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Experimental Study on Properties of Ternary Blended Fiber Reinforced Self Compacting Concrete

MD. Sameeruddin,

Under the Guidance of C. Manikanta Reddy, Assistant Professor,

M. Tech Department of Structural Engineering (Civil Department)

Anurag Engineering College, Telangana, India

ABSTRACT

Generally SCC requires a large content of binder and chemical admixtures Compared to ordinary concrete; its material cost is generally 20-50% higher, which has been a major, hindrance to a wider implementation of its use. There is growing evidence that incorporating high volumes of mineral admixtures and micro fillers as partial replacement for Portland cement in SCC can make it cost effective. However, the strength and durability of such SCC needs to be proven. Compared to normally vibrated concrete, self-compacting concrete possesses enhanced qualities and improves productivity and working conditions due to elimination of compaction. SCC generally has higher powder content than Normally Vibrated Concrete (NVC) which can increase cost and also cause temperature rise during hydration as well as possibly affect other properties such as creep and shrinkage, thus it is necessary to replace some of the cement by additions to achieve an economical and durable concrete.

Concrete is most widely used construction material because of ease of construction and its properties like compressive strength and durability. It is difficult to point out another material of construction which is versatile as concrete. It is well known that plain concrete is very good in resisting compressive strength but possesses low specific modulus, limited ductility and little resistance to cracking. Internal micro cracks inherently present in the concrete and its poor tensile strength is due to propagation of such micro cracks eventually leading to brittle failure of concrete.

The inclusion of fibers in SCC will extend its benefits. To improve strength properties it is useful to reinforce the concrete with fibers. Steel fibers are having good tensile strength and are also chemically inert, so a trail is made to improve the Self Compacting Concrete properties.

In this article steel fibers were used, and the effects of fiber inclusion on the workability of fiber reinforced self-compacting concrete (FR-SCC) is studied. It is observed that there is an overall improvement of all the properties of SCC with the blend of Fly Ash, Rice Husk Ash, Steel Fibers to improve the cement dispersion.

I INTRODUCTION

Concrete is the age old building material which is abundantly used in construction, and it is most likely that it will continue to have the same influence in future. However, these construction and engineering materials must meet new and higher demands. One direction in this evolution is towards self-compaction concrete (SCC) modified product that, without additional compaction energy, flows and consolidation under the influence of its own weight. The use of SCC offers a more industrial production. Not only will is reduce the risky tasks for labours, it can also reduce the in situ cast concrete constructions, due to fast construction quality, durability, surface finish and reliability of concrete structures.

Generally SCC requires a large content of binder and chemical admixtures compared to ordinary concrete; its material cost is generally 20-50% higher, which has been a major hindrance to a wider implementation of its use. There is growing evidence that incorporating high volumes of mineral admixtures and micro fillers as partial replacement for Portland cement in SCC can make it cost effective. However, the strength and durability of such SCC needs to be proven. Compared to normally vibrated concrete, self-compacting concrete possesses enhanced qualities and improves productivity and working conditions due to elimination of compaction. SCC generally has higher powder content than Normally Vibrated Concrete (NVC) and thus it is

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II LITERATURE REVIEW

GENERAL

This chapter deals with the review of literature related to fresh and hardened properties of SCC/FRSCC and effect of Flyash and Rice Husk Ash on properties of SCC.

FRESH PROPERTIES OF SCC

EFNARC(2002)[1] investigated that the SCC flows alone under its dead weight upto leveling, airs out and consolidates itself thereby without any entry of additional compaction energy and without a nameable segregation. Due to the high content of powder, SCC may show more plastic shrinkage or creep than ordinary concrete mixes. These aspects should therefore be considered during designing and specifying SCC. Current knowledge these aspects are limited and this is an area requiring further research.

