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Self-Compacting Concrete Containing Plastic Bag Waste Fibers Partially Replace by Sand

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***Abstract:** The production of self-compacting concrete SCC is a relatively new technology. Nowadays, the production of SCC is becoming more popular. However, the production of SCC requires more sensitive and efficient workmanship and equipment. This research presents the fresh and hardened properties of self-compacting concrete (SCC) containing plastic bag waste fibers (PBWF). Fibers were prepared by using waste plastic bags. Plastic bag waste fibers (PBWF) are used in varying percentages of fibers (0.5, 1, and 1.5%) replacement by weight of fine aggregate. L-box, U-box, and V-box tests were performed to assess the fresh properties of the prepared mixtures. The compressive strength of the concrete(M-30) was determined. Test results show that mixtures based on PBWF with 0.5%, 1%, and 1.5% met the criteria of self-compactibility (evaluated by U -box, L-box, and V-box) regardless of the fibers content. This research consists of (i) the development of a suitable mix for SCC containing PBWF that would satisfy the requirements of the workability; (ii) casting of concrete samples and testing them for compressive strength for 7days, 14days, and 28days.*

I. INTRODUCTION

SCC was formed first in Japan in the late 1980s to be mainly used for highly congested reinforced structures in seismic regions (Bouzoubaa and Lachemi, 2001). As the durability of concrete structures became an important issue in Japan. Adequate compaction by skilled workers was required to obtain durable concrete structures. This requirement started the development of SCC also its development was first reported in 1989 (Okamura and Ouchi, 1999). SCC can be defined as extremely performance material that flows under its own weight without requiring vibrators to achieve consolidation by complete filling of formworks even when narrow gaps between reinforcement bars prohibit access. SCC can also be used in situations where it is difficult or impossible to use mechanical compaction for fresh concrete, such as underwater concreting, cast-in-situ pile foundations, machine bases and columns and walls with congested reinforcement. Self-compacting concrete (SCC) describes one of the most important advancements in concrete technology for decades. Bad compaction or segregation may drastically lower the performance of mature concrete. SCC has developed to assure adequate compaction and facilitate placement of concrete in structures with heavy reinforcement and restricted areas.

The reuse of plastic wastes represents a major role in sustainable solid waste management. From different points of view, it helps to save natural resources that are not replenished. It decreases the pollution of the environment and helps to save and recycle energy production processes. Wastes and industrial by-products should be considered as potentially valuable resources merely awaiting appropriate treatment and application. Plastic wastes are among these wastes; their disposal has harmful effects on the environment due to their long biodegradation period.

Therefore, one of the logical methods for reducing their negative effects is applying these materials in other industries. Much research effort has focused on reusing waste materials from plastic industries in concrete. The addition of plastic waste to concrete corresponds to a new perspective in research activities. Ghernouti Y, et al(2018) developed SCC mixtures with plastic bag waste fiber (WFSCC) by changing the length of fibers (2, 4, and 6 cm) with various levels of inclusion (1, 3, 5 and 7 kg/m3) and two other mixtures, one with 1 kg/m3 of polypropylene fibers (PFSCC) and without fiber as reference (RSCC). The results are suggesting a possible use of PBWF for structural reinforcement of SCC, the appearance of these fibers in concrete preventing the position of microcracks. Although the incorporation of PBWF does not have much effect on the compressive and flexural strengths but it has an important impact on the split tensile strength value at 28 days. The change varies from 4% to 74%, it depends on the amount of fibers, and it is not affected by the length of PBWF.

In this study, we made a sample of SCC(Self-compacting concrete) with 0%, 0.5%, 1.0%, and 1.5% fiber replacement and conduct fresh concrete, and hard concrete tests results indicate the optimum percentage of fiber in SCC(self-compacting concrete) is 1.0% by weight of fine aggregate.

II. METHODOLOGY

In this research, we first decide the fibers we will use to replace fine aggregate. We are using plastic bag waste fibers to replace some percentage of fine aggregate. Then the selection of materials that are used in the concrete mix for durability and desirable strength.

Compaction criteria for concrete are chosen according to standards IS10262:2019. We are designing the self-compacting concrete grade of M-30 concerning IS10262-2019.

Then, replace the fine aggregate with plastic bag waste fibers as per the 0.5,1 & 1.5%.

Perform the workability and strength test and then analysis of all the test results.

