An Experimental Study on Effect of ceramic waste powder in self-compacting concrete properties.

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Abstract: In ceramic industry about 5-10% production goes as waste in various processes while manufacturing. (This waste percentage goes down if the technology is installed in the new units.) This waste of Ceramic Industries dumped at nearby places resulting in environmental pollution causing effect to habitant and agricultural lands. Self-compacting concrete (SCC) mixtures include high powder content (i.e. 450-600 kg/m3) which is needed to maintain sufficient stability/cohesion of the mixture and hence improving segregation resistance. In this study the utilization of CWP in making SCC is evaluated. The study involves two experimental phases. In the first phase; the main characteristics of the ceramic waste powder (i.e. chemical composition, specific surface area and scanning electron microscope) are examined. In the second phase; the effect of using CWP on fresh concrete properties and mechanical properties of SCC are investigated.

Key Words: *Ceramic powder, Aggregates*, fly ash, super plasticisers.

1. INTRODUCTION

The Self compacting concrete is an innovative concrete that does not require compaction and vibration for placing. "Self-Compacting Concrete is able to flow under its own weight and completely fills formwork and achieving full compaction even in congested Steel designed.'' The harden concrete has same engineering properties and durability as tradition vibrated concrete. It is environment friendly. As it is first developed in Japan Self Compacting Concrete has been considered as a great development in construction worldwide. The main property of SCC is its flow ability, so it can be placed under its own weight without vibration and compaction. The use of high powder content super plasticizers (SP) and viscosity modifying admixtures (VMA) seems to be a good solution in order to obtain SCC of high fluidity without segregation or bleeding during the transportation or placing. However cost of this type of concrete is slightly costlier than normal vibrated concrete. By using natural pozzolana such as silica fumes, fly ash and ground granulated blast furnace slag can reduced cost of material and increases the flow ability. In several studies it is shown that mineral additives have been widely used as a substitute for Ordinary Portland cement in many applications because of its fruitful properties which include cost-reduction, reduction in heat evolution, decreased permeability and increased chemical resistance. The formwork cost can be reduced as early strength is gained and as no of the respective use with self-compacting concrete are more than normal concrete. Congested reinforcement is possible. More innovative design, more complex shape of RCC member, thinner section are possible reducing bleeding problem, proper compaction in congested areas. Self-compacting concrete has high Fluidity to preventsegregation. Self-compacting concrete is also known by name as Self-consolidating concrete. The powder content of Self co Impacting concrete is relatively high. The ratio of fine aggregates to coarse aggregates is more in SCC.

For several years beginning in 1983, the problem of the durability of concrete structures was a major topic of interest in Japan. To make durable concrete structures, sufficient compaction by skilled workers is required. However, the gradual reduction in the number of skilled workers in Japan's construction industry has led to a similar reduction in the quality of construction work. One solution for the achievement of durable concrete structures independent of the quality of construction work is the employment of self- compacting concrete, which can be compacted into every corner of a formwork, purely by means of its own weight and without the need for vibrating compaction. The necessity of this type of concrete was proposed by Professor Hajime Okamura in 1986. Studies to develop self-compacting concrete, including a fundamental study on the workability of concrete, were carried out by Ozawa and Maekawa at the University of Tokyo.

2. OBJECTIVE OF STUDY

- To evaluate the fresh properties of M-30 & M-35 (Passing ability, Filling ability and Segregation resistance) of SCC with use of Ceramic Waste Powder 0% ,10% ,15% ,20%,25%,30% and Fly Ash 25% replaced by binder material.
- To evaluate the harden properties of M-30 & M-35 (Compressive strength ,Split tensile Strength and Flexural test) of SCC with use of Ceramic Waste Powder 0% ,10% ,15% ,20%,25%,30% and Fly Ash 25% replaced by binder material.
- To evaluate the durability of M-30 & M-35 Acid attack with MgSo4 and HCL solution of SCC with use of Ceramic Waste Powder 0% ,10% ,15% ,20%,25%,30% and Fly Ash 25% replaced by binder material.
- Partially replacement of Cement with Ceramic Waste Powder by weight in Self-Compacting Concrete.