• Jonas Gustafsson, Betongindustri AB Patrik Groth, LTU (1999) [2] conducted Steel fiber reinforced self-compacted slabs on ground. Slabs will be casted in order to enable measurements of fresh properties of SFRSCC as well as testing the hardened properties of samples made with the same concrete. The benefit is the fact that the the tests will be performed under realistic conditions at a batching plant instead of on only testing laboratory mixes. In the first two test series (A and B), which are reported here, mixes according to Bentongindustri's design are used. Later, it is planned to do additional tests using mixes according to INSA's mix design. Thus, comparison between various types of mix design for SFRSCC is possible.

MATERIALS

The materials used in this experimental study are Cement, Fine aggregate, Coarse aggregate, Water, Fly ash, Rice Husk Ash, Fibers, Superplasticiser and Viscosity Modifying Agent

IV GENERAL REQUIREMENTS OF MIX DESIGN

The friction between the aggregates limits the filling ability of SCC. This is why SCC contains a high volume of paste (cemen + additions + efficient + water + air), typically 330-400l/m3, the role is to maintain aggregate separation.

3.2 HIGH VOLUME OF FINE PARTICLES (<80µM)

In order to ensure sufficient workability while limiting the risk segregation or bleeding. SCC contains a large content of fine particles (around 500kg/m3). Nevertheless, in order to avoid excessive heat generation, Portland cement is generally replaced by mineral admixtures like limestone filler or fly ash. The nature and amount of filler added are chosen in order to comply with the strength and durability requirements.

3.3 LOW VOLUME OF COARSE AGGREGATE

It is possible to use natural rounded, semi-crushed aggregates to produce SCC. Nevertheless, as the coarse aggregate plays an important role on the passing ability of SCC in congested areas, the volume has to be limited generally speaking, the minimum aggregate size, D_{max}, is in between 10 to 20 mm. the passing ability decreases when D_{max} increases, which leads to a decrease of coarse aggregate content. The choice of D_{max} is thus possible but is only justified with low reinforcement content. Admixtures added to SCC can have a retarding effect on strength and temperature development in the fresh concrete, and this will have to borne in the min during construction process.

3.4 MIX DESIGN PRINCIPLES

To achieve the required combination of properties in fresh SCC mixes:

- The fluidity and viscosity of the paste is adjusted and balanced by careful selection and proportioning of the cement and additions, by limiting the water/powder ratio and then by adding a superplasticiser and (optionally) a viscosity modifying admixture. Correctly controlling these components of SCC, their compatibility and interaction is the key to achieving good filling ability, passing ability and resistance to segregation.
- In order to control temperature rise and thermal shrinkage cracking as well as

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strength, the fine powder content may contain a significant proportion of type l or ll additions to keep the cement content at an acceptable level.

V MIX DESIGN AND TEST METHODS:

Mix design is defined as process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economic as possible. The purpose of designing can be seen from the above definition is twofold. The first object is to make the concrete at the most economical.

TEST METHODS

SLUMP FLOW TEST AND T50CM TEST

The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. 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. The T $_{500}$ time is also a measure of the speed of flow and hence the viscosity of the self-compacting concrete.

Methodology

About 6 litre of concrete is needed to perform the test, sampled normally. The base plate and inside of slump cone are moistened. The base plate is placed on level stable ground and the slump cone centrally on the base plate and hold down firmly. The cone is filled without tamping and the extra concrete is simply striked off the concrete level with the top of the cone with the trowel. Any surplus concrete is removed from around the base of the cone. The cone is raised vertically and the concrete is allowed to flow out freely. Simultaneously, stopwatch is started and the time taken for the concrete to reach the 500mm spread circle is recorded (This is the T50 time).The final diameter of the concrete in two perpendicular directions is measured. The average of the two measured diameters is the slump flow in mm.