III. EXPERIMENTAL PROGRAM AND TEST PROCEDURE

A. *Materials*

1) *Cement:* Ordinary Portland cement which is extensively used in India was used in this study. The specific gravity of cement used was taken as 3.15.
2) *Coarse Aggregate:* The coarse aggregates used in this study were gravels, crushed stone, etc. The maximum aggregate size was 20 mm. The specific gravity of aggregates commonly used in construction varies from about 2.5 to 3.0 with a normal value of about 2.68. Water consumption shall not be more than 0.6 per unit by weight.
3) *Fine Aggregate:* River sand or Natural sand was used as fine aggregate. The specific gravity and absorption of the fine aggregates are typically 2.6 and 12%, respectively.
4) *Admixture:* Superplasticizer Conmix SP1030 is high range water reducing superplasticizer admixture. It drastically reduces the amount of water required to achieve the same workability of concrete at a nominal dosage. It enhances the strength and durability of concrete. It produces extremely workable and flowing concrete without loss of strength and with a reduced w/c ratio. It can be used in mass concrete work, precast concrete work, structural R.C.C construction, congested reinforcement areas, heavy industrial construction, etc. For high strength, water-reduced concrete the normal dosage range is from 400ml-800ml/per bag of cementitious material, including PFA, GGBFS, and micro silica. For high workability concrete, the normal dosage range is from 350ml -1000ml/per bag of cement. For normal water reduced and flowable concrete, a lower dosage of 100-250ml can be used.
5) *Recycled Plastic Bag Waste Fibers:* The used recycled PBWF is produced from plastic bag waste. The plastic bag waste is introduced into a regeneration at a temperature of around 250C and then exits as a fibrous pulp that passes through a tank of water for cooling and hardening. Then they will be cut into fibers length of 2-2.5cm. The recycled PBWF has a 1.6–2 mm diameter.

B. *Preparation And Casting Of Test Specimens*

Self-compacting concrete (SCC) is a special type of concrete that can be placed and consolidated under its own weight without any vibration effort due to its excellent deformability. At the same time, it is cohesive enough to be handled without segregation or bleeding. The mixing procedure and time are very important, thus the mixing process was kept constant for all concrete mixtures. All the ingredients were first mixed under dry conditions in the concrete mixer for one minute. Then 70% of the calculating amount of water was added to the dry mix and mixed thoroughly for one minute. The remaining amount of water was mixed with the superplasticizer and was poured into the mixer and mixed for five minutes. Later, required quantities of fiber were sprinkled over the concrete mix and mixed for one minute to get a uniform mix. Thus, the total mixing time was 8 min. After this sequence of preparation, flowability, the passing ability of prepared mixtures are measured. For each concrete mixture, three cubes of 150mm * 150mm specimen were cast. The specimens were de-molded after one day and then placed in a curing tank. For the sand, it was replaced by the fibres as per the percentage added.

C. *Test On Fresh Concrete*

The flowability and passing ability were evaluated by L-box, V-box and, U-box test. L-box test measures the fresh SCC passing ability and self-leveling. The test apparatus made from two prisms and set as an L form box with three bars and an opening slide at the bottom box connector. As the vertical box is fully filled, the slid then is opened that allows the fresh SCC flow to pass the steel bar. The self-leveling ratio is measured as the ratio between the heights of the fresh concrete surface at the beginning (h1) and at the end (h2). For acceptable SCC, the L-box ratio must be in the range of 0.8–1.0.

V-Box is used to determine the filling capacity(flowability) of the concrete with a maximum aggregate of 20 mm. The funnel is filled with about 12 liters of concrete and the time taken for it to flow through the apparatus is measured. The test measures the ease of flow of the concrete; shorter flow times indicate greater flowability. For SCC, a flow time in the range of 6 to 12 seconds is considered appropriate. The inverted cone shape restricts the flow, and prolonged flow times may give some indication of the susceptibility of the mix to blocking.

U-Box is used to measure the filling ability of SCC. The apparatus consists of a vessel that is divided by a middle wall into two compartments. It provides a good direct assessment of filling ability. For conducting the U-box test, one of the compartments of the apparatus is filled with the concrete sample, and filled concrete is left to stand for 1 minute. Then the sliding gate is lifted to allow the concrete to flow out into the other compartment. After the concrete comes to support, the height of the concrete in the compartment that has been filled is measured in two places and the mean height (H1) is measured. Also, the height in the other compartment (H2) is measured. The filling height is then calculated as H1- H2. The entire test has to be performed within 5 minutes. If the concrete flows as freely as water, at rest it will be horizontal, so H1- H2 = 0. Therefore, the nearer this test value, i.e., the 'filling height', is zero, the better the flow and passing ability of SCC.

