UTILIZATION OF METAKAOLIN AS A PARTIAL REPLACEMENT BY CEMENT WITHSELF-COMPACTING CONCRETE

Manu Vijay [1]
Associate Professor, Department of Civil Engineering, ATME College, Mysuru, Karnataka, India

Naveen Kumar S M [2]
Assistant Professor, Department of Civil Engineering, Adichunchanagiri Institute of Technology, Chikkamagaluru Karnataka, India.

---***---

Abstract: In current research an attempt has been to study the fresh and hardened characteristics of SCC mixes with partial substitute of cement by using industrial product consisting of Metakaolin(MK) through devlopM40 Grade self compacting concrete. To evaluate rheological properties of developed mixes is studied by way of trial and error technique to judge as SCC via allowable rheological trails as per EFNARC Guidelines. To develop conventional SCC and SCC Mixes with alternative of MK levels from 5-20% by way of weight of cement after with extraordinary combinations of Superplasticizer (SP) with suitable water cement ratio. To take a look at the hardened properties viz; compressive &splitting tensile strength of evolved SCC mixes in laboratory The general cubes and cylinders have been casted and cured for different ages and tested in the laboratory at the ages of 7,28 and 56 days respectively. Finally to compare outcomes of traditional SCC and SCC mixes with MK.

Keywords: Self compacting concrete metkolin

1.0 INTRODUCTION

Develop in Japan, during in 1983, had been centered on the removal of poor compaction whichwas diagnosed as a major purpose of poor sturdiness of concrete systems reported with the aid of Ouchi (1998). Scc is highly compaction concrete with much higher fluidity with out segregation and is capable of filling every corner of form work under its self weight best reported via Okamura (1997). SCC is a fluid mixture, which is appropriate for putting in difficult conditions and also in congested reinforcement, with out vibration. In order to fulfill the performance requirements the following three kinds of SCC available viz:

(i) Powder sort of SCC: This is proportioned to give the required self-compatibility by decreasing the water-powder ratio and offer ok segregation resistance
(ii) Viscosity agent type SCC: This type is proportioned to offer self-compaction by means of the use of viscosity modifying admixture to provide segregation resistance. Super plasticizers and air entraining admixtures are used for acquiring the desired deformability.
(iii) Combination type SCC: This type is proportioned so as to obtain self-compatibility mainly by way of lowering the water powder ratio, as in the powder type, and a viscosity modifying admixture is added to reduce the quality fluctuations of the fresh concrete due to the variation of the surface moisture content of the aggregates and their gradations at some stage in the production.

2.0 MATERIALS AND METHODS

2.1Materials used.

2.1.1 Cement: The cement used for the investigation become Portland pozzolana Cement (PPC-43grade).It showed to the necessities of Indian Standard Specification (IS: 1489-1(1991). 2.1.2 Sand: Good river sand in absence of any earthy rely and natural count. Particles are angular in form passing through 4.75mm and keeping on 150 micron sieve. Confirming to IS 383-1970 (Part1). 2.1.3 Coarse aggregates: The most size of aggregate is commonly used to 20mm. Aggregate of size 12 mm is perfect for structures having congested reinforcement. Confirming to IS 383-1970 2.1.4 Mixing water: Ordinary potable water of casted pH 7 is used for blending and curing the concrete specimen.

2.1.5 Admixtures forSCC

Super plasticizer: CONPLAST SP 430 is used. CONPLAST SP 430 is based on sulphonated naphthalene polymers and is used supplied as a brown liquid immediately dispersible in water. Conforming to IS 9103-(1999).

Metakaolin: Metakaolin is an artificial Pozzolana produced by means of burning decided on kaolinite clay within a specific temperature range (650 and 800˚C). MK is essentially made from silica and alumina in an amorphous state, that react with calcium hydroxide (CH) produced through Portland cement hydration to shape calcium hydrosilicate (C–S–H) and calcium hydroaluminosilicate (essentially gehlenite – C2ASH8)

3.0. METHODOLOGY DETAILS

The present research is to design M40 grade SCC with the aid of the usage of Nan Su technique of mix design and Rheological, Strength the Properties as according to EFNARC manual lines. The share is chosen in the variety of (0-20%)via weight of cement increased replacement of every 5% rate of increase respectively.**3.1 Mixture proportions:**

