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Experimental Study on the Mechanical behaviour of Sisal Fibre Reinforced Self-Compacting Concrete

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Abstract – *Self-Compacting Concrete is one which compacts under its own weight without any external vibration. It also possesses properties such as limited ductility, low cracking resistance and low tensile strength. This can be considerably overcome by adding fibres to SCC. With the view of sustainable development, in this study sisal, a natural fibre is used to reinforce Self-Compacting Concrete in four different percentages 0.25, 0.50, 0.75 and 1.00. Their effects on fresh state and hardened state were studied. The addition of sisal fibre reduced its workability and Self-Compacting Characteristics were also affected depending upon the fibre content. The experimental results showed that Sisal Fibre Reinforced Self-Compacting Concrete (SFRSCC) has improved mechanical properties. Optimum percentage of fibre content was found to be 0.5 for which compressive strength and split tensile strength were increased by 15% and 18.7% respectively.*

***Key Words*: sisal fibre reinforced self-compacting concrete, sisal fibre, slump flow, v funnel, l box.**

1. INTRODUCTION

Self-compacting concrete (SCC) is a concrete that can be placed and compacted under its own weight without mechanical vibration. In other words, the SCC should have sufficient flowability to ensure an appropriate filling of structural elements and enough viscosity to prevent settlement of coarse aggregate particles and to maintain the uniformity of concrete. Ordinary self-compacting concrete possesses low tensile strength, limited ductility and little resistance to cracking. Internal micro-cracks are inherently present in the concrete and its poor tensile strength is due to propagation of such micro-cracks, leading to brittle failure of concrete. This weakness can be considerably overcome by the inclusion of fibres in the concrete mix. These fibres enhance cracking resistance, thus improving the mechanical properties and extend the possible fields of application of SCC. So far synthetic fibres like steel fibre [1], polypropylene fibre [2], glass fibre and their combinations were used. Only few works have been carried out using natural fibre as reinforcement for self-compacting concrete.

In this project sisal fibre which is a natural fibre was added to self-compacting concrete in four different percentages 0.25, 0.5, 0.75 and 1. The fresh state properties of self-compacting concrete were determined to ensure whether they are within the permissible limits prescribed in EFNARC. Mechanical properties like compressive strength and flexural strength were also determined.

2. EXPERIMENTAL PROGRAM

2.1 MATERIALS

Cement used in this study was ordinary Portland cement. Fly Ash was used as mineral additive; it had a specific gravity of 2.1. The coarse aggregate was natural siliceous gravel of nominal size of 12.5 mm and below, a specific gravity of 2.63. The sand used was river sand with fineness modulus of 2.67, a specific gravity of 2.6. A sulphonated naphthalene polymer based super plasticizer was used in the study. The specific gravity of the admixture was 1.27. A Viscosity Modifying Admixture (VMA) was used to prevent segregation. Sisal fibre of 20mm length used in this investigation is shown in Fig.1.

Fig -1: Sisal Fibre

2.2 MIX DESIGN

Mix design was done based on Nan-su-et al method [3] and is given in table 1.

MIX DESIGN				
Cement (Kg/m³)	Water (Kg/m³)	Fine Aggregate (Kg/m³)	Coarse Aggregate (Kg/m³)	Fly Ash (Kg/m³)
394.2	190	855.8	712.5	142.1

Table-1

2.3 FRESH CONCRETE TESTS

SCC differs from the conventional concrete by the placing manner. The concrete is classified as SCC by fulfilling three requirements i.e. filling capability, passing capability and segregation resistance. To fulfil these necessities, basic tests such as slump flow test, V-funnel test for filling ability, L-box test for passing ability, were conducted. All these tests were conducted as per the methods stipulated in EFNARC.

2.4 COMPRESSIVE STRENGTH TEST

Cube specimens 150mm X 150mm X 150mm with 0%, 0.25%, 0.5%, 0.75% and 1.00% fibre contents were cast and 28 days compressive strength was determined.