D. Test On Hardened Concrete

Tests on hardened concrete have been performed to determine compressive strength. Compressive strength test has been determined at 7 days, 14 days, and 28 days in accordance with IS 10262:2019. For each concrete mixture, three cubes of 150mm * 150mm specimen were cast. These specimens are tested by a compression testing machine after seven days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete. The compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.

Compressive Strength = Load / Cross-sectional Area

IV. RESULTS

A. Material Result

1) Cement- OPC 43

Table no.1

S. NO.	PROPERTIES	Results	Standard value as per IS 8112-2013
1.	Specific gravity	3.15	3.15
2.	Normal consistency	31%	26-33%
3.	Initial setting time	85 min	30min(minimum)
4.	Final setting time	280 min	600min(maximum)

2) Fine Aggregate

Table no. 2

S. NO	TEST	Result	Standard value as per IS 393:1970
1.	Zone	II	
2.	Specific gravity	2.63	2.65
3.	Fineness modulus	3.1 %	2.6-3.2%
4.	Water absorption	0.9 %	0.3-2.5%

3) Coarse Aggregate

Table no. 3

S. NO.	Test	Result	Standard value as per IS IS 393:1970
1.	Specific gravity	2.64	2.5-3.0
2.	Water absorption	0.4 %	2%(max)
3.	Fineness modulus	8.0	5.5-8.0

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B. Workability Results

In the case of self compaction concrete we determine the degree of compaction with help of L-Box, U-Box and V-Box tests, following result are found from these tests-

1) *L- Box:* This test is perform for check degree of compaction and filling ability of SSC(self compacting concrete) by as the ratio between the heights of the fresh concrete surface at the beginning (h1) and at the end (h2).

Table no.4

Sample of concrete with percentage of fiber adulterant	H1(mm)	H2(mm)	H2/H1 (mm) (Acceptable range 0.8-1.0)
0% or control mix	105	95	0.905 (ok)
0.5% fiber	110	90	0.818 (ok)
01% fiber	115	93	0.808 (ok)
1.5% fiber	110	63	0.572 (block)

2) *U-Box:* U box test id done to check filling capability of self compacting concrete in this apparatus there are two compartment with one barrier between them, after level filling concrete we check the time of transfer concrete one compartment to other and check the level of concrete in two compartments.

Table no. 5

Sample of concrete with percentage of fiber adulterant	H1(mm)	H2(mm)	H1-H2 (mm)
0% or control mix	290	290	0
0.5% fiber	294	294	0
0.1% fiber	295	290	5 (blocking)
1.5% fiber	300	290	10 (blocking)

This time represents workability or filling capacity is decreases with respect to fiber mixing, the time of L-Box concrete should not be greater than 10 sec.

3) *V-box Test:* It is also perform the degree of compaction of SCC (Self compacting concrete), in this test we check the passing ability of concrete from V shape, test result data as following-

Table no. 6

Sample of concrete with percentage of fiber adulterant	Time taken to pass	Remark (acceptable range 6-12sec)
0% or control mix	7 second	No blocking
0.5% fiber	8 second	No blocking
01% fiber	11 second	No blocking
1.5% fiber	14 second	1 sample blocked

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C. Strength Results

Compressive tests of 7days, 15days, and 28 days were done on the sample with 0% fiber, 0.5% fiber, 1% fiber, and 1.5% fiber percentage. Concrete strength attains 65% in 7 days,90% in 15days, and 99% in 28 days, so all three chronological performances as following.

1) *7 Days Strength:* In this test 4 sample of 0%, 0.5%, 1%, and 1.5% fiber two cubes each tested on the 7^{th} day, the strength of 1% fiber contained sample is high, the strength graph up to 1% is in increasing order then it decreased their value in the terms of strength as present in following bar graph. As we design for M-30, so according to the minimum permissible value of compressive strength on the 7^{th} day is 20 N/mm^2.

