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Study on Fresh and Hardened Properties of High Strength Self Compacting Concrete with Metkaolinand Microsilicaas Mineral Admixture (M70 Grade)

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Abstract: Since ancient Rome, concrete has been widely used as a man-made stone due to its strong mechanical properties. The need for improving the performance of concrete and concern for the environmental impact arising from the continually increasing demand for concrete, has led to the growing use of alternative materials component. It is now clear that materials such as silica fume, rice hush ash ,fly ash, ground granulated blast furnace slag and metakaolin be produced from abundant natural material which are waste material have to be used to partially substitute cement or to complement it when high performance is needed.

Self-Compacting Concrete (SCC) belongs to a new generation of high performance concrete, which can be placed and compacted by its own weight with little or no vibration during construction. Self-Compacting Concrete was originally developed at the University of Tokyo, Japan in the late 1980's and now it is becoming a popular in the whole world. It is considered to be one of the most significant advance in concrete technology for the past decades. The present investigation is aimed to study on fresh and hardened properties of HSSCC with Metakaolin (MK) & Micro Silica(MS) as an admixture in the preparation of self-compacting concrete (HSSCC). In order to prepare suitable mix proportions for different grades of MK based HSSCC, investigations were undertaken replacing cement with 0%, 10%, 20%, 30%, 40% of MK. As per the European guidelines for Self-compacting concrete, slump flow test, V-funnel test and L-box test have been carried out on fresh properties of MK based HSSCC. The compressive strength, split tensile strength and flexural strength of the specimens have been analyzed for 7-days and 28 days curing. From the study it is observed that workability decreases with increase in Metakaolin. Whereas mechanical properties such as Compressive strength, Split tensile strength and Flexural strength test increase with increase in metakaolin up to 20% and decreases from 30% to 40%.

Non Destructive Test is also conducted to assess the quality of concrete in the hardened state. It was observed that quality of concrete is excellent for metakaolin replacement of 10%&20% and good for 30% replacement. Whereas quality of concrete is satisfactory for a 40% replacement.

Keywords: Concrete, Strength, Metakaolin, Micro-silica, Mineral Admixture, Workability.

I. INTRODUCTION

In general, a newly placed concrete is compacted by vibrating equipment to remove the entrapped air, thus making it dense and homogeneous; this is referred to as normally vibrated concrete (NVC) in this thesis. Compaction is the key for producing good concrete with optimum strength and durability (The Concrete Society and BRE, 2005). However, in Japan in the early 1980's, because of the increasing reinforcement volumes with smaller bar diameters and a reduction in skilled construction workers, full compaction was difficult to obtain or judge, leading to poor quality concrete (Okamura and Ouchi, 1999). Professor Okamura therefore proposed a concept for a design of concrete independent of the need for compaction. Ozawa and Maekawa produced the first prototype of SCC at the University of Tokyo in 1988 (Ozawa et al., 1989; RILEM TC 174 SCC, 2000). Since that time SCC has gone from a laboratory novelty to practical applications all over the world.

A. Advantages of Self Compacting Concrete:

1) Less noise from vibrators and reduced danger from Hand Arm Vibration Syndrome (HAVS).
2) Safe working environment.
3) Speed of placement, resulting in increased production efficiency.
4) Ease of placement, requiring fewer workers for a particular pour.
5) Better assurances of adequate uniform consolidation.
6) Reduced wear and tear on forms from vibrator.
7) Reduced wear on mixers due to reduced shearing action.
8) Improved surface quality and fewer bug holes, requiring fewer patching.
9) Improved durability.
10) Increased bond strength.

B. *Development of Self-Compacting Concrete:*

The development of Self Compacting Concrete (SCC) is considered as the most sought development in construction industry due to its numerous inherited benefits. In India, this technology is yet to realize its full potential. Central Road Research Institute (CRRI) [2005]New Delhi, has been working on SCC technology since the year 2000 and carried out significant research work on various aspects of SCC starting from selection of suitable ingredients including super plasticizer, viscosity modifying agent, mineral admixtures, mix proportion optimization, evaluation of the characteristic properties at fresh stage and hardened properties such as compressive strength, splitting tensile strength, flexural strength, Young's modulus of elasticity. Further, in-situ performance evaluation of the structural element cast by using SCC in comparison with conventional plasticized concrete of similar strength i.e. 50 MPa at 28 days were carried out by using semi-destructive and non-destructive test methods. Structural behavior of SCC in heavily reinforced T beams was conducted to study cracking pattern, deflection and ultimate load bearing capacity.

