Behaviour of Self-Compacting Concrete with Cement Replacement Materials

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Abstract: ***Self-compacting concrete is a type of special concrete which do not require vibration for compaction. The self-compacting concrete has a major disadvantage of its cost due to additional usage of chemical admixtures and Portland Cement .The cost of self-compacting concrete can be reduced by replacement of cement by cement replacement materials .In this paper fly ash, wood ash and their combinations are used as cement replacement materials. Fly ash is an mineral admixture that can be used in concrete. The Wood ash containing less Calcium oxide and significant quantity of Silicon dioxide may be used for replacement of cement. The incorporation of these replacement materials reduces the need for viscosity modifying agents. Higher durability and greater mechanical integrity can be achieved by lowering the water content in the concrete. Experimental investigations such as split tensile strength ,compressive strength , flexural strength of self-compacting concrete containing cement replacement materials are conducted to determine their Mechanical properties. Workability tests (slump,L-box, V-funnel) on the corresponding mix are also used to study the characteristics.The methodology adopted here is the cement replacement materials are replaced 10% and 20% by weight of ordinary Portland cement and the performance is measured. To improve the workability of the concrete 1.5 % of superplasticizer (glenium B233) by weight of the cement is used as chemical admixture. Guidelines given by EFNARC are followed to design the mix. From this investigation it is observed that the optimum replacement of 10% of wood ash and fly ash in self- compacting concrete increases the compressive strength of the of the concrete mixture.***

Keywords: Replacement of cement, EFNARC are followed

I. INTRODUCTION

Now a days the Portland cement concrete is used for constructing structures. They are always demand, producing carbon di oxide and highly energy-intensive, after steel and aluminum. So In this project the cement is replaced with cement replacement materials such as like fly ash, wood ash, etc. Concrete with self Compacting ability will have no difficulty during placing of concrete. The SCC performance evaluation widely differs depending on whether vibration is to be provided during placing of concrete[8].

A. Objectives

The Main objective of this experimental work is to study the structural behavior of M30 grade self compacting capacity of the concrete cast by partial replacement of cement with cement replacement materials. The main

objectives are (1)A range of results for the chosen tests to identify suitable SCC(2)Replacement of cement by cement replacement materials(3)Compare the mechanical properties between control mix and mix of cement replacement materials .

II. MATERIALS

A. Cement

To meet the need for higher strength concrete OPC grade 53 can be used. The minimum compressive strength of OPC 53 Grade Cement should not be less than 53 N/mm^2. For concrete of grade M-30 and above a saving of 8 to 10 % of cement may be achieved by using OPC 53 grade cement.

Table 1. Properties of Portland cement

Properties	Test results
Specific surface(m^2/kg)	293
Setting time test (minutes)	
Initial setting	190
Final setting	245
Specific gravity	3.15
Compressive strength (MPa)	
7-day	40.9
28-day	56

B. Fly Ash

The Fly ash is an industrial waste resulting from the combustion of pulverized coal in the boiler at the thermal power plants.The main source of fly ash in our country is mainly from thermal power plants.Fly ash exhibits the pozzalonic properties. The addition of fly ash concrete significantly influences the properties of concrete. For our project we have opted for flyash from METTUR THERMAL POWER PLANT.The specific gravity of fly ash used here is 2.41.

C. Wood Ash

The residual compounds left over after burning out of wood is Wood Ash. About 6% to 10% of the burnt wood is left as Ash. The % of Calcium oxide in wood Ash varies between 4% to 70%.Based on the calcium oxide % the wood ash may be used in application stage or in production stage. The wood ash consisting of lesser amount of Calcium oxide and significant amount of silicon dioxide can be used as a partial replacement of cement[8].

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The specific gravity of wood ash used is 2.21.

D. Super plasticiser

MasterGlenium SKY B233 is an admixture based on modified polycarboxylic ether. This product has been developed primarily for applications in high performance and highly durable concrete. Table 2. Provides the physical and chemical properties of the admixture. Masterglenium SKY 8233 is Chloride free & low has low alkali content. It is compatible with all types and grades of cements.

Table 2. Properties of MasterGlenium SKY B233

Particulars	Value
Chemical content	Polycarboxilic ether
Specific gravity	1.08
Chloride content	<0.2%
Solid content	35.46%
Compatibility	All types of cement
ph	7.02
viscosity	50-150s

E. Aggregates

Generally aggregates occupy 70% to 80% of the volume of concrete. Aggregate strength can play an important role,in high –strength concrete. In order to obtain a good concrete quality, aggregates should be hard and strong, free of undesirable impurities, and chemically stable. Table 3. represents the physical properties of fine and coarse aggregate. The nominal size of coarse aggregate used is 12.5mm.The amount of coarse aggregate used in self-compacting concrete is much lower when compared to the normal vibrated concrete.The fine aggregate is conforming to Zone III.

