A STUDY ON THE EFFECT OF MINERAL ADMIXTURES ON SELF COMPACTING CONCRETE

Kaustav Das[1], Bipul Goswami[2], Subhojit Chattaraj[3], Dr. Biman Mukherjee[4]

[1]student in m.tech, structural engineering, narula institute of technology, 7/1 kulia tangra 2nd lane kolkata - 700015
[2]student in m.tech, structural engineering, narula institute of technology, 96 SARAT BOSE ROAD, PO- RAJBARI, PS- AIRPORT, KOLKATA-81

[3]student in m.tech, structural engineering, narula institute of technology, 30 ramkrishna bhattacharya lane, p.o.- berhampore, dist-murshidabad, westbengal-742101
[3]professor, dept. of civil engineering, narula institute of technology, west bengal, india

---***---

Abstract - *SCC or Self Compacting Concrete is the most innovative type of concrete which is made in recent days. The concept of SCC has been introduced by PR. OKUMARA at OUCHI UNIVERSITY, in early 80's. SCC does not require any external vibration for its compaction, and it can flow on its own weight. There are several research work has been done on the fresh and the hardened properties of SCC, in this research the fresh properties of M35 design mix SCC is going to be observed according to EFNARC guideline. And the mix design is done by NAN SU ET AL method by replacing cement by Silica Fume, and GGBS at various proportions*

Key Words: NAN SU ET AL, EFNARC, Self-Compacting Concrete, Silica Fume, GGBS

1. INTRODUCTION

Self-compacting concrete (SCC) has been introduced in the year of early 80's by Professor Okumara at Ouchi University for producing a concrete which is independent of construction work and quality. The features of SCC are stated below:-

- Environmental friendly
- Require less labor
- Pass through congested reinforcement easily
- Does not require any vibration for being fully compacted
- Improved surface finish
- Improve hardened properties
- Enhancement in flow ability
- It prevents separation of concrete bleed water and aggregates and evenly penetrates
- SCC has a slump more than 600 mm
- Due to its heavy weight SCC can penetrates the desire location easily.

Properties of SCC:
I) Fresh SCC Properties:
The three main properties of SCC in plastic state are
a) Filling ability (excellent deformability)
b) Passing ability (ability to pass reinforcement without blocking)
c) High resistance to segregation.

a) Filling ability:
Self-compacting concrete must be able to flow into all the spaces within the formwork under its own weight. This is related to workability, as measured by slump flow test. The filling ability or flow ability is the property that characterizes the ability of the SCC of flowing into formwork and filling all space under its own weight, guaranteeing total covering of the reinforcement. The mechanisms that govern this property are high fluidity and cohesion of the mixture.
b) Passing ability:
Self-compacting concrete must flow through tight openings such as spaces between steel reinforcing bars under its own weight. The mix must not 'block' during placement. The passing ability is the property that characterizes the ability of the

SCC to pass between obstacles gaps between reinforcement, holes and narrow sections, without blocking. The mechanisms that govern this property are moderate viscosity of the paste and mortar and the properties of the aggregates, principally, maximum size of the coarse aggregate. Stability or resistance to the segregation is the properly that characterizes the ability of the SCC to avoid the segregation of its components, such as the coarse aggregates. Such a property provides uniformity of the mixture during transport, placement and consolidation. The mechanisms that govern this properly are the viscosity and cohesion of the mixture.

c) High Resistance to Segregation:

Self-compacting concrete must meet the requirements of passing ability and resistance to segregation. Its original composition remains uniform. The key properties must be maintained at adequate levels for the required period of lime (e.g. 20 min) after completion of mixing. It is property passing ability and property resistance to segregation that constitute the major advance, form a merely super plasticizer fresh mix which may be more fluid than self-compacting concrete mix. Latest developments in accordance with the objectives of the European SCC project aim to limit the admixtures used for general purpose SCC to only one by using new types and combinations of polymers. Experience has shown that such an admixture may have to add to generate and maintain compacting concrete using less liable materials.

(ii) Hardened Properties of SCC:

Self-compacting concrete and traditional vibrated concrete of similar compressive strength have comparable properties and if there are differences, these are usually covered by the safe assumptions on which the design codes are based. However, SCC composition does differ from that of traditional concrete as they are mixed in different proportions and the addition of special admixtures to meet the project specifications for SCC. Durability, the capability of a concrete structure to withstand environmental aggressive situations during its design working life without impairing the required performance, is usually taken into account by environmental classes. This leads to limiting values of concrete composition and minimum concrete covers to reinforcement.