3.Materials:

During the experimental work of this study, ordinary Portland cements Type I conforming to ASTM 150 was used. Natural coarse aggregates were obtained from Ras Al Khaima. The nominal maximum size, specific gravity, and absorption % of the used coarse aggregates were 10 mm, 2.65 and 1.0% respectively. While for the fine aggregates, two types were used namely: dune sand and crushed sand aggregates, with fineness modulus of 1.00 and 3.90 respectively. The specific gravity of the used fine aggregates was 2.63. Ground granulated blast furnace slag (i.e. slag) was used as filler in some of the mixtures with a specific surface area 432 m2 /kg and a specific gravity 2.93. Chemical analysis of CWP was conducted and showed that CWP is mainly composed of silica (SiO2) forming about 69.4% of the material. Furthermore, alumina also represents another major compound of CWP making about 18.2%. The total mix of silica and alumina oxides in CWP exceeds 80% of the total material weight. Other compounds included 3.19% Na2O, 3.53% MgO, 0.306% Cl, 1.89% K2O, 1.24% CaO, 0.617 TiO2, 0.83% Fe2O3, 0.266% ZrO2. Specific surface area (SSA) measurements using Blaine fineness method showed CWP to have SSA of 555 m2 /kg **4.Chemical Composition of CWP**

Materials	Cement (%)
SiO2	67.35
Al2O3	19.79
Fe2O3	2.52
Na2O3	0.15
K2O	4.13

TiO2	0.92
MgO	2.00
CaO	2.32

Fig -1 Ceramic waste powder

4.1 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/m3. Fly ash confirming to IS 3812:2003(Part 1 and 2) and passing through 150-micron sieve has been usedFly ash remains is a standout amongst the most widely utilized result materials in the development field looking like Portland bond (Pfeifer, 1969). It is an inorganic, non-combustible; finely isolated deposit gathered or hastened from the fumes gases of any modern heater). The greater part of the fly ash remains particles are strong circles and a few particles, called cenospheres, are empty). Likewise present are plerospheres, which are circles containing littler circles inside. The molecule sizes in fly ash remains fluctuate from under 1 μm to in excess of 100 μm with the run of the mill molecule estimate estimating under 20 μm. Their surface region is ordinarily 300 to 500 m2/kg, albeit some fly ash remains can have surface regions as low as 200 m2/kg and as high as 700 m2/kg. Fly cinder is principally silicate glass containing silica, alumina, iron, and calcium. The relative thickness or particular gravity of fly ash debris for the most part extends somewhere in the range of 1.9 and 2.8 and the shading is by and large dim or tan Fly ash are subdivided into two classes, F and C, which mirror the sythesis of the inorganic portions.

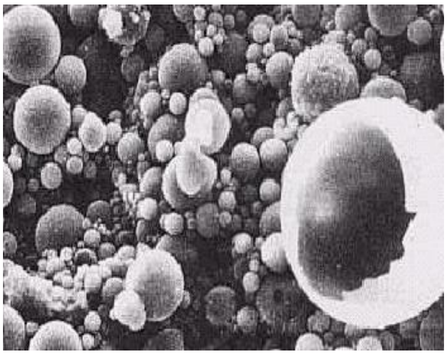


Figure2: Fly ash

from the lignitic coals and contain calcium alumino silicate glasses with the large amounts of calcium oxide, included in the smooth part In spite of the fact that their use is for the most part monetary (fly fiery debris is short of what one-a large portion of the cost of bond), the expansion of fly cinder has numerous specialized advantages.

4.2Super plasticizers:

Super plasticizers (high-go water-reducers) are low atomic weight, water dissolvable polymers intended to accomplish high measures of water decrease (12-30%) in solid blends keeping in mind the end goal to achieve a coveted droop (Gagne et al., 2000). These admixtures are utilized much of the time to deliver high-quality cement (> 50 MPa), since useful blends with water-bond proportions well underneath 0.40 are conceivable They additionally can be utilized without water decrease to create cements with high droops, in the scope of 150 to 250 mm (6 to 10 inches). At these high droops, solid streams like a fluid (and can fill frames effectively, requiring next to no vibration. These profoundly serviceable blends are called streaming cements and expect droops to be more than 190 mm (8.5 inches)

At the point when water-diminishing admixtures are utilized in solid blends, a few increments in compressive quality can be foreseen and these increments can be seen in as ahead of schedule as oneday if unnecessary hindrance does not happen.

