THOMSON REUTERS
ENDNOTE
[Mohammed, 3(11): November 2016] ISSN 2348 – 8034
DOI- 10.5281/zenodo.165722 Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

A STUDY ON STRENGTH CHARACTER OF SELF COMPACTING CONCRETE WITH FIBRE REINFORCED CONCRETE

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ABSTRACT

A self-compacting concrete (SCC) is the one that can be placed in the form and can go through obstructions by its own weight and without the need of vibration .its first development in Japan in 1988, SCC has gained wider acceptance in Japan, Europe and USA due to its inherent distinct advantages. The major advantage of this method is that SCC technology offers the opportunity to minimize or eliminate concrete placement problems in difficult conditions. It avoids having to repeat the same kind of quality control test on concrete, which consumes both time and labor. Construction and placing becomes faster& easier. It eliminates the need for vibration & reducing the noise pollution. It improves the filling capacity of highly congested structural members. SCC provides better quality especially in the members having reinforcement congestion or decreasing the permeability and improving durability of concrete.

The primary aim of this study is to explore the feasibility of using SCC by examining fresh and hardened properties by introducing glass (0.1%) and steel (1.5%) fibers of M40 Grade SCC and comparing the same with M40 Grade Plain SCC. Also, to study the fresh and hardened properties of M80 Grade SCC with varying Packing Factors i.e. 1.12,1.14,1.16,1.18 and comparing the same with M80 Grade conventional concrete

When the fiber reinforcement is in the form of short discrete fibers, they act effectively as rigid inclusions in the concrete matrix. Physically, they have thus the same order of magnitude as aggregate inclusions; steel fiber reinforcement cannot therefore be regarded as a direct replacement of longitudinal reinforcement in reinforced and prestressed structural members. However, because of the inherent material properties of fiber concrete, the presence of fibers in the body of the concrete or the provision of a tensile skin of fiber concrete can be expected to improve the resistance of conventionally reinforced structural members to cracking, deflection and other serviceability conditions. Compressive strength of concrete is measured by testing standard cubes (150mm x 150mm x 150mm) at the age of 7 days, 28 days and 90 days, The tests were conducted on varying percentages of steel fibers and studied for their torsional resistance for combined loading under torsion-bending-shear.The existing literature indicates that many researchers have studied the torsional strength, torsion to moment or torsion to shear of steel fiber reinforced concrete beams. However, scanty literature is available on testing of specimen blended with steel crimped fiber and flyash subjected to combined torsion, bending and shear.Hence, by observing the existing literatures, this work is carried out with different percentages of fibers with the inclusion of admixtures to form binary blended concrete to study the behavior of specimen subjected to combined torsion, bending and shear and to achieve the optimum fiber percentage for Binary Blended Fiber Reinforced Concrete Beams.

Keywords: Self-Compaction Concrete, Steel Fibers, Glass Fibers, Packing Factor

I. INTRODUCTION

1.1 General

To produce SCC, the major work involves designing an appropriate mix proportion and evaluating the properties of the concrete thus obtained. In practice, SCC in its fresh state shows high fluidity, self-compacting ability and segregation resistance, all of which contribute to reducing the risk of honeycombing of concrete. With these good properties, the SCC shows good performance in compressive strength test and can fulfill other construction needs because its production has taken into consideration the requirements in the structural design.

Compared with conventional concrete of similar mechanical properties, the greater material cost of SCC is due to the relatively high demand of cementitious materials and chemical admixtures, including high range water reducing admixtures (HRWRS) and viscosity enhancing admixtures (VEAs). Typically, the content in cementitious materials

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can vary between 450 and 525 Kg/m³ for SCC targeted for the filling of highly restricted areas and for repair applications. Such applications require low aggregate volume to facilitate flow among restricted spacing without blockage and ensure the filling of the form work without consolidation. The incorporation of high volumes of finely ground powder materials is necessary to enhance cohesiveness and increase the paste volume required for successful casting of SCC.

