International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES),(UGC APPROVED)
Impact Factor: 5.22 (SJIF-2017),e-ISSN:2455-2585
Research Symposium on
"Advancements in Engineering, Science, Management, and Technology"
Volume 5, Special Issue 04, April-2019.

Self-compacting Concrete incorporating Mineral Admixtures: A Review

Rahman Wali[1], Sunil Saharan[2], Chandan sahani[3], Bello safiyanu[4]

[1,2,3,4]Department of Civil Engineering, Sharda University

Abstract: Self-compacting concrete is a type of concrete which is able to consolidate, flow and fill all formwork by its own weight without any external vibration, and pass through very tight places like between reinforcement bars. For preparing SCC mix some additional materials (other than traditional materials) such as chemical and mineral admixtures are also required. In this study, an extensive literature reviews have been conducted on materials proportioning, different percentage of SP dosage and use of recycle aggregates for obtaining suitable fresh and hardened properties of self-compacting concrete. It also presents the effect of various types, various percentage and combination of mineral admixtures on the rheological properties, compressive strength, strain, electrical resistivity and tensile strength of SCC.

Keywords: SCC- Self compacting concrete, EFNARC, VMA-Viscosity modifying agent, Metakaolin

INTRODUCTION

Self-compacting concrete fist developed in japan in early nineteen eighty by professor Okamura, Initially for congested reinforced structures. Mix composition of self- compacting concrete is powder content (cement and mineral admixture i.e. fly ash, GGBS, silica fume, metakaolin, etc.), aggregates (fine and coarse), water and chemical admixture i.e. super plasticizer, viscosity modifying agent and air entraining admixture, etc.

A concrete mix can only be classified as self-compacting concrete if the requirement for all following three workability properties are fulfilled which are filling ability, passing ability and segregation resistance. For this properties we can use: Slump flow test and V-funnel test for flow ability (filling ability), L box test and U- box test for passing ability and V-funnel at T_5 minute for segregation resistance.

Fresh properties of SCC:

I. Filling Ability: to fill the formwork completely by its own weight.
II. Passing Ability: The ability of self-consolidating concrete to flow through tight opening like spacing between reinforcement bare.
III. Segregation Resistance: the ability of SCC to remains uniform throughout the process of transport and placing.

Self-compacting concrete can be prepared by using EFNARC guidelines and specifications. Following are the important acceptance criteria of self-compacting concrete as per EFNARC guidelines:-

I. Slump flow by Abrams cone:- 650mm to 800mm
II. V-Funnel:- 6sec to 12sec
III. V-Funnel @T_5:- 6sec to 15sec
IV. L-Box (h_2/h_1):- 0.8 to 1
V. U-Box (h_2-h_1):- 0mm to 30mm

Advantages of self-compacting concrete: it can placed faster without vibration than conventional concrete, decreasing numbers of skill labours than normal concrete, better surface, easy to place, it can give more durable concrete than normal concrete, increase strength, for very thin concrete sections.

Disadvantages of self-compacting concrete, Costly than conventional concrete, Mix design method and procedure is complicated.

LITERATURE REVIEW

Raju and Kiran kumar (2019) prepared three trials of SCC with superplasticizer (2%, 2.5%, and 3%), water- cement ratio (0.26. 0.28, 0.30 and 0.32), constant: - sand, cement and coarse aggregates 700 kg/m^3, 575 kg/m^3 and 833 kg/m^3, respectively. Second trial passed all the acceptance criteria of SCC and was considered as optimum one, where superplasticizer dosage and water- cement ratio was 2.5% and 0.28, respectively. In this mix, OPC Cement was partially replaced by weight with (4, 8, 12 and 16) % silica fume. They conducted L-box., V-funnel and slump flow test for fresh properties, and cubes, cylinders specimens for hardened properties of self-compacting concrete. SCC Mix with 12% silica fume showed better rheological properties and filling ability, passing ability and stability results were within the acceptable criteria as per EFNARC. They found that compressive strength and splitting tensile strength of SCC with 12% silica fume was higher than other SCC mixes.

