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Effects of Self Compacting Concrete Using the Discrete Models as Binary & Ternary Blends Of Silica Fumes and the Nanomaterials – A Review

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ABSTRACT
The effect of using nanosized[4],[5] pozzolanic materials [1], [12], 14] like Fly ash(FA) [3], Metakeolin (MK) [8],Silica fume(SF)[6],Rise husk ash(RHA)[14],Ground granulated blust furnace slag (GGBFS)[2] etc. as partial replacement with dry weight of Ordinary Portland Cement(OPC) to enhance the strength, durability, workability of concrete. The test results of fresh and the hardened properties of Self compacting concrete (SCC)[8],[19] incorporating pozzolanic materials at various percentage by fixing the Water to Binder (i.e. powder)ratio(w/b) of 0.45. The effects of pozzolanic materials properties of SCC were investigated by comparing the test results. Various tests [4],[5],[9] were conducted on fresh SCC like the slump flow, L-box passing ability of the SCC mixtures and T_{500}mm slump flow time were also done. Compressive strength test [9] along with the Initial surface absorption test(ISAT) and the Capillary suction test(CST)[7] were also performed on the hardened SCC[8]

Key Notes: *SCC, Discrete Models, Nanomaterials, Pozzolanic Material, OPC, w/b ratio etc.*

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I. INTRODUCTION

Nanoscience[4],[5],[9] and nanotechnology primarily deals with the synthesis, characterization, exploration, and exploitation of nanostructured materials[5]. These materials are characterized by at least one external dimension is in the size range from 1-100 nm. 1nm is equal to 10^{-9} m. A nanometer is one millionth of a millimetre. Approximately one lace times smaller than the diameter of a human hair. Scientists are also unable to established a proper definition of nanomaterials but they agreed about their tiny size. Most nanoscales materials are too small to be seen with the necked eye and even with conventional lab microscope also. They can be seen with powerful microscope like Atomic Force Microscopy(AFM), or Scanning Tunnelling Microscope(STM), or X-ray Diffraction (XRD) etc. Nanomaterials can be created both naturally and artificially. Naturally created nanomaterials are zeolite, burned clay, volcanic ash etc. and artificially created nanomaterials are FA, RHA, GGBS (it is simply called slag), SF, MK etc. The physical and chemical properties of nanomaterials can differ significantly from those of the bulk materials of the same composition. For an example when MK is used as partial replacement of OPC, it reacts with calcium hydroxide to form supplementary Calcium Silicate Hydrate(C-S-H) which is similar with the composition and structure to those obtained from OPC. The nano-materials are of twofold : one is the bottom-up approach, that is, the miniaturization of the components, as articulated by Richard P. Feynman, who stated lectured at the California Institute of Technology in 1959 that “there is plenty of room at the bottom” ; and the other is the self-assembly of molecular components, where each nano structured component becomes part of a superstructure. The prediction of Feynman to a large extend have been realised today as we celebrated the golden jubilee of nanotechnology on Dec. 29, 2009. Nanotechnology have effectively applied in plain and reinforced concrete structure due to the overall improvement of various properties of concrete like flow ability, compression, tension and torsion. Concrete is a composite material of aggregates and binders where binding materials are PC, pozzolanic materials and water.

II. SELF COMPACYINGT CONCRETE (SCC)

SCC[8],[19] is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature make it placing at confined sections with reinforcement. Another advantage of SCC is that less time required to place in large sections. Mixture proportions for SCC differ from those of ordinary concrete, in that the former has more powder content and less coarse aggregate. Aggregate Shape For SCC, rounded aggregates would provide a better flowability and less blocking potential for a given water-to-powder ratio, compared to angular and semi-rounded aggregates. Moreover, the presence of flaky and elongated particles causes of blocking problems in confined areas, and also increase the minimum yield stress (rheology terms are discussed in the next section).

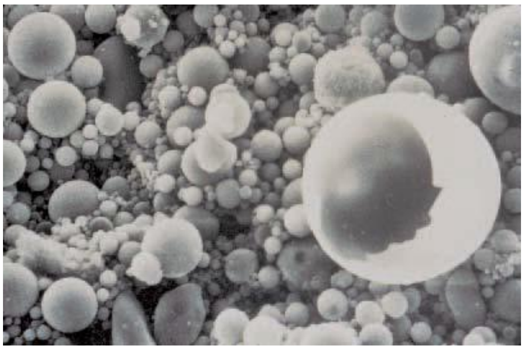

Fig. 1: SEM micrograph of FA particles
(Kosmatka et. al. 2003)

