Pertinence of Ceramic Waste in Self Compacted Concrete as Partial Equivalent of Cement

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Abstract - *The aim of this paper is to produce Self Compacting Concrete (SCC) with ceramic waste powder (CWP) from tiles as partial replacement of cement. Ceramic Waste includes the ceramic waste powder produced during the polishing of tiles and the tiles pieces. About 30% of the total material in ceramic tiles industry is discarded as waste and the disposal of such huge amount of waste in landfills causes environmental problems. So, these ceramic wastes can be converted into its powder form and it can replace cement partially in Self Compacted Concrete and thus, reducing the amount of ceramic waste in landfills.*

Self-Compacting Concrete is a special type of concrete that compacts under its own weight. This type of concrete has high flow ability, low yield stress and superior levels of surface finish without tendency of segregation. High flow ability makes it suitable for placing in difficult conditions and in sections with congested reinforcement. To achieve good flow ability and to maintain sufficient cohesion and stability in Self Compacting Concrete high powder content is required. The amount of cement cannot be increased to meet the demand of high powder content as it will cause cracking and will increase the cost of concrete. Ceramic Waste Powder has fine particle size and its chemical composition mainly consist of SiO_2 and Al_2O_3 (about 80%) making it a good material for replacement of cement.

In this study Mix design of M30 grade of Self Compacting Concrete would be done using Nan Su Method and then cement would be partially replaced by ceramic waste powder in 10% and 20% proportion by weight of cement. Test for fresh and hardened properties of Self Compacting Concrete would be conducted for the three mixes consisting 0%, 10% and 20% of ceramic waste powder and the results would be investigated.

Key Words: Ceramic waste, Self-Compacting Concrete, Flow ability.

A. INTRODUCTION

Self-compacted concrete is a special type of concrete that compacts under its own weight. This type of concrete has high flow ability, low yield stress and superior levels of surface finish without tendency of segregation. High flow ability makes it suitable for placing in difficult conditions and in sections with congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. Another advantage of SCC is that the time required to place large sections is considerably reduced. The inherited distinct features can be achieved by the addition of high powder content as filler (i.e. size < 0. 1 25 mm) in the concrete mixture. The filler enhances the rheological properties of the SCC mixture without the need for using higher cement contents and hence, reduces the cost and heat of hydration. India is ranked 3rd in the Global production of ceramic tiles and accounted for 6% of total production. Ceramic products are manufactured at extremely high temperatures between 1000 to 1250 degree Celsius and it results in very hard highly resistant to chemical, freezing and thermal shock. Due to these properties ceramic tiles can be used in the manufacturing of concrete as replacement of cement.

B. MATERIALS

1. CEMENT

OPC of grade 53 confirming to IS: 8112:1989 and EFNARC 2005 for materials of SCC is being used. The physical properties of Cement is as follows-

Table 1: Physical Properties of Cement

Details	Normal Consistency (%)	Initial Setting Time (min)	Final Setting time (min)	Specific Gravity
OPC	29	35	535	3.06

2. FINE AGGREGATE

The aggregate passing through 4.75 mm sieve and retaining on 150-micron sieve is termed as fine aggregates. Sand confirming to IS 383:1970 is being used. The properties of sand are as follows:

Table 2: Properties of Sand

Details	Specific Gravity	Water Absorption (%)	Bulk Density (kg/m³)
Sand	2.53	1.2	1332.72

3. COARSE AGGREGATE

Fractions of aggregate between 12.75 mm and 4.75 mm are being used as coarse aggregate. The maximum size of aggregate is 12.75 mm. Coarse aggregate confirming to IS 383:1970 have been used. The properties of aggregate are as follows:

TABLE 3: PROPERTIES OF COARSE AGGREGATE

Details	Specific Gravity	Water Absorption (%)	Bulk Density (kg/m^3)
Coarse Aggregate	2.55	0.8	1267.59

