Effect of Silica Fume on Concrete

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ABSTRACT

Due to over increasing population and limited resources of land we have to look to the sky to accommodate this increasing population and for that we are so much focused on making high rise buildings and other mega structures to utilise the resources of land to its fullest, but this cannot be achieved without improving our construction technique and materials. As we know that Concrete is one of the most widely used structural material hence its property and quality influence the construction a lot. Here in my project I have tried to evaluate those properties of concrete and the improvement in those properties by adding silica fume. Silica fume act as a filler material and fills the pores between cement particles, making it more dense and improving the microstructure of concrete and thus improving the mechanical properties of concrete, such as strength, impermeability, durability, elastic modulus and so on. It also improve the concrete by chemically reacting with hydration precipitation of Ca(OH2) and producing hydrated calcium silicate in alkaline conditions thus improving the consistency of concrete and workability. Compressive strength of concrete is the most important property of concrete, because other properties like stress-strain relationship, tensile strength, bond strength, modulus of elasticity, density, impermeability, durability etc. can be inferred from the compressive strength using established correlations. This paper presents review of literatures related to utilization of waste material.

Keywords : Slica Fume Concrete, OPC (Ordinary Portland Cement), HPC (Higher Performance Concrete), HRWRA (High Range Water Reducing Agent).

I. INTRODUCTION

Concrete is a mix of sand, gravel, water, and cement which results in solid mass. Concrete is strong in compression but has low tensile strength. Its tensile strength is approximately $\frac{1}{10}$ of the compressive strength. Lately, everyone is interested in improving properties of concrete by mixing / adding various pozzolanic materials in the concrete mixture. One of such material is silica fumes. Silica fume is also known as Micro silica, condensed silica fume, “micropoz” (trademark), silica dust, volatilized silica etc. Silica fume is being used in a lot many projects now a days due to its favorable effect in concrete for e.g. Bandra worli sea link in Mumbai used silica fume concrete mainly for better durability. Silica fume is a byproduct of production of ferrosilicon and silicon metal in an electric arc furnace. Silica Fume such extracted is usually composed of more than 90 percent silicon dioxide and traces of other oxide. Silica fume was first collected in 1947 and started testing in 1961. Silica fume particles are very small that gives a fineness of 15000 to 30000 m2 / Kg and specific gravity of about 2.22. It is around 100 times smaller than the particle of cement which makes it easier for micro silica particle to occupy the spaces (voids) left by the cement particles. Hence we can say that proper proportioning of micro silica, cement, HRWRA (high range water-reducing admixture) and aggregate produces a concrete with improved concrete properties.

High Performance Concrete (HPC) containing micro silica is one of the most important advanced materials in the present day to grow a nation’s infrastructure. In addition to increased strength and enhanced durability, concrete produced with micro silica posses increased resistance to abrasion, chemicals, corrosion, increases toughness and placement and life-cycle cost efficiency. In severe and extreme conditions the life of a RCC structure shortens a lot due to corrosion of reinforcement by chloride and other chemical attacks which can be directly linked to the permeability of concrete and as addition of silica fume to concrete mix reduces the permeability hence it increases the life of a structure which makes the structure more economical in the long run. Silica fume also increase the strength of concrete which in turn make the structure abrasion resistant and also reduces the size of the members which reduces the total volume of concrete to be used in the structure hence reducing the project cost and making the structure more economical. These features allow a civil engineer and architect to have better comfort zone and to design the structure more freely and optimizing the space to the fullest with modern designs.

II. LITERATURE REVIEW

Yunsheng Xu and et al. (1999), “Improving the workability and strength of silica fume concrete by using silane-treated silica fume” – Mortar with high workability even without a water-reducing agent and with high tensile and compressive strengths (3.1 and 78 MPa, respectively) was obtained by using as an admixture silica fume that had been surface treated with a silane coupling agent. The treatment enhanced the wettability of silica fume by water, thereby increasing the workability of the mortar mix. It also enhanced the bond between silica fume and cement, thereby increasing the strength and modulus, both under tension and compression. In particular, the tensile strength was increased by 31% and the compressive strength was increased by 27%. Moreover, the flexural storage modulus, loss tangent, and density were increased.

