A STUDY ON BEHAVIOUR OF SELF COMPACTING CONCRETE BY PARTIAL BLENDING OF CEMENT WITH METAKAOLIN AND FLYASH

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***ABSTRACT*: Self-compacting concrete (SCC) possesses enhanced qualities and improves productivity and working conditions due to elimination of compaction. SCC is suitable for placing in structures with congested reinforcement without vibration and it helps in achieving higher quality of surface finishes. However utilization of Metakaolin and Fly ash as an effective pozzalonic material which causes great improvement in the pore structure, also compatibility is affected by the characteristics of materials and the mix proportions, it becomes necessary to evolve a procedure for mix design of SCC. In the present investigation M_{35} grade SCC by using relevant guidelines (EFNARC) and mix design has been developed using Nan Su method.**

This experimental study is carried out to investigate the influence of metakaolin and Fly ash on the mechanical properties of self-compacting concrete. Here, for the strength point of view Flyash is replaced by 30% and for that Flyash(FA) content, metakaolin (MK) is replaced by percentage weight of cement i.e, (0%,5%,10%,15%,20%,25%,30%).The results showed that the combination of metakaolin and fly ash provides a positive effect on mechanical properties of self-compacting concrete. Besides, the sample incorporating the binary blend of cement with metakaolin and fly ash it is compared with normal SCC test results.

***KEYWORDS*: Fly ash, Metakaolin, Self Compacting Concrete, Pozzalona.**

I. INTRODUCTION

The development of self-compacting concrete (SCC) has been one of the most important material in the building industry. The purpose of this concrete concept is to decrease the risk due to human factor. The use of SCC is spreading worldwide because of its very attractive properties. SCC has properties that differ considerably from conventional slump concrete. "SCC is highly workable concrete that can flow through densely reinforced and complex structural element under its own weight and adequately fill all voids without segregation, excessive bleeding, excessive air migration or other separation and materials and without the need of vibration or other mechanical consolidation."

The properties such as, fluidity and high resistance to segregation enables the placement of concrete without vibrations and with reduced labour, noise and much less wear and tear of equipment. Use of Self Compacting Concrete overcomes the problem of concrete placement in heavily reinforced sections and it helps to shorten construction period. It is possible to improve the mechanical properties of concrete by using chemical and mineral additives. In this study the flyash and metakaolin are blended with cement

Fly ash is the mineral residue resulting from the combustion of ground or powdered coal in electric generating plant.It is finely divided. Fly ash consists of inorganic matter present in the coal that has been fused during coal combustion. It influences many properties of concrete in both fresh and hardened state. Gopalakrishna S et al. with their experimental study concluded that the addition of fly ash, compressive strength is enhanced up to 80 MPa with 25 % replacement of fly ash and also the fly ash blended concretes have superior durability properties.

Metakaolin is a valuable pozzolanic, and thermally activated aluminosilicate material obtained by calcination of kaolin clay within the temperature range of 700–850°C. MK is usually added to concrete in amount of 5 – 15% by weight of cement. Addition of metakaolin causes increase in mechanical strength, enhancement of long term strengths, decrease of permeability, porosity, reduction of efflorescence, increase of resistance to soluble chemicals like sulphates, chlorides and acids. Okankarahan et al. suggested that the addition of metakaolin decreases workability of fresh concrete mix. This disadvantage can be reduced by super plasticizers (SP) or increasing water to binder (W/B) ratio.

Materials like Metakaolin (MK), Fly Ash (FA) produces additional calcium silicate hydrate (C-S-H) gel, blocking existing pores and altering pore structures. The formation of that gel can improve the strength and durability of concrete. In this study, the effects of metakaolin in combination with and without flyash on mechanical properties are evaluated.

II. MATERIALS AND METHODOLOGY

2.1 Materials:

OPC (43 grade) is used for the investigation and construction works. It confirmed to the requirements of Indian standard Specification IS: 8112-1989. The tests on cement are carried out as per IS: 4031-1991.IS: 383-1970 defines the fine aggregates as particles, which will pass through 2.36 mm and retained on 0.150 mm IS sieve is used. It is also called as sand. Natural river sand is used for any construction work is used in the present study. Aggregate with Fineness modulus of 3.76 and specific gravity of 2.62 is used. Locally available crushed granite aggregate, passing sieve of size 20mm with 60% and 40% of aggregate passing

through 12.5mm retained on 6.3mm with the fineness modulus of 5.52 and specific gravity of 2.74 is used. Commercially available MK was used for this study whereas; FA was obtained from thermal power plant, tuticorin district, tamilnadu state, India

2.2 Chemical Admixtures:

Super plasticizer is essential for the creation of SCC. The job of SP is to impart a high degree of flow ability and deformability, however the high dosages generally associate with SCC can lead to a high degree of segregation. Conplast SP 430 is utilized in this project, which is a product of FOSROC Company having a specific gravity of 1.22 (conforming to IS: 9103:1999).

