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Effect of Ceramic Waste Powder in Self Compacting Concrete Properties: A Critical Review

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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. Therefore using of ceramic waste powder in concrete would benefit in many ways in saving energy & protecting the environment. The cost of deposition of ceramic waste in landfills will be saved. An attempt has been made to study the behavior of SCC with ceramic waste powder and understands the effect of the mineral admixtures on fresh & hardened properties of SCC and also investigates the compatibility of ceramic waste powders in SCC along with chemical admixture such as super plasticizers. Industrial waste ceramic waste powder would be used in self- compacting concrete. Primary aim of this study is investigate with substitute the ceramic waste powder by 0%, 10%,15%,20% ,25%, 30% and Fly ash 25% by the binder contain of self-compacting concrete. The various result outcomes and deciding the percentage of ceramic waste powder for best result of fresh and harden property of self-compacting concrete. The project can lead to the use of ceramic waste powder in Self compacting concrete, thus saving landfill and reduce CO2 emission by the use of less cement.*
Keyworeds: *Fly ash, Fresh and Harden property, Ceramic Waste Powder, SCC*

I. 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 prevent segregation.

Self-compacting concrete is also known by name as Self-consolidating concrete. The powder content of Self compacting concrete is relatively high. The ratio of fine aggregates to coarse aggregates is more in SCC.

II. Literature Survey

[1] Bernardinus Herbudiman, Adhi Mulyawan Saptaji (Elsevier-2013)

In these research paper, self compacting concretes are designed as follows: 1) water-powder ratio (w/p) is designed with 0.35, 0.32, and 0.29; 2) maximum dimension of coarse aggregate is limited by 15 and 20 mm; 3) dosages of traditional roof tile powder are 0%,10%,20%, and 30% from powder weight; 4)dosage of silica fume sets to be 5% for all trial mixes; 5) super-plasticizer is added with dosage of 0.5%, 1.0%, 1.2% and 1.5% from powder weight to achieve flow characteristic of self compacting concrete. 6) Aggregates are washed before mixing. The mix that has the largest slump spread is tested with V-funnel and L-shaped box. Specimens of cylinder with diameter of 10 cm and height of 20 cm are used in this research to determine the compressive strength and split-tensile strength. Maximum diameter of slump spread could achieve 65 cm. Duration in V-funnel test is 14.6 second. In L- shaped box, duration to reach 40 cm and to reach box-end are 45 and 65 second, respectively. Blocking/passing ratio (H2/H1) is 4.5/32. Optimum dosage of traditional roof tile powder is 20% at w/p of 0.35 and dosage of Super-plasticizer of 1% that has compressive strength of 44.11 MPa and split- tensile strength of 3.25 MPa. Washing aggregate before mixing could increase workability performance and increase compressive and split- tensile strength of 17.06 % and 42.37 %. Coarse aggregate with maximum dimension of 20 mm has compressive strength of 51.05 MPa. Optimum w/p is 0.32.And optimum dosage of super-plasticizer is 1.5% at dosage of traditional roof tile powder of 20%, dosage of silica fume of 5%, and proportion of coarse aggregate of 45% that has the largest compressive strength of 67.72 MPa.

[2] Khalid Najim, Ibrahim Al-Jumaily, Abdukhaliq Atea (Elsevier-2015)

The aim of their study was to investigate the use Cement Kiln Dust (CKD) as cement replacement material in producing high performance/self- compacting concrete. Different percentages of replacement by cement weight were tried including 10%, 20%, and 30% with keeping other constituents content constant. In order to characterize the structurally use of the produced concrete in civil infrastructure applications ,the rheological and some key mechanical properties were investigated in addition to some dynamic/damping properties. The results showed that there was a progressive decrease in flow ability and mechanical strength properties with increasing CKD replacement. However, high strength self-compacting concrete could be produced with up to 20% wt. CKD replacement while high performance/self compacting concrete was obtained with 30% wt. CKD replacement. CKD incorporation led to decrease the dynamic modulus of elasticity in parallel with increase the damping capacity. The final conclusion is that CKD can be used as a cement replacement material in producing high strength/high performance self-compacting concrete if the strength and rheology of the produced concrete is considered.

