WORKABILITY AND COMPRESSIVE STRENGTH OF BACTERIA ENRICHED STEEL FIBRE REINFORCED SELF COMPACTING CONCRETE

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ABSTRACT

Steel fiber reinforced self-compacting concrete is well accepted for better resistance for segregation, and effective use in congested reinforcements. It will have improved ductile property and crack propagation is minimum. As the need for sustainable materials is increasing all over the world, innovative technique for making the concrete more durable have significant importance. As the concrete is prone to cracking, the cracks make the concrete vulnerable because it degrade the concrete and corrode the steel reinforcement. Bacterial concrete is an advancement of modern concrete technology. The limestone precipitating bacteria's are introduced into the concrete during casting and when the cracks occurs in the presence of moisture, bacteria's precipitate and heal the cracks. So the introduction of combination of Self-healing characteristics and characteristics of Steel fiber reinforced self-compacting concrete is an advancement to the concrete industry. In this paper Micro silica is used to replace OPC up to 30%. Steel fiber is used up to 1.5% of total volume in Self compacting concrete. An optimum amount for the Micro silica replacement is 20% of OPC. The performance of Self compacting concrete under certain loads and the effect of healing is studied. The strength of healed concrete is also studied. The Bacteria enriched steel fiber reinforced self-compacting concrete possess good workability for a self-compacting concrete All together increase in Compressive strength and durability than normal self-compacting concrete is seen.

Keywords: - *Self compacting concrete, Steel fiber, Micro silica.*

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1. INTRODUCTION

Self-compacting concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. Another advantage of SCC is that the time required to place large sections is considerably reduced. In earlier days, to increase the strength and durability of the structure, the cracks which are formed will be repaired conventionally using epoxy injection or latex treatment or by providing extra reinforcement in the structure during the design phase to ensure that the crack width stays within a permissible limit. Main reason to prevent cracks or limit crack width is to enhance the durability of the structure. The propagation of crack can be limited by adding steel fiber into concrete. Over the last three decades, significant studies have been executed to examine the impact of steel fibers as reinforcing matrix on the mechanical properties and impact resistance. Steel fibers bridge gap between adjacent surfaces of existing micro-crack, delay crack formation and limit crack propagation by reducing the crack tip opening displacement. This mechanism is known as bridging mechanism. The steel fiber in concrete to minimize crack propagation also improve tensile property and the technique of incorporation of bacteria for crack healing, will improve the entire property and the durability of SCC.

2. LITERATURE REVIEW

Muhd Fadhil Nuruddin et al. (2014) [5] has studied the workability and compressive strength of ductile self-compacting concrete. DSCC with various cement replacement materials was conducted. Up to 20% of cement in DSCC was replaced by Microwave Incinerated Rice Husk Ash (MIRHA), Micro silica (SF) and Micro silica (FA) in certain ratios. The experiments of self-compacting ability such as V-funnel test, slump flow and L-box test were conducted in order to ensure the DSCC with various cement replacement materials fulfilled the requirements for self-compacting.

Naveen B. et al. (2016) [6] has studied the characteristics of bacterial concrete in structural members, the compressive strength values and tensile strengths values shows better strength for concentration of 35% fly ash with and without bacteria. In the flexural strength testing of beams shows 35% flyash with and without bacteria has less deflection when compared with controlled beam. Crack width results also proves that beam made with 35% flyash with bacteria has less crack width at ultimate load when compared with 0% flyash,35% flyash concentration beams.

Tomasz Ponikiewski et al. (2013) [7] has explored in their paper the basic influence trends of different composition and properties of steel fibres on fresh mixture and mechanical properties of SCC. Discussion about the results cover mechanism of fibres influence on mechanical effectiveness of moulding precast beams. The paper has shown the negative influence of fibres added to concrete mix on its rheological and workability properties. Optimal addition of superplasticizers improves its properties and becomes positive as an additive to concrete mixes. The work determines the distribution and orientation of steel fibres in SCC.

Wasim Khaliq et al. (2016) [8] in their paper they presents the process of crack healing phenomenon in concrete by microbial activity of bacteria, Bacillus subtilis. Bacteria were introduced in concrete by direct incorporation, and thorough various carrier compounds namely light weight aggregate and graphite nano platelets. In all the techniques, calcium lactate was used as an organic precursor. Specimens were made for each mix to quantify crack healing and to compare changes in compressive strength of concrete.