1.2 Development of Self Compaction Concrete

Portland cement concrete has been in use since 1824. In the early to mid-1980's, Professor Hajime Okamura at the University of Tokyo in Japan wanted to solve the issue of degrading quality in concrete construction. It was noticed that the concrete was not being placed correctly (specifically not being consolidated correctly), which resulted in poor performing concrete structures. The decrease in quality of concrete placement was due to decrease in skilled labor. As labor skilled in the construction of concrete aged and exited the workforce, there was a little training or passing of knowledge to the newer labor. This resulted in more and more unskilled, inexperienced labor placing concrete that was of low quality.

Compressive Strength

A test result is the average of at least three standard cured strength specimens made from the same concrete sample and tested at the same age. In most cases strength requirements for concrete are at an age of 28 days of curing. The concrete cubes, after 28days were tested for their compressive strength in the following manner. After cleaning of bearing surface of compression testing machine, the axis of the specimen was carefully aligned with the center of thrust of the plate. No packing was used between faces of the test specimen and platen of testing machine. The load was applied continuously without shock and increased continuously at the rate of approximately 140Kg/cm2/min until the resistance of the specimen to the increasing load broke down and no greater load could be sustained. The compressive stress calculated in Kg/cm2 from the maximum load sustained by the cube before failure.

Fiber Reinforced Concrete

Fiber reinforced concrete is defined as a composite material essentially consisting of conventional concrete or mortar reinforced by the random dispersal of short, discontinuous, and discrete fine fibers of specific geometry. The use of discontinuous, randomly oriented fibers has long been recognized to provide post-cracking tensile resistance to concrete. Thus, their use as shear reinforcement in reinforced concrete (RC) beams has been the focus of several investigations in the past four decades. Fiber reinforcement enhances shear resistance by transferring tensile stresses across diagonal cracks and reducing diagonal crack spacing and width, which increases aggregate interlock. The reduction in crack spacing due to the presence of fibers indicates that the use of fiber reinforcement could potentially lead to a reduction or even an elimination of the shear size effect in beams without stirrup reinforcement, whose shear strength is known to decrease as the overall beam depth increases. The effectiveness of fiber reinforcement to increase shear resistance, however, is dependent on several factors, including fiber properties (i.e., material properties, aspect ratio, and shape), fiber content, and bond stress versus slip response of fibers.

Fiber Mechanism

Fibers work with concrete utilizing two mechanisms: the spacing mechanism and the rack bridging mechanism. The spacing mechanism requires a large number of fibers well distributed within the concrete matrix to arrest any existing micro-crack that could potentially expand and create a sound crack. For typical volume fractions of fibers, utilizing small diameter fibers or micro fibers can ensure the required number of fibers for micro crack arrest.
The second mechanism termed crack bridging requires larger straight fibers with adequate bond to concrete. Steel fibers are considered a prime example of this fiber type that is commonly referred to as large diameter fibers or macro fibers. Benefits of using larger steel fibers include impact resistance, flexural and tensile strengths, ductility, and fracture toughness.

II. LITERATURE REVIEW

Surabhi.C.S, Mini Soman, SyamPrakash.V has Carried out an experimental study on cement content in the SCC mix is replaced with various percentage of limestone powder and the fresh and hardened properties were studied. It is observed that limestone powder can be effectively used as a mineral additive in SCC. They concluded that the result of 7 day and 28 day compressive strength increases with increase in content of limestone powder up to 20%. The improvement in compressive strength at 28 day is about 20% for a replacement of 20% of cement with limestone powder. But further addition of limestone powder reduces the strength. All the hardened properties like cylinder compressive strength, split tensile strength, flexural strength and modulus of elasticity improves with the addition of limestone powder.

Mayur B. Vanjare, Shriram H. Mahure (2012) has carried out an experimental study on to focus on the possibility of using waste material in a preparation of innovative concrete. One kind of waste was identified: Glass Powder (GP). The use of this waste (GP) was proposed in different percentage as an instead of cement for production of self-compacting concrete. The addition of glass powder in SCC mixes reduces the self-compatibility characteristics like filling ability, passing ability and segregation resistance. The flow value decreases by an average of 1.3%, 2.5% and 5.36% for glass powder replacements of 5%, 10% and 15% respectively.