[3] Muhd Fadhil Nuruddin, Kok Yung Chang, Norzaireen Mohd Azmee (Elsevier-2014)

Ductile self compacting concrete (DSCC) is one of the advanced materials which combines self compacting abilities and ductility to address the current industry problems. A study on DSCC with various cement replacement materials was conducted. Up to 20% of cement in DSCC was replaced by Microwave Incinerated Rice Husk Ash (MIRHA), silica fume (SF) and fly ash (FA) in certain ratios. The results show that DSCC with replacement of 10% FA and 10% MIRHA achieved the highest compressive strength without scarifying the self compacting abilities.

[4] A.S.E. Belaidi, L. Azzouz, E. Kadri, S. Kenai (Elsevier-2012)

This paper investigates the effect of substitution of cement with pozzolana and marble dust on the rheological and mechanical properties of self- compacting mortar (SCM)and self -compacting concrete (SCC). Cement was partially replaced by different percentages of pozzolana and marble dust (10–40%).Fresh property of Self-compacting concrete was measured by slump test, V-funnel flow test, J Ring, L Box and sieve stability tests. Compressive strength was defined at the ages of 7, 28, 56 and 90 days. The results indicate an improvement in the workability of Self compacting concrete with the use of natural pozzolana and marble dust. The Object of this study is to investigate the effect of Marble dust and natural pozzolana on the fresh and hardened properties of self-compacting concrete. The use of the Marble dust and natural pozzolana by substitution to cement has no negative effects on the workability of self-compacting concrete at a constant water/powder ratio and plasticizer content.

[5] Givanildo Azeredo, Marcelo Diniz (Elsevier- 2012)

Self-compacting concrete (SCC) is characterized by its special capacity of filling ability, passing ability and resistance to segregation by the action of its own weight without the presence of other external forces. These fresh properties are obtained thanks to the use of filler, where the limestone one is mostly used. Numerous industries produce a great amount of solid wastes, some suitable for use as filler in the production of SCC. This study aimed to develop a SCC with inclusion of wastes from the manufacturing of kaolin, through an optimum dosage of kaolin wastes and super plasticizer (sp) which were well established from the experiments. The paste dosage was defined by Marsh funnel and mini-slump tests and fresh properties of concrete were measured by L box, U box, J ring, V funnel and Abrams cone. The use of kaolin wastes in SCC production is pioneering. The mix-design method used was successful and it was validated by the several fresh properties results which provided to the concrete a SCC characteristic flowing behavior. Finally, including industrial waste in SCC has brought significant environmental benefits.

[6] Ilker Bekir Topçu, Turhan Bilir, Tayfun Uygunoglu (Elsevier- 2008)

The objective of their investigation is to use the Marble dust is directly without attempting any additional process. Thus, this would be another benefit advantage for this objective. For this objective, Marble dust has replaced binder of Self Compacting Concrete at certain contents of 0, 50, 100, 150, 200, 250 and 300 kg/m3. Then slump-flow test, L-box test and V-funnel test are conducted on fresh concrete of SCC. Further, compressive strength, flexural strength, ultrasonic velocity is determined at the end of 28 days for the hardened concrete specimens. The effect of waste Marble dust usage as filler material on capillarity properties of SCC is also investigated. According to conclusion, it is concluded that the workability of fresh SCC has not been affected up to 200 kg/m3 marble dust content. However, the mechanical properties of hardened SCC have decreased by using Marble dust, especially just above 200 kg/m3 content in SCC.