S. Bhanja and et al. (2002), “Investigations on the compressive strength of silica fume concrete using statistical methods” – The present paper deals with a mathematical model developed using statistical methods to predict the 28-day compressive strength of silica fume concrete with water-to-cementitious material (w/cm) ratios ranging from 0.3 to 0.42 and silica fume replacement percentages from 5 to 30. Strength results of 26 concrete mixes, on more than 300 test specimens, have been analyzed for statistical modeling. The ratios of compressive strengths between silica fume and control concrete have been related to silica fume replacement percentage. The expression, being derived with strength ratios and not with absolute values of strength, is independent of the specimen parameters and is applicable to all types of specimens. On examining the validity of the model with the results of previous researchers, it was observed that for results on both cubes and cylinders, predictions were obtained within 7.5% of the experimentally obtained values.

Houssam A. Toutanji and et al. (1999), “Effect of curing procedures on properties of silica fume concrete”, – The effect of curing procedure on hardened silica fume concrete is reported. The silica fume contents were 10%, 15%, 20%, and 30% by weight of cement. The aggregate to cementitious material ratios (cement + silica fume) ranged from 1.0 to 3.8. Three different curing methods were used: steam, moist, and air curing. Mechanical properties such as compressive strength, permeability, and permeable voids were determined. Steam curing was found to enhance the properties of silica fume concrete, whereas air curing exhibited adverse effects as com-pared to moist curing. Enhancement in the mechanical properties of silica fume concrete caused by steam curing was manifested by strength increase and permeability and permeable void volume decrease.

Cabrera, J.G. and et al. (2013), “Measurement of chloride penetration into silica fume concrete” – Chloride induced corrosion is a major factor affecting the service life of concrete structures. The likely effect of using silica fume to reduce chloride penetration has been measured using a ponding type experiment and an electrical method. It is concluded that due to the special properties of the silica fume mixes the electrical test is not a reliable way of measuring the effect but they are less permeable than the OPC mixes.

Smita Sahoo and et al. (2021), “Durability properties of concrete with silica fume and rice husk ash” – The present investigation explores the durability properties of concrete incorporated with silica fume (SF) and rice husk ash (RHA) as the replacements of Portland slag cement (PSC). PSC cement is selected for the study owing to its superior characteristics compared to other types of cement. Two groups of concrete mixes are considered in which SF and RHA are used as 5%, 10% 15% and 20% of PSC separately and properties are compared with the control mix having only PSC cement. Durability properties like acid resistance, rapid chloride permeability, carbonation resistance, transport test (water sorptivity, porosity and water permeability) of concrete are evaluated to deduce the effect of SF and RHA on the concrete matrix. In relation to the process of hydration, the behavior of RHA is observed to be different from SF. With 15% replacement SF and RHA, the 28 days concrete compressive strength is enhanced by 23.6% and 20.3%, respectively with reference to the control mix. However, the 90 days concrete strength becomes 31.7% and 30.95% higher than that of control mix. In terms of durability properties, the trend displayed by RHA is also very much similar to the SF concrete. The hydrated concrete samples are examined for the microstructural characteristics by the scanning electron microscopy (SEM). The microstructural changes caused by the improved reactivity of admixture and densification are associated with the improvement in the concrete characteristics. Finding from this experimental study suggest that the RHA has immense potential to significantly reduce the cost of concrete rather than SF, in rice producing Asian countries.

Canan Tasdemir, (1996), “Effects of silica fume and aggregate size on the brittleness of concrete” – The effects of silica fume and aggregate size on the softening response and brittleness of high strength concretes were investigated by measuring the fracture energy GF, the characteristic length lch and brittleness index B. Based on the fracture tests and microscopic studies at the aggregate-matrix interface, it was concluded that, in concretes without silica fume, the cement-aggregate interface had a profusion of calcium hydroxide and also much less dense calcium silicate hydrate, hence, the cracks usually developed at this weak interface, i.e. around coarse aggregate. However, in concretes with silica fume, the interfacial zone became stronger, more homogeneous and dense, hence, the cracks usually traversed the aggregates; transgranular type of fracture was observed. In these concretes, the fracture energy decreased dramatically especially for large size of aggregate case and as a result the brittleness index increased significantly.