4. CERAMIC WASTE

Ceramic Waste Powder was used as partial replacement of cement to increase the workability and other factors. Ceramic waste was accumulated from local factories of Jaipur and converted into powder form in Los Angeles Abrasion testing machine. Ceramic Waste Powder passing through 90-micron sieve has been used. The chemical composition of ceramic waste is as follows:

Table 4: CHEMICAL COMPOSITION OF CWP

Materials	Weight (%)
SiO_2	67.35
Al_2O_3	19.79
Fe_2O_3	2.52
Na_2O_3	0.15
K_2O	4.13
TiO_2	0.92
MgO	2.00
CaO	2.32

5. FLY ASH

Fly ash is being used as filler material to increase the powder content in the Self Compacting Concrete as according to EFNARC standards powder content should not be less than 450 kg/m^3. Fly ash confirming to IS 3812:2003(Part 1 and 2) and passing through 150-micron sieve has been used.

6. ADMIXTURE

Super plasticizer SP430G8DIS of FOSROC CHEMICALS has been used as admixture. It is used to produce high workability, segregation resistant, durable and pump able concrete.

7. WATER

Water is a crucial part of concrete as it reacts with cement and produces gel. Good quality salt free water has been used in concrete.

C. MIX DESIGN

Mix design of M30 grade of Self Compacting Concrete has been done using Nan Su Method confirming to EFNARC standards and IS 10262:2009. The w/c ratio was maintained 0.45 throughout the experiment. Three kind of mix were prepared. First was normal SCC without ceramic waste powder. In the subsequent two mixes cement was replaced by 10 and 20 % with ceramic waste powder. The three type of mix are as follows:

TABLE 5: MIX TYPES

S No.	Concrete Mix	OPC replacement with CWP (%)
1.	M0	0
2.	M1	10
3.	M2	20

TABLE 6: MIX PROPORTION (per m^3)

Mix	C (kg)	F.A (kg)	C.A (kg)	F (kg)	CWP (kg)
M0	435	762.32	593.23	195.75	0
M1	392	762.32	593.23	195.75	43.5
M2	348	762.32	593.23	195.75	87

C= Cement, F. A=Fine Aggregate,
C.A=Coarse Aggregate, F=Fly Ash, CWP=Ceramic Waste Powder, SP= Super plasticizer

The amount of admixture is 7.27 kg/m^3 and that of water is 251.81 kg/m^{3}for all three mixes. W/P ratio is 0.45

TABLE 7: MIX RATIO

	Concrete Design Mix proportions					
	C	F.A	C.A	F	CWP	SP
M0	1	1.75	1.36	0.45	0	0.016
M1	0.9	1.75	1.36	0.45	0.1	0.016
M2	0.8	1.75	1.36	0.45	0.2	0.016

D. EXPERIMENTAL INVESTIGATON

The testing of SCC consists of fresh and hardened concrete tests. The fresh concrete tests are done to check the workability of concrete and hardened concrete test are done to check the strength parameters of concrete. The fresh concrete tests are Slump flow test and Segregation resistance test. The hardened concrete tests include compressive strength test and split tensile strength test.

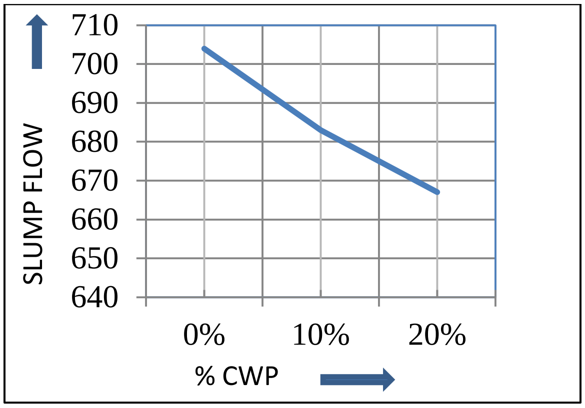
1. SLUMP FLOW TEST

Slump flow test is conducted for evaluating the workability and flow ability of concrete. The test was conducted on all three mixes with 0%, 10% and 20% replacement of cement with CWP and results were recorded.

