

Usage of Mineral Admixtures in Self Compacting Concrete- A Review

S. Arunchaitanya, E. Arunakanthi

Abstract- Self Compacting Concrete (SCC) is a special concrete, which is used to fill congested reinforcement without any vibration. This study mainly focused to know the result of mineral admixtures on self compacting concrete, which are prepared by partial replacement of cement and fine aggregate by mineral admixtures like copper slag, fly ash, silica fume etc.; called as industrial by-products. The objective of this paper is to know the behavior of the SCC, when it is in fresh and hardened states. Fresh and mechanical properties along with permeation characteristics have been discussed.

Keywords: Fly ash, Permeation characteristics, Self Compacting Concrete, Silica fume, Copper slag.

I. INTRODUCTION

SCC is extreme flow-able concrete which is being used to fill congested reinforcement without any vibration. It is eco-friendly by reducing the noise pollution which will form due to concrete vibrating machine and by minimizing labor cost, construction cost, time and improves durability. Even though this concrete becomes popular in civil engineering constructions, it also had some disadvantages like high material cost. SCC has some essential fresh properties they are passing, segregation resistance and filling ability. To acquire these properties concrete should mix with superplasticizers, which makes the concrete as uneconomical. Although material cost is high as discussed, it can be reduced by using industrial waste as alternative for cement and fine aggregate by partial replacement.

II. LITERATURE

M.C.Nataraja, Anvit Gadkar and Giridhar Jogin(2018) Developed a simple procedure to produce self compacting concrete based on the requirement of strength by slight modification to IS 10262:2009. Considered the limits prescribed by EFNARC and investigated on 25 mix proportions to obtain the relationship between compressive strength and water cementitious ratio of SCC. For this method, compressive strength ranges from 20MPa to 60MPa were considered by using poly carboxylic ether based high water reducing agent. It was observed that w/c from 0.47 to 0.37 was sufficient to obtain the strength values between 25 to 60MPa. Fresh properties and strength results occurred by this procedure were in good agreement.

M. Sri Rama Chand, P.Rathish Kumar, P.S.N.R. Giri, G. Rajesh Kumar (2018) investigated the durability, strength and microstructures of SCC by addition of self curing chemicals. Self curing compounds are used to overcome the improper curing and compacting issues. Hydrophilic, Super absorbent polymers and Hydrophobic chemicals can use as self curing compounds. Hydrophilic and Hydrophobic efficiencies were tested on M70 and M50 grade concretes. Polyethylene Glycol 4000, Liquid paraffin wax (LPW) with 0%, 0.1%, 0.5% and 1.0% was used in this study, which includes water retention capacity, compressive strength, RCPT, SEM, XRD, Sorptivity and Porosity tests. Results shows that LPW at 1% doesn't influence the strength of concrete and by using self curing compounds the strength obtained is 90% of the water curing specimen. XRD shows they will not increase the effect of freeze thaw effect and SEM confirmed that microstructure is dense in self curing self compacting concrete.

Athiyamaan. V & G. Mohan Ganesh (2018) Studied about SCC mix design using nan-su method and trail mixes were carried out by using Design of Experiments method (DOE). In trail mixes central composite design was farmed with variables; cement, superplasticizer, w/c, Fine aggregate and coarse aggregate. 33 trail runs were investigated and M16 numbered mix gave optimum results. And also noted that by decreasing coarse aggregate from 750Kg/m³ to 710 kg/m³ increase the rheological properties but signs against the strength, increasing of fine aggregate will results of maximum packing factor.

C. Sashidhar, B.Radhamma, J. Gurujawahar, C. Yedukondalu (2018) Studied about self compacting geopolymer concrete with 50:50 proportions using class F fly ash and GGBS with artificial sand as fine aggregate. EFNARC guidelines are considered for trail mixes to get optimum proportions and 8M, 10M, 12M NaoH issued in the experiment. Various fresh properties like segregation resistance, passing ability and filling ability were examined by using test methods; L-box, T500 slump flow, v-funnel and slump flow. It was observed that by increasing the NaOH morality the fresh properties are decreased and no adverse effect has been marked when self compacting geopolymer concrete mixes prepared with artificial sand.

K Ganesh Babu and B chandrasekhar (2018) worked on high performance self compacting concrete with fly ash of 25%, 35%, 50% and 70% as a cementitious content. Various water powder ratios were used ranging from 0.25-0.72. It was observed that fly ash based SCC ranging from 25-110 Mpa could be produced by replacing 70-25% of cement, charge passing through the specimen is also decreased by increasing the fly ash content.

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Durability tests like acid attack, corrosion tests shows better results by increasing fly ash percentage.

