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An Investigation On The Characteristic Properties Of SCC Using Fly Ash, GGBFS & CKD

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Abstract: *With growing population, industrialization, and urbanization, there is corresponding growth in the demand for infrastructure. It has occupied a unique position among modern construction materials. It gives considerable freedom to the architect to mould structural elements to any shape. Almost all concretes rely critically on being fully compacted. Insufficient compaction dramatically lowers ultimate performance of concrete in spite of good mix design. Self-compacting concrete (SCC) is an innovative concrete that does not requires vibration for placing and compaction. Popularity of using self-compacting concrete (SCC) in concrete construction is increased in many countries, since SCC is effectively applied for improving durability of structures while reducing the need of skilled workers at the construction site. Construction practice and performance, combined with the health and safety benefits, makes SCC a very attractive solution for both precast concrete and civil engineering construction. The utilization of by-product mineral admixtures is the best alternative for nowadays since it not only makes the concrete accomplish the proper performance but also reduce the concrete cost and environmental problems. It has been reported that economically competitive SCC can be produced by replacing up to 50% of PC with mineral additions. Based on the overall effects of various mineral admixtures, it seems that 10% replacement of various mineral admixtures can be regarded as a suitable replacement.*

Keywords *–Mineral admixtures, Ground Granulated Blast Furnace Slag, Self compacting concrete, Compressive strength, flexural strength.*

I. Introduction

With growing population, industrialization, and urbanization, there is corresponding growth in the demand for infrastructure. It has occupied a unique position among modern construction materials. It gives considerable freedom to the architect to mould structural elements to any shape. Almost all concretes rely critically on being fully compacted. Insufficient compaction dramatically lowers ultimate performance of concrete in spite of good mix design. Concrete is the most widely consumed material in the world, after water. Placing the fresh concrete requires skilled operatives using slow, heavy, noisy, expensive, energy-consuming and often dangerous mechanical vibration to ensure adequate compaction to obtain the full strength and durability of the hardened concrete. Self-compacting concrete (SCC) is an innovative concrete that does not requires vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same mechanical properties and durability as traditional vibrated concrete. Popularity of using self-compacting concrete (SCC) in concrete construction is increased in many countries, since SCC is effectively applied for improving durability of structures while reducing the need of skilled workers at the construction site.

The development of Self Compacting Concrete can be assumed to be the most important one into the building material's domain. This is due to the benefits that this concrete offers: The technology of producing Self Compacting Concrete can be considered as an energy conservation process. Since the electricity consumption for vibration is eliminated; - use of Self Compacting Concretes increases the lifetime of the construction moulds and reduces the necessity of skilled workers; SCC can be used for all types of structures due to the fact that it can be pumped at long distances without any of its segregation.

From the contractors point of view, costly labour operations are avoided, improving the efficiency of the building site.The concrete workers avoid poker vibration which is a huge benefit for their working environment.

When vibration is omitted from casting operations, the workers experience a less strenuous work with significant less noise and vibration exposure. Faster placement with less labour. Very good finishing surfaces of the elements made with Self Compacting Concrete, which is a cut in remedial costs. SCC is believed to increase the durability compared to vibrated concrete (this is due to the lack of damage to the internal structure, which is normally associated with vibration).Construction practice and performance, combined with the health and safety benefits, makes SCC a very attractive solution for both precast concrete and civil engineering construction. SCC is mainly used in highly congested reinforced concrete structure in seismic region and to overcome the problem of storage of skilled labours for the efficient compaction of concrete. Review of literature indicates that durability of SCC largely depends on the type of mineral admixtures.

II. Literature Review

Ali S. Al-Harthy, Ramzi Taha, et. al. [1] Investigated the use of cement kiln dust (CKD) as a cementitious material in concrete and mortar. CKD was added to concrete and mortar mixtures to study its effect on the strength and on the ability of the cover zone to absorb water, an important factor in the deterioration process. They reported experimental results on compressive strengths, flexural strength and toughness of concrete samples containing CKD. The sorptivity and the initial surface absorption tests (ISAT) of mortars were used to measure the absorption characteristics for different mortar samples containing CKD. They founded the substitution of cement with CKD does not lead to strength gain for all samples.

