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Experimental Study on High Strength SCC by Adding Nano Silica with Metakaoline as Partial Replacement for Cement

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ABSTRACT: Self-compacting concrete is one of the advanced outcomes of concrete research that can easily flow inside the highly congested reinforcement area and also the capability to compact with its own weight without showing segregation and bleeding. The performance of SCC by using nanosilica (NS) and metakaolin (MK) was studied for the properties of the concrete in a fresh state like workability and in the hardened state like compression and durability properties. By adding nano silica and metakaolin, with chemical admixture, it shows better improvement in the mechanical & durability properties. In this paper nano silica and metakaolin has been added partially by weight of cement as 1% and 10% respectively. Study has been seen that with nano silica from 1% to 3% a gain of strength is found. At NS 1% and MK 10% replacement the mechanical properties of the specimen like compressive strength, gives maximum result. In the same way the workability of SCC with 1% replacement of NS and 10% replacement of MK shows better flow ability with respect to other percentages. After wards adding of shows decline in strength. This paper also emphasizes the behavior of SCC on different durability tests as well as microstructure analysis.

I. INTRODUCTION

The development of new technology in the material science is progressing rapidly. In the last three decades, a lot of research was carried out throughout the globe to improve the performance of concrete in terms of strength and durability qualities. Consequently, concrete has no longer remained a construction material consisting of cement, aggregate, and water only, but has become an engineered custom-tailored material with several new constituents to meet the specific needs of construction industry. The growing use of concrete in special architectural configurations and closely spaced reinforcing bars have made it very important to produce concrete that ensures proper filling ability, good structural performance and adequate durability. In recent years, lot of research was carried out throughout the world to improve the performance of concrete in terms of its most important properties, (strength and durability). Concrete technology has under gone from macro to micro level study in the enhancement of strength and durability properties from 1980's onwards. Till 1980 the research study was focused only to flow ability of concrete, so as to enhance the strengths however durability did not draw lot of attention of the concrete technologists. This type of study has resulted in the development of SCC, a much-needed revolution in the concrete industries. SCC is highly engineered concrete with much higher fluidity without segregation and is capable of filling every corner of form work under its self-weight by Okamura (1997). Thus SCC eliminates the needs of vibration either external or internal for the compaction of the concrete without compromising its engineering properties. SCC is a fluid mixture, which is suitable for placing difficult conditions and also in congested reinforcement, without vibration. In principle, a self-compacting or self – consolidating concrete must have the following properties.

- Have a fluidity that allows self – compaction without external energy.
- Remain homogeneous in a form during and after the placing the concrete.
- Flow easily through congested reinforcement.

Self – consolidating concrete has recently been used in the pre – cast industry and in some commercial applications, however the relatively high material cost still hinders the wide spread use of such specialty concrete in various segments of the construction industry, including commercial and residential construction. The use of SCC is considered to have a number of advantages as:

- Faster placement
- Better consolidation around reinforcement.
- Easily placed in the walled element.

- Improves the quality, durability and reliability of the concrete structures.
- Reduces the total time of construction and the cost.

II. LITRATURE REVIEW

SANGA KRANTHI KUMAR et.al (2015) In the present investigation on “Influence of nano silica on strength and durability of self compacting concrete” In this work 40Mpa self- compacting concrete is developed using modified Nan-Su method of mix design Slump flow, J-Ring, V-funnel tests are conducted to justify the fresh properties of SCC and are checked against EFNARC (2005) specifications. Specimens of dimensions 150x150x150mm were cast without nano silica and with two different grades of nano silica which is in colloidal state with 16% and 30% nano content are added in different percentage

A. HEIDARI et.al(2015) in the present investigation report on “Properties of Self compacting concrete incorporating alginate and nano silica” This paper presents an experimental study on the properties and the durability of self compacting concrete (SCC) containing alginate in variety values with artificial stone resin, micro and nano silica. The values of 0.5 and 1% alginate, 10% micro silica, 0.5% nano silica and 0.5% artificial stone resin are used. Artificial stone resin is used as the super plasticizer.

M. IYAPPAN.et.al (2014) in the present investigation report on “high strength self compacting concrete with nano silica” This article presents the benefits of SCC with Nano silica, nano silica used as partial replacement of Portland cement in Self compacting concrete with different percentage, fresh and harden properties of SCC are established. There are three different replacement percentages of Nanosilica (0%,2%,4%,6%) is used in this study. The Hardened Properties like compressive strength, splitting tensile strength, Flexural strength was evaluated at 28 days.