M. Sri Rama Chand, P. Swamy Naga Ratna, K. L. Radhika, P. Rathish Kumar and C. Yedukondalu (2017) Investigated to optimize the proportions on particle packing model to obtain the requirements of self compacting concrete. Three models firstly Modified Toufar method, secondly J.D. Dewar method and last one Compressible Packing Method (CPM) were studied on M20, M40 and M60 grade concretes. It was discovered that particle packing methods MTM, JDDM and CPM with IS 383 grading shows that the percentage passing value of CPM coincides with upper limits of IS grading. MTM and JDDM are more coarse content and not suitable for SCC, where as CPM based optimization is suitable for designing SCC mixes.

Shaik Khaja Sameer, B. Jagadish Chakravarti and V. Ramesh (2017) Designed mix proportion using compressible packing model for M20, M40 and M60 self compacting concrete grades and suggested a modification zone gradations similar to IS 383 for SCC to achieve optimum mix. Sample mix design was presented to get an idea about the mix calculations for SCC. It was observed that compressive strength increases from 7 days to 28 days at a ratio of 0.71, 0.7 and 0.68 for M20, M40 and M60 grade concretes respectively. The relation between compressive strength and flexural strength, split tensile strength were developed.

B. Nagendra Kumar (2017) High strength self compacting concrete was developed by replacing natural river sand with quartz sand at a range of 20%, 40%, 60%, 80% and 100%. Specimens were casted in standard sizes and tested at periods of 7 days, 28 days, 90 days and 180 days. For every percentage of replacement, mix satisfies the fresh properties but at 100% replacement mix attains compressive strength of 100MPa for 28 days. Result shows that not only compressive strength but also split tensile and flexural strength increased with increase of quartz sand percentage.

S. Girish (2017) Studied about the importance of volume of paste and powder on hardened properties and of self compacting concrete(SCC) with perpetual water content, ranging from 175 lit/m³ to 210 lit/m³. Paste contents (0.38, 0.41 and 0.43) chosen to test with cement from 300 kg/m³ to 450 kg/m³. Results show that compressive strength of SCC increase with increase of volume paste for same water cement ratio and water content. 30% increase was observed at 190 lit/m³ and 35% at 175 lit/m³ and maximum compressive strength is noted at volume paste 0.14. By this, increase in strength as the paste is increased but beyond the particular amount strength values decreases due to decrease of coarse aggregate, load transfer within the body gets affected and strength may reduce.

H. Y. Leung, J. Kim, A. Nadeem, Jayaprakash J and M. P. Anwar (2016) Studied about water absorption of self compacting concrete with silica fume and fly ash by conducting sorptivity test. For this test two separate mix series were casted namely F-series and FS-series. In F-series ordinary Portland cement was replaced with 0%, 12.9%, 20%, 30%, 40% and 50% but in FS-series Fly ash fixed at 25% and cement replaced at 0%, 5%, 10% and 15% with silica fume. Water to powder ratio maintained at 0.38 and water content at 235.6kg/m³. From the results it can

conclude that OPC with silica fume and fly ash reduces sorptivity. Combination of flyash and silica fume decreases sorptivity than only using fly ash and also witnessed that there is no relation between strength and sorptivity. Behavior of compressive strength and surface absorption depends on proportion of mineral admixture and other environmental factors.

T. H. Patel, J. M. Srihaila, Prahalada. V (2016) explored the durability properties of High Performance Self Compacting Concrete by using sodium chloride (NaCl), Magnesium Sulphate (MgSO₄). Cement was substituted with Fly ash at 10%, 20%, 30% 40%, 50% and GGBS at 10%, 20%, 30%, 40%, 50% separately and experiments conducted and results were compared. Cubes casted at standard size and cured in water for 28 & 56 days but for durability study after 28 days water curing, cubes were cured in 10% concentration of NaCl & MgSO₄ solution for 28 and 56 days. Cement with 10% fly ash and cement with 20% GGBS gave maximum compressive strengths. It was observed that NaCl effects more on self compacting concrete(SCC) without fly ash and also without GGBS, by adding fly ash or GGBS acid resistance could be increased but, sulphate resistance is higher than chloride resistance.

Daniel C, Joel Shelton J, Vincent Sam Jebadurai S, Arun Raj E (2016) Studied on high strength self compacting concrete by using copper slag in place of river sand at an interval of 10% from 0% to 100% with water cement ratio at 0.4 and super plasticizer was maintained at 0.6%. Wet concrete properties like passing ability, flow ability and filling ability was tested by using L-box, U-box, V-funnel, slump flow test. Mechanical properties like flexural strength, split tensile strength, compressive strength were also known at 7 days and 28 days. By the increase of copper slag, workability improves and at 40% replacement shows the optimum values in both fresh and hardened properties.