Xiliang Ning et al. (2015) [9] to study the effects of macro steel fibres on the flexural behaviour of reinforced self-consolidating concrete beams. The major test variables are fibre contents and longitudinal reinforcement ratios. The ultimate load, mid-span deflections, steel reinforcement strains, crack width and crack spacing were investigated. The enhanced ultimate flexural capacity and reduced mid-span deflection due to the addition of steel fibres were observed. With the increasing of fibre contents, the strain in longitudinal reinforcement, crack width and crack spacing decreased significantly

3. MATERIALS AND METHOD

3.1. Bacteria

The bacteria Bacillus Subtilis strain no. JC3 is used in this study. The pure culture of Bacillus Subtilis was collected from the department of Agricultural Microbiology, College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur. Bacillus subtilis JC3 is a laboratory cultured soil bacterium. On nutrient agar plate, colonies of strain JC3 were round, convex, smooth and translucent. Size of the colony may reach up to 2-3 mm diameter after 24hrs of incubation in dark aerobic conditions at 37^oC. The organism produced a bluish green pigment that diffused into the medium. Individual cells of strain JC 3 were Gram positive, oval to rods, 0.6-0.8 μm in width and 2.0 to 3.0 μm in length, motile and multiplied by binary fission. The Scanned Electron Microscopy (SEM) is used to identify the precipitation in concrete.

3.2. Steel fibre

Loose hook ended steel fibre is used. It has greater flexibility with all Portland cements and admixtures, it also provides even distribution in the mix. It improves mechanical anchorage and improves micro crack mechanism, impact resistance, flexural strength and fatigue strength of concrete. Aspect ratio 50 and 30 mm length fibres are used with a diameter of 0.6mm.

3.3. Calcium lactate

Calcium lactate is a black or white crystalline salt made by the action of lactic acid on calcium carbonate. It is used in foods (as an ingredient in baking powder) and given medicinally. It is created by the reaction of lactic acid with calcium carbonate or calcium hydroxide. The addition increases presence of calcium in concrete.

3.4. Preparation of Specimens

The size of concrete cube and cylinder size are 150 x 150 x 150 mm and 100 x 300mm respectively. The M40 grade concrete mix design was carried out as per European standard (EFNARC) for SCC. The w/c ratio 0.35 was used. Micro silica was added by partial replacement of cement at the concentrations of 0%, 5%, 7.5%, 10%, 20%, 25%, and 30%. The concrete cubes, cylinders with and without bacteria and steel fibres were casted and cured for 28 days. Reinforced beam size used for testing is 150 x 150 x 700mm, bacteria enriched beams were casted for which Micro silica was added by replacing the amount of cement for optimum concentration from 0% to 30%, with different concentration of steel fibres like, 0%, 0.5%, 1% and 1.5% of total volume. The reinforced beams with bacteria were casted and cured for 28 days.

Table 1: Mix proportions

Material	Mix1	Mix2	Mix3	Mix4	Mix5	Mix6	Mix7
% of Micro silica	5	7.5	10	15	20	25	30
Cement	565.44	550.56	535.68	505.92	476.16	446.40	416.64
Micro silica	29.76	44.64	59.52	89.28	119.04	148.80	178.56
F.A	884.87	884.87	884.87	884.87	884.87	884.87	884.87
C.A	723.94	723.94	723.94	723.94	723.94	723.94	723.94
W/C Ratio	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Superplasticizer	3.39	3.3	3.21	3.04	2.86	2.68	2.50

4. RESULTS AND DISCUSSIONS

4.1. Workability

A highly flow able concrete is not necessarily self-compacting, because SCC should not only flow under its own weight but should also fill the entire form and achieve uniform consolidation without segregation. The workability is determined using standard tests like flow table test and J-Ring test. The results are:

Table 2: Workability of SCC with Micro silica

Micro silica concentration	Slump (Flow table test)
5%	685
7.5%	690
10%	680
15%	686

20%	695
25%	700
30%	712

Figure 1: J-Ring Test

Table 3: Workability of Steel fiber reinforced SCC

% of Steel fiber	Slump	J-ring
0.5	680	11
1	668	18
1.5	656	27

The results show that the increase in addition of Micro silica, there is an increase in slump value. The J-Ring test results on steel fiber reinforced SCC shows that the 0.5 and 1% addition of steel fiber has no visible blocking as it is in between the range of 0-25mm. But 1.5% of steel fiber shows minimal to noticeable blocking as it is above 25mm.

