IFERP
ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

An Experiental Investigation on Fresh And Durability Properties of Self Compacting Concrete using Various Blended Cements

[1] P.Manjula [2] Prof C. Sashidhar
[1]PG scholar in structural engineering, JNT University, Anantapur, India
[2]Professor, Department of Civil Engineering, JNT University, Anantapur, India

***Abstract:*— Self compacting concrete is a concrete that can flow through congested reinforcing bars with elimination of compaction, and without undergoing any significant segregation and bleeding. SCC requires high volume of cement and sand. Use of high volume of cement increases CO2 emissions and leads to the green house effect, and continuous digging of sand from rivers causes depletion of rivers and creates lot of environmental problems. Use of supplementary materials may reduce the above problems with-out altering the SCC performance. This paper presents the fresh and durability properties of SCC using supplementary Cementatious materials like fly ash (25%), silica fume (10%) or Metakaolin (10%) robo sand in place of natural sand; coarse aggregate of size 12mm; GLINIUM 8630 as super plasticizer. The mix proportions were calculated by following European Federation of National Associations for Representing Concrete (EFNARC) guidelines. Mixes were prepared and tested for results. Slump flow, V-funnel and L-box tests are conducted to examine the fresh properties, acid (HCl&H2SO4) resistant and dry shrinkage are for the durability studies. This study shows that quaternary blended cement gives fresh properties and durability properties better than the ternary blended SCC.**

***Keywords:*-- blended cement, fly ash, Metakaolin, self compacting concrete, Silica fume, super plasticizer.**

I. INTRODUCTION

Development of SCC is the most important development in the building industry. The use of SCC is increasing day by day because it has the properties flowing ability, filling ability and segregation resistance [1]. These properties made the concrete more workable and self consolidating by completely filling the formwork without the need of any mechanical vibrations. The above properties of SCC are obtained by use of high volume of cement, but it is assessed that around 0.9 tons of carbon dioxide is discharged in nature for the creation of 1 ton of concrete. Emission of large amount of CO2 results in increase of global warming. To make the SCC eco-friendly there is a much need of alternative materials to cement. By products of industrial waste like fly ash (FA), silica fume (SF),

Metakaolin (MK), GGBS etc. Supplementary Cementatious Materials used as partial replacement or in addition to OPC in concrete [2], [3]. Prajapati et al carried out investigations on SCC using different levels of FA. They concluded that for the same fresh properties addition of FA decreases the amount of SP used [4]. Silica Fume consists of approximately 100 times smaller particles than the average cement particles [5]. Hassan et al (2000) concluded that the addition of silica fume increases the early age strength and long term properties of concrete [6]. Metakaolin (MK), a product of kaolin mineral can be produced in large quantities as kaolin has widely spread reserves in India [7]. Researchers have shown that MK has both puzzolonic and microfiller properties [8]-[10]. D.M.Roy et al (2001) conclude that Chemical resistance is expanded in the sequence of SF to MK to FA for the replacement to 15-30% of cement [11]. According to Hassan et al (2012) the durability of SCC containing MK is higher than that of SCC containing same amount SF [12]. Zhang and Malhotra (1995) found that for 10% metakaolin (MK) requires same amount of SP as required SF but SF concrete sets quicker than MK concrete [13]. Anirudh et al infers that resistance to acid attack is more for concretes made with SF+MK [14]. The addition of pozzolans and OPC generally creates smaller pores, and drying shrinkage adirectly associated with the water in the smaller pores [15]

Amount sand in SCC should be over half of the total aggregate [16]. Sand can be natural or artificial but sand must be of uniform grading and absorption characteristics should be closely observed [17]. Therefore amount of sand required for SCC is more than that of CC, if natural sand is used in, large scale mining of river sand creates environmental problems, and solution for this problem is usage of artificial sand. Researchers have shown that use of robo sand gives the better strength than with river sand [19].

