STUDY ON FRESH AND HARDENED PROPERTIES OF SELF COMPACTING CONCRETE WITH METAKAOLIN AS MINERAL ADMIXTURE (M40 GRADE)

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ABSTRACT

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

1. 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. The increasing numbers of papers published every year that deal with all aspects of SCC, e.g: mix design, rheological and physical properties and applications in practice indicate research on this technology is thriving.

Recommendations on the design and applications of SCC in construction have now been developed by many professional societies, including the American Concrete Institute (ACI), the American Society for Testing and Materials (ASTM), Center for Advanced Cement-Based Materials (ACBM), Precast Consulting Services (PCS) and Reunion International des Laboratories et Experts des Matériaux, systems de construction et ouvrages (RILEM) etc.

2. LITERATURE REVIEW

This chapter deals with the review of literature related to development of Self compacting concrete, workability, mechanical properties and durability of self-compacting concrete subjected to high temperatures. A wide variety of sources, international in origin and dated from the early development of SCC to the present, are summarized in this review

Self-compacting concrete extends the possibility of use of various mineral by-products in its manufacturing and with the densification of the matrix, mechanical behavior, as measured by compressive, tensile and flexural strength, is increased. On the other hand, the use super plasticizers or high range water reducers, improves the stiffening, unwanted air entrainment, and flowing ability of the concrete. Practically, all types of structural constructions are possible with this concrete. The use of SCC not only shortens the construction period but also ensures quality and durability of concrete. This non-vibrated concrete allows faster placement and less finishing time, leading to improved productivity.

In the following, a summary of the articles and papers found in the literature, about the self-compacting concrete and some of the projects carried out with this type of concrete, is presented.

Nan Su [2001]: Nan Su proposed a simple mix design method. The main focus in this method was to fill voids in loosely filled aggregate with paste of binder. It is defined as the ratio of mass of aggregate of tightly packed state in SCC to that of loosely packed state. His mix design totally depends on Packing factor (PF). A higher PF indicates greater amount of aggregate content, which will require less binder and generally will have less flow ability and vice versa. He concluded that the PF determines the aggregate content and influences the strength, flow ability and self-consolidating ability. In this mix design method the volume of sand to mortar in the range of 52-58% and found that the PF value was the controlling factor for filling height of U-box test.

Hagime Okamura & Masahiro Ouchi Investigation for Establishing a rational mix design method and self compact ability testing methods have been carried out from the view point of making SCC a standard concrete.

Naveen Kumar, C. Kiran, et.al The investigation is carried out and proved that SCC can be produced with cement content as low as 200 kg/m3 of concrete. High Strength SCC can be obtained through incorporation of Metakaolin.

Dr. Hemant Sood, Dr. R K Khitoliya et.al. It is highlighted that the use of European Standards by various researchers for testing SCC in Indian condition.

3. METHODOLOGY

Wide spread applications of SCC have been restricted due to lack of standard mix design procedure and testing methods. It is pertinent to mention that only features of SCC have been included in Indian Standard Code of practice for plain and reinforced concrete (fourth revision), [2000]. Slump flow test, L-box test, V-funnel test, U-box test are recommended by EFNARC [European Federation of Producers and Applicators of Specialist Products for Structures, May 2005] for determining the properties of SCC in fresh state.
A total of 24 cubes of standard size 150 mm x 150 mm x 150 mm, were cast for determining the compressive strength, respectively.
. The mix proportion for M40 grade was arrived, taking the various different percentage replacement of cement with metakaolin into consideration.

4. MIX PROPORTION

M40-concrete
53 grade of cement
Size of aggregate 10mm
Water cement - 0.38
Water content – 205 kg^m3
W/c=208/0038=547.368kg/m^3
Wc=547.368*0.38=207.99kg/m^3
Volume of cement = 0.173m^3
Volume of w 208m^3
Volume of chemical admixture is 0.6%
0.6/100*547.368=3.28
Specific gravity 3.28/1.09*1/1000=0.003m^3
Mass oc ca:
Ca=1055.95kg/m^3
Mass of fine aggregate:
Fa=553.945kg/m^3

FOR 0%:
Volume of 6 cubes = 6*0.15^3=0.02025
Total quantity=wc+c+fa+ca+=2365.263kg/m^3
Total weight = t.q*0.02025=47.89kg
Factor weight =47.89*1.25=59.87
Cement=13.85kg
Fine aggregate=14.02kg
Coarse aggregate=26.72kg
Water=5.26
Chemical admixture=0.03156=31.5ml

5% of metakoaline, 95% of opc:
Cement=95%
Metakoaline=5%*cement=27.368

Quantities:
Cement=13162kg
Metakoalinem54.36kg

10%:

Cement 90%*cement=492.63kg/m^3
Metakoaline=10%*cement=54.73kg/m^3

Quantity;
Cement=12.46kg
Metakoaline=1.385kg

15%:

Cement=85%*cement=465.26kg/m^3
Metakoaline=15%*cement=82.1052kg/m^3

Quantity:
Cement=11.77kg
Metakoaline=2.07kg

5. EXPERIMENTAL PROGRAM

Wide spread applications of SCC have been restricted due to lack of standard mix design procedure and testing methods. It is pertinent to mention that only features of SCC have been included in Indian Standard Code of practice for plain and reinforced concrete (fourth revision), [2000]. Slump flow test, L-box test, V-funnel test, U-box test, Orimet test & GTM Screen test are recommended by EFNARC [European Federation of Producers and Applicators of Specialist Products for Structures, May 2005] for determining the properties of SCC in fresh state.