2.5 SPLIT TENSILE STRENGTH TEST

Cylinder specimens 150mm diameter and 300mm height with 0%, 0.25%, 0.5%, 0.75% and 1.00% fibre contents were cast and split tensile strength was determined. Tensile strength of specimens was computed based on the following equation:

Split tensile strength = $2P / (\pi LD)$

Where, P is the maximum tensile force, L is length of cylinder, and D is diameter of cylinder.

3 RESULTS AND DISCUSSION

3.1 FRESH CONCRETE PROPERTIES

To determine the workability, filling ability and passing ability of self-compacting concrete, Slump flow test, V funnel test and L box test were done respectively.

The slump flow values of SFRSCC have shown in Fig.2 shows decrease with increase in fibre content which indicates reduction in workability. There was maximum decrease in slump by 16.6% for SFRSCC with 1% fibre content. The V-funnel time which indicates the filling ability of concrete is shown in Fig.3. The V-funnel time increased with increase in fibre content with maximum increase of 77.3% for SFRSCC with 1% fibre content but was within the limits prescribed by EFNARC. The L-Box test results represented in Fig.4 shows reduction in the ratio with increasing fibre percentage with maximum reduction of 13.9% for SFRSCC with 1% fibre content.

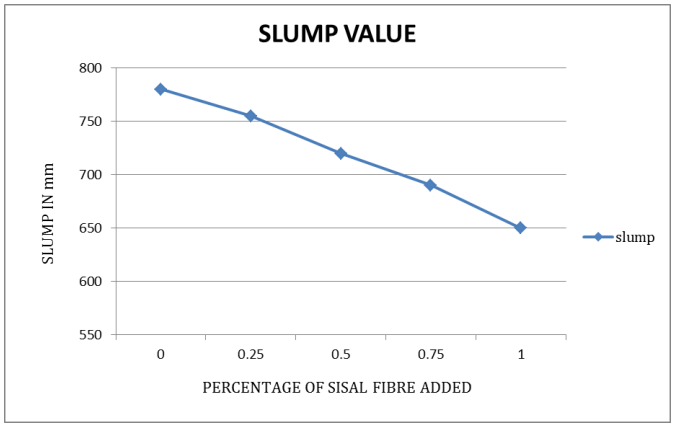

Fig -2: Slump flow test

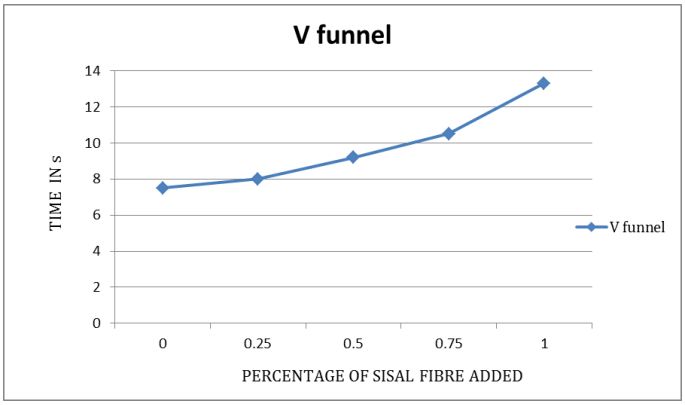

Fig -3: V Funnel Test

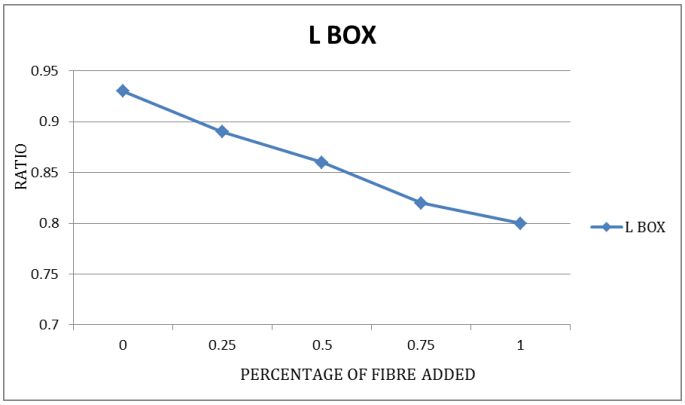

Fig -4: L Box Test

3.2 COMPRESSIVE STRENGTH TEST

The results shown in Fig 5 indicates that compressive strength increased by 15% for SFRSCC with 0.5 % fibre content and it decreased for higher percentage of fibre content.