[7] Erhan Guneyisi, Mehmet Gesoglu, Asraa Al- Goody, Suleyman Ipek (Elsevier-2015)

This research paper addresses the effect of nano- silica (NS) and fly ash (FA) content on the fresh and rheological properties of self-compacting concrete (SCC). Four SCC series were designed with constant total binder content of 570 kg/m3 and at a water-to- binder (w/b) ratio of 0.33. Portland cement (PC) was substituted with NS with replacement levels of 0%, 2%, 4%, and 6% by weight in all SCC series. FA was not used in the production of first concrete series while in second, third, and fourth concrete series, FA was used at replacement levels of 25%, 50%, and 75% of total binder content by weight, respectively. Fresh properties of mixtures were experimentally investigated in terms of slump flow diameter, T50 slump flow time, V-funnel flow time, and L-box height ratio.

[8] Mostafa Jalal, Alireza Pouladkhan, Omid Fashini Harandi, Davoud Jafari (Elsevier- 2015)

This paper presents the effects of some admixtures including silica nano particles, silica fume and Class F fly ash on different properties of high performance self compacting concrete (HPSCC). For this purpose, a fraction of Portland cement with the aim of cement content reduction was replaced different fractions of pozzolanic admixtures. The rheological properties of fresh concrete were observed through slump flow time and diameter and V-funnel flow time. T hermal properties were investigated via thermo gravimetric analysis (TGA) test. Transport properties evaluated by water absorption, capillary absorption and chloride ion penetration tests.

[9] Ahmet Beycioglu, H.Yilmaz Aruntas (Elsevier- 2014)

This paper presents the results of an experimental investigation carried out to study the effect of Low Lime Fly Ash (LLFA), Granulated Blast Furnace Slag (GBFS) and Micronized Calcite (MC) on both workability and mechanical properties of Self Compacting Concretes (SCCs). In their experimental program, Portland cement was partially replaced with LLFA and GBFS as 20%, 40% and 60% by weight of total binder and also MC was partially replaced with total aggregates as 5% and 10% for all mixtures containing LLFA and GBFS.

[10] Chaijun Shi, Zemei Wu, KuiXi Lv, Linmei Wu (Elsevier-2015)

Mixture design is a very important step in production and application of concrete. Many mixture design methods have been proposed for self-compacting concrete (SCC). This paper presents a critical review on SCC mixture design methods in publications. Based on principles, those methods can be classified into five categories including empirical design method, compressive strength method, close aggregate packing method and methods based on statistical factorial model and rheology of paste model. The procedures, advantages and disadvantages of each method were discussed. The most appropriate method should be chosen according to actual situations to obtain high quality SCC with satisfactory properties.

[11] Sumit Mahajan, Dilraj Singh (IJETAE-2013)

An experimental investigation has been carried out to study the comparative study on the use of different materials as binder content in self-compacting concrete and their effects on the workability and strength properties are checked. Different combinations of Fly ash, Metakaolin and Sawdust, ash are used to keeping the percentage (%) of Ordinary Portland cement constant at 70% of the total binder content. Fly ash content amount is varied from 0 to 30% and Metakaolin and Saw dust ash (SDA) content amount from 0 to 15%. Water-binder ratio is maintained at 0.41%. Fresh property tests such as V-funnel test, Slump flow test, L-box test and J-Ring test are executed and Hardened properties like compressive strength and splitting tensile strength are checked at different days of curing.

[12] N R Gaywala, D B Raijiwala (JERS-2013)

An experimental investigation has been carried out to study the research on different harden properties of SCC using the Ordinary Portland Cement "Ultratek" made and low-calcium fly ash from Birala Glass, Kosamba, Gujarat, as binder materials in making the concrete mixes along other ingredients locally available in Gujarat. The hardened properties like compressive strength, split tensile strength, flexural strength and impact strength were found in experimental work and compared with M25 grade of concrete. In the present context the SCC can be proved as boon to construction industry. The maximum compressive strength for SCC can be obtained by addition amount of 15% of fly ash in mix as compared to addition amount of 25%, 35%, 45% and 55% cement substitution with fly ash. The maximum tensile strength for SCC can be obtained by addition amount of 15% of fly ash in mix as compared to addition amount of 25%, 35%, 45% and 55% cement substitution with fly ash. The maximum flexural strength for SCC can be obtained by addition amount of 15% of fly ash in mix as compared to addition amount of 25%, 35%, 45% and 55% cement substitution with fly ash. The maximum pull out strength for SCC can be obtained by addition of 15% of fly ash in mix as compared to addition amount of 25%, 35%, 45% and 55% cement substitution with fly ash.

