STUDY OF PROPERTIES OF SELF COMPACTING CONCRETE WITH METAKAOLIN AND OTHER MINERAL ADMIXTURES

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ABSTRACT

Self compacting concrete is highly flow able and yet stable concrete that can spread readily into place and fill formwork without any consolidation and without undergoing significant change in properties, in general, SCC reduced time of noise pollution.

It is need of time to enhance the utility of SCC in respect with speedy constructions such as works of retrofitting and to improve impermeability and early age strength. In view of these, high Pozzolanic materials as met kaolin are used in SCC as a replacement of the cement.

Self-compacting concrete (SSC) a new kind of high performance concrete (HPC) have been developed in japan (1986). The development of SCC has made casting of dense reinforcement and mass concrete convenient, has minimized noise. Fresh self compacting concrete flows into form work and around obstructions under its own weight to fill it completely and self-compact (without any need for vibration), without any segregation and blocking. The elimination of need of compaction leads to better quality concrete and substantial improvement of working condition. SCC mixes generally have a much higher content of fine filler, including cement produce excessively high compressive strength concrete.

It is proposed to study the behavior of SCC with met kaolin admixture and to understand the effect of other mineral admixtures Fly Ash and GGBS in combination with Met kaolin on fresh and hardened properties of SCC.

INTRODUCTION

GENERAL

The self-compacting concrete is that which gets compacted due to its self-weight and is de-aerated (no entrapped air) completely while flowing in the formwork. In densely reinforced structural members, it fills completely all the voids and gaps and maintains nearly horizontal concrete level after it is placed. It consists of same components as conventionally vibrated normal concrete i.e. cement, aggregates, water, additives or admixtures.

Almost all concretes rely critically on being fully compacted. Insufficient compaction dramatically lowers ultimate performance of concrete in spite of good mix design. Concrete is the most widely consumed material in the world, after water. Placing the fresh concrete requires skilled operatives using slow, heavy, noisy, expensive, energy-consuming and often dangerous mechanical vibration to ensure adequate compaction to obtain the full strength and durability of the hardened concrete. Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same mechanical properties and durability as traditional vibrated concrete.

The SCC has been described as the most revolutionary development on concrete construction for several decades. Originally to offsets a growing shortage of skilled labour, economically because of

- Faster construction
- Reduction in site manpower
- Better surface finishes
- Easier placing
- Improved durability
- Greater freedom in design thinner concrete sections
- Reduce noise levels
- Absence of vibration
- Safer working environment

Self-compacting concrete (SCC) offers various advantages in the construction process due to its improved quality, and productivity. SCC has higher powder content and a lower coarse aggregate volume ratio as compared to normally vibrated concrete (NVC) in order to ensure SCC's filling ability, passing ability and segregation resistance. If only cement is used in SCC. It is therefore necessary to replace some of the cement by additives, to achieve an economical and durable concrete. Nowadays, the ecological trend aims at limiting the use of natural raw materials in the field of building materials and hence there is an increased interest in the use of alternative materials (waste) from various industrial activities, which presents significant advantages in economic, energetic and environmental terms.

This study aims to focus on the possibility of use of "Met kaolin", "Fly Ash" and "Ground Granulated Blast Furnace Slag (GGBS)" to improve the properties of SCC.

OBJECTIVE

The influence of curing methods on the compressive strength of M50 grade Self-compacting concrete using Met kaolin as supplementary cementing material is studied in this project.

In this study, the **"*The European Guidelines for Self Compacting Concrete*" (May 2005) of European Project Group** was used. An economical SCC of Standard Concrete strength (50 MPa at 28 days) to a conventional concrete was developed. This flow ability can be attained by adding high range water reducer admixtures (HRWRA) and/or incorporating supplementary cementing materials (SCM). Different SCM's have been successfully used previously for the production of SCC, such as fly ash, silica fume, and slag. In this project Met kaolin is used as SCM.

TESTING PROCEDURE AND RESULTS.

Compressive strength of cubic specimens (BS 1881: Part 108: 1983)

Procedures

- Remove cube from the curing tank.
- Wipe off surface water and grit with a damp cloth.
- Wipe test machine platens with dry cloth.
- Place the test cube centrally on the lower platen of the test machine with the rough surface of the test cube facing towards you.
- Lower the top platen onto the cube and ensure a uniform seating by gently rotating the top platen as it is brought to bear on the cube.
- Make sure that test machine is set to the correct loading and pointers are zeroed.
- Apply the load without shock and continuously increase at approximately 15 MPa per minute.
- Record the maximum load the cube can sustain.

