit fibres and wood fibres can be used in SCC [10].

Plastic which is a non-biodegradable material neither decays nor degenerates completely in water or in soil. Plastic when burnt releases many toxic gases which is not only dangerous to health of living beings but also results in environmental pollution [8]. The disposal of such waste plastics is a major challenge to the municipalities especially in the metropolitan cities and such waste plastics can be used in the form of fibres to impart some additional desirable qualities to the concrete [8]. In this experimental investigation an attempt has been made to study the flow and strength characteristics of SCC with the addition of various percentages of waste plastic fibres into it.

II. EXPERIMENTAL WORK

In this experimental investigation an attempt has been made to study the flow and strength characteristics of self-compacting concrete with the addition of various percentages of waste plastic fibres into it.

1.1 Materials Used:

- *Cement:* Ordinary Portland Cement-53 grade was used having a specific gravity of 3.15 and it satisfies the requirements of IS: 12269-1987 specifications. The physical and mechanical properties of tested cement are given in Table No.1
- *Ground granulated blast furnace slag*: GGBS obtained from Bellary steel plant was used. The GGBS used was having Specific gravity of 2.62. The properties of tested GGBS are given in Table No.2 and Table No.3
- *Fine aggregates:* Manufactured sand was used as fine aggregate. The sand used was having specific gravity of 2.6 and bulk density is 1550kg/m^3 and confirmed to grading zone-II as per IS: 383-1970 specification.
- *Coarse aggregates:* The coarse aggregates used in the experimentation were 12.5 mm and down size aggregate and tested as per IS: 383-1970 and 2386-1963 (I, II and III) specifications. The aggregates used were having specific gravity of 2.72 and bulk density is 1430kg/m^3
- *Water:* Ordinary potable water free from organic content, turbidity and salts was used for mixing and for curing throughout the investigation.
- *Superplastizers:* Glenium B_{233} an admixture of new generation based on modified polycarboxylic ether was used. The varied dosage of superplasticizer adopted in the experimentation are given in Table No.4
- *Fibres:* The waste plastic fibres were obtained by cutting waste plastic pots, buckets, cans, drums and utensils. The waste plastic fibres obtained were all recycled plastics. The fibres were cut from steel wire cutter and it is labour oriented. The thickness of waste plastic fibres was 1mm and its breadth was kept 2.5mm and these fibres were straight. The different volume fraction of fibres and suitable aspect ratio 50 were selected and used in this investigation [8].

2.2 Experimental Procedure

1.2.1 Mix Proportioning, casting and curing:

The mix proportion (Cement: GGBS: Fine aggregate: Course aggregate 1: 0.705: 3.34: 2.62) for M_{40} grade of concrete was done by using Nan Su method, throughout the work. The super plastizers dosage was varied for different percentage of fibres. In this work experimental investigation one control mix and eight (8) different mixes were prepared and the details of the mixes are as shown in Table No.5

The specimens were casted, de-moulded and cured for 28days as per the routine procedure and were taken out only at the time of testing. The compressive strength test was conducted as per IS: 516-1959 specification on specimens of size 150 x150 x 150 mm. The splitting/Indirect tensile strength (Brazilian test) test was conducted as per IS: 5816-1999 specification on specimens of diameter 150 mm and length 300mm. Flexural strength test was conducted as per IS: 516-1959 specification on specimens of size 150 x 150 x 750mm.Two point loading was adopted on a span of 400mm. Impact strength test was conducted as per ACI 544 Committee recommendations. A steel ball weighing 0.89 kg was dropped from a height of one meter on the impact specimens of size 250mm x 250mm x 30mm, which were kept on the floor. The care was taken to see that the ball was dropped at the center point of specimen every time. The number of blows required to cause first crack and final failure were noted. The numbers of blows were converted into impact energy by the formula-

Impact energy = mghN = w/g x g x h x N = whN (N-m)

Where, m = mass of the ball
w = weight of the ball =0.89kg = 8.9N
g =Acceleration due to gravity
h =Height of the drop =1m
N =Average number of blows to cause the failure

Table 01: PHYSICAL PROPERTIES ORDINARY PORTLAND CEMENT-53 GRADE (IS: 12269-1987)