It is for the most part concurred that increments in compressive quality are up to 25% more prominent than would be foreseen from the decline in water-bond proportion alone. Presumably, this mirrors the improvement of a uniform microstructure when the bond is scattered The decrease of the water-bond proportion and the formation of a more uniform pore structure imply that the penetrability of cement can be diminished by the utilization of super plasticizers, alongside

5.Slump Flow test:

The slump flow test is used to assess the horizontal free flow of SCC in the absence of obstructions. The basic equipment used is the same as for the conventional Slump test. The test method differs from the conventional one by the fact that the concrete sample placed into the mould is not rodded and when the slump cone is removed thesamplecollapses (Ferraris, 1999). The diameter of the spread of the sample is measured, that is a horizontal distance is determined as opposed to the vertical distance in the conventional Slump test. The Slump Flow test can give an indication as to the consistency, filling ability and workability of SCC. The SCC is assumed of having a good filling ability and consistency if the diameter of the spread reaches values between 650mm to 800mm.

Fig3. Slump flow test

5.1L-Box test:

This method uses a test apparatus comprising of a vertical section and a horizontal trough into which the concrete isallowed to flow on the release of a trap door from the vertical section passing through reinforcing bars placed at the intersection of the two areas of the apparatus (Dietz *et al.*, 2000). The time that it takes the concrete to flow a distance of 200mm and 400mm into the horizontal section is measured, as is the height of the concrete at both ends of the apparatus (H1 & H2). The L-Box test can give an indication as to the filling ability and passing ability.

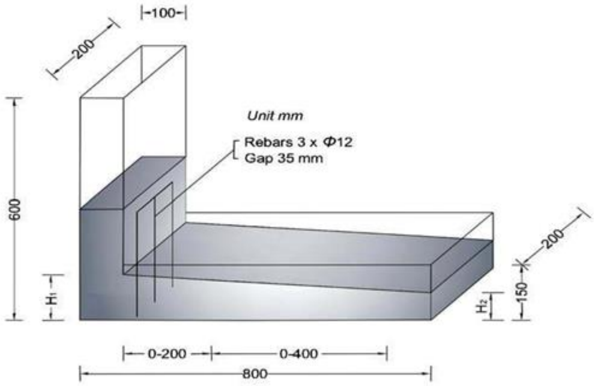


Fig4. L box test

6.Test results

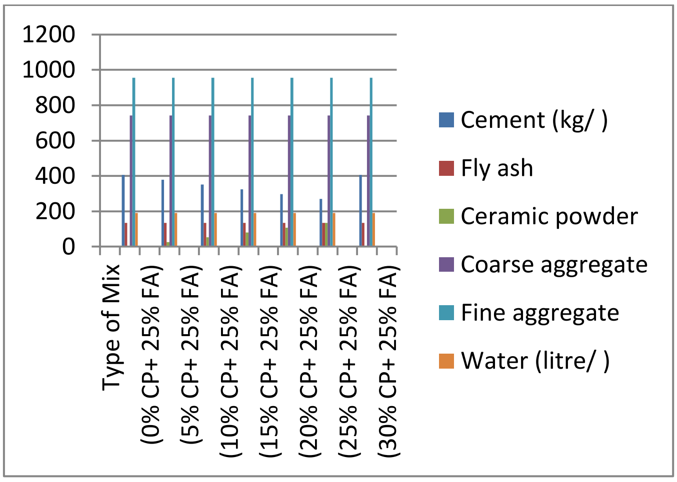
- Ceramic waste powder is directly obtained from ceramic wall tiles industries, while finishing process of tiles (sizing). The Fineness of CWP is same like cement used in this experiment. CWP used in this experiment is obtained CWP is ready to use waste in place of cement, therefore it can be a cost effective factor Specific gravity of ceramic waste powder is 2.76.

Test Result of Ceramic Waste Powder

Sr. No.	Test Name	Test Result
1	CaO	5.82%
2	SiO2	59.50%
3	Fe2O3	1.12%
4	Al2O3	29.52%
5	MgO	0.26%
6	SO3	0.18%
7	Loss on Ignition	0.90%

Table: Mix Design of M-35 Grade Concrete

Type of Mix	Cement (kg/)	Fly ash	Ceramic powder (kg/)	Coarse aggregate (kg/)	Fine aggregate (kg/)	Water (litre/)
MIX-1(0% CP+ 25% FA)	405	135	0	741.69	955.12	191.4
MIX-2(5% CP+ 25% FA)	378	135	27	741.69	955.12	191.4
MIX-3(10% CP+ 25% FA)	351	135	54	741.69	955.12	191.4
MIX-4(15% CP+ 25% FA)	324	135	81	741.69	955.12	191.4
MIX-5(20% CP+ 25% FA)	297	135	108	741.69	955.12	191.4
MIX-6(25% CP+ 25% FA)	270	135	135	741.69	955.12	191.4
MIX-7(30% CP+ 25% FA)	405	135	0	741.69	955.12	191.4