This paper would make contributions the limited research about the MK replacement. After that, seven different kinds of mixtures were received including control and MK based totally mixtures. These are indicated as: (NSCC) for ordinary SCC, MK based totally Mix-1 (MK5%), MK based totally Mix-2 (MK10%), MK based totally Mix-3 (MK15%), MK based Mix-4 (MK20%). During the manufacturing of clean SCC, all ingredients had been jumbled together dry state. Afterwards, a chemical admixture has been introduced within the mixing water and this answer is delivered to the aggregate. Mixing process has been continued till the combination has the consistency of self-compatibility.

3.2 Mix design for SCC. The technique of mix design for SCC proposed and utilized in this observe is primarily based on a method developed in Taiwan by way of Nan Su. This approach is composed of the following steps.

3.2.1MixDesignMethod

(i)Estimation of coarse and quality aggregates content: The content material of first-class and coarse aggregates may be calculated as follows:The parameter considered inside the mix layout.

S/a ratio: It is a ratio of high-quality aggregate to overall mass of combination, which ranges typically from 50 to 57%, (S/a) has been taken as 50%. (ii)PF-Packing factor: It is defined as a ratio of mass aggregate of tightly packed stated to that loosely packed state. The fee ratio of mixture after lubrication and compaction in SCC is ready 59-68%. In this take a look at the PF values is selected to be 1.18.

Wfa=Massof FA

Wca=Massof CA

Wfal=BulkdensityofFA

Wcal=Bulkdensityof CA

fc=GradeofConcrete
CF=Correctionfactor
Step1:Calculationof

FA
Wfa=PFXWfal×S/a=1.18×1120×(50/100), Wfa=674.43 kg/m^3.

Step2:CalculationofCA.

Wca=PFXWcal×S/a=1.16×1341×(1-50/100),Wca=722.91 kg/m^3.

Step3: CalculationofcementContent

C=fc1/20=6892.86/20=344.64kg/m3.
Step4: Calculation of Mixing Water Content Required by Cement. The content of mixing water required with the aid of cement can then be received using under Equation through deciding on water/ binder ratio as 0.38.

Wwc=[w/c]×C=[0.38]×344.64,Wwc=130.96kg/m3.

Step5: Finalquantities

Cement = 344.64 kg/m3, FA=674.43 kg/m^3, CA=722.91 kg/m^3, WC=130.96kg/m^3, Ratio =1:1.96:2.09

Mix proportion obtained by Nan-Su, Method is 1:1.96:2.09 and w/p ratio as 0.38

4.0 RESULTS AND DISCUSSION

The primary materials used in the present work are examined within the laboratory that allows you to verify the properties of different substances to fulfill the IS code provisions. Further, tested the cement, pleasant combination and coarse aggregates used inside the investigation and the properties of these substances evaluated inside the laboratory are tabulated in Tables 4.1 and 4.2 respectively

Table 4.1: Test results of cement and Metakaolin (MK)

Sl.No	Material	Test	Results obtained
	Cement	Specific gravity	3.10
		Initial setting time (min)	33
		Final setting time (min)	336
		Fineness (%)	7
		Compressive strength at 7-days (MPa) 28-days(MPa)	 33.00 45.00
2	Metakaolin	Specific gravity	2.35

Table 4.2: Test results of Fine aggregate and coarse aggregate

Sl.No	Material	Test	Results obtained
1	Fine aggregate	Specific gravity	2.58
		Bulk density (Kg/m^3)	1143
		Water absorption (%)	1.80
		Fineness Modulus	2.32
2	Coarse aggregate	Specific gravity	2.75
		Bulk density (Kg/m3)	1225.3
		Water absorption (%)	0.46%

The test results of cement, Met kaolin (MK), fine aggregate and coarse aggregates obtained in the laboratory satisfies the BIS Code requirements.

4.1 Properties of fresh concrete: The SCC concrete for specific trial mixes considered in the current research are as shown in Table 4.3&4.4 all applicable info of an ordeal mixes are considered.