C.D. Atis and et al. (2005), “Influence of dry and wet curing conditions on compressive strength of silica fume concrete” – This paper reports a part of an ongoing laboratory investigation in which the compressive strength of silica fume concrete is studied under dry and wet curing conditions. In the study, a total of 48 concretes, including control Portland cement concrete and silica fume concrete, were produced with four different water–cement ratios (0.3, 0.4, 0.5, 0.6), three different cement dosages (350,400, 450 kg / m3) and three partial silica fume replacement ratios (10%, 15%, 20%). A hyperplastisizer was used in concrete at various quantities to provide and keep a constant workability. Three cubic samples produced from fresh concrete were demoulded after a day; then, they were cured at 20 2oC with 65% relative humidity (RH), and three other cubic samples were cured at 20 2oC with 100% RH until the samples were used for compressive strength measurement at 28 days. The comparison was made on the basis of compressive strength between silica fume concrete and control Portland cement concrete. Silica fume concretes were also compared among themselves. The comparisons showed that compressive strength of silica fume concrete cured at 65% RH was influenced more than that of Portland cement concrete. It was found that the compressive strength of silica fume concrete cured at65% RH was, at average, 13% lower than that of silica fume concrete cured at 100% RH. The increase in the water–cementitious material ratios makes the concrete more sensitive to dry curing conditions. The influence of dry curing conditions on silica fume concrete was marked as the replacement ratio of silica fume increased.

Ha-Won Song, Jong-Chul Jang, Velu Saraswathy Keun-Joo Byun, (2007), “An estimation of the diffusivity of silica fume concrete” – Deterioration and durability of concrete structures mainly depend on diffusivity and permeability of concrete. Silica fume (SF) influences concrete diffusivity in several ways. As a mineral admixture for high performance concrete, SF develops diffusivity and permeability of concrete as well as strength by densifying the microstructure of interfacial transition zone (ITZ) of concrete and by producing less diffusible and less permeable pozzolanic CSH gel than conventional CSH gel of normal concrete during cement hydration and also reducing the overall (bulk and ITZ) capillary porosity for fixed degree of cement hydration. Based on a microstructure model, a procedure for predicting the diffusivity of high strength SF concrete is developed by considering water-to-binder ratio, SF replacement ratio, and degree of hydration as major influencing factors. Results of the diffusivity calculated using the procedure is verified with results of several experiments. Subsequently, effects of SF on the diffusivity of concrete are evaluated. Finally, an optimum SF replacement ratio which can reduce reasonable diffusivity of concrete is proposed for durable concrete.

N. Yazdani and et al. (2008), “Accelerated Curing of Silica-Fume Concrete” – Silica fume is a common addition to high-performance concrete mix designs. The use of silica fume in concrete leads to increased water demand. For this reason, Florida Department of Transportation (FDOT) allows only a 72-h continuous moist cure process for concrete containing silica fume. Accelerated curing has been shown to be effective in producing high-performance characteristics at early ages in silica-fume concrete.

However, the heat greatly increases the moisture loss from exposed surfaces, which may cause shrinkage problems. An experimental study was undertaken to determine the feasibility of steam curing of FDOT concrete with silicafume in order to reduce precast turnaround time. Various steam-curing durations were utilized with small laboratory specimens. The concrete compressive strength, surface resistivity, and shrinkage were determined for various durations of steam curing. Results indicate that steam cured silica-fume concrete met all FDOT requirements for the 12, 18, and 24 h of curing periods. All steam cured samples demonstrated excellent durability up to 1 year of age. It was recommended that FDOT allow 12 h steam curing for concrete with silicafume.