J. Prabhakar, P. Devadas Manoharan and M. Neelamegan[1] undertaken investigation to study the durability characteristics of SSC with fly ash. The concrete mix was designed as per modified NAN-SU method and the cement was replaced with 10%, 20% and 30% of fly ash. Specimens were casted to test the compressive strength & flexural strength. By replacing 20% of the cement with fly ash in SCC, the durability properties was comparable to that of normal concrete. And the durability properties were found to be improved at replacement levels of 20% and 30%.

M. Maslehuddin, O.S.B. Al-Amoudi, et. al. [5] Reported the results of a study conducted to assess the properties of Ground Granulated Blast Furnace Slag (GGBFS), blended cement concretes. Cement concrete specimens were prepared with 0%, 5%, 10%, and 15% GGBFS, replacing ASTM C 150 Type I and Type V. The compressive strength of concrete specimens decreased with the quantity of GGBFS. However, there was no significant difference in the compressive strength of 0 and 5% GGBFS cement concretes. A similar trend was noted in the drying shrinkage strain. The performance of concrete with 5% GGBFS was almost similar to that of concrete without GGBFS.

III. Test Method For Fresh SCC

The main characteristics of SCC are the properties in the fresh state. SCC mix design is focused on the ability to flow under its own weight without vibration, the ability to flow through heavily congested reinforcement under its own weight and the ability to obtain homogeneity without segregation of aggregates.

Several test methods are available to evaluate these main characteristics of SCC. The tests have not been standardized by national or international organizations. The more common tests used for evaluating the compacting characteristics of fresh SCC are described below.

1. The Slump Flow Test
2. The V-Funnel Test
3. The L- Box Test

Table 3.1 gives the recommended values for different tests given by different researchers for mix to be characterized as SCC.

Table 3.1: Recommended Limits for Different Properties

Sr. No.	Property	Range
1.	Slump Flow Test	600-800 mm
2.	V-funnel	6-12 sec.
3.	L-Box H2/H1	≥ 0.8

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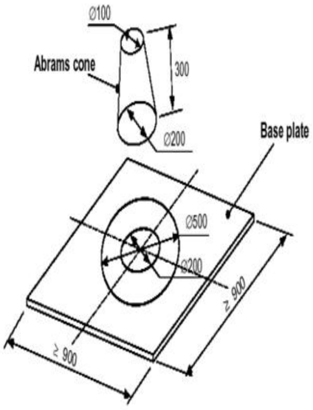


Fig. 3.1: Base plate and Abrams cone

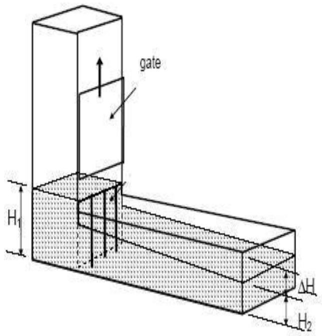


Fig. 3.2: L-Box Apparatus

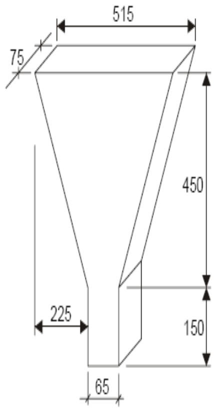


Fig. 3.3: V-funnel apparatus

IV. Mixture Proportioning Procedure

4.1 Modified NAN-SU method for mixture Proportion procedure for SCC.

The steps to be followed under the modified mixture proportion procedure are briefly explained below.

Step 1: Calculation of quantity of Fine and Coarse aggregate.

The coarse aggregate and fine aggregate contents are determined by knowing packing factor (PF), which is the ratio of mass aggregate of tightly packed state to of that loosely packed state.

$$W_{fa} = PF\ W_{fal} \times \frac{s}{a}$$

$$W_{ca} = PF \times W_{cal} \times \left(1 - \frac{s}{a}\right)$$

where,
s/a – Ratio of fine aggregate to total mass aggregate.
Wfa – Mass of the fine aggregate per cum.
Wca – Mass of the coarse aggregate per cum.
Wfal – Unit volume mass of fine aggregate
Wcal – Unit volume mass of coarse aggregate

Table 1. Correction Factor

Grade of concrete	M20	M25	M30	M35	M40	M45	M50
Correction factor	2.36	2.02	1.75	1.535	1.38	1.29	1.26

Step 2 : Calculation of cement content

As mentioned earlier in Nan-Su method at Step 2, generally, HPC or SCC used in Taiwan provides a compressive strength of 0.14 Mpa/kg of cement. However, this is not enough for normal grades to gain the required strength, Hence correction factors are introduced and the same are mentioned in the Table. 1

$$C = CF\left(\frac{fc}{0.14}\right) \text{ or } CF\,(7f_c)$$

where,
C.F – Correction factor for the cement
fc - designed strength of the concrete

Step 3: Calculation of mixing water content required by cement.