Mixes 1 to 2 had been preliminary trials received from Nan-Su method of design blend to achieve stoop glide. Mix three to five changed into kept steady however super plasticizer is being varied. Although this mix executed a hunch go with the flow of 433 mm, therefore within the next mix with regards to preceding blend, dosage of SP and cloth share is kept consistent and w/p ratio is varied. At mix eight bleeding appeared, then blend 9 is marked as control mix. Finally the Slump flow of 600 becomes done from the w/p ratio of 0.42. Then the alternative of cement is done with MK with the obtained trial mix (1:1.6:1.6) and w/p ratio of 0.44

Table 4.3: Trial mixes to develop SCC.

Further results of rheological properties of SCC mixes with various percentages of MK replacement levels are as shown in

Slno	Mix ratio	SP (%)	W/P (ratio)	Slump flow(mm)	J-ring (mm)	V-Funnel (Sec)	Remarks
1	1:1.96:2.09	-	0.38	-	-	-	-
2	1:1.96:2.09	-	0.39	-	-	-	-
3	1:1.96:1.90	1	0.39	-	-	-	-
4	1:1.96:1.90	1.1	0.39	-	-	-	-
5	1:1.96:1.90	1.2	0.4	-	-	-	-
6	1:1.96:1.90	1.2	0.41	-	-	-	-
7	1:1.80:1.85	1.2	0.42	-	-	-	-
8	1:1.80:1.80	1.3	0.41	554	13	42.25	-
9	1:1.70:1.80	1.4	0.43	630	12.7	34.30	Control mix
10	1:1.70:1.75	1.4	0.44	637	12	21.50	-
11	1:1.65:1.70	1.5	0.45	646	11.5	18.40	Bleeding
12	1:1.6:1.65	1.5	0.45	648	10.8	16.35	Bleeding
13	1:1.60:1.60	1.5	0.45	652	9	15.20	Bleeding
14	1:1.60:1.60	1.5	0.44	660	8	14.50	Satisfied

Table 4.4.

The hardened propitiates of SCC are compressive Strength and splitting tensile strengths. However Investigation they may be evaluated by changing cement via Metakaolin (MK).Table 4.5 Hardened properties of SCCFurther results of rheological properties of SCC mixes with various percentages of MK replacement levels are as shown in Table 4.4.

Table 4.4: Fresh properties of SCC

Specifications	Slump flow(mm)	V-funnel T_{5min}	J-ring(mm)
NSCC	660	14.50	8
SCC_FA05%	682	13.20	8
SCC_FA10%	694	12.45	9
SCC_FA15%	700	13.20	9
SCC_FA20%	700	14.50	10

Table 4.5 Hardened properties of SCC Further results of rheological properties of SCC mixes with various percentages of MK replacement levels are as shown in Table 4.4.

Table 4.5 Hardened properties of SCC

Specifications	7-day (MPa)	28- day (MPa)	56- days (MPa)
NSCC	33.03	44.3	46.06
MK 05%	34.29	44.43	49.58
MK 10%	36.03	46.86	53.85
MK 15%	38.33	49.66	57.46
MK 20%	35.43	41.13	52.25