2.3 Cement Blend mixture:

The present work aims to achieve the Self Compacting Concrete by blending cement with fly ash up to 30% and metakaolin (replacement with 30% of fly ash i.e., 5%, 10%, 15%, 20%, 25%, 30%). Flyash with the specific gravity of 2.126 and Metakaolin wih the Specific gravity of 2.355 is used in the present study.

2.4 Mix Proportions and Casting Of Concrete:

Self Compacting Concrete needs more advanced mix design than traditional vibrated concrete and more careful assurance with more testing and checking, at least in the beginning when using SCC.

The Mix design is carried trough NAN-SU method. With reference to the design several attempts were conducted to obtain the optimum mix for a grade of M35. While carrying the experiments it is concentrated to achieve the SCC mix without segregation and bleeding since the focus is to achieve free flow. In the present study totally 8 mixes were prepared and designated as Mix 1 (without blending of cement), Mix 2 (Cement+ 30% FA+0% MK), Mix 3 (Cement+ 25% FA+5% MK), Mix 4 (Cement+ 20% FA+10% MK), Mix 5 (Cement+ 15% FA+15% MK), Mix 6 (Cement+ 10% FA+20% MK), Mix 7 (Cement+ 5% FA+25% MK), Mix 8 (Cement+ 0% FA+30% MK) for a mix proportion of 1:1.5:1.28 with a super plasticizer amount of 1.28% by weight of cement with water cement ratio of 0.384.

Mechanical mixer is used to mix the concrete. The Fresh properties and hardened properties (Compressive Strength and Split tensile strength) tests are conducted for each mix and results are compared with normal SCC. The mixes proportions arrived are shown in table 1.

2.6. Fresh state properties of SCC

Slump flow, V-funnel at 5 minutes, L-box tests were performed in the laboratory confirming to EFNARC specifications on fresh SCC mixes to find filling ability, passing ability and segregation resistance. The fresh state properties of SCC mixes are shown in Table 1

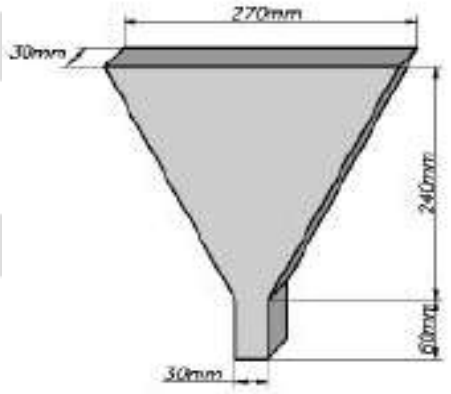


Figure 1: Typical V- Funnel Apparatus

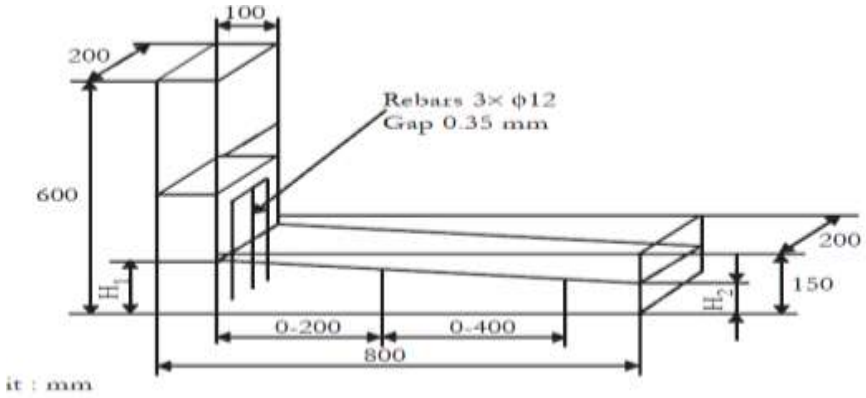


Figure 2:Typical L-Box Test Apparatus

Figure 3: Concrete Flow under Slump Test and Typical Slump Cone Test Apparatus

2.7. Compressive strength of SCC

Compressive strength of normal SCC mix and combination of MK and FA blended cement SCC cube was determined as per IS 9013-1997. 6 moulds were casted for each mix and tests were carried after 7 and 28 days of curing period.

2.8 Split Tensile Strength:

Splitting tensile strength test for normal SCC mix and combination of MK and FA blended cement SCC cube was determined as per IS 5816-1999 after 7 and 28 days of moisture curing. The Compressive Strength and split Tensile strength values for each mix is tabulated in table 2 and the graphical variations are shown.