C. *Applications of Self-Compacting Concrete:*

1) Dam (concrete around structure)
2) Diaphragm wall
3) Tunnel (lining, immersed tunnel, fill of survey tunnel)
4) Tank (side wall, joint between side wall and slab)
5) Pipe roof
6) Bridge construction
7) Concrete products (block, culvert, wall, water tank, slab, and segment)

D. *Mechanism for Achieving Self-Compatibility*

Simply increasing the water content in a mix to achieve a flow able concrete like SCC is obviously not a viable option. Instead, the challenge is to increase the flow ability of the particle suspension and at the same time avoid segregation of the phases. The main mechanism controlling the balance between higher flow ability and stability are related to surface chemistry. The development of SCC has thus been strongly dependent on surface active admixtures as well as on the increased specific surface area obtained through the used fillers.
Hajime Okamuraet al.,[2003] and Ozawa Ketal.,[1989] have employed the following methods to achieve self-compactability.

1) Limited aggregate content
2) Low water-powder ratio
3) Use of Super Plasticizer (SP)

E. *Objectives of the Project*

The scope of present work is to study on fresh and hardened properties of Self Compacting Concrete with metakaolin& micro-silica as mineral admixture (M70 Grade). The work focused on replacement of metakaolin 10%,20%,30%,40% &micro silica 8%,with a Packing factor of 1.10. The Concrete mixes contains different proportions of Metakaolin& cement and constant proportions of water binder micro-silica, Coarse aggregate and Fine aggregate for constant water-cement ratio 0.27. The mix proportions are obtained on the basis of NAN-SU mix design.
Non Destructive Test is also conducted to assess the quality of concrete in the hardened state.

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II. MIX DESIGN PROCEDURE

A. Procedure for mix design of M70 SCC

"With respect to Nan Su's procedure of mix design for SCC, the factors that affect the mix proportions were PF, FA to TA ratio and filler material content. In Nan Su's type mix design Fly Ash and GGBS together are considered as mineral admixtures. But in the present investigation, Nan Su's type mix design is slightly changed by considering Metakaolin (MK)and Micro-silica(MS) as mineral admixture. In the current study MK plus MS is considered as set of mineral admixture. In this study Micro Silica content was taken as 8% by weight of Cement based on trials. For achieving High Strength Self Compacting Concrete (M70grade) Micro Silica is added. From "the hardened and fresh studies conducted on Self Compacting Concrete in the current study, it was found that there was a change in the quantities of mix related to PF and water cement ratio".

Mix Components	Concrete Mixes				
	MIX 1 0%	MIX 2 10%	MIX 3 20%	MIX 4 30%	MIX 5 40%
	Qty.	Qty.	Qty.	Qty.	Qty.
CEMENT	574.02	517.00	459.216	401.81	344.41
C.A	790.94	790.94	790.94	790.94	790.94
F.A	829.4	829.4	829.4	829.4	829.4
WATER	173.26	173.26	173.26	173.26	173.26
METAKAOIN	52.400	109.802	167.2	224.608	282.08
S.P	11.28	11.28	11.28	11.28	11.28
MICRO SILICA	40.18	40.18	40.18	40.18	40.18
V.M.A	1.722	1.722	1.722	1.722	1.722

Table1. Quantities of mix for different percentage of Metakaolin as mineral admixture

III. METHODOLOGY

The experimental program consisted of casting and testing specimens for testing the fresh and hardened properties on M70 grade of concrete with metakaolin as filler material. Nan Su method of mix design [2001]was adopted to arrive at the suitable mix proportions. The mix proportion for M20 grade was arrived, taking the different w/c ratios into consideration. A total of 30 cubes of standard size 100 mm x 100 mm x 100 mm, 30 prisms of standard size 100 mm x 100 mm x 500 mm and 30 cylinders of 150 mm diameter and 300 mm height were cast for determining the compressive strength, flexural strength and split tensile strength respectively.

A. Materials

The materials used in the experimental investigation of SCCwere

1) Ordinary Portland cement-53 grade
2) Coarse Aggregate of size 10mm
3) River sand
4) Water
5) Admixture a. Mineral Admixtures (Metakaolin)
6) Mineral Admixtures (Micro Silica)
7) Chemical Admixtures (B233)

B. Cement

Ordinary Portland cement of 53 grade [IS: 12269-1987, Specifications for 53 Grade Ordinary Portland cement] has been used in the study. It was procured from a single source and stored as per IS: 4032 – 1977. Care has been taken to ensure that the cement of same company and same grade is used throughout the investigation. The cement thus procured was tested for physical properties in accordance with the IS: 12269 – 1987.

