BEHAVIOUR OF HIGH PERFOMANCE CONCRETE WITH MICRO SILICA AND FLYASH

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ABSTRACT

Silica fume or microsilica is a byproduct of the reduction of high-purity quartz with cool in electric furnaces in the production of silicon and ferrosilicon alloys. Silica fume is also collected as a byproduct in the production of other silicon alloys such as ferrochromium, ferromanganese, Ferro magnesium, and calcium silicon. Before the mid – 1970s, nearly all silica fume was discharged into the atmosphere, After environmental concerns necessitated the collection and land filling of silica fume, it became economically justified to use silica fume in various application. Silica fume consists of very fine vitreous particles with a surface area ranging from 60,000 to 150,000 ft^2/lb or 13,000 to 30,000 m^2/kg when measured by nitrogen absorption techniques, with particles approximately 100 times smaller than the average cement particle. Because of its extreme fineness and hi silica content, Silica fume is a highly effective pozzolanic material. Silica fume is used in concrete to improve its properties. It has been found that therefore helps in protecting. Reinforced concrete is a widely used, versatile, economical and generally durable construction material. Premature deterioration of reinforced concrete structure is however, a subject that is currently of great concern. Durability of concrete has become an integral part of the design phase of project. Proper design detailing, selection of the mix and materials and ensuring proper practice of concreting are the vehicles of achieving durable structure. Addition mineral admixture such as silica fume, fly ash and ground granulated blast furnace slag in concrete improves the durability of concrete. This study investigate the effect of silica fume on the strength and permeability characteristic of high performance concrete in normal condition and aggressive environment. High performance silica fume concrete provides enhanced resistant to chemical attack and has better durability and impermeability. Silica fume as an admixture in concrete has opened up one more chapter on the advancement in concrete technology. The use of silica fume in conjunction with super plasticizer has been the backbone of modern high performance concrete The aim of this study was to investigate the possibility of developing high performance concrete (HPC) using silica fume (SF) at water cement ratio of 0.45 and 0.50 were considered. The test specimens are coasted and cured unto 7 to 28 days. At a normal temperature and the compressive strength, modules of elasticity and initial surface absorption (ISA) of hardened concrete were determined in the laboratory.Tthe test results will be compared.

Keywords : *Flyash, High Performance Concrete, Strength, Micro Silica, Super Plasticizer***.**

I. INTRODUCTION

The large scale production of cement has imposed many environmental problems on one hand and unrestricted depletion of natural resources on the other hand. This threat to our ecology has led to many investigations in the usage of industrial by-products as supplementary cementations material in making concrete. Another problem in this fast growing world is to encompass the durability and the strength of the structures.High Performance Concrete (HPC) has been developed over the last two decades, and was primarily introduced through private sector architectural design and construction such as high rises and parking garages. Public agencies tend to be more conservative than the private sector when it comes to changing specifications, but the public sector now is committed to incorporating this technology in the field.By using of by-products such as silica fume and fly ash with super plasticizer we can achieve high performance concrete, which possess high workability, high strength, and high modulus of elasticity, high density, high dimensional stability, low permeability and resistance to chemical attack. HPC is often called "durable" concrete because its strength and impermeability to chloride penetration makes it last much longer than conventional concrete.High-strength and high-performance concrete are widely used throughout the world and to produce them it is necessary to reduce the water/binder ratio and increase the binder content. Super plasticizers are used in these concretes to achieve the required workability;

moreover, different kinds of cement replacement materials are usually added to them because a low porosity and permeability are desirable. Silica fume is the one of the most popular pozzolanas, whose addition to concrete mixtures results in lower porosity, permeability and bleeding because their oxides (SiO_2) react with and consume calcium hydroxides, which is produced by the hydration of ordinary Portland cement. The main results of pozzolanic reactions are: lower heat liberation and strength development; lime-consuming activity; smaller pore size distribution.In HPC, materials and admixtures are carefully selected and proportioned to form high early strengths, high ultimate strengths and high durability beyond conventional concrete.