Gritsada Sua-iam, Natt Mukal (2015) Studied about self consolidating concrete which prepared with recycled alumina and fly ash waste as mineral admixtures. Fly ash replaced at fixed 20% and recycled alumina waste replaced at 0%, 25%, 50%, 75% and 100%. Fresh and mechanical properties were examined by using, J-ring, V-funnel, slump flow, compression strength; quality of concrete by using ultra pulse velocity test. In the results it was observed that alumina waste up to 75% as optimum and satisfied all the conditions given by the EFNARC and best results shown than the conventional concrete, achieved compressive strength up to 56MPa at 28 days age.

M. Fadee, R.Mirhosseini, R. Tabatabaei & M.J. Fadaee(2015) Investigated about usage of copper slag as cementitious material in self compacting concrete(SCC); physical and chemical analyses were performed. Cement was replaced with copper slag at 20%, 25%, 30%, 35% and 40%, and tests were conducted to know the variation of fresh and mechanical properties with and without copper slag. V-funnel and J-Ring tests on wet concrete, compressive strength at 7, 14, 28 and 42 days age on hardened concrete were conducted.

In the results, it shows that copper with 40% gives better passing ability and filling ability than without copper slag. Copper slag with 20% gives 85 percentage of compressive strength without slag, by this it was recommended to use at 20%.

T. Adhavanathan, V. Vinoth (2015) M30 grade concrete was used to investigate the consumption of copper slag as fine aggregate and cement replaced with fly ash moderately. In this study copper slag used at level of 0%, 10%, 20%, 30% up to 100%. Fresh concrete properties and hardened concrete properties are studied at 7,14,28 days and by results it was concluded that 30% of copper slag obtains the optimum results and concrete replaced by 40% of fly ash increases the compressive strength, the maximum split tensile strength obtained at 40% copper slag and maximum flexural strength at 60% copper slag.

K. S. Jhansirani and A. Jagannathan (2015) Durability was studied on self compacting concrete by considering acid resistance, sulphate resistance, alkaline, sorptivity, chloride penetration. In this study fly ash and silica fume was used as cementitious material by replacing fly ash at 10%, 20%, 30% and silica fume at 5%, 10%, 15%, and 20%. Not only observed the results by using fly ash and silica fume separately but also by combining them at different levels. From the results it was identified that silica fume shows more resistance against the acid, alkaline, chlorine penetration then the fly ash and also when combine both. It also observed that by increasing of mineral admixtures in self compacting concrete both fresh and durability properties are increased.

V. Karthik, Dr. G. Baskar (2015) Mainly studied about durability of self compaction concrete with copper slag used as fine aggregate at levels of 20%, 40%, 60% and 80%. By conducting fresh concrete tests like T50, V-funnel, slump flow, L-box, J-ring to examined the fresh properties. Durability properties were studied by using weight loss technique. To conduct durability tests like acid resistance, sulphate resistance and corrosion tests, various chemicals like sulphuric acid, ferrous sulphate and sodium chloride solutions were used. From the results it was concluded that at 60% copper slag in concrete as fine aggregate gave the more durable concrete.

Iman Afshoon and Yasser Sharifi(2014) Investigated about influence of Ground Copper Slag as a binding material on the fresh properties of self compacting concrete(SCC). In this investigation water – powder ratio was maintained at 0.51 and cement replaced at a levels of 0%, 5%, 10%, 15%, 20%, 25% and 30% with ground copper slag. Tests on wet concrete like slump flow, viscosity index, J – ring, V-funnel, L-box, air content and setting times were conducted. Due to usage of ground copper slag as cementing material slump flow increases, viscosity decreases, passing ability decreases, air content also decreased but setting increased.

R. Vasumitha and Dr. P. Srinivasa Rao (2013) developed M80 grade concrete by using microsilica, quartz powder in addition to the cement, chemical admixtures are used. Water cement ratio maintained at 0.215 and as part of hardened properties; split tensile strength, compressive strength, flexural strengths were calculated. For durability characteristics tests like rapid chloride penetration test (RCPT), acid resistance by using HCl, H₂SO₄, Na₂SO₄ were

conducted on designed grade of concrete. Acid attack tests are carried out based on weight loss technique, from the results it was perceived that the specimens are more resistant to 5% Na₂SO₄ than 5% H₂SO₄ and 5% HCl. Chloride ion penetrability getting decreased by the increasing of age and obtained values are at a range of very low.