Table 3. Physical properties of fine and coarse aggregate

S.no	Physical Properties	Test Results	
		Fine Aggregate	Coarse Aggregate
1	Specific gravity	2.66	2.85
2	Water absorbtion	3.09%	0.85%
3	Bulk density	1706 Kg/m^3	1758 Kg/m^3

III. MIX PROPORTION

One control and two mixes with cement replacement materials is prepared and examined to determine the properties of self- compacting concrete. Table 5 represents the Mix Proportion of self-compacting concrete mixtures. After various trial mixes, the water/powder ratio was concluded as 0.35.The total powder content obtained finally was 550kg/m3 .Final % of superplasticiser used was 1.5 % by mass of cement.Table 4. represents mixture propotion of self-compacting concrete and table 5. represents the EFNARC limitations for self-compacting concrete.[3][9].

Table 4. Mixture proportion for fly ash and wood ash self-compacting concrete(kg/m3)

Materials	Specimen-1	Specimen-2	Specimen-3
Cement	440	352	352
Fly ash	110	-	55
Wood ash		110	55
Water	192	192	192
Admixture	8.25	8.25	8.25
Fine aggregate	972	972	972
Coarse aggregate	708	708	708

Table 5.EFNARC guidelines for self-compacting concrete[3].

Property	Required	Obtained
Coarse aggregate	< 50%	40 %
Water/Powder ratio	0.8 – 1.1	1.03
Total powder content	400 – 600 kg/m^3	550 kg/m^3
Sand content	> 50 %	60 %
Free water	< 200 lit	192
Sand content	<= 40% of the mortar(by volume)	49.37 %
Paste volume	>40 %	38.8

IV. MECHANICAL PROPERTIES

Compressive strength studies were studied on cube moulds of 150 mm × 150 mm × 150 mm, while cylindrical moulds of size 150 mm × 300 mm were used for the determination of split tensile strength. The flexural strength studies were carried out in prisms of size 100 mm × 100 mm × 500 mm. An overall of 64 no of specimens were casted and tested .

Before determining the hardened properties of concrete the workability properties such as L-box , Slump flow, V-funnel were done to access their filling ability and passing ability. The Flow ability of SCC is determined using slump flow test [9]. The slump value should be between 650mm-800mm.The filling ability is determined using V-Funnel Test. Time required for the concrete to flow down is noted in seconds. The V-funnel test is performed according to the procedure given by EFNARC Guidelines. The time taken for the SCC in V-funnel test should fall below 12 sec. In the L-Box test, the acceptable value should be at the least 0.8 .

V. RESULTS AND DISCUSSION

The fresh and hardened properties of self-compacting concrete using waste materials (fly ash, wood ash)as a partial replacement of cement has been investigated in this study.The study has been done according EFNARC Guidelines .

A. Fresh properties

The slump flow values of self-compacting concrete with cement replacement materials are presented in Table 6. The slump flow values of all SCC mixtures exhibited satisfactory results between 660mm to 690 mm, indicating good deformability of the concrete mix. The slump values are better for mix proportions with higher percentage cement replacement materials which can be inferred from Table.7. A lower amount of super plasticizer is more sufficient when we replace cement with mineral admixtures to maintain the flow ability of the concrete but, the addition of flyash and wood ash has resulted in additional dosage of super plasticizer .Comparing to other mineral admixtures, the fly ash particles had a spherical geometry and a coarse particle size, causing a significant reduction in surface area. In addition, as the density of Fly Ash is low which gives high paste volume while replacing the cement by fly ash resulting in reducing the friction there by improving the plasticity and cohesiveness, leading to increase in workability [5][9]. A value of at least 650 mm is required for self-compacting concrete. Table 5 and 6 represents the limitations and fresh properties of specimen-1(20% Fly ash),specimen-2(20% Wood ash), specimen-3(10% Fly ash & 10% Wood Ash),.The results obtained from the experimental investigations are within the limits of EFNARC guidelines.

Table 6. Limitations specified in EFNARC Guidelines.