III. RESULTS AND DISCUSSIONS

After testing compressive strength after 7^{th} day and 28^{th} day curing period it is found that

1) It is observed that by blending the cement with 10% fly ash and 20% metakaolin content could develop greater early strength. The compressive strength attained for 7 days is 35.14 MPa i.e, >90% of target strength. By observing above results the 7 days strength of normal SCC, the combination of (10%FA+20%MK, 5%FA+25%MK, 0%FA+30%MK) has shown greater results than 25%FA+5%MK, 20%FA+10%MK. This may be due to improved adhesion properties of concrete by the introduction of Metakaolin in greater amount.
2) But the strength gained after 28 days curing period for 15% FA+15% MK, %FA+20%MK, 5%FA+25%MK, 0%FA+30%MK has reached target strength rather than 30%FA+0%MK, 25%FA+5%MK, 20%FA+10%MK. The 28days compressive strength of Normal SCC mix is 52.84 N/mm^2 whereas in the Blended mix it is 46.09 N/mm^2 in economical concern. The highest value is found in blended mix 8 with 30% MK i.e., 5.09.
3) The same variations is observed in Split Tensile Strength, it is found that for normal SCC the value is 5.11 N/mm^2 whereas in the Blended mix it is 4.27 N/mm^2 in economical concern. The highest value is found in blended mix 8 with 30% MK i.e., 5.42.

IV. TABLES

Table 1: Chemical properties of Metakaolin and Fly ash Compared to Ordinary Portland Cement:

Type	Meta kaolin%	OPC %(43)	Fly Ash%
SiO_2	51.36	22.48	56.2
Al_2O_3	32.40	7.12	21.7
Fe_2O_3	2.31	3.01	5.93
CaO	0.78	59	4.28
MgO	0.16	1.77	1.92
K_2O	0.62	1.303	1.99
Na_2O	0.26	0.36	0.63
$S0_3$	0	4.2	0.49
L.O.I	0.98	1.5	1.78

Table 2: Results on Fresh Properties of concrete Confirming EFNARC Guidelines

Sl. No	Blended Mix	Mix Designation	Slump Diameter in mm	Slump flow test @ T50 (sec)	V-Funnel Test at 5 minutes	L- Box Test (h2/h1)
1	Normal SCC MIX	Mix 1	720	3.6	8	0.93
2	Cement+30%FA+0%MK	Mix 2	685	4	9.1	0.96
3	Cement+25%FA+5%MK	Mix 3	680	4.2	9.3	0.91
4	Cement+20%FA+10%MK	Mix 4	670	4.3	9.7	0.87
5	Cement+15%FA+15%MK	Mix 5	670	4.7	11	0.83
6	Cement+10%FA+20%MK	Mix 6	665	5.0	13.1	0.81
7	Cement+5%FA+25%MK	Mix 7	660	5.7	14.8	0.72
8	Cement+0%FA+30%MK	Mix 8	660	6.1	17.3	0.68

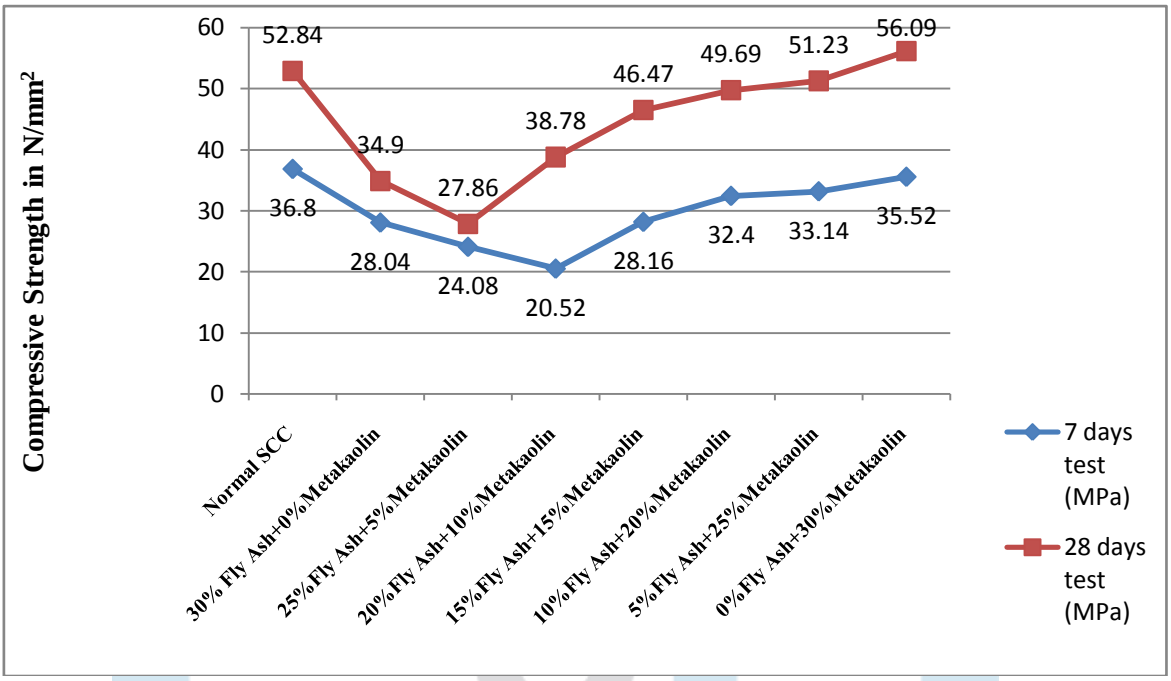
Table 3: Results on Compressive Strength and Split Tensile Strength