1.1 OBJECTIVE

- The main objective of the present investigation is to study the behavior of high performance reinforced concrete beams (replacement of cement with silica fume and fly ash).
- To study the mechanical properties of cube, cylinder and prisms proportioned with silica fume and fly ash.

2. LITERATURE REVIEW

1.“Durability of Ternary Blend Concrete with Silica Fume and Blast-Furnace Slag:Laboratory and Outdoor Exposure Site Studies” by Roland Bleszynski. He concluded that the combination of SF and blast-furnace slag offers increased resistance to ASR expansion and chloride ingress than the use of one of these materials alone.
2. “Effect of silica fume on cement hydration and temperature rise of concrete in tropical environment” by M. H. Zhanga; He concluded that the relatively high curing temperatures the degree of cement hydration in the paste with silica fume was lower than that in the control cement paste at early ages. However, the pozzolanic reaction started even before 24 hrs after water was added.
3. “Microsilica– characterization of an unique additive**”** *By Elkem AS,* He conclude that silica fume, is not a hazardous substance. When applied as advised it is unlikely to acquire adverse lung diseases. There is insufficient evidence for the carcinogenicity of silica fume. Upon long term exposure to microsilica dust at concentrations above recommended occupational exposure limits chronic obstructive pulmonary disease is suspected. Dust protection masks should therefore be worn when handling dry microsilica.

3. EXPERIMENTAL PROGRAMME

3.1 SILICA FUME

Micro silica**,** also known as Silica fume, is a byproduct of producing silicon metal or ferrosilicon alloys. Micro silica consists primarily of amorphous (non-crystalline) silicon dioxide (SiO_2). The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Because of its fine particles, large surface area, and the high SiO_2 content, silica fume is a very reactive pozzolan when used in concrete. It has been found that Micro silica improves compressive strength, bond strength, and abrasion resistance; reduces permeability; and therefore helps in protecting reinforcing steel from corrosion. Micro silica is available in two forms - densified and undensified. Densified Micro silica is most popularly used in concrete construction. It is produced by tumbling undensified micro silica particles in a silo, to form weak agglomerates with bulk densities between 400-720 kg/m^3. Our Micro silica is genuine, not adulterated, directly collected from Ferrosilicon & Silicon Metal factories. They have stable SiO_2 content and high Pozzolanic Strength Activity. According to SiO^2 content, our Micro silica range from 85% to 97%.Concrete with MICRO SILICA can be effectively used to build marine structures like ports and dams because of the array of advantages it offers – like higher strength and durability, low permeability, reduced damage due to chloride and chemical attacks, protection from steel corrosion and extended service life of the structure.Micro silica or silica fume results from the production of silicon or silicon bearing metal alloy and is collected from the exhaust gases. Silica fume reacts with calcium hydroxide in the presence of water to form cementing compounds consisting of calcium silicate hydrate resulting in well packed concrete mix. Thus, micro silica is a highly efficient pozzolanic material and can be used as a replacement of cement in concrete to improve the efficiency of the binder paste and there by impart favorable properties to cement concrete.

3.2 FLYASH

Flyash is one of the promising pozzolanic materials that can be blended with Portland cement for the production of durable concrete and at the same time it is a value added product. Addition of flyash to Portland cement not only improves the strength of concrete, but also forms a calcium silicate hydrate (CSH) gel around the cement particles which is highly dense and less porous. This may increase the strength of concrete against cracking. The use of Flyash to replace a portion of Cement has resulted in significant savings in the cost of Cement production. Micro silica is another supplementary cementations material to increase the strength. The strength of the concrete alone is not sufficient, the degree of harshness of the environmental conditions to which concrete is exposed over its entire life is equally important. Therefore, both strength and durability have to be considered at the design stage. So far a systematic and detailed investigation on the corrosion performance of flyash blended concrete and micro silica concrete is very scarce. In the present investigation, a realistic approach has been made using different techniques. Corrosion performance was evaluated using rapid chloride ion permeation test and impressed voltage test and potential-time studies and the results were discussed.