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

The objective of the present study is to investigate the effect ternary blended (OPC+FLYASH+SF/MK) and quaternary blended (OPC+FLYASH+SF+MK) cements on fresh and durability properties of SCC. In this project instead of natural sand robo sand of FM 2.7 was used for the investigation

II. EXPERIMENTAL PROCEDURE

2.1 materials

The materials employed were as follows

1. 53 grade Ordinary Portland cement confirming to IS:12269-1987 with 25% cement is replaced by class F flyash confirming to IS:3812-2000 is used in all the mixtures. Metakaolin and silica fume are obtained from ASTRRA chemicals pvt ltd, Chennai, used in 10% replacement to cement.

Table1. Chemical and physical properties of cementational materials

Chemical composition	**Cement (%)**	**Class F fly ash (%)**	**Silica fume (%)**	**Metakaolin (%)**
% Silica (Sio_2)	19.79	65.6	99. 5	-
% Alumina (Al_2O_3)	5.67	28.0	0. 08	-
% Iron Oxide (Fe_2O_3)	4.68	3.0	0. 04	-
(Sio_2)+ (Al_2O_3)+ (Fe_2O_3)	-	-	-	96.88
% Lime (Cao)	61.81	1.0	0. 01	0.39
%Magnesia (Mgo)	0.84	1.0	0. 01	0.08
% Sulphuric Unhydrated (SO_3)	-	0.07	-	-
Physical properties				
Specific gravity	3.15	2.06	2.62	2.60

2. Robo sand of maximum size 4.75mm and locally available crushed aggregate of size 12mm both confirming to IS:383-1970 are used as fine and coarse aggregate.

Table2. Physical properties of sand

S.No	Property	Test result
1	Specific gravity	2.63
2	Bulk density	1560 kg/m3
3	Fineness modulus	2.7

3. Fresh colorless, odorless potable water is used. Commercially available GLENIUM 8630 is used as water reducing agent. GLENIUM 8630 is based on modified polycarboxylic ether. Glenium 8630 is a Light brown liquid having Relative Density : 1.08± 0.01 at 25°C, pH : > 6at 25°C, Chloride ion content : < 0.2%

2.2 Mix proportion

In the present study Mixes were prepared by keeping cement (65%) with fly ash (25%) same throughout the experiment. Remaining 10% of cement is replaced by metakaolin or silica fume or both (as shown in table 4). Robo sand as fine aggregate, coarse aggregate of 12mm size and GLINIUM 8630 SP are also same for the all mixes. Detailed descriptions of mixes are shown in the table 3 and table 4. All the mix proportions were calculated by following EFNARC, 2005 [19] guidelines. Optimum dosage of superplasticizer has been done as over dosage may leads to segregation and bleeding. Water binder ratio fine and coarse aggregate content is kept same for all the mixes. Mix proportion of SCC and trail mix composition is tabulated as follows. Paste volume for all the mixes kept as 38.1%.

2.3 Tests on fresh properties

Totally three mixes were prepared and tested for fresh and durability properties. Filling ability, passing ability and stability of mixtures can be considered as the distinguishing properties of fresh SCC. These requirements are not common to conventional concrete and, therefore, are handled through special tests. These tests should be done carefully to make sure that the capability of SCC to be placed remains acceptable

The Slump flow test is simple and reliable to measure flow ability of SCC. It can also be used at site. Slump flow is the average diameter of the concrete that can flow maximum when the cone is lifted.T_{50} Time can be measured simultaneously with slump cone test.

After raising the cone stopwatch is started and the time taken for the concrete to reach the 50cm spread circle is recorded (This is the T50 time).

An estimate of the viscosity and the ability to parts through the narrow-opening can be obtained using the V-funnel test.

The resistance to blocking of concrete can be known by using the L-box test. This test result indicates the one-dimensional flowability in a restrained condition. This test is useful in two ways - both blocking and lack of stability can be detected visually. The size of the opening and its relative distance from the concrete could be varied to obtain a better understanding of the potential for blocking at a lower velocity of flow.