N. Venkata Rao, M. Rajasekhar, Mohd Mujeeuddiahmed (2013) studied about durability properties of high strength self compacting concrete by maintaining water cement ratio at 0.24 and all fresh properties of SCC was examined as per the guidelines given by EFNARC. To study durability properties, acid attack and sulphate attack was considered, for this study 8% HCl, 8% H₂SO₄, 8% Na₂SO₄ were used and weight loss technique was used to determine the durability properties. It showed that the designed grade was more resistant against the sodium sulphate than hydrochloric acid and sulphuric acid. Acid attack resistance also determined by conducting compressive strength test after immersing specimens in 5% HCl, 5% H₂SO₄, 5% Na₂SO₄ in alternative days and it was observed that compressive strength decreased at 16.31%, 47.07% and 19.8% while using HCl, H₂SO₄ and Na₂SO₄ respectively.

III. RESULTS & DISCUSSIONS

This section discusses the effect of mineral admixtures on self compaction concrete’s durability, strength and fresh properties which were considered from the previous research studied in literature.

A. Slump flow:

Slump flow is the common test to assess the horizontal free flow of fresh concrete. Slump flow results from all the mixes are within the EFNARC range of 650 - 800 mm. By adding mineral admixtures in the cement, slump flow increased at satisfactory level when compared with conventional SCC which are shown in Table. I.

B. L- Box:

To know the passing ability of SCC. By using mineral admixtures like fly ash, silica fume, GGBS etc., as binding material in place of cement with different intervals improves the passing ability when compared with control SCC. EFNARC suggested that values should be within the range of 0.8 to 1.0 shown in the below table I.

C. V- Funnel:

Used to assess the viscosity and filling ability of SCC and as per the guideline given by EFNARC the minimum and maximum time taken for flow is 6 sec and 12 sec respectively. Using of fly ash, silica fume, GGBS, etc., as cementitious materials, they reduces the filling time by 30% when compared between with and without admixtures.

I. Fresh properties of SCC while using Fly ash and Copper slag

Mix	Slump flow	V - Funnel (sec)	L - Box (h ₂ /h ₁)
SCC	675	12	0.9
FA10%	682	11	0.86
FA20%	692	11	0.84



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FA30%	710	10	0.81
CS10%	720	12	0.9
CS20%	700	10	0.8
CS30%	700	10	0.85
CS40%	720	10	0.8
CS50%	750	10	0.85
CS60%	750	08	0.9
CS70%	785	08	0.87
CS80%	650	08	1.3
CS90%	680	06	0.83
CS100%	600	06	0.9

D. Hardened Properties:

Compressive strength, split tensile strength and flexural strength comes under hardened properties. Fly ash used as cement at partial levels and copper slag as fine aggregate also used partially. The comparative results which was studied in this paper is presented in the below table. It shows that by increasing fly ash up to 30% gives the optimum strength values and also fine aggregate replacement can use up to 40%. Results were shown comparatively with conventional SCC in the below table II.

II. Hardened properties of SCC while using Fly ash and Copper slag

Mix	Increase or decrease in % with respective conventional SCC at 28 days		
	Compressive Strength	Split Tensile Strength	Flexural Strength
FA10%	7.3	8.04	40
FA20%	26.3	15.51	67
FA30%	38.06	18.39	93.33
CS10%	2.12	10.8	6.50
CS20%	4.21	18.65	12.67
CS30%	7.76	26.49	15.41
CS40%	9.85	39.55	19.52
CS50%	4.21	34.32	13.69
CS60%	7.76	21.26	31.84
CS70%	-2.82	13.43	16.43
CS80%	-4.99	2.61	12.67
CS90%	-8.46	-18.28	4.79
CS100%	-9.85	-29.10	-1.02

IV. CONCLUSIONS

In this paper studied about usage of mineral admixtures in self compacting concrete by knowing the effect on strength and durability properties. Based on the literature, the following conclusions have been made.

1. Fresh properties are improved with addition of mineral and chemical admixtures.
2. Fly ash can improve fresh properties up to 5% at 20-30% replacement and by using copper slag at 70% gives the maximum values.
3. Compressive strength, split tensile strength and flexural strengths increased 38.06%, 18.65% and 93.33% when fly ash used at 30% of mineral admixture.
4. Compressive strength, split tensile strength and flexural strengths increased 9.85%, 39.55% and

19.52% when copper slag used as fine aggregate 40% .

5. Durability properties like acid resistance, sulphate resistances were improved with percentage increase of admixtures.
6. Ultra pulse velocity test shows that quality of concrete has been improved.
7. Improved concrete density was observed by SEM analysis.
8. Fine aggregate can be replaced with copper slag up to 40% which shows better results than the conventional self compacting concrete.

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