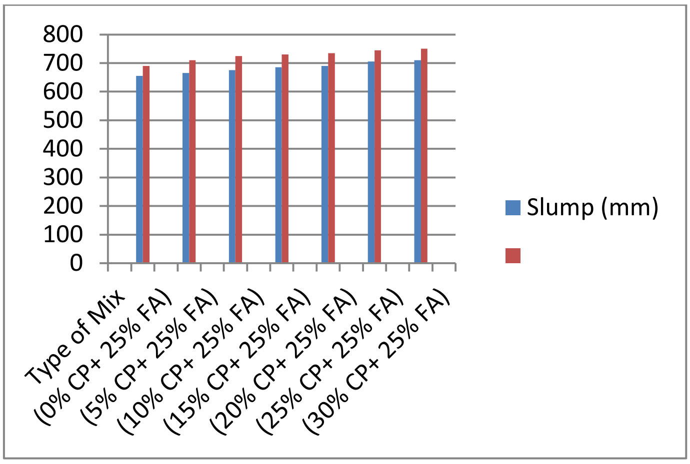


Graph: M-35 Grade Concrete Mix Design variations

Table: Fresh Properties of M-30 & M-35GradeConcrete

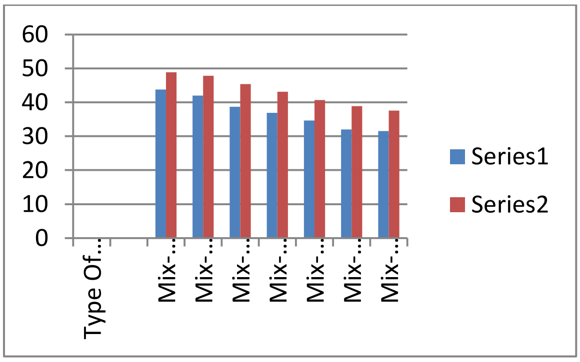
	M-30			M-35		
Type of Mix	Slump (mm)	V-Funnel (sec)	L- Box (h2/h1)	Slump (mm)	V-Funnel (sec)	L- Box (h2/h1)
	650-800 mm	8-12 sec.	0.8-1	650-800 mm	8-12 sec.	0.8-1
MIX-1 (0% CP+ 25% FA)	655	10.8	0.82	690	11.2	0.86
MIX-2 (5% CP+ 25% FA)	665	10.5	0.84	710	10.5	0.88
MIX-3 (10% CP+ 25% FA)	675	9.6	0.86	725	9.2	0.89
MIX-4 (15% CP+ 25% FA)	685	9.1	0.89	730	8.8	0.91

MIX-5 (20% CP+ 25% FA)	690	8.8	0.91	735	8.7	0.92
MIX-6 (25% CP+ 25% FA)	705	8.4	0.93	745	8.1	0.94
MIX-7 (30% CP+ 25% FA)	710	8.2	0.94	750	7.9	0.96



Graph: Slump Test

Fig5. Compressive strength test



Graph: Compararision of Compressive Strength M-30 & M-35 grade 28 days

7.Conclusion:

Various tests were carried out on different mixes of concrete containing ceramic powder and fly ash along with control mixes in self compacting concrete.

Based on experimental investigation, following observations are made on the fresh property, hardened properties and durability of SCC :

- The Use of Ceramic powder and fly ash by substitution to binder has no negative effect on Fresh Properties of SCC.
- In Slump flow test, the result shows that by replacing the ceramic powder to 10% by binder contain there will be increase in the slump flow by 3.05% in M-30 and 5.07 % in M-35 Grade of Concrete.
- In V-Funnel Test, the result shows that by replacing the ceramic powder to 10% by binder contain there will be decrease in the time of V-Funnel test by 11.11% in M-30 and 17.85% in M-35 Grade of Concrete.
- In L-Box test, the result shows that by replacing the ceramic powder to 10% by binder contain there will be increase in the ratio (H2/H1) of L-box test by 4.88% in M-30 and 3.49 % in M-35 Grade of Concrete.
- In Hardened property such as Compressive strength, Flexural strength and Split tensile, there is decrease in the strength of SCC with increase in the percentage of ceramic waste powder.

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