Many research work has been performed on the fresh and hardened properties of SCC and is has been found that there is no any standard mix design procedure for SCC.

The methods which are used for SCC mix:

There is no standard method for mix design of SCC. Many academic institutions, admixture, ready-mixed, precast and contracting companies have developed their own mix proportioning methods.

TRIAL MIX METHODS

1. The Japanese Method.
2. Sedran et al Method.
3. Method proposed by Gomes, Ravindra Gettu et al.
4. Nan-Su et al Method.
5. Method proposed by Jagadish Vengala.
6. European practice and specifications.

All these methods are developed based on the guidelines given by the EFNARC. The mix composition is chosen to satisfy all specifications given by EFNARC for the concrete in both the fresh and hardened states. In my research work I am going to use Nan-Su et al Method for producing M35 SCC and by incorporating different mineral admixtures of FA, and GGBFS with appropriate dosage of super plasticizer (SP) at different replacement levels of FA and GGBFS.

2. OBJECTIVES SIGNIFICANCE AND OUTLINE OF THE PRESENT RESEARCH WORK

There is ample scope of improvement in different areas of self-compacting concrete which needs to be further investigation and are highlighted:

1. It has been a general practice of researcher to alter the mix design by trial and error method as there is no conventional method of mix design of self-compacting concrete.
2. Workability of concrete is adversely affected by mineral admixtures. Hence in many cases super plasticizer content were varied to maintain a constant workability revealed effect of SP on the strength of concrete at same W/C ratio have not been taken into consideration
3. Since the mix proportioning of self-compacting concrete is yet to be standardized, the same has found to vary from one designer to another designer in order to produce the perfect mix proportion. So there is a lack of simplified, generalized guidelines for proportioning self-compacting concrete mixes.
4. The replacement percentage of mineral admixtures has been considered to the percentage corresponding to which the strength attains maximum value after 28 days.

Significance of the present research work

The present research work aims to produce a simplified guideline for self-compacting concrete so that it can be produced with trial and error method following a simplified guideline. Because self-compacting concrete is much more environmental friendly and economic than normal concrete. And Silica Fume and GGBS are industrial by-product abundantly produce in India and concrete can serve as a safe of these waste mineral thereby helping in its disposal and utilization. The investigation revealed that by maintaining the super plasticizer dosage along with mineral admixtures it is possible to maintain the required slump value that is workability according to EFNARC guidelines.

Slag self-compacting concrete is yet to reach its users due to the following reasons-

1. Lack of simplified, generalized guidelines for proportioning concrete mixes.
2. To promote economic and environmental friendly sustainable concrete.
3. To find the source of good quality mineral admixtures collected from West Bengal in the production of self-compacting concrete using OPC as the main binder.
4. To make proper utilization of slag which has been a byproduct from cement industry and prevent isolation and wastage of cement proportion.

Objectives of the present research work

1. Produce self-compacting concrete by NAN SU'S METHOD
2. W/C ratio ranges from 0.45 to 0.35, binder content ranging from 300 to 400 kg/m3 and the cement replacement varies from 15% to 25%.
3. Compressive strength of the concrete samples has been measured at 7, 14, and 28 days.
4. Fresh properties of self-compacting concrete has been measured by EFNARC guide line.
5. On basis of the result of the present investigation a simplified method of mix proportioning of concrete with mineral admixtures can be proposed.

3. Material Used

Ingredient Used	Key features
Cement	53 grade Ordinary Portland Cement
Fly Ash	Siliceous fly ash, a mixture of fields I & II from ESP from Kolaghat Thermal power plant and confirming to IS:3812
GGBS	A waste by product collected and refined from cement industry
Fine aggregate	River sand conforming to zone II of IS:383
Coarse aggregate	Crushed, angular graded coarse aggregate of 12.5 mm nominal maximum size as per IS:383
Water	Lab tap water
Chemical admixture	A SNF based super-plasticizer Sikament 2004 NS (A SIKA PRODUCT) with solid content 38.5%

4. Result and observation

The following mix designation has been followed. The alphabets A and B represents the cementitious material content of 300 kg/m^3 and 400 kg/m^3. The alphabets E, F, G refer to W/C ratios of 0.45, 0.40, and 0.35 respectively. The alphabets I, J, K, L stands for fly ash replacement of 10, 15, 20, 25% respectively. The numerical values 10, 15, 20, 25 stands foe GGBS replacement of 10%, 15%, 20% and 25% respectively. For example EI10 stands for a sample which binder content is 300 kg/m^3 with W/C ratio 0.45, where the cementitious material is replaced by both 10% of fly ash and 10% of GGBS. Mix Designation and Mix proportioning table are given below