Calculation

$f_c = Pmax / A$

Where f_c = compressive strength;

P_{max} is the maximum load that cube sustained

A = the cross sectional area of the cube.

Splitting tensile (indirect) strength of cylindrical concrete specimens (ASTM C496-85 or BS 1881 : Part 117 : 1983)

Procedures

- Remove the cylinders to be tested from curing room and wipe cylinders with a damp cloth to remove surface water.
- Draw diametrical lines on opposite sides along the length of the specimen.
- Place the cylinder into the test jig and place the jig centrally in the compression machine.
- Apply load without shock and increase at a rate of 1.5 MPa per minute.
- Record the maximum load sustained by the specimen.

Calculations

$f_{ct} = 2P/\pi DL$

Where f_{ct} is the indirect tensile strength

P is the maximum load sustained by the specimen

D is the diameter of the specimen

L is the length of the specimen.

Flexural strength test (BS 1881: Part 118: 1983)

Procedures

- Remove beam from the curing tank and wipe off excess surface water with a damp cloth
- Place the beam in the testing machine so that the top (rough) surface is facing towards you. (This ensures that top and bottom surfaces of the beam are parallel so that loading is uniform across the width.) Loading is applied through 2 rollers, each at a distance of L/3 from the supports on either side.
- Apply the loading without shock and increase at a constant stroke rate (0.02mm/min.).

Calculations

The flexural strength of each beam shall be expressed as the modulus of rupture f_b and calculated to the nearest 0.05 MPa as follows:

$f_b = PL/bd^2$

Where
P is the ultimate load (in N)
L is supporting roller distance (in m)
bis width of the beam (in m)
d is the depth of beam (in m)

TEST RESULTS

CF1M25 Cubes(100x100x100mm) 7days					CF1M25 Cubes(100x100x100mm) 28days				
S No	**Designation**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**	**S. No**	**Designation**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**
1	CF1M25- 1	2.140	206.5	20.65	1	CF1M25- 3	2.384	389.4	38.94
2	CF1M25- 2	2.24	190.0	19.00	2	CF1M25- 4	2.225	369.6	36.96
					3	CF1M25- 5	2.162	360.3	36.03
	Average	**2.19**	**198.25**	**19.82**		**Average**	**2.257**	**373.1**	**37.31**

Table 7.1: Concrete cubes SCC with Fly Ash Casted on 20.01.2015

CF2M25 Cubes(100x100x100mm) 7DAYS					CF2M25 Cubes(150x150x150mm) 7DAYS				
S.No.	**Designation**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**	**S.No.**	**Destination**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**
1	CF2M25-1	2.138	236.1	23.61	1	CF2M25-4	7.332	414.0	18.40
2	CF2M25-2	2.214	188.4	18.84	2	CF2M25-5	7.238	346.8	15.41
3	CF2M25-3	2.216	208.8	20.80	3	CF2M25-6	7.278	440.9	19.59
	Average	**2.12**	**211.1**	**21.1**		**Average**	**7.23**	**400.56**	**17.8**

Table 7.2: Concrete cubes SCC with Fly Ash Casted on 24.02.2015

CF2M25 Cubes(100x100x100mm) 28DAYS					CF2M25 Cubes(150x150x150mm) 28DAYS				
S.No.	**Designation**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**	**S.No.**	**Destination**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**
1	CF2M25-1	2.210	437.7	43.87	1	CF2M25-4	7.182	920.5	40.91
2	CF2M25-2	2.242	417.8	41.78	2	CF2M25-5	7.372	969.3	43.08
3	CF2M25-3	2.246	438.4	43.84	3	CF2M25-6	7.556	888.0	39.46
	Average	**2.23**	**431.3**	**43.1**		**Average**	**7.37**	**925.5**	**41.16**

Table 7.3: Concrete cubes SCC with Fly Ash Casted on 24.02.2015

CF2M25 Cylinders(150Φx300mm) 28DAYS					CF2M25 Beams(100x100x500mm) 28DAYS				
S.No.	**Designation**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**	**S.No.**	**Destination**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**
1	CF2M25-1	11.266	205.7	11.64	1	CF2M25-1	10.630	8.72	1.308
2	CF2M25-2	11.232	217.5	12.3	2	CF2M25-2	10.164	7.82	1.173
3					3	CF2M25-3	10.394	8.44	1.268
	Average	**11.24**	**211.6**	**11.97**		**Average**	**10.39**	**8.32**	1.249