[13] B.H.V. Pai1, M. Nandy, A. Krishnamoorthy, P.K. Sarkar, Philip George (AJER-2014)

This research project represent producing and comparing Self compacting concrete incorporating Fly ash and Rice husk ash as supplementary cementing materials in terms of their properties like compressive strength, split tensile strength and flexural strength. The Self-compacting concrete mixes containing fly ash, and that containing rice husk ash as filler materials were tested for their fresh properties as per EFNARC guidelines. Both Self- compacting concrete mixes have satisfied all the acceptance criteria laid down by EFNARC guidelines. The hardened properties like compressive strength, split tensile strength and flexural strength were checked and found that not all the test results were satisfactory. But a comparative study of the test results shows that self-compacting concrete containing fly ash has better compressive strength, split tensile strength and flexural strength than self- compacting concrete containing Rice Husk Ash.

[14] Dhiyaneshwaran, Ramanathan, Baskar, and Venkatasubramani (JJCE-2013)

An experimental investigation has been carried out to study the workability and durability characteristics of SCC with Viscosity Modifying Admixture (VMA), and containing Class F fly ash. The mix design for self-compacting concrete was arrived as per the Guidelines of European Federation of National Associations Representing for Concrete (EFNARC). During this investigation, Self compacting concrete was made by usual ingredients such as cement, fine aggregate, coarse aggregate, water and mineral admixture fly ash at various replacement levels (10%, 20%, 30%, 40% and50%). The plasticizer (SP) used was Glenium B233 and the viscosity modifying agent (VMA) used was Glenium Stream 2. The experiments are carried out by water-powder ratio is taken 0.45. Fresh property is determined by using tests such as slump flow, T50, V-funnel, L-Box and U-box tests. The durability of concrete is tested by acid resistance, Sulphate attack and saturated water absorption at 28, 56 and 90 days.

[15] Krishna Murthy, Narasimha Rao, Ramana Reddy, Vijaya Sekhar Reddy (IOSRJEN-2012)

This paper presents an experimental procedure for the design of self-compacting concrete mixes. The relative proportions of key components are considered by volume rather than by mass. A simple tool has been designed for self compacting concrete (SCC) mix design with 29% of coarse aggregate, replacement of cement with Metakaolin and class F fly ash, combinations of both and controlled SCC mix with 0.36 water/cementitious ratio(by weight) and 388 litre/m3 of cement paste volume. Crushed granite stones of size 16mm and 12.5mm are used with a blending 60:40 by percentage weight of total coarse aggregate. Detailed steps are discussed in this study for the SCC and its mortar.

[16] Hardik Patel, Dr. N.K.Arora, Shraddha R. Vaniya (IJSRD-2015)

Ceramic waste is one of the most active research areas in the field of construction. Ceramic waste powder is waste from ceramic wall floor tiles industries. Ceramic products made up of different raw materials like china clay, potash, ball clay, dolomite, feldspar, talc and different chemicals for maintaining viscosity of raw material, glazing and finishing of finished goods. Manufacturing of ceramic wall tiles is manufactured under very high temperature up to 2000oc. Therefore pozzolanic reactivity would be possible, which is responsible strength and durability in cement concrete. When product is in finishing touch (sizing) there is a waste in powder form like cement. Ceramic waste powder is settled by sedimentation and then dumped away, which results in environmental pollution and land exploitation.

[17] Zoran Grdic, Iva Despotovic, Gordana Toplicic curcic (ACE- 2008)

The objective of their investigation is to use different type of additives such as fly ash, silica fume, hydraulic lime and a mixture of fly ash and hydraulic lime.SCC is one of "the most revolutionary development." in concrete research. This concrete is able to flow and to fill the formwork without compaction. There are several methods for testing the fresh property in SCC. The most frequently used are slum−flow test, L−box and V−funnel.