Alexandra et al., (2018) prepared two mix proportions of self-compacting concrete, in one mix proportion, they replaced the cement with fly ash and in second with lime stone powder respectively. They conducted Slump flow, T50cm, V-funnel and L-box for workability. The following mix proportions passed all the fresh properties tests i) 350 kg/m^3 cement, 200 l/m^3 water, 0.35 water- powder ratio, 220 kg/m^3 fly ash and Second 410 kg/m^3 cement, 150 l/m^3 water, 160 kg/m^3 filler and 3.17% superplasticizer. Where in second mix proportion 32% water and 7% superplasticizer was required less than first one. It was also found that the compressive strength of fly ash SCC was slightly less in early age but it was much more than SCC with silica fume at lateral ages.

Kanish Kapoor et al., (2016) prepared two series of mixtures proportions, in first series 50% nature coarse aggregates replaced with recycled coarse aggregates and natural fine aggregates was replaced with 0%, 25% and 50% recycle fine aggregates. In second series 100% nature coarse aggregates was replaced with recycled coarse aggregate and nature fine aggregates was replaced with 0%, 25% and 50% recycled fine aggregates. They studied its effect on strength and permeability properties of self-compacting concrete. In both mixes 30% OPC was replacement with fly ash and total powder content and water- powder ratio was constant 615 kg/m^3 and 0.45 respectively. Slump flow, L-box and V- funnel tests were carried out for fresh properties and cubes specimens were casted for water penetration. They observed that generally compressive strength was decreasing with replacements of natural aggregates with recycles aggregates. And reductions of second series were more than first one. Mix design with replacement of 50 % of nature coarse aggregates and 25 % nature fine aggregates with recycled aggregates showed better workability performance. They also observed that water absorption and water penetration depth was increasing with increase in replacement due to old mortar adhered with recycled coarse aggregates but recycled fine aggregates had better permeability results.

Venkatakrishnaiah and Sakthivel (2015) produced self-compacting concrete by using high volume fly ash combined with other mineral admixtures. They prepared three mix designs, in first 50 % cement was replaced with fly ash, in second (50% fly ash, 20% GBBS and 30% cement) were used and in third (50% fly ash, 20% GBBS, 5%silica fume and 25% cement) were used. Total binder material and super-plasticizer dosage were kept constant 600 kg/m^3 and 0.6 % respectively. In all mixes 30% coarse aggregate of maximum size 10 mm and remaining 70% coarse aggregate of size 20 mm were used. In third mix viscosity modify agent was also used. They observed that first mix proportion was more flow-able than other two mix designs. In second mix design use of GBBS enhanced the viscosity of concrete and third mix designs with use of silica fume increased flow-ability of self compacting concrete.

Yaghuob et al., (2015) replaced (0%, 5%, 10% and 15%) OPC with micro silica and studied their impact on properties of self-consolidating light weight concrete. They prepared total eight mix designs in which superplasticizer and water-powder ratio was kept constant 0.2% and 0.5 respectively. Natural sand was replaced with two types of coarse aggregates (Pertile and Leca) and crush lime stone aggregates were used as coarse aggregate. They carried out Slump flow, L-box, U-box, V-funnel and j-ring tests for fresh properties and cubes specimens (10×10×10) cm were casted and tested after 3 days, 7 days, 28 days and 90 days respectively for compressive strength. They found that mix proportion without micro silica was not workable and self- compacting light weight concrete in which they used Leca type of aggregates showed better results than the concrete in which they used pertile type of aggregates. Flow ability and segregation resistance of self compacting concrete was enhanced with 5% micro silica but some values were not in the workability range as per EFNARC standards. Use of 15% silica fume showed better workability performance and maximum compressive strength.

Panda and Bal (2013) performed various trails on mix designs in which 10%, 20%, 30% and 40% natural sand was replaced with recycled aggregates. They studied their effects on fresh and hardened properties of self-compacting concrete and compared with conventional concrete. They prepared six mix designs; one of them was M-25 conventional concrete with nature coarse aggregates, four of them were M-25 self-consolidating concrete. Superplasticizer and viscosity modifying agent was kept constant 0.6% by weight of cement and 0.34% by weight of water respectively. They performed Slump flow test, T50cm, V-funnel and L-box tests for fresh properties of self-compacting concrete. Results of the tests for fresh properties of self-compacting concrete were within the range as per EFNARC standard. They found that the compressive strength of conventional concrete was high at all the ages of curing and compressive strength of self-compacting concrete was decreasing with percent increase coarse aggregate replacement with recycled coarse aggregates. They also found that after days the compressive strength, split tensile and flexural was increased.