Blended Mix	Mix Designation	Compressive Strength in N/mm^2		Split Tensile Strength in N/mm^2
		7 Days	28 Days	28 Days
Normal SCC MIX	Mix 1	36.80	52.84	5.11
Cement+30%FA+0%MK	Mix 2	28.04	34.90	3.51
Cement+25%FA+5%MK	Mix 3	24.08	27.86	2.64
Cement+20%FA+10%MK	Mix 4	25.52	38.78	3.70
Cement+15%FA+15%MK	Mix 5	28.16	46.47	4.27
Cement+10%FA+20%MK	Mix 6	32.40	49.69	4.71
Cement+5%FA+25%MK	Mix 7	33.14	51.23	5.12
Cement+0%FA+30%MK	Mix 8	35.52	56.09	5.42

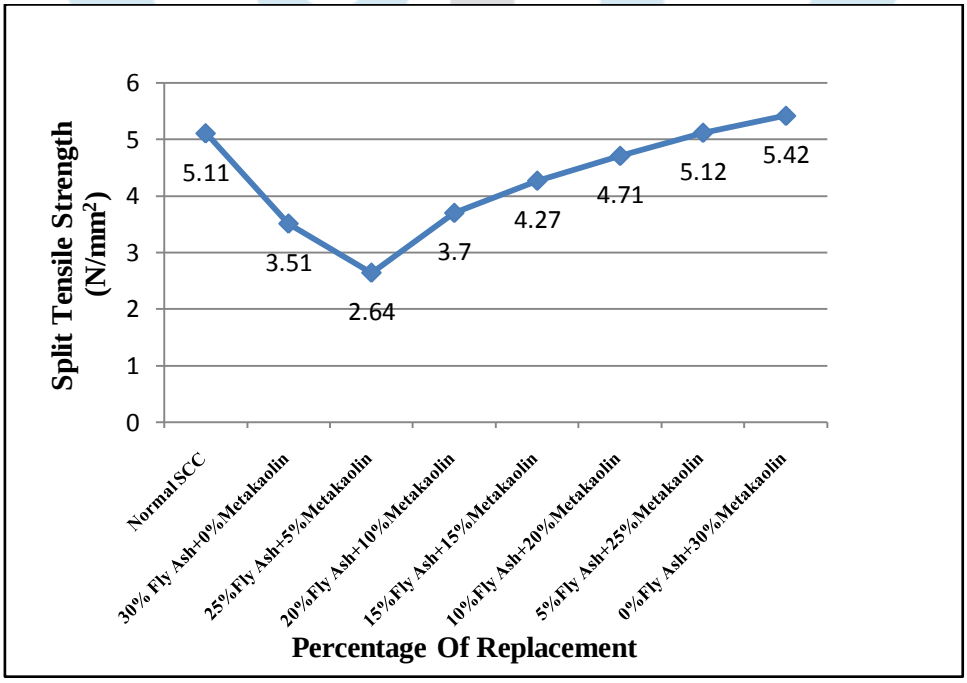
IV. GRAPHS

Graphical variations of Compressive Strength and Split Tensile Strength are shown below:

1. Graphical Representation of Compressive Strength on 7 and 28 days



2. Graphical Representation of Split Tensile Strength on 28 days



V. CONCLUSIONS

1) Due to the disparity in the fineness, metakaolin is more reactive than fly ash. So that, the strength attainment of SCC is more for the greater percentage of blending with metakaolin.
2) Apart from all the mixes, 15%FA+15%MK mix holds well in achieving both target strength and also by economical consideration with 46.47 N/mm^2 compressive strength and 4.27 N/mm^2 Split Tensile Strength.
3) The time taken by blended SCC to set after casting is greater when compared with Normal concrete.

4) As with any special concrete, exquisite care is necessary while handling, placing and curing to end up with the desired qualities.
5) But as per the observation it is found the Fly Ash in later stages develops high strength rather than metakaolin and cement which is proved in high volume Fly Ash Concrete.

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