III. VISCOSITY MODIFYING AGENTS(VMA)

The conventional method of improving the stability of flowing SCC is to increase the fines content by using a large amount of filler, reactive or inert. Of late, however, attempts are being made to reduce the fines content (and paste content) to the levels of normal concrete (in doing so, reducing the potential for creep and shrinkage) and use viscosity modifying agents(VMAs)[20],[21] to improve the stability. Current research shows that SCC produced with low powder content and VMA had similar fresh concrete properties as SCC with high powder contents produced without VMA. VMAs have been in use for a long time. They were mainly used for underwater concreting in the past, but are now also used in self-compacting concrete. Most VMAs have polysaccharides as

active ingredient; however, some starches could also be appropriate for control of viscosity in SCC . The sequence of addition of VMA and superplasticizer into the concrete mixture is important. If VMA is added before the superplasticizer, it swells in water and it becomes difficult to produce flowing concrete. To avoid this problem, VMA should be added after the superplasticizer has come into contact with the cement particles. Another method of addition is to disperse the superplasticizer in mixing water, and then add VMA to this mixture.

IV. METAKAOLIN(MK)

The un-purified materials thermally activated ordinary clay and kaolin clay are often called MK, and it showed few amount of pozzolanic properties. But the removal of un-reactive impurities with the help of water processing ordinary MK can changed into 100% reactive pozzolanic materials. Such type of MK white or cream in colour and performed as a High Reactivity Metakaolin (HRM). This HRM shows high pozzolanic reactivy and reduction in calcium hydroxide[$Ca(OH)_2$]even as early as one day. It is also observed that the cement paste undergoes distinct densification and at the same time improved in strength and decrese in permeability. The role of MK on the strength, water absorption, permeability, fresh and hardened properties & its fineness & content in SCC was studied by *Wild et. al.[15] Khatib and Clay[16]*. It was found that 20% MK content gave long term strength, decrease in water absorption by capillary action & higher permeability resistance. The compressive strength of SCC also decreased with the increase in the MK amount and with the reduction of its finesses. MK is a dehydroxylated form of the clay mineral kaolinite. MK was grinded in a high speed ball grinding mill and it reduced to a nano scale. The picture of nano metakaolin taken by SEM(Scanning Electron Microscope). But as per *IS: 456-2000* Pozzolanic materials MK having fineness between 70 to 90 m2/N may be used as pozzolanic material in concrete. The resulting material has high pozzolanicity. Hence similar to the other supplementary materials discussed so far, MK is a pozzolanic material, but, unlike the other materials, it is not a by-product because it is made under carefully controlled conditions *(Justice et. al. 2005).* By heating kaolinitic clay, one the richest natural clay minerals, MK is obtained. For the kaolinite to break down and produce an amorphous material for pozzolanic and latent hydraulic reactivity, a temperature between 650 and 900°C is necessary. It is only within this temperature range that the C-S-H in cement paste can be produced as the result of the reaction of MK with $Ca(OH)_2$. Indeed, within the ITZ(Intrafacial Transition Zone), which is

between the paste fractions and aggregate, this reaction is very crucial because it can enhance the strength in MK concrete (*Justice et. al. 2005[23];Poon et. al. 2001[17]*. According to *Wild and Khatip1997[15]; Bentz and Garboczi1991[25]*, it is in this region that a high concentration of aligned $Ca(OH)_2$ crystals can result in increased porosity and lower strength. By reacting to the $Ca(OH)_2$ produced by cement hydration, MK can dandify the structure of the hydrated cement paste. Compared with SF systems, It has been reported that MK systems have a higher initial reactivity due to their higher rates of pozzolanic reaction and $Ca(OH)_2$ consumption *(Poon et. al., 2001)[17]* Moreover, MK incorporation may be the cause of the earlier and faster reaction with $Ca(OH)_2$ *Wild and Khatib 1997[15], Justice et. al. 2005[23]* MK is used as an additive to concrete (approximately 10% of the cement mass) when very high strength and very low permeability are needed in special applications *(Kosmatka et. al., 2003[18]*,. Regarding the physical properties of MK, (*http:// www.metakaolin.com)* The typical chemical properties of MK *Ambroise et. al. 1994[24]*. The uses of MK for various types of concrete are listed as : (1) Glass fiber-reinforced concrete. (2) Fiber cement and ferrocement products. (3) HSC(High Strength Concrete) and HPC(High Performance Concrete) (4) Precast concrete for architectural, civil, industrial, and structural purposes. (5) Pool plasters, repair material, mortars and stuccos.