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C. Fine Aggregates

The fine aggregate used was locally available river sand without any organic impurities and conforming to IS: 383 – 1970 [Methods of physical tests for hydraulic cement]. The fine aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density.

D. Coarse Aggregate

The coarse aggregate chosen for SCC was typically round in shape, well graded and smaller in maximum size than that used for conventional concrete. The size of coarse aggregate used in self compacting concrete was 10mm. The rounded and smaller aggregate particles provide better flow ability and deformability of concrete and also prevent segregation. Graded aggregate is also important particularly to cast concrete in highly congested reinforcement or formwork having small dimensions. Crushed granite metal of sizes 10 mm graded obtained from the locally available quarries was used in the present investigation. These were tested as per IS 383-1970 [Methods of physical tests for hydraulic cement]. The physical properties like specific gravity, bulk density, flakiness index, and elongation index.

E. Water

Water used for mixing and curing was potable water, which was free from any amounts of oils, acids, alkalis, sugar, salts and organic materials or other substances that may be deleterious to concrete or steel confirming to IS : 3025 – 1964 part22, part 23 and IS : 456 –2000 [Code of practice for plain and reinforced concrete]. The pH value should not be less than 6. The solids present were within the permissible limits as per clause 5.4 of IS: 456 – 2000.

F. Mineral Admixtures

High flow-ability is one of the main requirements of SCC. This can be achieved by using mineral admixtures. These mineral admixtures should have the fineness same as that of cement. These mineral admixtures are either inert fillers or reactive in nature. Inert fillers include Quartz powder and lime stone powder while reactive fillers are fly ash, GGBS, etc. The reactive mineral admixtures affect the concrete properties in many ways.

1. Metakaolin

Metakaolin is supplementary cementations material that conforms to ASTM specification. Metakaolin is unique in that it is not the byproduct of industrial process nor is it entirely natural. It is derived from a naturally occurring mineral and is manufactured specifically for cementing applications. Metakaolin is refined kaolin clay that is fired (calcined) under carefully controlled conditions to create an amorphous alumino-silicate that is reactive in concrete. Like other pozzolans, Metakaolin reacts with the calcium hydroxide (lime) byproducts produced during cement hydration. Calcium hydroxide accounts for up to 25% of the hydrated Portland cement and calcium hydroxide does not contribute to the concrete's straight or durability. Metakaolin combines with the calcium hydroxide to produce additional cementing compounds, the material responsible for holding concrete together. Less calcium hydroxide and more cementing compounds means stronger concrete.

Metakaolin differs from other supplementary cementations materials (SCMs), like fly ash, silica fume, and slag, in that it is not a by-product of an industrial process. It is manufactured for a specific purpose under carefully controlled conditions. Metakaolin is produced by heating of the most abundant natural clay minerals, to temperatures of 650-900 °C Metakaolin also decreases concrete permeability, which in turn increases its resistance to sulfate attack and chloride attack, Metakaolin may reduce autogenous and shrinkage and avoids cracking.

Fig 1.Micro silica

Fig 2. A Pile of Metakaolin and Spread of concrete

J. Micro silica

Micro silica is predominantly silicon dioxide. Its prime characteristic is particle size which would be as low as 0.2 micron, which is about 100 times smaller than Portland cement grains. The extremely small grain size of micro silica is responsible for its high reactivity with free lime in the concrete to form a strong and non-permeable paste. The other important properties which established micro silica as a formidable building material are its imperviousness to water, low permeability to chloride ion and resistant to sulphate and acid attack. Because of high surface area and high contents of amorphous silicon in silica fumes, the latter acts as a highly active Pozzolans and reacts more quickly than ordinary Pozzolans. The presence of micro silica brings reduction of bleeding in fresh concrete and in consequences, significant improvements in the density of the transition zone and in the mechanical behavior of hardened concrete. The strength of the transition zone can be further enhanced by a Pozzolanic reaction.

K. Chemical Admixtures

Glenium B233It is high performance concrete super plasticizer based on modified poly carboxylic ether. It has been developed for application in high performance concrete, where the highest durability and performance is required. It is compatible with all Portland cements that meet recognized international standards.