Test methods	Minimum	Maximum	Units
V-funnel	8	12	sec
L-box	0.8	1	h_2/h_1
Slump flow	650	800	mm

Table 7. Fresh properties of self-compacting mixes

Mixture	Slump(mm)	V-funnel (sec)	L-box (h_2/h_1)
specimen -1	710	16	1
specimen -2	660	19	0.82
specimen -3	680	18	0.91

B. Mechanical properties

The properties of SCC at 7 Days and 28 Days are shown in Figs. 1,2 and 3 and in Table 8, 9 and 10.It is evident from the results that the 28 day strength of combination of 10% fly ash and 10% wood ash yields more strength when compared to the control mix at the early stage. The pozzolanic reaction of fly ash and wood ash combination were insufficient to increase the compressive strength. The slower pozzolanic reaction plays a vital role at 28 days strength.

Table 8.compressive strength of control, fly ash and wood ash mixes.

Mixture	7 Days(N/mm^2)	28 days(N/mm^2)
specimen -3	31.4	39.6
specimen -1	32.72	38.5
specimen -2	28.36	35.75

Table 9. Flexural strength of control, fly ash andwood ash mixes.

Mixture	7 Days(N/mm^2)	28 days(N/mm^2)
specimen -1	7.25	8.15
specimen -2	6.37	7.42
specimen -3	6.87	8.35

Table 10.splitting tensile strength of control, fly ash and wood ash mixes.

Mixture	7 Days(N/mm^2)	28 days(N/mm^2)
specimen-1	2.01	2.16
specimen -2	1.94	2.01
specimen -3	1.98	2.28

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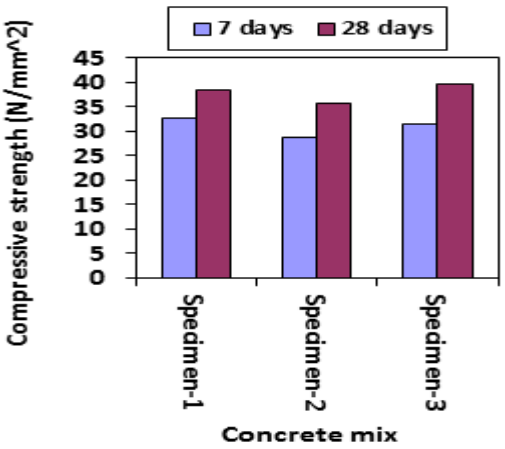

Fig.1 Compressive strength Vs Concrete mix

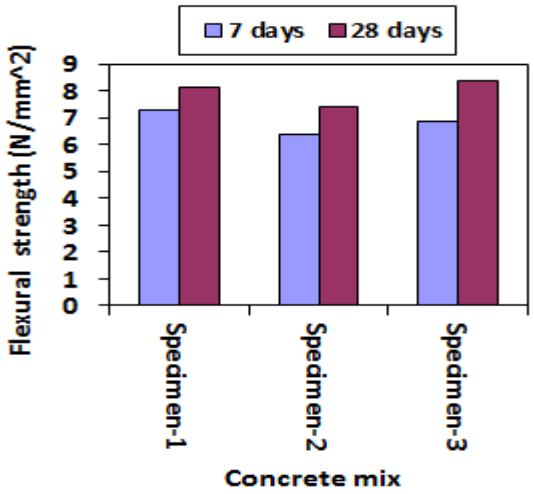

Fig.2Flexural strength Vs Concrete mix

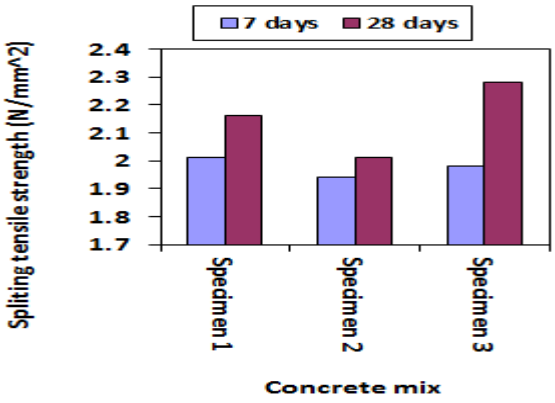

Fig.3Spliting tensile strength Vs Concrete mix

VI. CONCLUSION

Fresh and Mechanical properties for various mixes has been determined by various test methods and their results are as follows

1. Optimum water/powder ratio chosen from trial mixes as 0.35 by weight, the ratio beyond this causes segregation.
2. All SCC proportions had a accepatable performance in the fresh state. Among the cement replacement materials considered the fly ash combination showed good workability properties compared to others.
3. The mechanical properties of SCC shows significant performances and the higher compressive strength has been obtained for combination of fly ash and wood ash .
4. The increase in the replacement of wood Ash results in decrease in its strength. 10 % replacement of wood ash along with fly ash could be optimum consideration for mechanical properties.

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