Properties	Results	Permissible limit as per IS: 12269-1987
Fineness	28.4 m^2/N	Should not be more than 22.5m^2/N
Normal consistency	26%	-
Setting Time a. Initial b. Final	160 Min 350 Min	Should not be less than 30 Min Should not be more than 600 Min
Specific gravity	3.14	-
Compressive strength of mortar cubes for a. 3days. b. 7days. c. 28 days	33.0 N/mm^2 45.5 N/mm^2 62.5 N/mm^2	Should not be less than 27 N/mm^2 Should not be less than 37 N/mm^2 Should not be less than 53 N/mm^2

Table 02: CHEMICAL PROPERTIES OF GGBS

Properties	Results (%)
Insoluble residue	0.83
Manganese Oxide	0.25
Magnesium oxide	10.13
Sulphide sulphur	0.75
$CaO+MgO+1/3Al_2O_3$ $SiO_2+2/3Al_2O$	1.10
$CaO+MgO+$ $Al_2O_3SiO_2$	1.84

Table 03: PHYSICAL PROPERTIES OF GGBS

Properties	Results
Specific Gravity	2.86
Fineness % (by wet sieve on 45μ sieve)	10.2
Specific surface (m^2/Kg)	314
Glass content %	93.26

The workability (Slump flow, T_{50cm}, J-ring, V-funnel and L-box tests) and strength (compressive strength, tensile strength, flexural strength and impact strength) test results of Self-compacting concrete with various percentage additions of waste plastic fibres are given in Table No.6 and Table No.7

III. EXPERIMENTAL RESULTS

Table 5.0: Mix proportions of SCC for various percentage additions of waste plastic fibers.

Mix	% of fibre	W/P ratio by mass	Cement (kg/m^3)	GGBS (kg/m^3)	Fine Agg. (kg/m^3)	Coarse Agg. (kg/m^3)	Total Powder (kg/m^3)	SP %
$SCC_{0.00}$	0.00	0.35	280	197.5	936	734	477.5	0.60
$SCC_{0.25}$	0.25	0.35	280	197.5	936	734	477.5	0.62
$SCC_{0.5}$	0.50	0.35	280	197.5	936	734	477.5	0.65
$SCC_{0.75}$	0.75	0.35	280	197.5	936	734	477.5	0.72
$SCC_{1.00}$	1.00	0.35	280	197.5	936	734	477.5	0.80
$SCC_{1.10}$	1.10	0.34	280	220	936	734	500	0.81
$SCC_{1.20}$	1.20	0.34	280	220	936	734	500	0.82
$SCC_{1.30}$	1.30	0.34	280	220	936	734	500	0.84
$SCC_{1.40}$	1.40	0.34	280	220	936	734	500	0.86

Table 6.0: Test results of SCC for various percentage additions of waste plastic fibers in fresh state.

Mix	% of fibre	Slump flow (760-850) (for class SF2)	T_{50cm} (□2forVS1) (> 2 forVS2)	V-funnel (□8 forVF1) (9 to25 for VF2)	V-funnel T_{5min} (+3 sec)	J –Ring (0-10mm)	L-box- (>0.75)
$SCC_{0.00}$	0.00	800	2	8	12	3	0.80

$SCC_{0.25}$	0.25	795	2.5	8.36	11.5	5	0.85
$SCC_{0.5}$	0.50	780	3	9.5	13	8	0.93
$SCC_{0.75}$	0.75	750	4	12	15	10	1.00
$SCC_{1.00}$	1.00	735	8.5	18	21	10	1.80
$SCC_{1.10}$	1.10	780	9.0	19.5	22	12	1.93
$SCC_{1.20}$	1.20	780	9.2	21	24	12	1.93
$SCC_{1.30}$	1.30	770	10	23	27	11	1.93
$SCC_{1.40}$	1.40	764	10.4	24	28	12	1.85

Table 07: Test results of compressive, split tensile, flexural and impact strength tests.

Sl no	% OF FIBRE	AVERAGE COMPRESSIVE STRENGTH AFTER 28 DAYS IN N/mm^2	AVERAGE SPLIT TENSILE STRENGTH AFTER 28 DAYS IN N/mm^2	AVERAGE FLEXURAL STRENGTH AFTER 28 DAYS IN N/mm^2	Average Impact Resistance (blows)		Average Impact Energy (Nm)	
					1st crack	Failure	1st crack	Failure
1	0.0	57.21	3.38	4.04	3	5	23.28	40.74
2	0.25	58.04	3.68	4.38	4	6	32.01	52.38
3	0.50	62.16	4.11	4.86	4	7	32.01	64.03
4	0.75	64.14	4.38	6.86	4	8	31.52	66.93
5	1.00	65.26	4.59	7.06	4	10	34.92	90.22
6	1.1	64.61	4.24	6.91	4	11	37.83	93.13
7	1.2	61.04	3.94	6.70	5	14	40.74	119.32
8	1.3	60.57	3.79	6.61	4	8	31.52	66.93
9	1.4	57.75	3.55	6.49	3	7	29.06	58.28