Fig.1 shows 7days of compressive strength

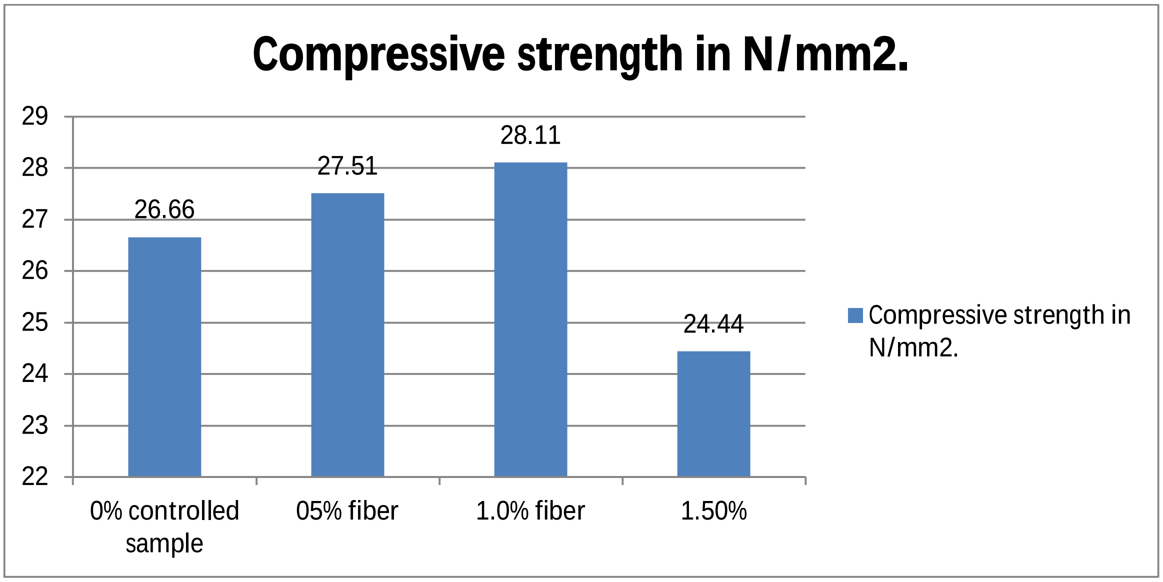

Fig.1 compressive strength at 7 days

2) *14 Day Strength:* In this test 4 sample of 0%, 0.5%, 1%, and 1.5% fiber two cubes each tested on the 14^{th} day, the strength of 1% fiber contained sample is high, the strength graph up to 1% is in increasing order then it decreased their value in the terms of strength as present in following bar graph. As we design for M-30, so according to the minimum permissible value of compressive strength on the 14^{th} day is 27 N/mm^2.