Guru et al., (2013) replaced 35% Ordinary Portland cement with class F fly ash and used moderate fines for achievement of cost effective normal strength self- compacting concrete. They prepared three mix designs with different paste volume (36, 37.7 and 38.8)%, coarse aggregates 28% (60% of 20 mm and 40% of 10 mm), water- cement ratio was kept constant 0.36 and superplasticizer and viscosity modify agent were used with different percentage. Slump flow, T50cm, V-funnel and L-box tests were conducted for fresh properties of concrete and cylinders were casted and tested for hardened properties of self-compacting concrete for 28days, 56days and 112days. First two mixes passed all the workability tests but third mix showed better results than other two because of high paste volume (38.8 %) and high fines content (495 kg/m^3). Compressive strength of all mixes was same after 28days but compressive strength after 56 and 112 days was higher than conventional concrete.

Ramanathan et al., (2012) studied the effect of mineral admixture on fresh and hardened properties of self-consolidating concrete. They prepared ten mix designs in which one was reference mix and in rest of them (30, 40 and 50) % cement was replaced with GBBS, fly ash and silica fume, respectively. Fine aggregate, coarse aggregates and water-binder ratio was kept constant at 900 kg/m^3, 600 kg/m^3 and 0.35, respectively with different dosage of superplasticizers. Slump flow, V-funnel, U-box, L-box and T50cm tests were used for fresh properties, cubes, cylinders and prisms for hardened properties of self-compacting concrete. Generally GBBS series had shown better workability results than fly ash and silica fume series but 30% silica fume mixture had high strength and passed all tests of workability so they had selected it as optimum mix design.

Rahmat and yasin (2012) studied the effect of metakaolin on the properties of self compacting concrete. They prepared total 15 mix proportions with three water- powder ratios (0.32, 0.38 and 0.45) and 0%, 5%, 10%, 15% and 20% replacement of cement with metakaolin. Slump flow, T50cm, V-funnel and L-box tests were performed for workability and cubes and cylinders were casted and tested for hardened properties of self-compacting concrete. They found Slump flow and L-box ratio were decreasing with increment in percent replacement of cement with metakaolin. From the results it can be concluded that viscosity modifying agent was not needed in metakaolin mixes. Compressive and splitting tensile strength was much higher in all the ages of curing but in early age it was more significant than later with (10-15) % of metakaolin. They also tested Self-compacting concrete for Ultrasonic Pulse Velocity, water absorption and electrical resistivity and self compacting concrete made with (10-15) % metakaolin showed better performance. From this study, it can be concluded that 10% of metakaolin and lower water- cement ratio can enhance the fresh and hardened properties of self-compacting concrete.

Maghsoudi et al., (2011) used Leca as light weight aggregate for production of self-consolidating light weight concrete and the studied the effect of Leca on hardened properties of self-consolidating light weight concrete. They prepared several mix proportions; out of them two mix passed all the workability criteria of self-compacting concrete. They casted Cube specimens (10×10×10) cm and prism specimens (10×10×45) cm and tested them for compressive strength and modulus of elasticity respectively. Compresive strength and modulus of elasticity of Mix 2 (in which low water-cement ratio, lower water content, high cement content, high silica fume content, low lime stone powder, low superplasticizer dosage, and high quantity of sand was used) were better than Mix 1. They produced self-consolidating light weight concrete of density of 1900 kg/m^3 with the use of Leca but the disadvantages were low compressive strength of 20.5 MPa and 28.5 MPa after 28 days and 90days, respectively.

Khaleel et al., (2011) studied the impact of various types of aggregates (crushed gravel, uncrushed gravel and lime stone), size and their texture on the properties of self-consolidating concrete. They prepared Total 12 mix proportions in which sand was kept constant, various dosages of super-plasticizer were used and 10% ordinary Portland cement was replaced with metakaolin. Fresh properties of all mixtures were in the range as per EFNARC standard. Uncrushed gravel, small maximum size of coarse aggregates showed better results than crushed gravel and lime stone. They assessed that hardened properties like modulus elasticity, compressive and flexural strength were higher of the mixtures which produced with uncrushed aggregates than crushed aggregates because of rough surface of aggregates and small size. Use of Metakaolin enhanced both fresh properties hardened properties of self compacting concrete.