The experimental program consisted of casting and testing specimens for testing the fresh and hardened properties on M40 grade of concrete with metakaolin as filler material.

MATERIALS

The materials used in the experimental investigation of SCC were

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

A. Compressive strength test

The compressive strength test is used to determine the strength of concrete. The sample dimensions are 150mm×150mm×150mm. Generally compressive strength conducted on samples of concrete at 7days,28days. In this project, the compressive strength test performed at 7days and 28days. The procedure of compressive strength followed in this project according to IS-516:1959. The compressive strength conducted on 3 samples for each temperature condition cured of concrete. The values of every sample cube cured under different temperatures were noted. The average values of 2 samples of concrete taken as final value of strength.

Compressive Strength (N/mm2) = Failure load/cross sectional area.

$\sigma = P/A$

Where,

P=Applied load,

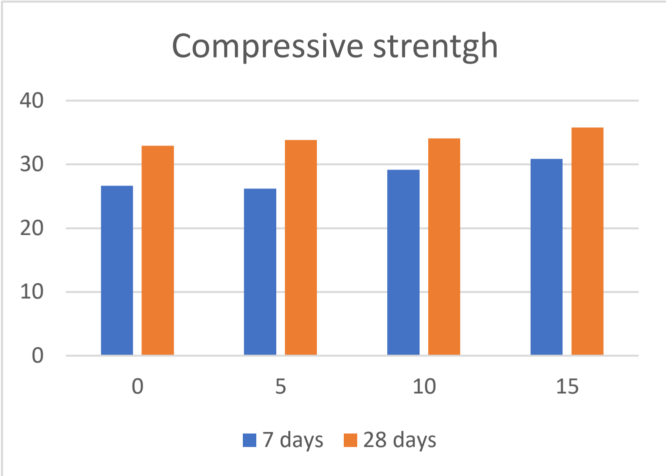
A= Cross-sectional Area

Fig 1: Compressive Strength test

The results of compressive strength are given below,

Table 4: Test results of Compressive strength test

Type Of Mix	Compressive Strength (N/mm2)	
	7days	28days
SCCMK0	26.65	32.93
SCCMK5	27.18	33.82
SCCMK10	29.16	34.10
SCCMK15	30.85	35.80



B. Split tensile strength test

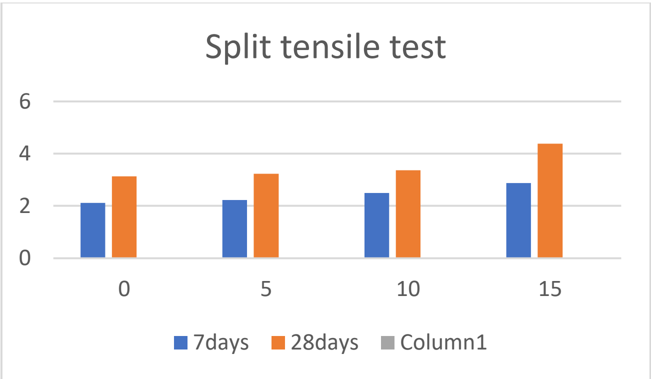
Split tensile strength is applying a diametric compressive load along the entire length until failure occurs. This loading induces tensile stresses on the plane containing the applied load and compressive stresses in the area around the applied load. In this experiment, split tensile strength test is performed for 7&28 days on the cylinders. The procedure for split tensile strength is followed according to IS 5816:1999. Split rigidity was determined by conducting split tensile strength test.

$$S = 2P/\pi DL$$

Where, P = Failure Load (KN), D = Diameter of Specimen(150 mm), L = Length of Specimen (300 mm)

Fig 2: Split Tensile Strength test

Type Of Mix	Split tensile strength (N/mm2)	
	7days	28days
SCCMK0	2.12	3.13
SCCMK5	2.22	3.23
SCCMK10	2.49	3.37
SCCMK15	2.88	3.45



CONCLUSION

As the water Metakaolin rises from 0% to 15%,

- The powder content increases and the aggregate content remains the same.
- The workability increases gradually as the percentage increases from 0% to 15%.
- The change in the percentage variation of flow values as the percentage of metakaolin increases from 0%, 5%, 10%, 15%. the reason for this is the powder content increases as the water cement ratio is constant.
- The compressive strength, split tensile strength increased with the increase in the percentage of metakaolin from 0% to 15%.
- The optimum percentage of metakaolin is taken as 15% for w/c=0.38.
- The presence of metakaolin improved both early ages and longterm compressive strength of SCC.

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