By Safwan A. Khedr and et al. (1995), "Resistance of Silica-Fume Concrete to Corrosion-Related Damage" – The effectiveness of silica-fume concrete in resisting damage caused by corrosion of embedded steel has been investigated using an accelerated impressed voltage-testing setup. The silica-fume concrete included 0, 10, 15, 20, and 25% silica as equal replacement of ordinary portland cement. Concrete samples were cured in either fresh water or 4% NaCl saline water for a 7- or 2X-day curing period. Samples were saturated surface-dry at the beginning of the accelerated-corrosion testing to simulate actual conditions of superstructures. A susceptibility-to-corrosion (STC) index was calculated from test results. The setup and index have the potential of being used in a concrete-mix design approach that directly considers exposure to corrosive environments. The performance of silica-fume concrete in resisting damage caused by corrosion was improved. This improvement was optimal at a silica-fume dosage of 15%, and found to be several times better than the control mix. It was most significant at 2X-day curing, when pozzolanic action had a chance to take place. Electrical resistivity was higher for silica-fume concrete, but alone could not characterize the concrete's resistance to corrosion damage.

Ahmed Shuraim and et al. (2016), "Coupled Effect of Coarse Aggregate Type and Silica Fume on Creep Coefficients of High-Strength Concrete" – Standard concrete creep prediction models are essential for structural design; however, it would be unrealistic to expect accurate prediction results without calibration and validations through experimental studies involving local materials and conditions. This paper reports on the long-term creep of high-strength concrete based on experimental work of six independent concrete mixtures involving three types of aggregate, where three mixtures of them incorporated 10% silica fume. Creep testing was conducted with consideration of standard guidelines for loading and strain measurements for up to 2.5 years. Creep coefficients computed from measured strains indicated a substantial influence of the silica fume and aggregate types. The study found that two of the examined models were capable of producing reasonable predictions of the creep for concretes without silica fume. On the other hand, the a current industry model showed reasonable prediction of the creep of concretes with silica fume while underestimating creep for concretes without silica fume. Finally, a mixed formulation model with features from two of the models is proposed and calibrated for concretes with or without silica fume.

Chao-Shun Chang and et al. (2008), "Research on the Shrinkage Deformation and Crack Development of High-Strength High-Performance Concrete Containing Silica Fume" – High-strength high-performance concrete containing silica fume may easily cause cracking at early age. In this research, self designed edge restrained plate specimens of 600 mm × 600 mm × 100 mm in dimension were cast with silica fume concrete and embedded optic fiber sensor (SOFO) for tests, which include image analysis, crack development observation, and continuously detection of the shrinkage deformation of concrete at early age. Test results indicated that the shrinkage deformation of concrete at the age of 1-3 hours is 0.01 mm, equal to a strain of 20×10-6 (mm/mm) or a tensile stress of about 2.4 MPa, so the plastic cracking may occur within one hour. The shrinkage deformation of concrete at the age of 3-12 hours increased to a strain of 278×10-6 (mm/mm), indicating a relatively great growing rate of crack development. After the age of 12 hours, the volume change tends to a stable situation that the shrinkage crack will occur only when the shrinkage stress becomes greater than the corresponding tensile strength of concrete.

Seyedhamed Sadati and et al. (2015), "Long-term performance of concrete surface coatings in soil exposure of marine environments" – Given the time-dependent microstructural modifications in cement matrix, long-term monitoring of concrete in natural exposures will be necessary. The present research addresses the long-term performance of concrete specimens embedded in coastal soil of a harsh marine environment for 88 months. Chloride ion diffusion, binding capacity, and effects of carbonation and surface coatings were investigated for concrete mixtures with up to 12.5% silica fume (SF) and water-to-cementitious materials ratios (w/cm) of 0.4 and 0.5. Three types of surface coatings, including bitumen and rubber emulsion, polymer modified cementitious coating, and polyurethane, were also incorporated. It was observed that concentration of bound chloride ion is decreasing as a result of an increase in SF content from 0 to 12.5% and increasing the w/cm from 0.4 to 0.5. Slight carbonation was observed at 88 months; with carbonation depths limited to 5.5 mm. Decrease in chloride binding capacity was observed in carbonated areas. Depth of concrete cover to reach 50 and 100 years of service life was calculated. It was observed that a concrete cover of 200 mm can secure 100 years of service life while incorporating a concrete mixture with w/cm of 0.5 and 100% portland cement. The required thickness of cover was reduced to 35 mm in the case of the mixture cast with 12.5% SF and w/cm of 0.4. Coating equivalency lines were developed to compare the efficiency of the investigated coatings with corresponding combinations of w/cm and SF replacement level.