1) Uses

a) High workability without segregation or bleeding
b) Precast concrete
c) High early and ultimate strength concrete
d) High performance concrete for durability

L. Super plasticizer

Super plasticizer GLENIUM B233of Fosroc chemical India Ltd. was used as water reducing admixture. It increases workability.

M. Existing Tests for Fresh SCC Mixes

1) Slump Flow Test
2) U box test method
3) L box test method
4) V Funnel Test and V Funnel test at T5 minutes

N. Non Destructive Tests

1) Rebound hammer test
2) Ultrasonic Pulse Velocity

IV. DISCUSSIONS OF TEST RESULTS

A. Discussion on Proportions of Mix Used forM70 SSC

Self-Compacting Concrete with Metakaolin and Micro-silica as mineral admixture for M70 grade was taken up. “Nan Su method of mix design [2001] was adopted to design the M70 SCC mix”. Nan Su method of design is based on the basic concept that the paste of fillers are filled in the aggregate voids keeping that the concrete available has flow ability, self-consolidating ability and other required properties of self-consolidating concrete.

B. Effect of Metakaolin on Fresh Properties

The workability decreased with the increase in the metakaolin.

1) As the metakaolin increases from 0% to 10% Slump value decreases by 0.714%, T500 value increased by 1.94%, V funnel value increased by 16.77%, V funnel at T5 minutes increased by 5%,L box value decreased by 3.06 %, U box value increases by 33.33%.
2) As the metakaolin increases from 0%to20% Slump value decreases by 2.142 %, T500 value increased by 8.09%, V funnel value increased by 24.45 %, V funnel at T5 minutes increase by 18.1 %, L box value decreased by 16.122 %, U box value increases by 66.67 %.

3) As the metakaolin increases from 0% to 30% Slump value decreases by 4.285 %, T500 value increases by 15.29%, V funnel value increases by 26.096%, V funnel at T5 minutes increases by 20.57 %,L box value increases by 13.26 %, U box value increase by 100%.
4) As the metakaolin increases from 10% to 40% Slump value decreases by 6.42 %, T500 value increases by 18.93%, V funnel value increases by 29.385%, V funnel at T5 minutes increases by 23.04 %,L box value increases by 16.32%, U box value increases by 133%.
5) From the above results we observed that the workability decreases gradually as the percentage of metakaolin increases from 0% to 40%. Further it is observed that the change in the percentage variation of flow values increases as the percentage of metakaolin increases from 10% to 20% ,20% to 30%, and 30% to 40% the reason for this is the powder content increases as the water cement ratio is constant.

V. CONCLUSIONS

From the detailed experimental work done on SCC mix with an aim to study on fresh and hardened properties of Self Compacting Concrete with constant w/c ratio and replacement of metakaolin (10%,20%,30%&40%) as mineral admixture the following conclusions are arrived.

A. *Effect of Metakaolin Ratio*:

As the water Metakaolin rises from 0% to 40%,

1) The powder content increases and the aggregate content remains the same.
2) The workability decreases gradually as the percentage increases from 0% to 40%.
3) he change in the percentage variation of flow values decreases as the percentage of metakaolin increases from 0% to 20% and 30% to 40%, the reason for this is the powder content increases as the water cement ratio is constant.
4) The compressive strength, split tensile strength and flexural strength increased with the increase in the percentage of metakaolin from 0% to 20% & decreases from 30% to 40%.
5) he percentage variation of strength values increases as the percentage of metakaolin increases from 0% to 20% and decreases from 30% to 40% the reason for this is the powder content increases as the water cement ratio is constant .It leads to decrease the binding capacity of the concrete mix.
6) The optimum percentage of metakaolin is taken as 20% for w/c=0.27.
7) The presence of metakaolin improved both early ages and long term compressive strength of HSSCC. Based on the Non Destructive Tests it is concluded that quality of concrete,
8) Is Excellent for metakaolin 10% and 20%
9) Is Good for metakaolin 30%.
10) Is Medium for metakaolin 40%

B. *Scope of The Future Work*

The effect of metakaolin on fresh and hardened properties of SCC was presented may be extended to the SCC in combination with other mineral admixtures such as Fly ash, Rice husk ash, cement kiln dust etc.

The effect of packing factor on fresh and hardened properties of Self Compacting Concrete with metakaolin as mineral admixture can be consider for further study.