Table 3.1: Chemical Properties of Flyash

Chemical properties	IS:3812-1981	Fly ash MTPP
$SiO_2+Al_2O_3+Fe_2O_3$,min% by mass	70.0	90.5
SiO_2, min% by mass	35.0	58
CaO max % by mass	5.0	3.6
SO_3, max % by mass	2.75	1.8
Na_2O, max % by mass	1.5	2
L.O.I, max 5 by mass	12.0	2
MgO, max %by mass	5.0	1.91

PROPORTIONING OF CONCRETE

Table 3.2: Mix ratio details

Water	Cement	Fine aggregate	Coarse aggregate
148.61	571.57	610.27	1171.8
0.26	1	1.06	2.05

Table 3.3: Mix Proportions

Mix	**SF (%)**	**FLY ASH (%)**	**Cement (kg/m^3)**	**SF (kg/m^3)**	**FLY ASH (kg/m^3)**	**Fine Aggregate (kg/m^3)**	**Coarse Aggregate (kg/m^3)**	**SP %**
M1	0	0	571.57	0		610.27	1171.8	0.5
M2	5	0	542.99	28.58		610.27	1171.8	0.5
M3	10	0	514.41	57.16		610.27	1171.8	0.5
M4	15	0	485.83	85.74		610.27	1171.8	0.5
M5	5	10	485.83	28.58	57.16	610.27	1171.8	1
M6	10	10	457.26	57.16	57.16	610.27	1171.8	1
M7	15	10	428.68	85.74	57.16	610.27	1171.8	1

Table 3.4: Types of tests and specimen sizes

S.No	Type of Tests	Properties studied	No of specimens	Specimen size
1	Concrete strength related properties	Compressive strength	42	150 x 150 x 150 mm cubes
		Flexural strength	21	100 x 100 x 500 mm prisms
		Split tensile strength	21	100 x 300 mm cylinders

Table 3.5: Compressive Strength Test Results

Mix	% of silica fume	% of Flyash	SP %	7days (MPa)	28days (MPa)
M1	0	0	0.5	42.33	54.67
M2	5	0	0.5	40.67	55.00
M3	10	0	0.5	44.33	61.33
M4	15	0	0.5	39.67	56.33
M5	5	10	1	42.33	58.67
M6	10	10	1	39.33	57.64
M7	15	10	1	41.00	55.34

Table 3.6: Split Tensile Strength Result

Mix	% of silica fume	% of Flyash	SP %	28 Days (MPa)
M1	0	0	0.5	4.98
M2	5	0	0.5	5.03
M3	10	0	0.5	5.90
M4	15	0	0.5	5.02
M5	5	10	1	5.62
M6	10	10	1	5.41
M7	15	10	1	5.19

Table 3.7: Flexural Strength Result

Mix	% of silica fume	% of Flyash	SP %	28 Days (MPa)
M1	0	0	0.5	4.59
M2	5	0	0.5	5.13
M3	10	0	0.5	5.24
M4	15	0	0.5	5.04
M5	5	10	1	5.11
M6	10	10	1	5.20
M7	15	10	1	5.09

4. RESULT AND DISCUSSION

- The maximum cube compressive strength is obtained for Mix M3 with 10% of silica fume.
- The maximum split tensile strength is obtained for Mix M3 with 10% of silica fume. Its 28 days strength is 5.90MPa.
- The maximum flexural strength is obtained for Mix M3 with 10% of silica fume. Its 28 days strength is 5.24MPa.
- The test indicates that when more pozzolanic material is added to concrete, the Water Absorption will reduce

5. CONCLUSION

In this study, the specific gravity, fineness modulus, moisture content of cement, Silica fume, fine aggregate and coarse aggregate are analyzed. Using this properties mix design is calculated.