Dr. D.V. PRASADA RAO et.al (2014) In the present experimental investigation “A study on influence of fly ash and nano silica on strength properties of SCC” the cement is partially replaced by 20% and 30% of Fly Ash and Nano-Silica 1.5%, 3% and 4.5% by weight. The influence of combined application of Fly Ash and Nano-Silica on compressive strength, split tensile strength, flexural strength and modulus of elasticity of M25 grade of concrete is investigated. Mechanical properties were obtained by performing strength tests for specimens cast with different percentages of ground and unground Based on the test results, it can be observed that concrete prepared with 20% Fly Ash and 3% Nano-Silica combination possesses improved properties compared to the controlled concrete.

B. KARTHIKEYAN et.al (2014) In the present investigation on “Microstructural analysis of strength properties of concrete with nano silica” the Fly Ash and Nano-Silica on compressive strength, split tensile strength, flexural strength and modulus of elasticity of M25 grade of concrete is investigated study reports part of the experimental investigations on using nano- sized mineral admixtures in concrete as a partial replacement of cement. Mechanical properties were obtained by performing strength tests for specimens cast with different percentages of ground and unground microsilica in partial replacements such as 5%, 10% and 15% by weight of cement. From the results it is understood that cubes cast with 10% replacement are showing better strength performance.

P. kirhthika.et.al (2014) In the present investigation on “concrete composites with nano silica, condensed” In the present experimental investigation, High Strength Concrete Mixes of M60 and M80 are studied for their mechanical properties. A combination of mineral admixtures like nano silica (nS) and condensed silica fume with OPC is used as replacement to cement in certain proportions and the strength properties are studied. Similarly a combination of nanosilica and fly with OPC is studied for strength properties. It is found that in the triple blended mixes studied, there is a gradual increase in the strength upto 2 percent of nano silica with 10 percent CSF in the mix and above this there is a gradual decrease in the strengths.

III. METHODOLOGY

Although, a characteristic of materials used in making SCC and their mix proportions influences SCC, one of the challenges in making SCC is there is no proven mix design procedure. In this study the methodology adopted, covers the development of SCC mixes using industrial bi-product such as GGBS and the study of fresh and hardened properties of developed SCC mixes in the laboratory.

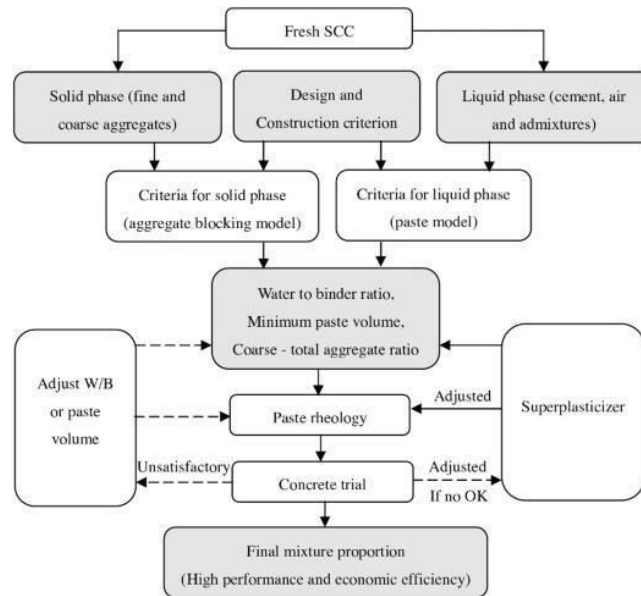


Fig 1: Methodology flowline

SCC must be highly workable so that it can move under the force of gravity without vibration, during mixing, transportation, handling, and placement. It is so highly flow able that the conventional slump test cannot distinguish between different levels of SCC. However, SCC must also viscous enough, so that the mortar suspends and carries coarse aggregate, maintaining a homogenous, stable mixture, resistant to segregation,

a. Nano Silica: Colloidal silica (silicon dioxide) nanoparticles are an important class of nanomaterials with hundreds of thousands of tons produced annually for a wide range of applications including abrasives, sorbents, catalysis, filtration, electronics, textiles and fabrics, and paints and coatings. At nano Compose, we offer a selection of silica nanomaterials as standard products, including solid silica nanoparticles, mesoporous silica nanoparticles, and silica shelled metal nanoparticles. We are highly skilled at modifying silica surfaces and fabricating a variety of silica morphologies on a custom basis. The specific gravity of nano silica is 1.03, and they are silica particles with a maximum size of 10 nm. In addition, nano silica is a water emulsion with 50 % of drysolid and PH of 10. The control mix which was exclude of nano silica.

b. Metakaolin: Metakaolin is an artificial pozzolana produced by burning selected kaolinite clay within a specific temperature range (between 650 and 800 C). When heated to 700–900 C, kaolin becomes calcined, losing up to 14% hydroxyl water and changing into MK. Because the production of MK can be closely controlled, a higher degree of purity and pozzolanic reactivity can be obtained with proper quality control. MK is basically made up of silica and alumina in an amorphous state, that react with calcium hydroxide (CH) produced by Portland cement hydration to form calcium hydro silicate (C–S–H) and calcium hydro aluminosilicate (essentially gehlenite – C2ASH8). There is a consensus in the literature that the pozzolanic reaction between MK and CH helps to refine the binder capillary porosity.