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

Table4. Binder proportions for SCC trail mixes

material	Mix1	Mix2	Mix3
Blending	**Ternary**	**Ternary**	**Quaternary**
Proportion (kg/m^3)	**10%MK**	**10%SF**	**5%MK+5%SF**
Cement (65%)	358.5	358.5	358.5
Fly ash (25%)	119.50	119.50	119.50
MK	47.80	-	23.90
SF	-	47.80	23.90

Fig1: Slump flow test

Table 3 mix proportions for SCC

Type of mix	Binder	Fine Aggregate	Coarse Aggregate	Water	W/P ratio	SP	VMA	Paste lt/m^3
Proportion (Kg/m^3)	525.80	863.36	721.60	178.29	0.339	7.65	0	388.25
Ratio	1	1.64	1.37	0.339				

Fig2: V funnel test *Fig3: L-box test*

2.4 Tests on durability properties

All the mixes which passed above fresh properties tests and attain required range of values were tested for various durability properties like dry shrinkage test, acid resistant test and water absorption test as per Indian Standards.

III. RESULTS AND DISCUSSIONS

3.1 Fresh properties

Metakaoiline or silica fume was used to replace the 10% of cement. To examine the fresh properties tests are carried out and results are presented in table 5.

Table 5. Workability tests result

Mixes		Slump flow(mm)	T_{50} time(sec)	V-funnel	L-box (H_2/H_1)
EFNARC standards		**650-850**	**2-6**	**6-12**	**0.8-1.0**
Mix1	10%MK	726	3.2	9.6	0.87
Mix2	10%SF	717	4.7	10	0.85
Mix3	5%MK+5%SF	745	2.36	7.2	0.88

By comparing the results obtained from workability tests with EFNARC standard values all the mixes has satisfies the requirements of EFNARC. Results obtained from workability tests are shown in below graphs by taking fresh property value on Y-axis and FM on X-axis.