Fig. 2: Metakaolin powder

V. WATER REDUCERS (PLASTICISERS)

The admixtures are principally surface reaction agent they conform negative charge on individual cement particles ,such that they are kept in a dispersed or suspended state due to inner particle repulsion . (a) To achieve a high strength by decreasing the w/c at the same workability as an admixture free mix. (b)To achieve the same workability by decreasing the cement content so as to reduce the heat of hydration in near conc. (c) To increase the workability,so as to easy placing in proper location .

VI. HIGH RANGE WATER REDUCING ADMIXTURE (HRWRA)

HRWRA are principally surface reactive agents. It produced negative charges into individual cement particles also its hydrated particles dispersed and suspended into inner part repulsion. Thus it conform high mobility to the particles. The HRWRA helps in achieving excellent flow at low water contents and VMA reduces bleeding and improves the stability of the concrete mixture. HRWRA is based on polycarboxylate ethers and typically used plasticize in the mix. It is chemically different from normal plasticizers and it permits 30% reduction of water without reducing the workability. By using of super plasticizers, SCC having high strength and high performance. The following polymers are commonly used as super plasticizers.

i) Sulphonated Melamine Formaldehyde Condensates(SMF)
ii) Sulphonated Napththalane Formaldehyde Condensates(SNF)
iii) Polycarbonate Ester

VII. SUMMERY OF THE LITERATURE REVIEW

Sl. No.	Author & (Year)	Concrete mixture ID (for max. Compressive strength)	Compressive Strength (for 100% OPC)at 28D of curing (MPa)	Only Max. Compressive Strength at 28D of curing (MPa)	%Icrease of Comp. Strn. at 28D
1	*A.Singh et. al. (2004)[26]*	*65% OPC + 30% FA + 5% SF*	*-*	*33.74*	*-*
2	*M.Avaran et.al (2008) [27]*	*80% OPC + 20% R-BSuper plasticizer*	*38.29*	*39.51*	*3.2*
3	*O. Kayali et. al.(2010) [28]*	*90% OPC + 10% SF*	*76.8*	*73.4*	*-4.43*
4	*E.Güneyisi et. al. (2010) [13]*	*85% OPC + 15% MK*	*80*	*99.9*	*25*
5	*B.Bhardwaj et. al. (2010)[30]*	*80% OPC + 10% LS + 10% MK*	*31*	*35.95*	*16*
6	*R. A khan et. al. (2011)[31]*	*70% OPC + 20% F+ 10% MK*	*-*	*41.54*	*--*
7	*Kannan V. et. al. (2012)[32]*	*80% OPC + 20% MK*	*40.77*	*57.17*	*40.23 (at7D)*
8	*F.Soleymaniet.al .(2012)[33]*	*99.5% OPC + 0.5%* Cr_2O_3	*36.8*	*47*	*28*
9	*B. B. Patil et. al.(2012)[34]*	*92.5% OPC + 7.5% HRM*	*63.7*	*69.04*	*8.4*
10	*A. Fathi et. al. (2013)[35]*	*95% OPC + 5% SF*	*76.4*	*80.42*	*5.3*
11	*Shobana K.S et.al.(2013)[36]*	*85% OPC + 15% SF*	*14.49 (For 7 D)*	*14.46 (For 7D)*	*-0.21*

12	*Sadegh Habashi. A et. al. (2014)[37]*	*97% OPC + 3% NS*	*35.5*	*43.5*	*23*
13	*Jainender Sharma. et. al. (2014) [38]*	*80% OPC + 10% LS + 10% MK*	*31.02*	*35.92*	*16*
14	*Chandrakant U. et. al. (2014) [39]*	*90% OPC + 10% MK or 80% OPC + 20% MK*	*--*	*40.66*	*--*
15	*M. Nazeer et. al. (2014)[40]*	*100% OPC*	*56*		*--*
16	*R.Manju et. al. (2014)[41]*	*50% OPC +25% FA + 15% MP + 10% LP*	*25.15*	*42.4*	***69***
17	*K. Kaur et. al. (2015)[42]*	*91.2% OPC + 8% MK+ 0.8% LS*	*56.35*	*65.03*	*15.4*
18	JumahJessicaJaleelV *et.al.(2015) [43]*	*90% OPC + 10% MK*	*40*	*50.2*	*26*
19	*ShaikhMohd Zubair et. al. (2015) [44]*	*75% OPC +15% FA+10% SF*	*--*	*79*	*-*

Table 1: Pricise Of The Literature Review

VIII. CONCLUSION

*R.Manju et.al.(2014)*replace cement with 25 % of FA, 10% LP and 15%MP by the dry weight of OPC,got the max. Comp. Strength which is the height % value in review.

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