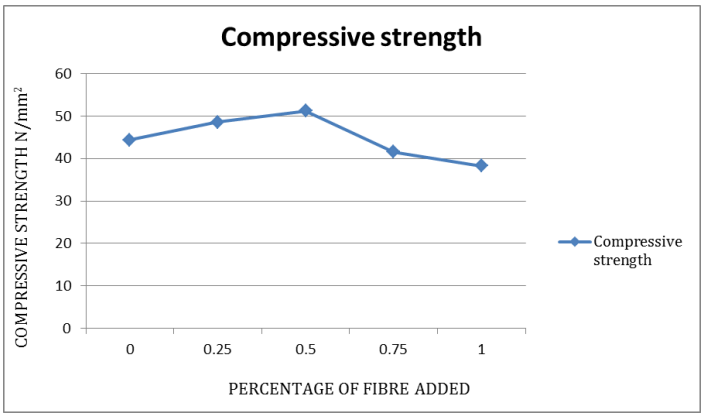

Fig -5: Compressive strength test results

3.3 SPLIT TENSILE STRENGTH TEST

Fig.6 shows the split tensile strength of SFRSCC increased with increase in fibre content up to 0.5% after which it reduced. However the split tensile strength of SFRSCC is higher compared to control specimen. The increase in split tensile strength for 0.5% fibre content observed was 18.7%.

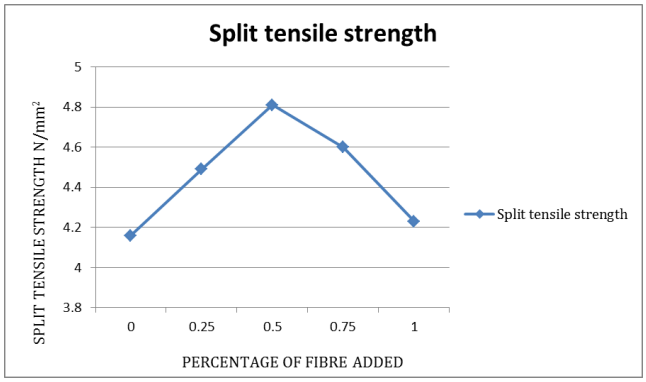

Fig -6: Split tensile strength test results

4 CONCLUSIONS

The limitations of Self-Compacting concrete such as limited ductility, reduced resistance to cracking and low tensile strength were increased by adding sisal fibres to SCC. In this project, the fresh state properties and mechanical properties of sisal fibre reinforced SCC were studied and the conclusion is as follows,

1. The fresh state properties of SCC such as workability, filling ability and passing ability were affected with the addition of sisal fibres but the values lie within the range prescribed by EFNAARC
2. Since the compressive strength and split tensile strength of SFRSCC increases up to 0.5% and then gradually decreases, the optimum content of sisal fibre was found to be 0.5%
3. The increase in compressive strength for SFRSCC with optimum content of 0.5% fibre content is 15% in comparison with control specimen.
4. The increase in split tensile strength for SFRSCC with optimum content of 0.5% fibre content is 18.7% in comparison with control specimen.
5. Therefore by adding sisal fibres to self-compacting concrete the mechanical properties such as compressive strength and tensile strength were enhanced.

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