- The super plasticizer demand of concrete containing fly ash and silica fume increases with increasing amount of fly ash and silica fume. The increase is primarily due to the high surface area of the fly ash and silica fume.
- Fresh concrete containing fly ash and silica fume is more cohesive and less prone to segregation.
- The compressive strength of high performance concrete containing 10% of silica fume is 10.85% higher than the normal concrete.
- The split tensile strength of high performance concrete containing 10% of silica fume is 15.59% higher than the normal concrete.
- The flexural strength of high performance concrete containing 10% of silica fume is 22.80% higher than the normal concrete.
- As the age of concrete increases, the compressive strength also increases. Silica fume concrete attains high strength than silica fume with flyash concrete.

REFERENCE

1. Neville A.M, “High performance concrete” Journal of materials and structures,1988.
2. B.V.B Pai “HPC mixes-some thoughts on testing” TCDC international workshop at SERC Chennai,April 1997.
3. Ziad Bayasi and Jing Zhou “properties of silica fume concrete and mortar” ACI materials, Journal july – August 1993.
4. M.Khalid,S.P.Mehrotra,M.L.Verma, “Performance of multi blend cement concrete under aggressive environment”, The Indian concrete journal Jan2002.
5. S.J.Williamson and L.A.Clark, “The influence of the permeability of concrete on reinforcement corrosion”, Magazine of concrete research 2001.
6. Nakin Suksawang, Hani H. Nassif and Padit Tanchan (2006) “Comparison of Elastic Modulus Equations for High Performance Concrete (HPC) with Pozzolanic Materials” “International Conference on Pozzolan, Concrete and Geopolymer Khon Kaen, Thailand, May 24-25, (2006)” page no.237-246.

7. D. Mostofinejad and M. Nozhati(2005) "Prediction of the Modulus of Elasticity of High Strength Concrete" "Iranian Journal of Science & Technology, Transaction B, Engineering, Vol. 29, No. B3(2005)" page no.311-321.
8. H. Abdul Razak. and H.S. Wong (2004) "Re-Evaluation of Strength and Stiffness Relationships for High-Strength Concrete""Asian Journal of Civil Engineering (building and housing) Vol. 5, Nos 1-2(2004)" page no. 85-99.
9. S. Bhanjaa,, B. Sengupta(2004)"Influence of silica fume on the tensile strength of concrete" "Cement and Concrete Research 35 (2005)" page no.743–747.
10. M. Mazloom , A.A. Ramezanianpour , J.J. Brooks (2004) "Effect of silica fume on mechanical properties of high-strength concrete" "Cement & Concrete Composites 26 (2004)" page no. 347–357.
11. Ji Yajun, Jong Herman Cahyadi(2003) "Effects of densified silica fume on microstructure and compressivestrength of blended cement pastes" "Cement and Concrete Research 33(2003)" page no. 1543–1548.
12. J.M.R. Dotto, A.G. de Abreu, D.C.C. Dal Molin, I.L. Meuller (2003) "Influence of silica fume addition on concretes physical propertiesand on corrosion behaviour of reinforcement bars" "Cement & Concrete Composites 26 (2004)" page no.31–39.
13. B.K. Raghu Prasad, G. Appa Rao and R. Patnaik (2001)"Influence of Strength on the Fracture Energy of HPC" " Transactions Paper # 1743(2001)" pg no.1-12.
14. M.I. Khan, C.J. Lynsdale(2001) "Strength, permeability, and carbonation of high-performance concrete" "Cement and Concrete Research 32 (2002)" page no. 123–131.
15. Duval and E.H. Kadri(1998) "Influence of Silica fume on the Workability and the Compressive Strength of High-Performance Concretes" "Cement and Concrete Research, Vol.28,No.4(1998)"pageno.533–547.