Saravanan et al (2002) has submitted a paper on Fiber Reinforced Polymer (FRP) as an external reinforcement is used extensively to address the strength requirements related to flexure and shear in structural systems. But the strengthening of members subjected to torsion is yet to be explored. In this paper, the behavior and performance of reinforced concrete members strengthened with externally bonded Glass FRP (GFRP) sheets subjected to pure torsion is presented. The variables considered in the experimental study include the fiber orientation, the number of beam faces strengthened (three or four), the effect of number of FRP plies used, and the influence of anchors in U-wrapped test beams. Experimental results reveal that externally bonded GFRP sheets can significantly increase both the cracking and the ultimate torsional capacity. Predicted strengths of the test beams using the proposed theoretical models were found to be in good agreement with the experimental results.

T.D. Gunneswara Rao (2003) has carried out an investigation consisted of short-term tests on plain steel fiber reinforced concrete members of same cross sectional area varying the volume fraction of fibers and strength of concrete. The volume fraction of the fiber varied from 0% to 1.2% at an equal interval of 0.3%. The grades of concrete considered for the study are 20, 30, 40 and 50MPa). Thus, 20 beams of size 100_200_2000 mm were cast for testing under pure torsion. During the casting of each beam three companion cube specimens and three cylindrical specimens for assessing the compressive strength and split tensile strength of the matrix were cast and cured along with the corresponding beams under same conditions of environment. He concluded that a minimum volume fraction of fiber content of 0.9% is required to impart noticeable ductility to the SFRC beams under torsion.

III. EXPERIMENTAL WORK

3.1 Experimental Approach:

A concrete of grade M40 for various packing factor was designed and developed using Nan Su model. The fresh and hardened properties of a designed self-concrete concrete was determined. It was perceived that packing factor 1.14 is optimum, when we consider the hardened properties but it is having considerably low flow-ability when compared with packing factor 1.12. Because of its maximum paste content it requires low amount of super plasticizer for attaining the desired slump flow which also have a negative effect on setting time of concrete From literature, it was perceived that the addition of fibers will have a drastic effect on workability by taking this into consideration we have chosen 1.12 for finding the effect of fibers on strength properties (compression, tension and flexure) of concrete. In this study for a packing factor of 1.12 we are using glass, steel and hybrid fibers for determining its fresh and hardened properties of fiber reinforced self-compacting concrete. We also designed and developed a mix for high strength self-compacting concrete of grade M80 for packing factor .

Slump Flow and T50

The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. It was first developed in Japan 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.

ISSN 2348 – 8034
Impact Factor- 4.022

Assessment of test

This is a simple, rapid test procedure, though two people are needed if the T50 time is to be measured. It can be used on site, though the size of the base plate is somewhat unwieldy and level ground is essential. It is the most commonly used test, and gives a good assessment of filling ability. It gives no indication of the ability of the concrete to pass between reinforcement without blocking, but may give some indication of resistance to segregation. It can be argued that the completely free flow, unrestrained by any boundaries, is not representative of what happens in practice in concrete construction, but the test can be profitably be used to assess the consistency of supply of ready-mixed concrete to a site from load to load.

Interpretation of result

The higher the slump flow (SF) value, the greater its ability to fill formwork under its own weight. A value of at least 650mm is required for SCC. There is no generally accepted advice on what are reasonable tolerances about a specified value, though ± 50mm, as with the related flow table test, might be appropriate. The T50 time is a secondary indication of flow. A lower time indicates greater flow ability. The Brite EuRam research suggested that a time of 3-7 seconds is acceptable for civil engineering applications and 2-5 seconds for housing applications. In case of severe segregation most coarse aggregate will remain in the centre of the pool of concrete and mortar and cement paste at the concrete periphery. In case of minor segregation a border of mortar without coarse aggregate can occur at the edge of the pool of concrete. If none of these phenomena appear it is no assurance that segregation will not occur since this is a time related aspect that can occur after a longer period.