B.B. Sabir, (1997), "Mechanical properties and frost resistance of silica fume concrete" – Freeze-thaw tests were carried out on air-entrained and non-air-entrained concrete prisms containing different dosages of condensed silica fume (CSF). Six concrete mixes were made incorporating 0, 5 and 10% CSF as partial replacements for OPC. The performance of the concrete prisms exposed to 210 cycles of freezing and thawing was assessed from weight, length, resonance frequency and pulse velocity measurements of the test specimens before and after freezing and thawing. Tests were also conducted to determine the compressive and flexural strengths and the static modulus of elasticity. Although the control concrete gave better durability factors (92%) than those obtained for the CSF concrete (85%), the physical appearance of the CSF prisms exhibited less scaling.

Marlova P. Kulakowski, (2009), "Carbonation-induced reinforcement corrosion in silica fume concrete" – This study presents the results of carbonation depth and carbonation-induced reinforcement corrosion in concrete samples with silica fume additions of up to 20% and water/binder ratios ranging from 0.30 to 0.80. The behavior of the additions is determined by the w/b ratios. For w/b ratios lower or equal to 0.45-0.50, carbonation processes in these materials are controlled by the porosity of the material and the consumption of Ca(OH)2 has a negligible effect on carbonation. For higher w/b ratios, the consumption of Ca(OH)2 plays a significant role. At the same time, the results of reinforcement corrosion indicate that the effect of silica fume additions depends on their concentration. In concentrations equal to or lower than 10%, silica fume will not reduce corrosion resistance and it may actually increase it when used in concentrations below this level. When used in concentrations greater than 10%, silica fume increases the potential for carbonation-induced reinforcement corrosion.

III. CONCLUSION

The utilization of the industrial by product and other natural minerals as supplementary cementitious materials has been investigated widely for recent years. The work reviewed demonstrates that slica fume is an effective supplementary cementitious material and this material are effective in consumption of Port landite and helps in early strength and has considerable effect in long term strength, slica fumes helps in filling the pore and thereby reducing pore structures in cement paste. The cost and environmental impact of the slica is comparatively less compared to OPC. Wider realization of the benefits of slica in concrete will lead to greater demands and this will leads to cost effectiveness and reduces the environmental impacts due to cement industry.

IV. REFERENCES

[1]. A.M. Neville & J.J. Brooks (Concrete Technology)

[2]. ACI Committee 226 1987 Silica fume in concrete - a report ACI Materials Journal, March-April, pp.158-166

[3]. Ahmed Shuraim, Fahid Aslam, Raja Rizwan Hussain and Abdulrahman M. Alhozaimy, (2016), “Coupled Effect of Coarse Aggregate Type and Silica Fume on Creep Coefficients of High-Strength Concrete”, Journal of Materials in Civil Engineering, July 2016, 28(12): 04016159.

[4]. Ajileye (2012). Investigations on Micro silica (Silica Fume) As Partial Cement Replacement in Concrete, Global Journal of Researches in Engineering Civil and Structural engineering.

[5]. Amudhavalli, N. K. & Mathew, J. (2012). Effect of silica fume on strength and durability parameters of concrete. International Journal of Engineering Sciences & Emerging Technologies.

[6]. B.B. Sabir, (1997), “Mechanical properties and frost resistance of silica fume concrete”, Cement and Concrete Composites, Volume 19, Issue 4, 1997, Pages 285-294. https://doi.org/10.1016/S0958-9465(97)00020-6.

[7]. Bhikshma (2009) Asian journal of Civil engineering (Building & Housing).

[8]. Bradley-Williams, T.S. 1986 The production of micro silica Concrete Magazine, Vol.20, no.8, pp.17-18.

[9]. By Safwan A. Khedr,1 Member, ASCE, and Ahmed F. Idriss2, (1995), “Resistance of Silica-Fume Concrete to Corrosion-Related Damage”, Journal of Materials in Civil Engineering, May 1995, 7(2): 102-107.