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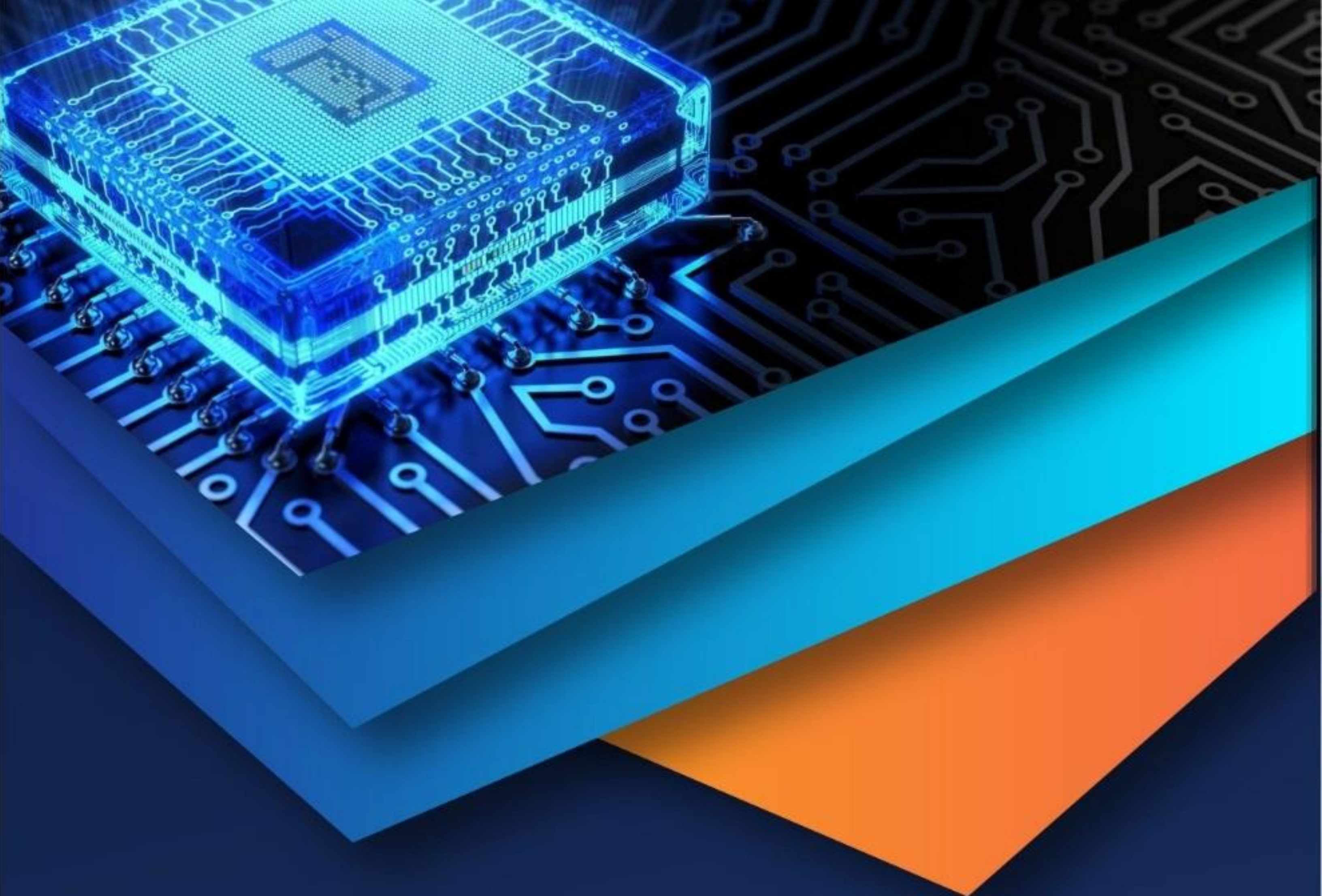
REFERENCES

[1] Nan Su, Kung-Chung Hsu, His-WenChai"A Simple Mix Design Method for Self-Compacting Concrete" Cement and concrete Research 31 (2001) 1799-1807.
[2] Okamura, H. and Ouchi, M., (2003). "Self-compacting concrete", Journal of Advanced Concrete Technology, Vol. 1, No. 1, April, pp. 5-15.
[3] Naveen Kumar C. Jagadish V and Ranganath R.V." Self-Compacting Concrete with Fly Ash and Metakaolin", The Indian Concrete Journal, April 2006, pp33-39.
[4] The European Guidelines for Self Compact Concrete Specification, Production and Use Feb 2002 and May 2005
[5] M.S. Shetty "Advanced Concrete Technology" Third Edition S. Chand & Co. Ltd., New Delhi, 1992



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