Flexural strength of concrete

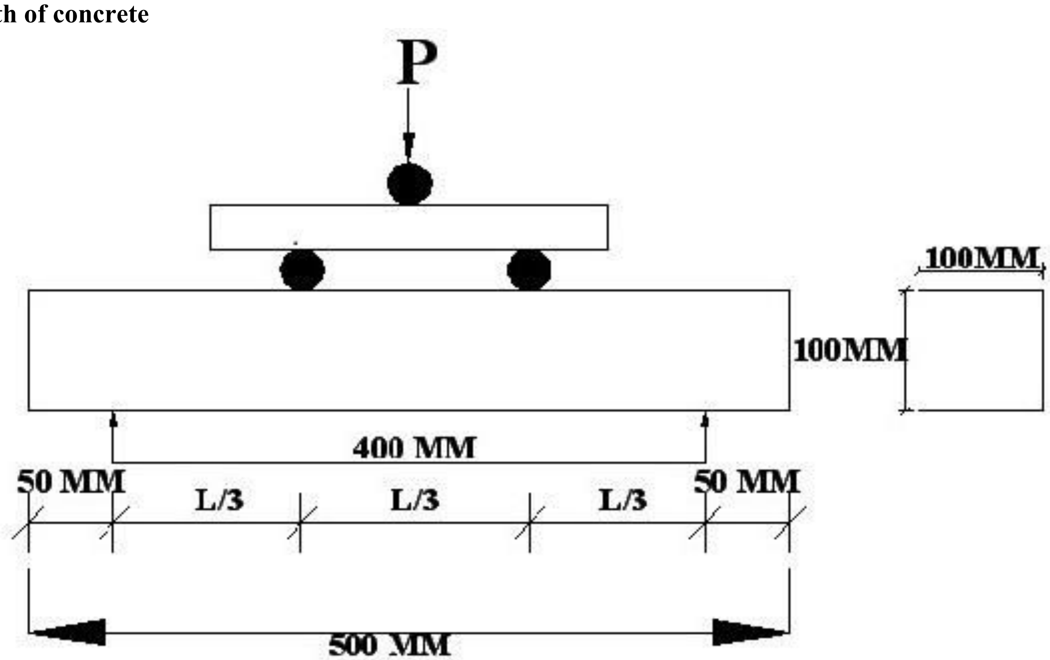


Figure 4.9: Flexural Test Setup

Procedure

1. Test specimens shall be prepared by moldings concrete to a beam section, curing and storing in accordance with standard procedure. The section of the beam shall be square of 100 mm or 150 mm. The overall length of the specimen shall be 4d to 5d. The ratio of d to the maximum particle size of aggregate shall be not less than three.