4.2. Compressive strength

Compressive strength test on cubes of SCC. SCC contains Micro silica as a partial replacement on cement. The obtained results are shown

Table 4: Compressive strength of SCC with Micro silica

Micro silica concentration	28days Compressive strength (N/mm^2)
5%	41.47
7.5%	42.12
10%	43.26
15%	45.86
20%	47.17
25%	44.96
30%	41.81

As per the results obtained it is seen that the optimum amount of Micro silica which can effectively added in SCC is 20%. As the amount of micro silica increased beyond the 20% there is decrease in the compressive strength Bacteria enriched steel fiber reinforced SCC made with an optimum amount of Micro silica.

Table 5: Compressive strength of steel fiber reinforced SCC

% of Steel fiber	28days Compressive strength (N/mm^2)
0.5	49.10
1	56.12
1.5	51.76

The results of compressive strength and workability shows that 1% addition of steel fiber is more effective compared to other percentage of steel fiber addition. Micro silica has effect on the compressive strength, the ultra-fineness of Micro silica fills all the pores of Concrete matrix and densify the concrete. The pozzolonic reaction between silica and free calcium hydroxide also has an effect on the improvement of compressive strength.

5. CONCLUSION

The present study has shown that the mineral admixture and self-healing agent added to SCC has a considerable increase in compressive strength.

1. SCC with partial replacement material of cement have a slump in the range of 650-800mm.
2. SCC with 20% replacement of cement with Micro silica has better compressive strength.
3. 1% of steel fiber addition in SCC has effective performance, which has a compressive strength of 56.12 N/mm^2

The bacteria enriched steel fiber reinforced concrete is a practical concept with good compressive strength and flow ability.

REFERENCES

[1] Falguni Soneri, Darshika Patel(2016) "An Attempt to Enhance the Properties of Concrete using Bacteria" *Global Research and Development Journal for Engineering,* vol.2, pp.41- 46.

[2] Ghosh P., Mandal S., Chattopadhyay B., Pal S.,(2010) Use of microorganism to improve the strength of cement mortar, *Cement and concrete research* vol.35 pp.1980–1983.

[3] Jeevetha T., Krishnamoorthi Dr S., Rampradheep G.S.(2014) "Study on the properties of Self-compacting concrete with Micro silica" *IJIRSET* vol.3, pp. 11239-11244.

[4] Jonkers H.M., Thijssen A., Muyzer G., Copuroglu O., Schlangen E.(2010), "Application of bacteria as self-healing agent for the development of sustainable concrete", *Ecological Engineering.* Vol.36, pp. 230–235.

[5] Muhd Fadhil Nuruddin, Kok Yung Chang, Norzaireen Mohd Azmee(2014) "Workability and compressive strength of ductile self-compacting concrete (DSCC) with various cement replacement materials" *Construction and Building Materials* vol: 55 pp: 153–157.

[6] Naveen B., Sivakamasundari S. (2016) "Study of strength parameters Of bacterial concrete with Controlled concrete and Structural elements made with Concrete enriched with Bacteria" *International conference on Engineering innovations and solutions*,pp.53-59.

[7] Tomaz ponikiewski, Jacek(2013) "Properties of SFRSCC for optimal rheological and mechanical properties in precast beam" *Concrete And Concrete Structures Conference,* pp. 290-295.

[8] Wasim Khaliq, Muhammad Basit Ehsan (2016) "Crack healing in concrete using various bio influenced self-healing techniques",*Construction and Building Materials* vol:102, pp:349–357.

[9] Xiliang Ning, Yining Ding, Fasheng Zhang, Yulin Zhang(2015) "Experimental study and prediction model for flexural behaviour of reinforced SCC beam containing steel fibers" *Construction and Building Materials* vol: 93, pp: 644-653.

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