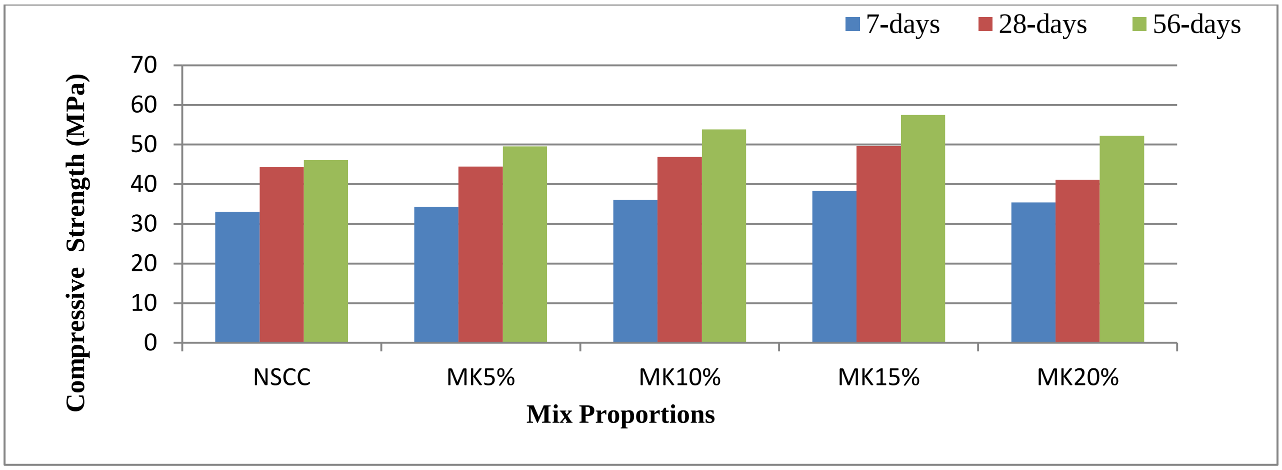

Fig.4.1: A Graph of compressive strength of SCC with Metakaolin at 7, 28 and 56 days

Observation: It can be seen from the graph the optimum 15% replacement levels of MK. The maximum Compressive strength gained 38.33, 49.66, 57.46 MPa at 7, 28 & 56 days of curing period.

Splitting tensile strength results of SCC, when cement partially replaced by MK for different ages is reported in Table 4.6. A graph of splitting tensile strength of SCC With different Mix Proportions is as shown in Fig. 4.2

Table 4.6: Splitting tensile of strength results

Specifications	7-day(MPa)	28- day(MPa)	56- days(MPa)
NSCC	2.67	4.36	4.97
MK05%	3.08	5.03	5.33
MK10%	4.07	5.60	6.43
MK 15%	5.03	6.30	7.20
MK20%	4.50	4.50	5.30

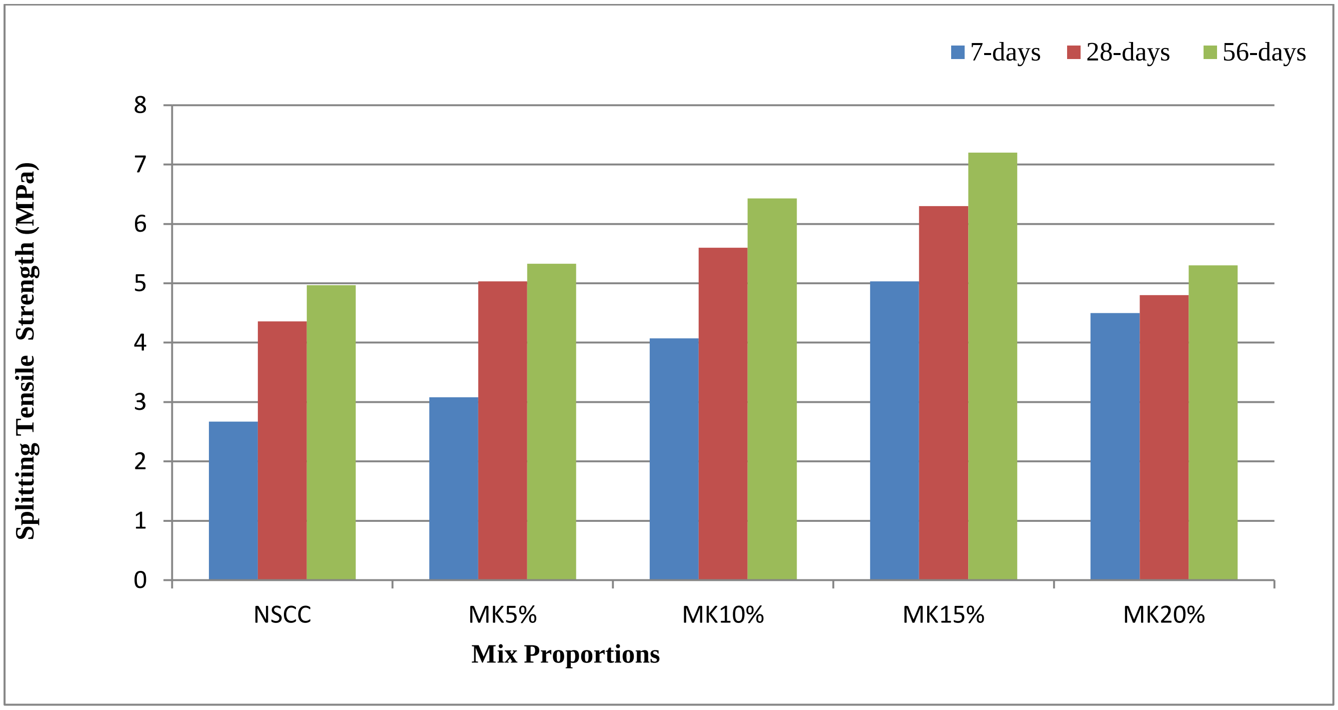

Fig 4.2: A Graph of splitting tensile strength of SCC with Metakaolin at 7, 28 and 56 days.