ISSN 2348 – 8034
Impact Factor- 4.022

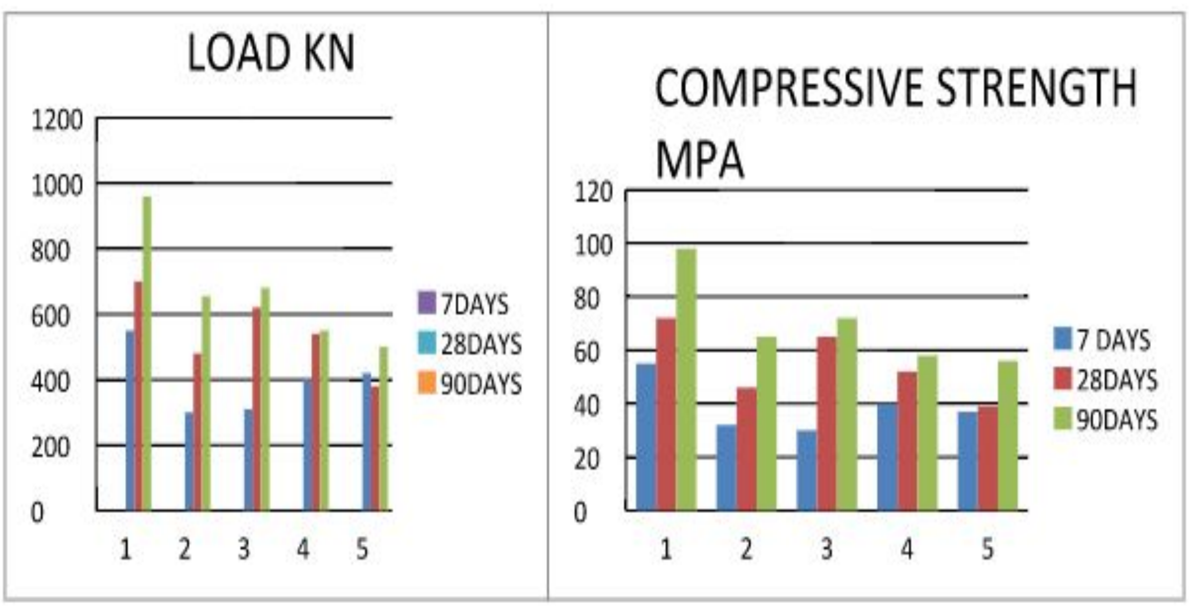
2. Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e. span) shall be 3d and the distance between the inner rollers shall be d. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.
3. The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machine correctly centered with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be normal to the direction of loading.
4. The load shall be applied slowly without shock at such a rate as to increase the stress at a rate of .06 + .04 N/mm2 per second.

Compressive strength of cube

The following are the test results for compressive strength of M40 grade SCC with varying packing factor:

Table 5.1: Compressive Strength of M40 grade SCC with varying packing factors

SPECIMEN IDENTIFICATION	PACKING FACTOR	LOAD KN			COMPRESSIVE STRENGTH MPA		
		7DAYS	28DAYS	90DAYS	7 DAYS	28DAYS	90DAYS
C11	0	550	700	960	55	72	98
S11	1.12	300	480	655	32	46	65
S12	1.14	310	620	680	30	65	72
S13	1.16	400	540	550	40	52	58
S14	1.18	420	380	500	37	39	56



ISSN 2348 – 8034
DOI- 10.5281/zenodo.165722
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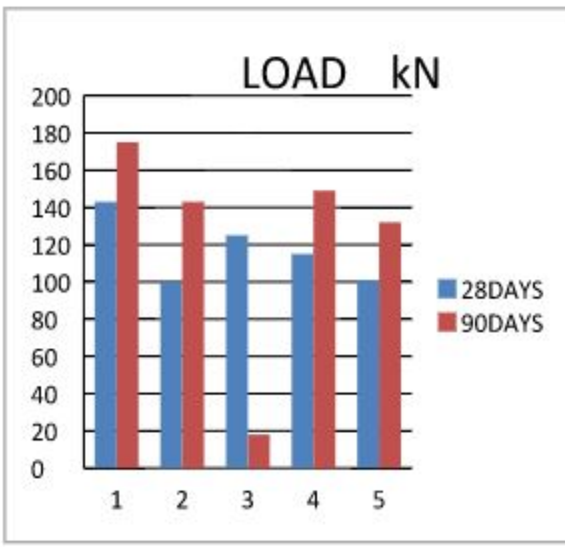
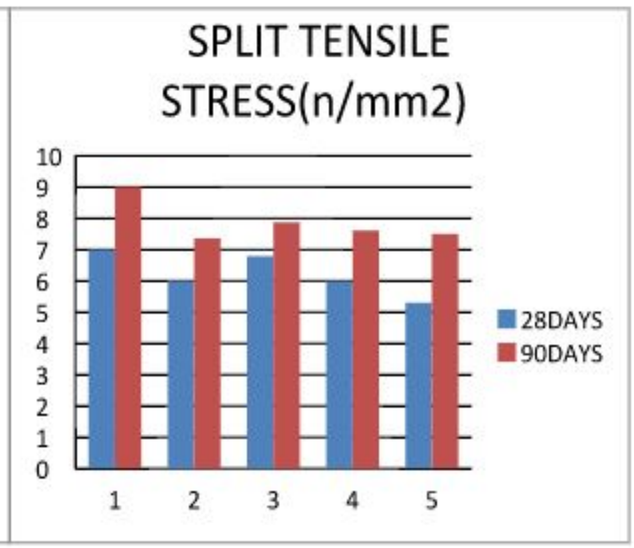
Split Tensile Strength of cylinder