Mix Designation table

SL No	*Mixes*	*Binder content (kg/m³)*	*w/c*	*Fly ash replacement (%)*	*Slag replacement (%)*
1	AEI10	300.00	0.45	10	10
2	AEJ15			15	15
3	AEK20			20	20
4	AEL25			25	25
5	AFI10	300.00	0.40	10	10
6	AFJ15			15	15
7	AFK20			20	20
8	AFL25			25	25
9	BGI10	400.00	0.35	10	10
10	BGJ15			15	15
11	BGK20			20	20
12	BGL25			25	25

Mix proportioning table

Mixes	w/c	Cement (kg/m³)	Fly ash (kg/m³)	Slag (kg/m³)	Aggregates (kg/m³)		Water (kg/m³)	S.P (%)
					C.A	F.A		
AEI10	0.45	240	30	30	809.31	821.35	135	2.0
AEJ15		210	45	45	809.31	821.35		
AEK20		180	60	60	809.31	821.35		
AEL25		150	75	75	809.31	821.35		
AFI10	0.40	240	30	30	809.31	821.35	120	1.8
AFJ15		210	45	45	809.31	821.35		
AFK20		180	60	60	809.31	821.35		
AFL25		150	75	75	809.31	821.35		
BGI10	0.35	320	40	40	780.00	844.00	140	1.6
BGJ15		280	60	60	780.00	844.00		
BGK20		240	80	80	780.00	844.00		
BGL25		200	100	100	780.00	844.00		

Results of the fresh properties of the SCC

Sl. No	Mixes	T50cm slump flow (sec)	V funnel(sec)	J ring (mm)
1	AEI10	4	10	5
2	AEJ15	3	11	8
3	AEK20	4	9	7
4	AEL25	4	8	6
5	AFI10	4	11	6
6	AFJ15	4	12	9
7	AFK20	4	10	10
8	AFL25	3	11	8
9	BGI10	3	12	10
10	BGJ15	4	10	8
11	BGK20	5	9	10
12	BGL25	5	10	9

Results of the hardened properties of the SCC

Sl. No	Mixes	Compressive strength (MPa)		
		7 days	14 days	28 days
1	AEI10	18	30	38.9
2	AEJ15	20	32	39
3	AEK20	17	28	34.5
4	AEL25	18	28	36
5	AFI10	19	27	40.5
6	AFJ15	20	32	42
7	AFK20	17	28	39.5
8	AFL25	19	28	37
9	BGI10	25	35	39.5
10	BGJ15	26	35	40.6
11	BGK20	28	39	41.7
12	BGL25	30	40	42.5

Observations and conclusion

From the results of the experiments it has been observed that all the mixes are obtaining the fresh properties of self-compacting concrete in their fresh states but in the case of hardened state mixes with higher binder content is giving high strength with respect to other mixes. And it has been observed that at 400 kg/m^3 binder content and at 25% replacement the mix gives maximum strength and binder content 300 kg/m^3 at 25% replacement and 0.35 w/c gives best result in fresh properties.

So it has been concluded that we must use 0.35 w/c ratio 300 kg/m^3 binder content and 25% (of cement content) both fly ash and GGBS to get best possible result.

5. REFERENCES

[1] Japan Society of Civil Engineers, ―Recommendation for Construction of Self Compacting Concrete, 157- 164 pp., 1998.

[2] IS: 12089 (Specification for Granulated Slag for Manufacture of Portland Slag Cement), Indian Standard Code of Practice, 1987.

[3] Nan Su., Kung-Chung Hsu., and His-Wan Chai., ―A simple mix design method for self compacting concrete, Journal of Cement Concrete Research Vol. 31, No. 12, 1799-1807 pp., Dec. 2001.

[4] IS: 12269 (53 Grade Ordinary Portland cement Specifications), Indian Standard Code, 1987.

[5] IS: 383 (Specification for coarse and fine aggregates from natural sources for concrete), Indian Standard Code of Practice, 1970.

[6] IS: 10262 (Concrete Mix Proportioning-Guidelines), Indian Standard Code, 2009.

[7] Khayat, K.H., Hu, C., Monty, H., ―Stability of SCC, advantages and Potential applications‖, In: Proceedings of RILEM international conference on selfcompacting concrete.

[8] Pai .B.H.V, Nandy M., K.H, Sarkar.P.K, Ganapathy.C.P, -Experimental study on self compacting concrete containing industrial by-products, European Scientific Journal, vol12, ISSN 1875-7881, April, 2014

[9] Specification and Guidelines for Self-Compacting Concrete February 2002, EFNARC.