Table 7.4: Concrete cubes SCC with Fly Ash Casted on 24.02.2015

CF2MF25 Cubes(100x100x100mm) 7DAYS					CF2MF25 Cubes(100x100x100mm) 28DAYS				
S.No.	**Designation**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**	**S.No.**	**Destination**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**
1	CF2MF25-1	2.24	246.8	24.68	1	CF2M25-3	2.318	524.5	52.45
2	CF2MF25-2	2.28	230.1	23.01	2	CF2M25-4	2.282	531.7	53.17
	Average	**2.26**	**238.45**	**23.84**		**Average**	**2.23**	**528.1**	**52.81**

Table 7.5: Concrete cubes SCC with Metakaolin& Fly Ash Casted on 03.03.2015

CF2MF25 Cubes(150x150x150mm) 28DAYS				
S. No.	**Destination**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**
1	CF2MF25-4	7.570	1046.1	46.49
2	CF2MF25-5	7.428	1107.9	49.24
3	CF2MF25-6	7.504	1144.0	50.84
	Average	**7.50**	**1099.3**	**48.8**

Table 7.6: Concrete cubes SCC with Metakaolin& Fly Ash Casted on 03.03.2015

CF2MF25 Cubes(100x100x100mm) 7DAYS					CF2MF25 Cubes(100x100x100mm) 28DAYS				
S.No.	**Designation**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**	**S.No.**	**Destination**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**
1	CF2MF25-1	2.20	292.6	29.26	1	CF2MF25-1	2.254	549.6	54.96
2	CF2MF25-2	2.26	287.6	28.76	2	CF2MF25-2	2.262	588.8	58.88
	Average	**2.23**	**290.1**	**29.01**		**Average**	2.258	569.2	56.92

Table 7.7: Concrete cubes SCC with Metakaolin& Fly Ash Casted on 13.03.2015

CF2MF25 Cylinders(150Φx300mm) 28DAYS					CF2MF25 Beams(100x100x500mm) 28DAYS				
S.No.	**Designation**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**	**S.No.**	**Destination**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**
1	CF2MF25-1	11.266	205.7	11.64	1	CF2MF25-1	10.630	8.72	1.308
2	CF2MF25-2	11.232	217.5	12.3	2	CF2MF25-2	10.164	7.82	1.173
3					3	CF2MF25-3	10.394	8.44	1.266
	Average	11.25	211.6	11.97		**Average**	10.396	8.46	1.249

Table 7.8: Concrete cubes SCC with Metakaolin& Fly Ash Casted on 13.03.2015

CF2M25 Cubes(100x100x100mm) 7DAYS					CF2M25 Cubes(100x100x100mm) 28DAYS				
S.No.	**Designation**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**	**S.No.**	**Destination**	**Weight (Kg)**	**Ultimate Compressive Load(KN)**	**Stress (Mpa)**
1	CF2M25-1	2.276	471.7	47.17	1	CF2M25-4	2.31	770.7	770.7
2	CF2M25-2	2.300	562.2	56.22	2	CF2M25-5	2.40	630.5	630.5
3	CF2M25-3	2.306	449.9	44.49	3	CF2M25-6	2.40	657.2	657.2
	Average	**2.29**	**494.6**	**49.4**		**Average**	**2.37**	**686.13**	**686.13**

Table 7.9: Concrete cubes SCC with Metakaolin& GGBS on 24.03.2015

CF2M25 Cubes (150x150x150mm) 28DAYS				
S.NO	**Designation**	**Weight (KG)**	**Ultimate compressive load (KN)**	**Stress (Mpa)**
1	CF1MG25-1	7.738	455.4	202.4
	Average	**7.738**	**455.4**	**202.4**