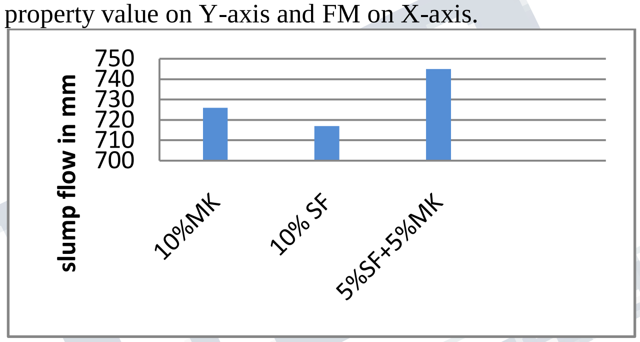

Fig4: slump flow value

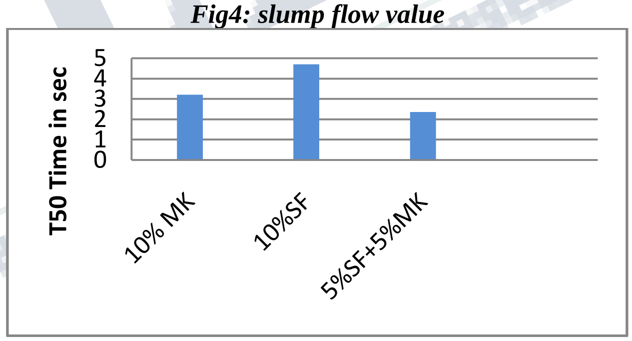

Fig5: T_{50} time in sec

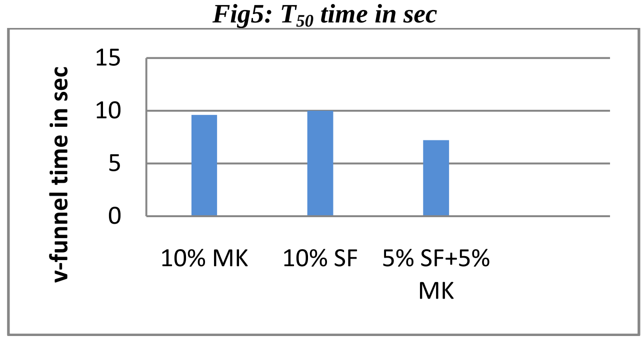

Fig6: V-Funnel time in seconds

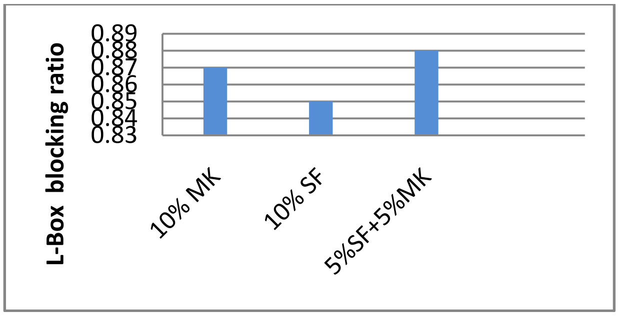

Fig7: L-Box ratio

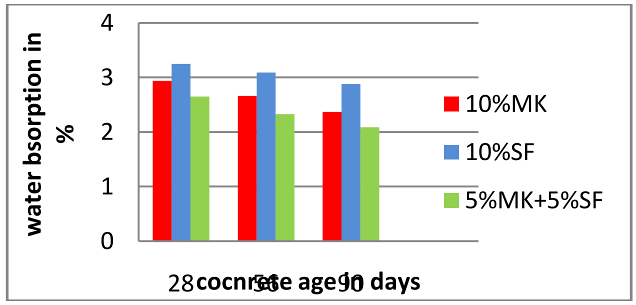

Fig8: water absorption test graph

From the above graphs it was observed that for the quaternary blended SCC slump flow and L-box ratio is more and T_{50} and V-funnel time is less. Ternary blended SF SCC has less slump flow and L-box ratio. Quaternary blended SCC exhibits better workability than ternary SCCs.

3.2 Durability properties

In this paper durability studies are examined for the SCC Compressive strength of SCC for 28 days is also determined o know the strength by testing cubes in CTM, compressive strength values for different blended cements are given below.

Table6. Compressive strength

	10%MK	10%SF	5%MK+5%SF
Compressive strength in N/mm^2	41.33	41.66	44.8

Water absorption test

Water absorption of SCC after 28, 56&90 days of curing is calculated. After each curing period surface (w_2) dry weight and oven dry weight (w_1) of specimens are measured. Water absorption is calculated as below and values shown in table

Water absorption (%) = $\{(w_2\text{-}w_1)/ w_1\}$X100

Table7. Water absorption test

Age (days)	Water absorption (%)		
	10%MK	**10%SF**	**5%MK+S%SF**
28	2.94	3.25	2.65
56	2.66	3.09	2.33
90	2.37	2.88	2.09

Significant reduction was observed in the water absorption values of SCC mainly due to continued pozzolanic action of fly ash with the age and micro filling of fly ash, SF and MK. The above results show that water absorbing values are more for Silica fume than the Metakaolin. Incorporation of Metakaolin reduces the water absorbing capacity. Mix which has both MK&SF has the least water absorbing nature.

Dry shrinkage test

This test was performed accordance with ASTM C 157(2008). For each concrete mixture two 150mmX300mm cylinders were casted. After moisture curing for 0, 14, 28, 56, and 90 days specimens were brought out and kept drying in a controlled environment at 23±2^{0}C and 50%±4% relative humidity. The length change of all specimens was measured by a length compactor having digital extensometer.

Table8. Dry shrinkage test

Age (days)	Dry shrinkage in micro strain		
	10%MK	**10%SF**	**5%MK+5%SF**
0	0	0	0
14	264	295	242
28	358	383	336
56	437	465	427
90	524	568	523

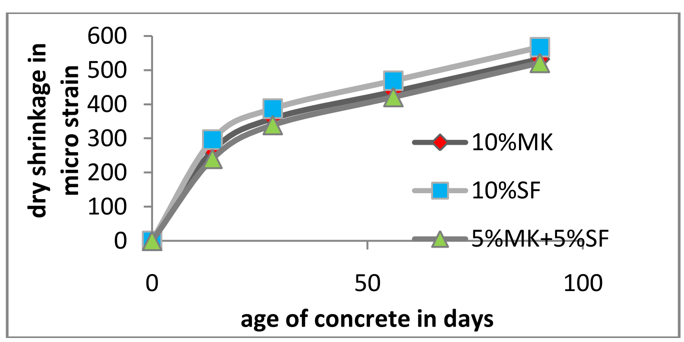

Fig9: Dry shrinkage test graph

The above graph shows that dry shrinkage increases with the age. Use of silica fume in SCC enhances the dry

IFERP
connecting engineers... developing research

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 2, Issue 3, March 2017

shrinkage, this effects diminishes when SF used along with the MK. Results shows that SCC_2.5_5%MK+5%SF has the less shrinkage strain.