VI RESULTS AND DISCUSSIONS

GENERAL

Results obtained from experimental investigation to study the properties of ternary blended FRSCC are discussed in detail as given below:

FRESH PROPERTIES OF TERNARY BLENDED SELF COMPACTING CONCRETE

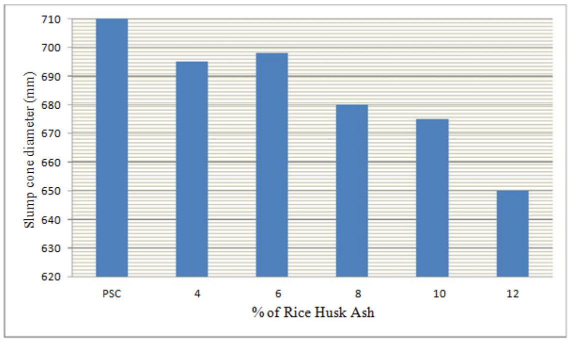

Figure 6.1 Slump cone diameter Vs % of Rice Husk Ash

DISCUSSIONS

Based on the present investigation, the studies of strength behavior of the Steel Fiber Reinforced Self Compacting Concrete, and the following observations have been made.

1) From Table 6.1 with a constant rate of 30% Fly Ash, the Rice Husk Ash is added up to 12% starting from 4% with an increase of 2% in each case. The obtained mix has satisfied the EFNARC specifications.

2) Dramix fibers of aspect ratio 80/60 are added up to 2% with an increase of 0.5%. From Table 6.2 the SFRSCC have satisfied the EFNARC specifications up to 2% by volume of concrete. Beyond 2% EFNARC specifications are not satisfied.

3) From Table 6.3 Ternary blended SCC has improved the compressive strength with age. The maximum value being 26.06 MPa and 39.59 MPa for 7 and 28 days respectively. The optimum percentage value of Rice Husk Ash may be taken as 6%.

4) From Table 6.4 the SFRSCC has improved the compressive strength with age irrespective of amount of fibers added to the concrete. The SFRSCC has improved the compressive strength as % of fibers in concrete increased. The optimum value of fibers may be taken as 1.5% by volume of concrete.

5) From Table 6.5 the flexural strength of SFRSCC has been increasing with respect to the increased amount of steel fibers. Though it may be affected by aspect ratio. There was about 21.5% increase in flexural strength when compared to plain SCC.

6) From Table 6.6 the SFRSCC has shown an improvement in split tensile strength with respect to the increase in the amount of Dramix steel fibers. There was about 12.2% increase in split tensile strength when compared to plain SCC.

7) From Table 6.7 there was not much significant reduction in cost from SCC to

Ternary Blended SCC. However the cost depends on the availability of material. Since in this project Rice Husk Ash is bought from Orissa, the cost was somewhat more.

CONCLUSIONS

This study shows that Rice Husk Ash can be used as replacement to cement in SCC.

By using RHA heat of hydration is reduced and also cost analysis shows not much variation in cost, though it is economic than ordinary concrete.

Optimum percentage of SCC mix containing RHA and Fly Ash as partial replacement of cement was found to be 6% and 30%.

Ternary mix exhibited better consistency in compressive strength development, which indicates a synergy of inert particle interaction between Ordinary Portland Cement, Rice Husk Ash and Fly Ash which enhanced compressive strength property.

The SCC developed compressive strength ranging from 24.00 MPa to 29 MPa and from 33.00 MPa to 40 MPa at 7 and 28 days respectively.

The Dramix steel fibers are suitable for SCC up to 2% by volume of concrete.

The Dramix steel fibers of aspect ratio 80/60 have shown overall improvements of all the properties.

The SFRSCC developed compressive strength ranging from 26.00 MPa to 35.00 MPa and from 39.00 MPa to 42 MPa at 7 and 28 days respectively.

The SCC developed split tensile strengths ranging from 3.25 to 5.13 Mpa at 28days.

The SCC developed flexural strengths ranging from 4.69 to 6.62Mpa at 28 days.

This study has shown that FRSCC can also be applied locally for construction of concrete pavements, base slabs which require not much higher strength.

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