TABLE 8: SLUMP FLOW

MIX	% CWP	SLUMP FLOW (mm)
M0	0	704
M10	10	683
M20	20	667

According to EFNARC standards slump flow should be between 600-800 mm.



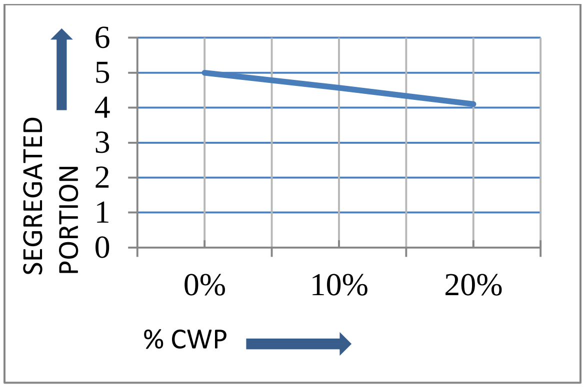
% CWP V/S SLUMP FLOW

2. SEGREGATION RESISTANCE

Segregation resistance test is another test to determine the fresh concrete properties of SCC. Self Compacting Concrete should have anti segregation property.

TABLE 9: SEGREGATION VALUES

MIX	% CWP	SEGREGATED PORTION (%)
M0	0	5
M10	10	5.24
M20	20	5.37

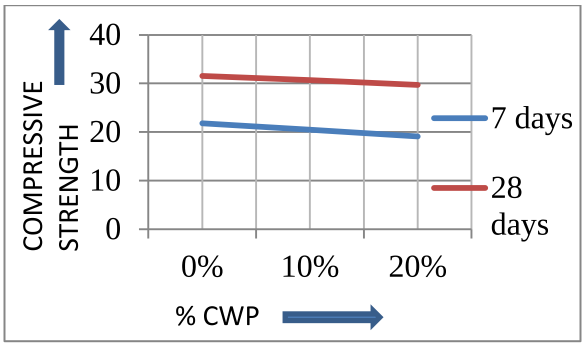


3. COMPRESSIVE STRENGTH

Compressive strength test is conducted on Compression Testing Machine on cube specimens of 150*150*150 mm dimension.

Cubes were casted and then moulds were removed after 24 hours. Compressive strength was determined after 7 and 28 days of curing respectively.

MIX	% CWP	COMP. STRENGTH	
		7 DAYS (N/mm²)	28 DAYS (N/mm²)
M0	0	21.78	31.56
M10	10	20.44	30.67
M20	20	19.11	29.67



E. RESULTS

Following things were observed from the experimental investigations on fresh and hardened SCC properties:

1. The results of slump flow test show that the flow ability of SCC of all the three mixes with 0 to 20% CWP content are according to the range specified by EFNARC standards, that is between 600-800 mm. The flow ability decrease with the increase in CWP content from 0 to 20 %.
2. The results of Segregation resistance show that the segregated portion decreases with the increase in CWP content. Addition of CWP increases the property of Segregation Resistance.
3. The results of Compressive Strength test after 7 and 28 days curing shows that the compressive strength decreases with increase in CWP content. But still the strength parameters satisfy the strength required at 7 and 28 days respectively.

F. CONCLUSION

The result of experiments shows that both fresh as well as hardened concrete properties changes on addition of ceramic waste powder. The fresh concrete property slump flow decrease slightly in SCC with ceramic waste as compared to normal SCC. But the change is well within the acceptable limit. The segregation resistance of SCC with CWP is more than normal SCC and this is one property which increased on addition of CWP. Compressive Strength both 7 and 28 days' decreases slightly but is well within acceptable limits.

From the following results it can be deciphered that CWP can be used as partial replacement of cement. But, this is a vast field and further research is needed.

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