Halit yazici (2007) investigated fresh, hardened and durability properties of self-compacting concrete. He prepared total nine mix designs in which one was control mix and in four mixes cement was replaced with (30%, 40%, 50% and 60%) high volume fly ash and in rest fly ash combined with 10% silica fume were used. Total powder content was 600 kg/m^3. He conducted Slump flow, V-funnel and T50cm for fresh properties and cubes and cylinders specimens used for hardened properties of self-compacting concrete. In general workability tests results were close to each other except in which 50% and 60% fly ash was used which were not acceptable. He observed that compressive strength was decreasing with increase in the amount of Fly ash content. 10% S.F and fly ash showed better compressive, splitting tensile strength and modulus elasticity.

CONCLUSION

Based on the above study, it can be concluded that mineral admixtures (silica fume, fly ash, GBBS, metakaolin, etc) can be used for development of self- compacting concrete. And use of Fly ash can increase the workability more than others mineral admixtures.

Silica fume can be used to produce high strength self-compacting concrete and it also enhances the resistance against bleeding and segregation of fresh concrete. From the above study it can be concluded that the use of Metakaolin can improve early strength more than later ages strength of self-compacting concrete and it can also enhance the viscosity of self compacting concrete without the use of VMA.

From the literature it was also found that the workability and compressive strength of conventional SCC can be increased by the use of chemical and mineral admixture.

REFERENCES

1. Raju and Kirankumar (2019), "Role of Silica Fume in Producing High Strength Self-Compacting", Sustainable Construction and Building Materials, Springer DOI.10.1007/978-981-13-3317
2. Coșa Alexandra, Hegheș Bogdan, Negruțiu Camelia and Zoltan (2018), "Mix design of self-compacting concrete with limestone filler versus", International Conference Interdisciplinarity in Engineering, Procedia Manufacturing 301–308
3. Kanish Kapoor and S. P. Singh (2016), "Water Permeation Properties of Self Compacting Concrete Made with Coarse and Fine Recycled Concrete Aggregates", Int J Civ Eng DOI 10.1007/S40999-016-0062
4. Venkatakrishnaiah and Sakthivel (2015), "Bulk Utilization of Fly ash in Self Compacting Concrete", KSCE Journal of Civil Engineering, E-ISSN 1976-3808
5. Yaghuob Mohammadi, Seyyed Sajjad Mousavi, FarnamRostami, Akbar Danesh and NasimIrani Sarand (2015), "The Effect of Silica Fume on the Properties of Self-Compacted Lightweight Concrete", Current World Environment, Vol. 10(Special Issue 1), 381-388
6. K C Panda and P K Bal (2013), "Properties of self compacting concrete using recycled coarse aggregate", Nirma University International Conference on Engineering, Elsevier 159 – 164
7. Guru Jawahar, Sashidhar, V.Ramana Reddy and J. Annie Peter (2013), "Design of cost-effective M 25 grade of self- compacting concrete", Materials and Design 49 (Elsevier), PP: 687–692
8. P. Ramanathan, Baskar, Muthupriya, and R. Venkatasubramani (2013), "Performance of Self-Compacting Concrete Containing Different Mineral Admixtures", KSCE Journal of Civil Engineering 17(2): 465-472, DOI 10.1007/S12205-013-1882-8

9. Rahmat Madandoust and Yasin Mousavi (2012), "Fresh and hardened properties of self-compacting concrete containing metakaolin", Construction and Building Materials 35 (Elsevier), PP: 752–760.

10. A. A. Maghsoudi, Sh. Mohamadpour and M. Maghsoudi (2011), "Mix design and mechanical properties of self compacting light weight concrete", International Journal of Civil Engineering, Vol. 9, No. 3

11. O. R. Khaleel, S. A. Al-Mishhadani and H. Abdul Razak (2011), "The Effect of Coarse Aggregate on Fresh and Hardened Properties of Self-Compacting Concrete (SCC)", Procedia Engineering 14 Elsevier, PP: 805–813

12. Halit Yazci (2007), "The effect of silica fume and high-volume Class C fly ash on mechanical properties, chloride penetration and freeze–thaw resistance of self-compacting concrete", Construction and Building Materials 22, PP: 456–462

13. Dilpreet Singh and Megha Gupta (2019), "A review on effect of different chemical admixtures on high strength concrete", IJTIMES, E-ISSN 2455-2585

14. Nishant Kumar (2016), "Study on effect of silica fume on of M40 grade of concrete", International Journal of Engineering Research and Technology, Vol. 5, Issue 5

15. Bisakha Chalisey and Nishant Kumar (2019), "Effect of sulphate attack on mechanical properties of engineered cementitious composite concrete: A review," IJTIMES, E-ISSN 2455-2585