Acid resistance test

Acid resistance measured in the loss in weight of specimens after immersed in water with 5% acid. In this study specimens were immersed in HCl and H_2SO_4 solutions separately after 28 days of moisture curing. For 28, 56 &90 days of acid immersion weight loss were calculated.

Table9. Acid resistance test

Age (days)	Weight loss (%)					
	10%MK		10%SF		5%MK+5%SF	
	HCl	H_2SO_4	HCl	H_2SO_4	HCl	H_2SO_4
28	2	6.35	2.3	6.83	1.51	6.12
56	3.18	14.43	3.6	15.17	2.61	14.26
90	3.96	20.06	4.57	21.5	3.22	19.7

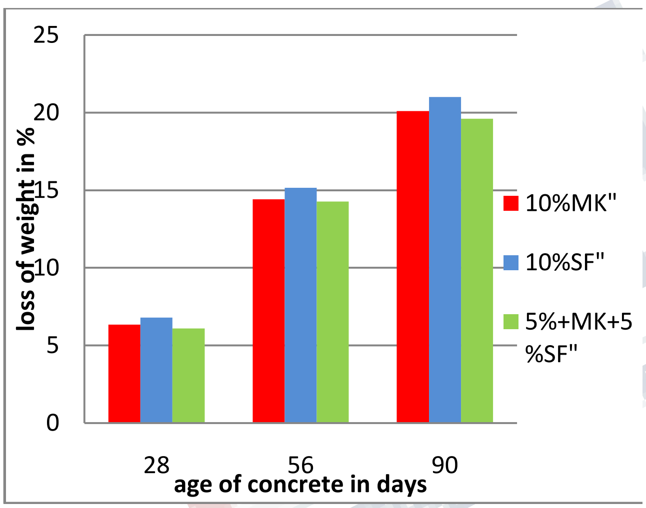

Fig10: H_2SO_4 resistance test graph

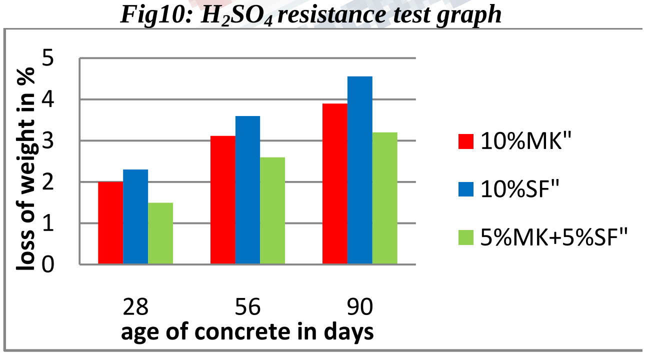

Fig12: HCl resistance test graph

Fig13: After 90 days of HCl and H_2SO_4 immersion

From the results, the acid attack resistance increases when cement replaced by flyash, SF and MK than other two mixes, quaternary blended concrete has the dense hardened cement paste and aggregate interface with low porosities, which increases resistance against acid. The loss of mass within the concrete was the maximum for SF where as moderate for the MK and least for the MK+SF conditions.

IV. CONCLUSION

1. All the mixes have success fully attained fresh properties as per EFNARC guidelines.
2. Fresh properties for blending of Metakaolin and silica fume shows the greater fluidity than other mixes.
3. From results it was observed that cement mixed with quadruple blending showed more resistance to the shrinkage than other mixes.
4. Specimens are severely affected by immersing in 5%H_2SO_4 solution than the 5%HCl solution. Loss of mass is more in H_2SO_4 solution than in HCl.
5. Resistance to acid attack is more for quaternary blended SCC, less for ternary blended SF SCC, moderate for ternary blended MK SCC
6. So finally it is concluded that the quaternary blend of SCC given more fluidity, more resistance to acid attack and less dry shrinkage, so this mix is optimum than other mixes.