IV. MIX DESIGN PROCEDURE

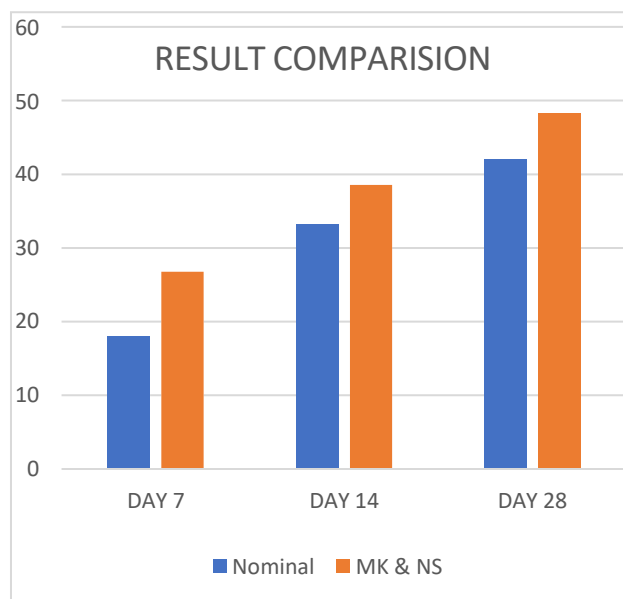
The content of fine and coarse aggregates can be calculated and the parameter considered in the mix design is as follows.

- S/a ratio: It is a ratio of fine aggregate to total mass of aggregate, which ranges usually from 50% to 57%, (S/a) is been taken as 50%.
- PF-Packing Factor: It is defined as a ratio of mass aggregate of tightly packed state to that loosely packed state. In this study the PF values is selected to be, 1.2.
- Wfa= Mass of the fine aggregate per cum.
- Wca= Mass of the coarse aggregate per cum.
- Wfal= Bulk density of fine aggregate.
- Wcal= Bulk density of coarse aggregate.
- Calculation of fine aggregate $Wfa = PF * Wfal * S/a$

- Calculation of coarse aggregate $W_{ca} = PF * W_{cal} * (1 - S/a)$
- Calculation of cement $C = (f_c / 0.14) * CF$
- Calculation of Mixing Water Content Required by Cement

The content of mixing water required by cement can then be obtained using the Equation. $W_{wc} = [w/c] * C$.
 Mix proportion obtained by Nan-Su, Method is 1:2.20:2.26 and w/p ratio 0.8

V. RESULTS



MIX PROPORTIONS	COMPRESSIVE LOAD IN MPa		
	7DAYS	14DAYS	28DAYS
NOMINAL MIX	18.05	33.20	41.98
10%MK+1%NS	26.76	38.56	48.20

Observations: It has been observed that the compressive strength of SCC produced with the combination of admixtures such as Nano Silica and Metakaolin is significantly higher than that of nominal mix. Also, it has been observed that the SCC blocks have lower density than that of nominal mix due to lower density of admixtures used

VI. CONCLUSIONS

Based on the laboratory investigation the following important conclusions are arrived.

- SCC mixes require high powder content and high range of superplasticizer dosage to achieve good rheological properties of SCC.
- The time of addition of superplasticizer is very important and it is generally added after the addition of 50-70% of water.
- SCC fills the formwork and encapsulates the reinforcements without vibration, to achieve compaction by its own weight and gives an excellent surface finish.
- On the basis of test results, cement can be replaced by the blend of SF and MK up to 15% without affecting strength of the mixes.

- It is observed that compressive strength increases up by the increasing the replacement of cement by Silica fume and Metakaolin

VII. SCOPE FOR FUTURE WORK

The following experimental studies can be conducted in future with respect to SCC.

- There are lot more mineral admixtures which are industrial waste products. The other type of ingredient's wastages can be used to manufacture SCC to reduce the problems of environmental problems.
- It is also suggested to study the different hardened properties for later ages such as 90 days and 180 days to decide the optimal percentage of blend of SF and MK .
- The effect of addition of SF and MK on the shrinkage and the creep properties of SCC containing more than two admixtures.
- When SCC becomes so widely used that it is seen as the "Standard concrete" rather than a "Special concrete", we will have succeeded in creating durable and reliable concrete structures that require very little maintenance work.
- It is also suggested to study the fresh and hardened properties of the blend of SF and MK by increasing the percentage of admixtures.

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