Observation: It can be seen from the graph the optimum 15% replacement levels MK. The maximum Splitting tensile strength gained 5.03, 6.30, 7.20 MPa at 7, 28 & 56 days of curing period.

5.0 CONCLUSIONS

Based on the investigations Conducted in the laboratory the following conclusions are arrived.

1. Trial and error procedure have to be adopted for maintaining flow ability, self-compatibility and obstruction clearance as in line with changed Nan Su method until to arrive constant SCC blend.
2. From the experimental work, it's discovered that first-rate plasticizer more desirable the flow ability of the SCC and the usage of MK.
3. SCC produced with extraordinary mineral admixtures likeMK satisfied the clean concrete homes as in step with EFANARC guidelines.
4. It is discovered that, gradual increase inside the strength of SCC blend when the cement is replaced by way of MK up to 15%. This additionally reduces the cement content by means of growing the MK thus lowering the similarly value of SCC mixes developed.
5. The MK in region of cement will be very low in cost and also can help inside the application of Industrial wastes and in keeping the ecological balance, thus reducing the consumption of cement.

REFERENCES

[1] M.Rame Gowda, M.C. Narasimhan, Karisddappa and S.V. Rajeeva "Study of properties of SCC using Quarry dust" The Indian concrete journal (54) – Vol. 83, No. 8,(2009), pp. 54-60.
[2] Naveen kumar.S.M, M.Rame Gowda (2013 Dec 12th-14th) "Development and study of behavior of conventional and SCM mixes", 2ndInternational conference on modulation and simulation in Civil Engineering, "ICMSC", TKM College of Engg, Kollam, Kerala.

[3] E. Todorova, G. Chemev(2013)"Influence of Metakaolinite and stone flour on the properties of self-compacting concrete" Journal of Chemical Technology and Metallurgy, pp196-201.
[4] ParatibhaAggarwal, Aggarwal and Surinder M Gupta (2008),"Self-Compacting Concrete procedure for Mix Design" Leonardo Electronic Journal of Practices and Technologies, Issue 12,pp 15-24.
[5] Khatib .J.M.(2008) "Metakaolin concrete at a low water to binder ratio construction and building material" , pp1691-1700.
[6] Hajime okamura, Masahiro ouchi (2003), "Self Compacting Concrete" Journal of Advanced Concrete Technology, volume 1, pp 5-15.
[7] EFNARC, (February 2002), "Specifications and Guidelines for Self-Compacting Concrete", EFNARC, UK (www.efnarc.org), pp.1-32.
[8] Nan Su, Kung-Chung Hsu and His-Wen Chai (2001), "A simple mix design method for self-compacting concrete" Cement and Concrete Research, 31, pp. 1799–1807.
[9] Okamura.H and Ouchi. M (1999) "Self compacting concrete development present use and future Rilem publication", (pp.3-14).
[10] Okamura.H and Ozawa.K (1995) "Mix design for self-compacting concrete", concrete Library of JSCE. (pp. 107-120).
[11] A.A.A.Hassan, M Lachemi, "Effect of Metakaolin on the Rheology of SCC".MetakaolinArgical (Net material, htpp://www.ags-mineraux.com).
[12] Indian Standards (IS: 383-1970),"Indian Standards code of practice for selection of Aggregates".
[13] Indian Standards (IS: 1489-1991),"Indian Standards code of practice for selection of PPC".
[14] Indian Standards (IS: 516-1959),"Indian Standards code of practice for Compressive strength".
[15] Indian Standards (IS: 5816-1999),"Indian Standards code of practice for Split tensile strength".
[16] Indian Standards (IS: 9103-1999),"Indian Standards code of practice for selection of Admixtures".