REFERENCES

[1] Khayat K H 1999 Workability, testing, and performance of self-consolidating concrete. ACI Mater. J. 96(3): 346–353

[2] Ilangovana R., Mahendrana N. and Nagamanib K., "Strength and durability properties of concrete containing quarry rock dust as fine aggregate", ARPN Journal of Engineering and Applied Sciences, 3(5), 2008, pp. 20-26.

[3] Mindess S., Young J. F. and Darwin D., "Concrete", Prentice Hall, 2003

[4] Prajapati K., Chandak R. and Dubey S. K., "Development and Properties of Self Compacting Concrete Mixed with Fly Ash", Research Journal of Engineering Sciences, 1(3), 2012, pp. 11-14.

IFERP connecting engineers... developing research
ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

[5] Mohammad Iqbal Khan and RafatSiddique (2011), "Utilization of silica fume in concrete: Review of durability properties", Resources, Conservation and Recycling, 57, 30–35.

[6] Hassan K.E., Cabrera J.G., Maliehe R.S., 2000, "The effect of mineral admixtures on the properties of high performance concrete", Cement&Concrete Composites, 22,pp 267271 11.

[7] Basu, P. C., Mavinkurve, S., Bhattacharjee, K. N., Deshpande, Y., & Basu, S. (2000). "High reactivity metakaolin: A supplementary cementitious material", In *Proceedings ICI-Asian conference on ecstasy in concrete*, 20–22 Nov, Bangalore, India (pp. 237–436).

[8] Wild, S., & Khatib, J. M. (1997).",Portlandite consumption of metakaolin cement Pastes and mortar",. *Cement and Concrete Research*,*27*(1), 137–146.

[9] Wild, S., Khatib, J. M., & Jones, A. (1996).",Relative strength, pozzolanic activity and cement hydration in superplasticised metakaolin concret",. *Cement and Concrete Research*,*26*(10), 1537–1544.

[10] Poon, C. S., Lam, L., Kou, S. C., Wong, Y. L., & Wong, R. (2001) "Rate of pozzolanic reaction of metakaolin in high-performance cement pastes". *Cement and Concrete Research*,*31*(9), 1301–1306.

[11] DM Roy, P Arjunan, and MR Silsbee. "Effect of silica fume, metakaolin, and lowcalcium fly ash on chemical resistance of concrete. Cement and Concrete Research", 31(12):1809–1813, 2001.

[12] Assem A.A. Hassan, Mohamed Lachemi, Khandaker M.A. Hossain "Effect of metakaolin and silica fume on the durability of self-consolidating concrete", Cement & Concrete Composites 34 (2012) 801–807.

[13] Zhang, M.H. and Malhotra, V.M. (1995), "Characteristics of a thermally activated alumino-silicate pozzolanic material and its use in concrete", Cement and Concrete Research, 25(8): 1713-1725.

[14]Anirudh H. Shirke, Ayan A. Sengupta, Piyush K. Bhandari, "Performance Characteristics of BlendedCement", International Journal of Innovative Research in Science, Engineering and Technology,2014

[15] Mokarema DW, Weyers RE, Lane DS. "Development of a shrinkage performance specifications and prediction model analysis for supplemental cementitious material concrete mixtures". Cement Concrete Res 2005;35(5):918–25.

[16] Kapoor Y., Munn C. and Charif K., "Self-Compacting Concrete-An Economic Approach", 7th International Conference on Concrete in Hot & Aggressive Environments, Manama, Kingdom of Bahrain, 2003, pp. 13-15.

[17] EFNARC. 2002. Specification and guidelines for self-compacting concrete. European Federation of Producers and Applicators of Specialist Products for Structures.

[18] M R Chitlange, 2010, Appraisal of Artificial Sand Concrete, IE(I) Journal Volume 90

[19] EFNARC. 2005. Specification and guidelines for self-compacting concrete. European Federation of Producers and Applicators of Specialist Products for Structures.