Table 7.10: Concrete cubes SCC with Metakaolin& GGBS on 24.03.2015

Table 7.11: SCC with Metakaolin& other Mineral admixtures

Sl. No.	**Description**	**Mix-1 (Cement &Flyash)**		**Mix-2 (Cement &Metakaolin)**		**Mix-3 (C+MK+FA)**		**Mix-4 (C+MK+FA)**		**Mix-5 (C+MK+GGBS)**	
		Quantity	**Unit**	**Quantity**	**Unit**	**Quantity**	**Unit**	**Quantity**	**Unit**	**Quantity**	**Unit**
1	Date of Casting	24-02-2015		20-01-2015		03-03-2015		13-03-2015		24-03-2015	
2	Fine aggregate	559	kg	775	kg	718.57	kg	610	kg	857	kg
3	Coarse aggregate	460	kg	636	kg	591.43	kg	502.75	kg	705	kg
4	Total Binder	588.75	kg	477	kg	697.86	kg	591.5	kg	831	kg
5	Cement	212.75	kg	201	kg	280.72	kg	238.5	kg	334	kg
6	Metakaolin	-	kg	276	kg	175.00	kg	148	kg	209	kg
7	Fly ash	376	kg	-	kg	242.14	kg	205	kg	-	kg
8	GGBS	-	kg	-	kg	-	kg	-	kg	288	kg
9	Water	248	kg	238.62	kg	267.14	kg	280	kg	285	kg
10	water/binder	0.42		0.50		0.38		0.47		0.34	
11	Super plasticizer	7.09	kg	8.59	kg	10.214	kg	11.4	kg	10.2	kg
	% SP/Total binder=	1.20	%	1.80	%	1.46	%	1.93	%	1.23	%
		FOSROC-Auramix400		**FOSROC-Auramix400**		**FOSROC-Auramix400**		**BASF MGAce30JP (1.05kg) MGSky8321 (10.35kg)**		**BASF MGAce30JP(9.7 kg) MGSky8321(0.5 kg)**	
12	T_{500}	2.63	Sec	3	Sec	3	Sec	3.5	Sec	3.4	Sec
13	Slump	605	M	595	mm	600	mm	595	mm	695	mm

	Flow Φ		m								
14	V-Funnel V_f	6	Sec	4	Sec	5.6	Sec	2.65	Sec	8	Sec
15	L-box T_{20}	1.55	Sec	1	Sec	0.6	Sec	0.33	Sec	0.9	Sec
16	L-box T_{40}	2.94	Sec	2	Sec	1	Sec	1	Sec	1.8	Sec
17	L-box H_1	73	mm	78	mm	73	mm	74	mm	74	mm
18	L-box H_2	65	mm	65	mm	68	mm	67	mm	73	mm
19	Passing Ability $A=H_2/H_1$	0.89		0.83		0.93		0.91		0.99	
20	Compressive Strength-7days	17.80	MPa	23.67	MPa	24.49	MPa	29.01	MPa	49.4	MPa
21	Compressive Strength-28days	41.16	MPa	34.15	MPa	48.86	MPa	56.92	MPa	68.61	MPa

*BASF chemicals are used. As per the direction of chemist master Glenium Sky 8321 was initially used (10.35Kg). it was found that the concrete is being stiff. The Master Glenium Ace 30JP (1.05Kg) was used to get flow ability.

CONCLUSION

1) For better passing ability, fly ash based self compacting concrete requires more binder, when compared to metakaolin based self compactingconcrete .
2) Requirement of super plasticizer is more of 21.15 % for the metakaolin based self compacting concrete.
3) Requirement of water is less of 3.78 % for the metakaoline based self compacting.
4) When metakaoline is mixed with fly ash, the total binder content is increased.Water cement ratio is decreased.
5) Strength is increased for metakaoline and fly ash self compacting concrete.
6) With increase in total binder content for mix-5, when compared to mix-4, the passing ability is also improved.
7) The strength of mix-5 has increased by 20.53% due to the cumulative effect of total binder content, increase in cement and decrease in water binder ratio instead of fly ash GGBS is added in mix-5, super plasticizer is being same in both the cases.
8) Even though the cement binder ratio in mix-1(fly ash based scc) is less, when compared to cement binder ratio in mix-2(metakaoline based scc). In mix-1(fly ash based scc), the strength is more by 17.3% when compared to mix-2(metakaoline based scc), that shows fly ash as admixture has influence on strength.
9) Because of increase of super plasticizer in metakaolin base, the water cement content has decreased by 3.78%.
10) The strength for fly ash based is increased when compared to the strength for metakaolin by 20.52%.
11) In mix-3 along with the cement two admixtures metakaolin and fly ash were used and with the same super plasticizer compared to mix-2 in wichonly one admixture is used, so there is an increase in strength compared to mix-2 by 43% due to two reasons.
    - Additional cement used
    - Fly ash which gave more strength just like in mix-1.

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