[10]. C.D. Atis*, F. Ozcan, A. Kılıc, O. Karahan, C. Bilim, M.H. Severcan, (2005), “Influence of dry and wet curing conditions on compressive strength of silica fume concrete”, Building and Environment, 40: 1678–1683.

[11]. Cabrera, J.G. and Claisse, P.A., (2013), “Measurement of chloride penetration into silica fume concrete”, Cement and Concrete Composites,12 (3): 157-161.

[12]. Cakir 2014 Influence of Silica fumes on mechanical and physical properties of concrete Housing and Building National research center (HRBC) Journal.

[13]. Canan Tasdemir, Mehmet A. Tasdemir, Frank D. Lydon, Ben I.G. Barr, (1996), “Effects of silica fume and aggregate size on the brittleness of concrete”, Cement and Concrete Research, Volume 26, Issue 1, January 1996, Pages 63-68.

[14]. Chao-Shun Chang, Chung-Hao Wu, Tsong Yen, Tsao-Hua Hsu, (2008), “Research on the Shrinkage Deformation and Crack

Development of High-Strength High-Performance Concrete Containing Silica Fume", October 2008.
[15]. Ghutke, V. S. & Bhandari, P.S. (2014). Influence of silica fume on concrete. IOSR Journal of Mechanical and Civil Engineering.
[16]. Ha-Won Song, Jong-Chul Jang, Velu Saraswathy Keun-Joo Byun, (2007), "An estimation of the diffusivity of silica fume concrete", Building and Environment, Volume 42, Issue 3, March 2007, Pages 1358-1367.
[17]. High performance concrete by Sh ahmed, Sp shah
[18]. Houssam A. Toutanjib, *, Ziad Bayasia, (1999), "Effect of curing procedures on properties of silica fume concrete", Cement and Concrete Research, 29: 497–501.
[19]. M.L. Gambhir (concrete technology)
[20]. Marlova P. Kulakowskia,*, Fernanda M. Pereirab, Denise C. C. Dal Molinc, (2009), "Carbonation-Induced Reinforcement Corrosion in Silica Fume Concrete", Construction and Building Materials, March 2009.
[21]. N. Yazdani, F.ASCE1; M. Filsaime2; and S. Islam3, (2008), "Accelerated Curing of Silica-Fume Concrete", Journal of Materials in Civil Engineering, AUGUST 2008, 20(8): 521-529.
[22]. Pradhan & Dutta, D. (2013). Effects of Silica Fume in Conventional Concrete. International Journal of Engineering Research and Applications.
[23]. Roy, D. K. (2012). Effect of Partial Replacement of Cement by Silica Fume on Hardened Concrete. International Journal of Emerging Technology and Advanced Engineering.
[24]. S. Bhanjaa, B. Senguptab, (2002), "Investigations on the compressive strength of silica fume concrete using statistical methods", Cement and Concrete Research, Volume 32, Issue 9, September 2002, pp. 1391-1394.
[25]. Sasikumar (2016). Experimental Investigation on Properties of Silica Fumes as a Partial Replacement of Cement. International Journal of Innovative Research in Science.
[26]. Seyedhamed Sadati, Mahdi Arezoumandi, Mohammad Shekarchi, (2015), "Long-term performance of concrete surface coatings in soil exposure of marine environments", July 2015, Construction and Building Materials 94(10):656-663, DOI:10.1016/j.conbuildmat.2015 .07.094.
[27]. Sharma & Seema (2012). Effect of partial replacement of cement with silica fume on compressive strength of concrete. International journal of research in technology and management.
[28]. Silica fume user manual 2.
[29]. Smita Sahooa, Pravat Kumar Parhia,*, Bikash Chandra Pandab, (2021), "Durability properties of concrete with silica fume and rice husk ash", Cleaner Engineering and Technology, 2: 100067, pp. 1-10, https://doi.org/10.1016/ j.clet. 2021.100067.
[30]. Yunsheng Xu, D.D.L. Chung *, (1999), "Improving the workability and strength of silica fume concrete by using silane-treated silica fume", Cement and Concrete Research, 29: 451–453.

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