III. Conclusions

1) The self-compacting concrete with traditional roof-tile powder has same type of strength development with the normal concrete. The washing process could increase concrete compressive and split-tensile strengths up to 17% and 42% respectively.
2) The replacing of OPC with CKD (Cement Kiln Dust) appears to be negative influence on both rheological and mechanical properties. However, even with 30% CKD replacement slump flow class and viscosity classes could be achieved based on EFNARC limitations. HPC (High Performance Concrete) that is suitable for most civil infrastructure applications (from 28 MPa to 35 MPa) was obtained with 30% CKD replacement.
3) The DSCC (Ductile Self Compacting Concrete) mixes proposed fulfilled the requirements of self compacting abilities. DSCC with various cement replacement materials can be used as high strength ductile self compacting concrete with the appropriate water/binder ratio and super plasticizer.
4) The use of the Marble dust and natural pozzolana by substitution to cement has no negative effects on the workability of self-compacting concrete at a constant water/powder ratio and plasticizer content.
5) Any utilization of industrial waste contributes to minimizing the environmental impact. The using of KW1 (Coarse Kaolin Waste) and KW2 (Fine Kaolin Waste) in a SCC is a considerable attempt to reduce the large volume of the industrial wastes from the manufacture of kaolin that has been deposited in the environment.
6) When the properties of fresh Self compacting concrete such as slump-flow, V-funnels time, blocking ratio, air content and unit weight are considering as a criterion to determine the optimum usage in Self compacting concrete. Marble dust can be said that the usage of amount below 200 kg/m3 content is suitable for improving all of these properties.
7) The compressive strength of SCC mixtures was decreased by increasing FA (Fly Ash) content. Lowest compressive strength values were observed in the fourth concrete series. NS (Nano Silica) utilization up to 4% increased the compressive strength of SCC mixture while use of NS at 6% replacement level decreased it.
8) Higher amount of mineral admixtures combined with small fractions of nano powders would be promising technique toward Self Compacting concrete as a key material along with energy saving in construction and building technology.
9) The SCC's workability performance can be increased with the use of high volumes of LLFA (Low Lime Fly Ash) and GBFS (Granulated Blast Furnace Slag). It also led to the consumption of the industrial wastes, thus providing a twofold benefit.
10) Mixture design is a critical step to obtain high quality SCC. A good SCC mixture design method should consider: (1) widely applicable; (2) strong robustness for variable raw materials; (3) technical requirements, (4) sustainability and (5) cost.
11) The addition of Saw dust ash as a binder in Self compacting concrete along with fly ash reduces both the compressive and split tensile strength of Saw dust ash (SDA) mixes. The mix proportion to 10% SDA and 20% fly ash replacement shows maximum compressive and tensile strength as compared to other SDA mixes.
12) SCC gives good finishing as compared to ordinary concrete without any external mean of compaction. Also Self-compacting concrete gives good durability properties as compared to the ordinary concrete.
13) The Self-compacting concrete mixes containing fly ash, and that containing rice husk ash as filler materials satisfies all the acceptance criteria laid down by EFNARC guidelines.
14) The workability of SCC can be increased with the increase of dosage of super plasticizer and the required slump value fulfilling the criteria of EFNARC.
15) Self-Compacting Concrete is considered to be the most promising building material for the expected revolutionary changes on the job site. Self compacting concrete mix design tool is developed based on the key proportions of the constituents. This tool is very simple and user friendly for the self compacting concrete mix design. It can be used for the SCC mix with or without blended cement and coarse aggregate with or without coarse aggregate blending.
16) A constant liquid/slag ratio the alkali activator dosage influenced the setting times. Increasing the alkali activator reduced the setting time both initial and final. The compressive strength of M 25 grade

concrete increase up to 30% replace of ceramic waste by weight of cement. Concrete on 30% replace of ceramic powder the cost of concrete is reduced up to 13.27% in M 25 grade.

17) There is improvement on the behavior of SCC with addition of Fly Ash to the mixture containing hydraulic lime.

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