Table 5.2: Split tensile strength of M40 grade SCC with varying packing factors

SPECIMEN IDENTIFICATION	PACKING FACTOR	LOAD KN		SPLIT TENSILE STRESS(n/mm2)	
		28DAYS	90DAYS	28DAYS	90DAYS
C11	0	143	175	7	9
S11	1.12	100	143	6	7.36
S12	1.14	125	18	6.79	7.87
S13	1.16	115	149	5.98	7.61
S14	1.18	101	132	5.3	7.5

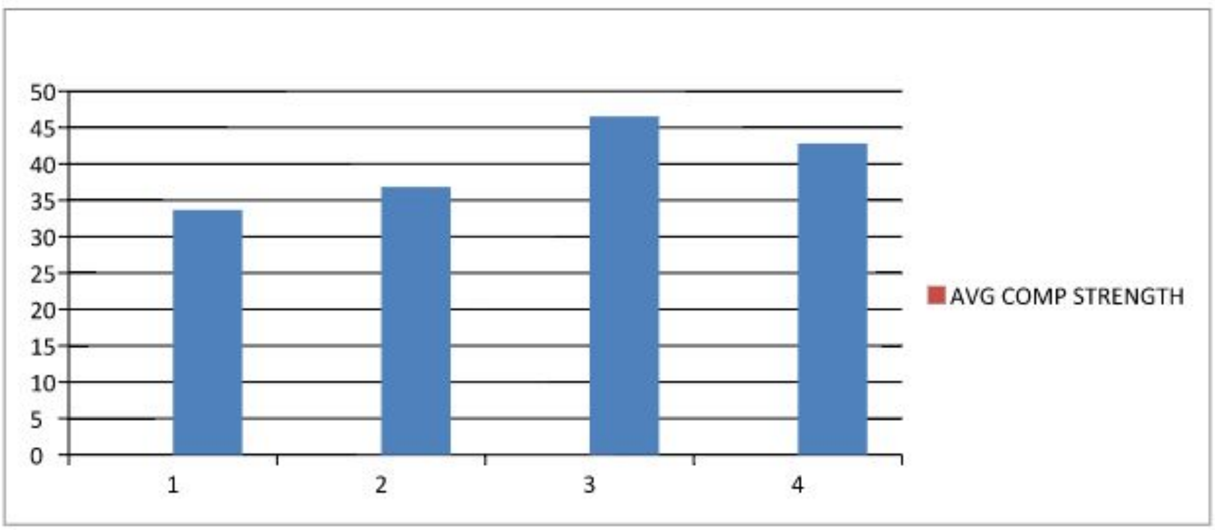
The following are the test results of split tensile strength of M40 grade SCC with varying packing factors





S.No	Description of Specimen	% of Fiber	Compressive Strength (N/mm2)	Avg. Compressive Strength(N/mm2)
1	C1	0%	33.33	33.67
2	C2	0%	34.00	
3	C3	0.50%	36.00	36.83
4	C4	0.50%	36.71	
5	C5	0.50%	37.78	
6	C6	0.75%	46.67	46.53
7	C7	0.75%	44.89	
8	C8	0.75%	48.04	
9	C9	1%	42.67	42.81
10	C10	1%	41.78	
11	C11	1%	44.0	

Table 4.1 Cube Compressive strength Concrete with various percentages of steel fibers at 28 days.



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