IV. OBSERVATIONS AND DISCUSSIONS

Based on the experimental results and observations the following discussions were made

The requirements for SCC in fresh state according to EFNARC 2005 guidelines should be selected from one or more of the following characteristics and then specified by class or target value.1) flowability accessed by slump flow 2)Viscosity assessed by T_{50} or V funnel 3)Passing ability assessed by L box or J ring 4)Segregation resistance by Vfunnel and T_5

It can be observed that all the mixes from 0% fibre to 1.4% fibre satisfy flowability measured by slump flow, viscosity assessed by T_{50} and passing ability assessed by L box out of the four key characteristics hence can be considered as SCC mixes.

It has been observed that from the experimental results, the addition of waste plastic fibres from 0.25% to 1.0% by weight of cement has shown increase in strength characteristics (compressive strength, split tensile strength, flexural strength) of SCC compared to SCC without plastic fibres and then starts decreasing after 1.0% addition of waste plastic fibres into it.The impact strength increases for fibre content upto 1.2% and then decreases. This is because higher volume of fibrrs interferes with cohesiveness of concrete mix. Improper mixing of fibres with matrix takes place due to balling effect of fibres which increases the airvoids in the mix and in turn reduces the strength.

It has been observed that from the experimental results, it is possible to design a waste plastic fibre reinforced SCC by incorporating GGBS in mix design. The WPFRSCC has satisfied the requirement of flow ability, viscosity and passing ability of SCC as suggested by EFNARC

V. CONCLUSIONS

Based on the experimental results the following conclusion can be drawn

1. It can be concluded that the maximum compressive strength, split tensile strength, flexural strength can be achieved at 1% addition of waste plastic fibres with respect to an aspect ratio of 50. Maximum impact strength can be achieved at 1.2% fibre content with an aspect ratio of 50.

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REFERENCES

[1]. EFNARC, “Specification and guidelines for Self-compacting concrete”, European Federation of Produces and Applicators of Specialist Products for Structures, May 2005

[2]. Hardik Upadhyay, Pankaj Shah, Elizabeth George, “ Testing and Mix Design Method of Self-Compacting Concrete”, National Conference on Recent Trends in Engineering & Technology, B.V.M. Engineering College, V.V. Nagar, Gujarat, India, 13-14 May 2011

[3]. Kishor S. Sable, Madhuri K. Rathi, “Effect of different types of steel fibre and aspect ratio on mechanical properties of Self- compacting concrete”, International Journal of Engineering and Innovative Technology,Vol.2, issued 2012

[4]. Krishna Rao. B and Ravindra.V, “Steel fibre reinforced Self-compacting concrete incorporating class-F fly ash”, International Journal of Engineering Science and Technology,Vol.2(9),pp.4936-4943, 2010

[5]. Nan su, Kung-Chung Hsu and His-Wen Chai, “A simple mix design method for Self-compacting concrete”, Cement and concrete Research,Vol.31,pp.1799-1807, 2001

[6]. Okamura Hajime and Ouchi Marahiro,”Self-compacting concrete”, Journal of Advanced Concrete Technology, Vol.1, No.1, pp.5-15, 2003

[7]. Ouchi M, “Current condition of Self-Compacting Concrete in Japan”, The Second International RILEM symposium on SCC, Ozawa K, Ouchi M, pp.63-68, 2001

[8]. Prahallada M.C. and Prakash K.B, “Investigations on various Aspect Ratios of Waste Plastic Fibre Reinforced Concrete “New Building Materials & Construction World”, pp.51-54, July 2001

[9]. Shanthappa B.C. Prahallada M.C. and Prakash K.B, “Characteristics of Self Compacting Concrete Subjected to Sustained Elevated Temperatures” *i*-manager’s Journal of Civil Engg”, Vol.3, Issue No: 2, pp.1-9, March - May 2013

[10]. Steffen Grunewald, Joost C. Walraven, “Parameter-Study on the Influence of Steel Fibers and Coarse Aggregate Content on the Fresh Properties of Self-Compacting Concrete”, Cement and Concrete Research pp.1793–1798, 2001