Fig. 2 shows 14days of compressive strength

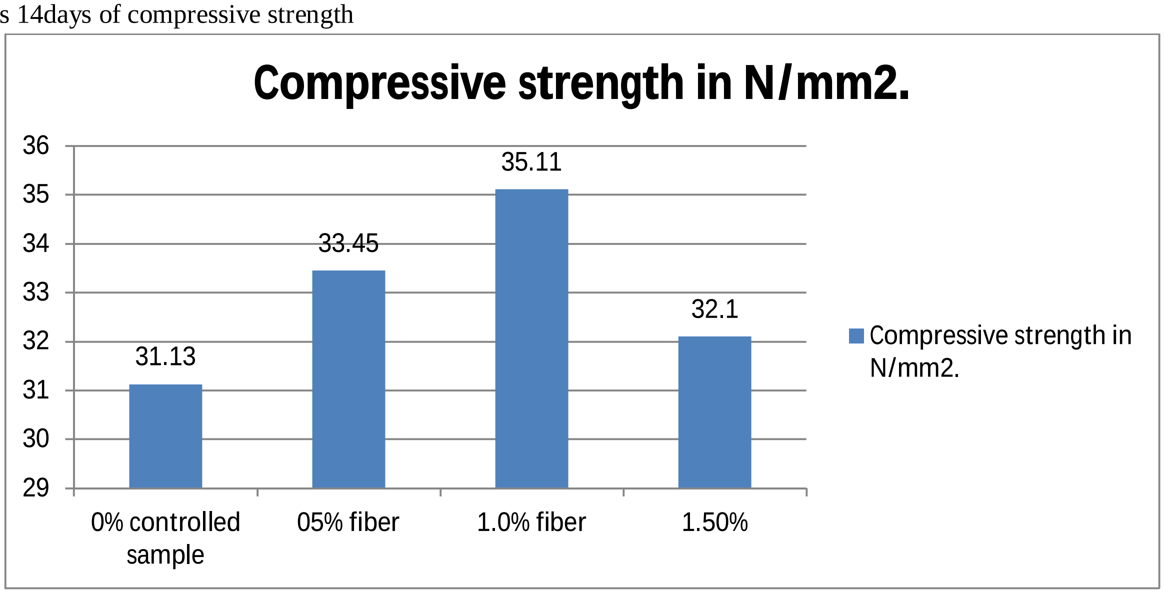

Fig.2 compressive strength at 14 days

3) *28 Day Strength:* In this test 4 sample of 0%, 0.5%, 1%, and 1.5% fiber two cubes each tested on the 28th day, the strength of 1% fiber contained sample is high, the strength graph up to 1% is in increasing order then it decreased their value in the terms of strength as present in following bar graph. As we design for M-30, so according to the minimum permissible value of compressive strength on the 28th day is 30 N/mm^2.

Fig. 3 Shows 28 days of compressive strength

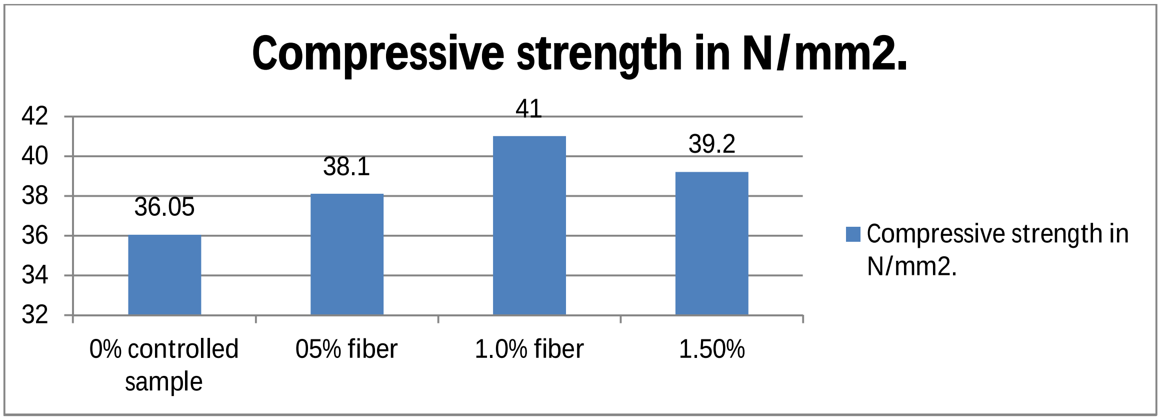

Fig.3 compressive strength at 28 days

V. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

The workability result of the sample, in the L-box test 1.5% of fibre sample is block and other 0.5 and 1% sample is pass.

U-box test 0 and 0.5% sample is pass but 1 and 1.5% sample is fail.

V-funnel test ,0.5and 1.0% sample is pass but 1.5% sample is blocking.

In the U-Box test(workability test) of SCC 2 samples are blocked. So, with the help of increase the quantity of admixture gives the perfect value of SCC.

The results shows 7 days compressive strength of 0.5% fibres and 1% fibres SCC improved by 3.18% and 5.43% but 1.5% fibres SCC is decreases at 9.08%. These results show the compressive strength is decreasing after 1.0% fiber mixing so the optimum point found is 1.0%.

The results shows 15days compressive strength 0.5% fibres and 1% fibres SCC improved by 7.45% and 12.78% but 1.5% fibres SCC is decreases at 3.11%. These results show the compressive strength is decreasing after 1.0% fiber mixing so the optimum point found is 1.0%.

The results of 28 day compressive strength 0.5% fibres and 1% fibres SCC improved by 5.68% and 13.73% but 1.5% fibres SCC is decreases at 8.73%. These results show the compressive strength is decreasing after 1.0% fiber mixing so the optimum point found is 1.0%.

This result indicates up to 1% fiber replacement is possible in self-compacting concrete and up to 1% fiber replacement also gives a significant increment in compressive strength as 5.43%, 12.78%, and 13.73% of 7 days, 15 days, and 28days respectively.

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