The relationship between. compressive strength and water cement ratio in SCC is similar to that of conventional concrete.

$$W_{wc} = \frac{w}{c} \times C$$

Where,
Wwc - Mixing water content required by cement, kg/m 3
W/C – The water-cement ratio by weight, which can determined by compressive strength.

Step 4 : Calculation quantity of filler

Filler is used to increase the content of powder. An ASTM flow test is conducted with filler paste for different water-filler rations. Ths volume of filler paste Vpf can be calculated as follows.

$$V_{pf} = 1 - \frac{W\,ca}{1000 \times G\,ca} - \frac{W f a}{1000 \times G f a} - \frac{C}{1000 \times G\,c} - \frac{Ww}{1000 \times G\,w} - Va$$

Amount of filler required $W_f = \frac{(V\,pf \times 1000 \times Gf)}{(1 + \left(\frac{W}{p}\right) \times Gf}$

where,
Wf – mass of filler,
Va – Air content in %
w/p – water powder ratio
Gf – Sp. gravity of filler

Step 5: Calculation of mixing water content needed in SCC

The mixing water content required (Ww) for SCC is the total amount of water needed for cement and filler in mixing. Therefore, it can be calculate as follows.

$$Ww = \left(1 + \frac{Wf}{P}\right) \left(\frac{W}{C}\right)C + \left(\frac{W}{F}\right) Wf$$

where,
Wf – mass of filler,
p- Total powder content Cement + Filler)

Step 6: Calculation of super plasticizer dosage

The quantity of super plasticizer is determine from experience or from its saturation point. Water content to be added in the mix can be corrected, so that requirement of SCC can be satisfied.

Step 7 : Trial mixes and tests on SCC properties

Trial mixes are to be carried out taking quantity of ingredients as calculated above. Then, the quality control tests for SCC are performed to ensure that the requirements of filling ability, passing ability and flow ability are as required.

These steps have been followed to find out the quantity of all the ingredients for normal grades of SCC. By calculation mix proportion is 1:2.67:2.04:0.07
With this proportion we do not get satisfied result after taking different trials, satisfactory result is obtained with mix proportion **1:1.86:1.60:0.68**

V. Results

FLY ASH

Mix Proportion -:

Types	FlyAsh-10%	FlyAsh-20%	FlyAsh-30%
Proportion	1: 1.86: 1.60 :0.68	1: 1.86: 1.60: 0.68	1: 1.86: 1.60 :0.68
Cement	27.00Kg	24.00Kg	21.00Kg
Sand	55.80Kg	55.80Kg	55.80Kg
Aggregate	48.00Kg	48.00Kg	48.00Kg
FlyAsh	23.40 Kg	26.40 Kg	29.40 Kg
Total Powder	50.40 Kg	50.40 Kg	50.40 Kg
SP (0.8%)	403.20 ml	403.20 ml	403.20 ml
W/P (0.36)	18144 ml	18144 ml	18144 ml

Fresh Properties-:

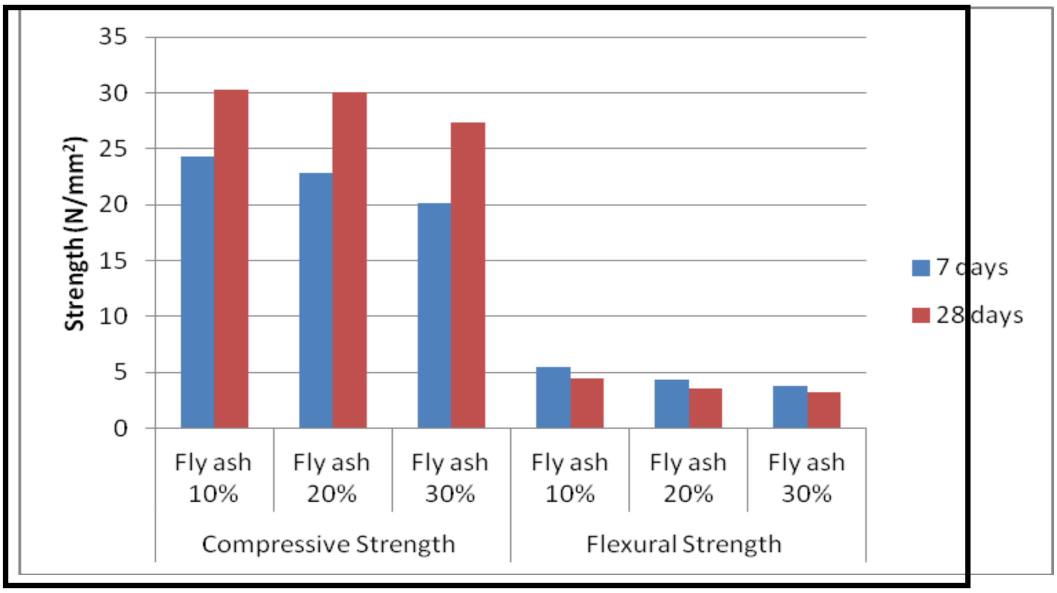
Types	FlyAsh-10%	FlyAsh-20%	FlyAsh-30%
Slump Flow Test	700mm	690mm	670mm
V-Funnel Test	2.63 sec.	3.4 sec	4.20 sec
L-Box Test	0.922	0.889	0.850

Hardened Properties-:(7 Days)

Types	FlyAsh-10%		FlyAsh-20%		FlyAsh-30%	
Compressive Strength	24.5 Mpa	24.33 Mpa	22 Mpa	22.83 Mpa	22 Mpa	20.17 Mpa
	24 Mpa		24 Mpa		20 Mpa	
	24.5 Mpa		22.5 Mpa		18.5 Mpa	
Flexural Strength	5.4 Mpa	5.5 Mpa	4.32 Mpa	4.32 Mpa	3.92 Mpa	3.79 Mpa
	5.67 Mpa		4.32 Mpa		3.62 Mpa	

Hardened Properties-:(28 Days)

Types	FlyAsh-10%		FlyAsh-20%		FlyAsh-30%	
Compressive Strength	32 Mpa	30.33 Mpa	32 Mpa	30Mpa	30 Mpa	27.33 Mpa
	30 Mpa		28 Mpa		27 Mpa	
	29 Mpa		30 Mpa		25 Mpa	
Flexural Strength	4.59 Mpa	4.49 Mpa	3.51 Mpa	3.51 Mpa	3.24 Mpa	3.24 Mpa
	4.39 Mpa		3.51 Mpa		3.24 Mpa	



CKD (Cement Kiln Dust)

Mix Proportion -:

Types	CKD-10%	CKD-20%	CKD-30%
Proportion	1: 1.86: 1.60 :0.77	1: 1.86: 1.60: 0.77	1: 1.86: 1.60 :0.77
Cement	27.00Kg	24.00Kg	21.00Kg
Sand	55.80Kg	55.80Kg	55.80Kg
Aggregate	48.00Kg	48.00Kg	48.00Kg
CKD	26.1 Kg	29.1 Kg	32.1 Kg

Total Powder	53.1 Kg	53.1 Kg	53.1 Kg
SP (1.2%)	637.2 ml	637.2 ml	637.2 ml
W/P (.38)	20178 ml	20178 ml	20178 ml
Date of casting	20-03-2013	21-03-2013	22-03-2013

Fresh Properties-:

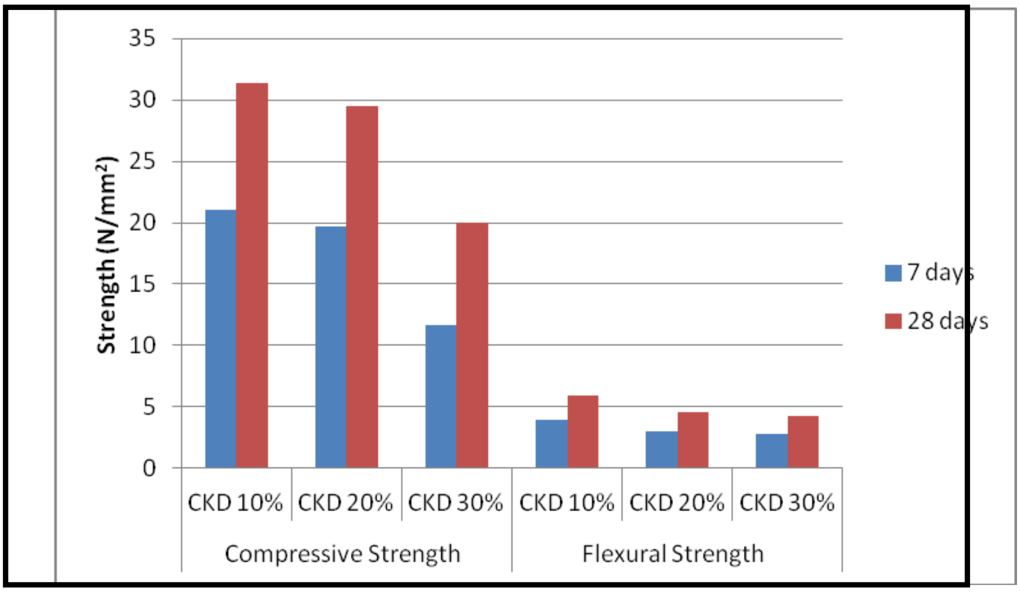
Types	CKD-10%	CKD-20%	CKD-30%
Slump Flow Test	660 mm	660 mm	650 mm
V-Funnel Test	2.60 sec	2.76 sec	3.47 sec
L-Box Test	0.86	0.807	0.80

Hardened Properties-:(7 Days)

Types	CKD-10%		CKD-20%		CKD-30%	
Compressive Strength	20 Mpa	21 Mpa	18 Mpa	19.67 Mpa	10 Mpa	11.66 Mpa
	21 Mpa		21 Mpa		12 Mpa	
	22 Mpa		20 Mpa		13 Mpa	
Flexural Strength	3.5 Mpa	3.92 Mpa	2.84 Mpa	3.04 Mpa	2.7 Mpa	2.84 Mpa
	4.32 Mpa		3.24 Mpa		2.97 Mpa	

Hardened Properties-:(28 Days)

Types	CKD-10%		CKD-20%		CKD-30%	
Compressive Strength	30 Mpa	31.33 Mpa	27 Mpa	29.5 Mpa	18 Mpa	20 Mpa
	31 Mpa		31.5 Mpa		20 Mpa	
	33 Mpa		30 Mpa		22 Mpa	
Flexural Strength	5.28 Mpa	5.88 Mpa	4.27 Mpa	4.57 Mpa	4.06 Mpa	4.26 Mpa
	6.49 Mpa		4.87 Mpa		4.46 Mpa	



Ground Granulated Blast Furnace Slag (GGBFS)

Mix Proportion **-:**

Types	GGBFS-10%	GGBFS-20%	GGBFS-30%
Proportion	1: 1.86: 1.60 :0.79	1: 1.86: 1.60: 0.79	1: 1.86: 1.60 :0.79
Cement	27.00Kg	24.00Kg	21.00Kg
Sand	55.80Kg	55.80Kg	55.80Kg
Aggregate	48.00Kg	48.00Kg	48.00Kg
GGBFS	26.7 Kg	29.7 Kg	32.7 Kg
Total Powder	53.7 Kg	53.7 Kg	53.7 Kg
SP (0.6%)	322.2 ml	322.2 ml	322.2 ml
W/P (.38)	20406 ml	20406 ml	20406 ml

Fresh Properties-:

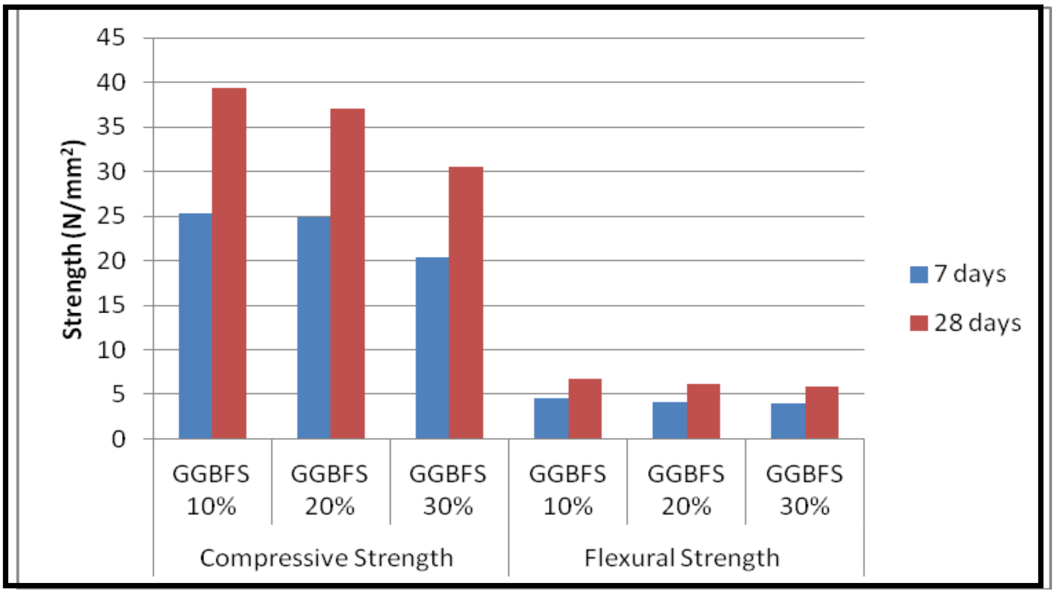
Types	GGBFS-10%	GGBFS-20%	GGBFS-30%
Slump Flow Test	710mm	670mm	650mm
V-Funnel Test	3.4 sec.	3.54 sec	4.14 sec
L-Box Test	0.89	.88	.85

Hardened Properties-:(7 Days)

Types	GGBFS-10%		GGBFS-20%		GGBFS-30%	
Compressive Strength	24 Mpa	25.33 Mpa	23.5 Mpa	24.83 Mpa	19 Mpa	20.33 Mpa
	26 Mpa		25 Mpa		21 Mpa	
	26 Mpa		26 Mpa		21 Mpa	
Flexural Strength	4.59 Mpa	4.49 Mpa	4.32 Mpa	4.12 Mpa	3.78 Mpa	3.92 Mpa
	4.39 Mpa		3.92 Mpa		4.05 Mpa	

Hardened Properties-:(28 Days)

Types	GGBFS-10%		GGBFS-20%		GGBFS-30%	
Compressive Strength	37 Mpa	39.33 Mpa	35.5 Mpa	37 Mpa	28.5 Mpa	30.5 Mpa
	39 Mpa		37.5 Mpa		32 Mpa	
	42 Mpa		38 Mpa		31 Mpa	
Flexural Strength	6.90 Mpa	6.75 Mpa	6.49 Mpa	6.19 Mpa	5.68 Mpa	5.88 Mpa
	6.60 Mpa		5.89 Mpa		6.09 Mpa	



VI. Conclusion

- The utilization of by-product mineral admixtures is the best alternative for nowadays since it not only makes the concrete accomplish the proper performance but also reduce the concrete cost and environmental problems.
- Incorporating such materials further enhances the fresh properties of SCC concrete.
- It has been reported that economically competitive SCC can be produced by replacing up to 50% of PC with mineral additions.
- The construction industry's desire for cost savings, greener practices, and enhanced structural durability are driving factors in the adoption of GGBFS into more concrete mixtures.
- As long as the correct proportions are used when replacing Portland cement with GGBFS, the durability of the structure will be enhanced, leading to a longer life for the concrete.
- In fresh state, some of the mix results values were out of the standard range and therefore before casting the concrete, the properties of freshly mixed concrete must be checked for SCC.
- With the increase in fly ash, expansion of soil decreases and drainage characteristics becomes better and make it suitable for sub-grade and sub-base.
- The workability of concrete increases whereas temperature and bleeding decreases with the increase in fly ash in concrete.
- There is limitation in addition of fly ash in concrete to maintain the workability of concrete.
- The addition of Cement kiln dust in SCC mixes increases the self compactability characteristic like filling ability, passing ability and segregation resistance.
- Higher % of CKD used the lower the amount of Admixture required to achieve Self-compactability. From result it is said that the CKD has Fluidizing effect in the mix.
- The compressive strength & flexural strength of SCC increases for 7 days to 28 days of curing, with replacement levels of 10%, 20%, 30 % of cement by various mineral admixtures.
- But it can also be seen that compressive strength & flexural strength is maximum for 10% replacement as compared to 20% and 30 %.
- Based on the overall effects of various mineral admixtures, it seems that 10% replacement of various mineral admixtures can be regarded as a suitable replacement.

REFERENCES

[1] Vilas V. Karjinni and Shrishail. B. Anadinni, Mixture proportion procedure for SCC, The Indian concrete journal, June 2009, pp 35-41.
[2] Bhal, N.S. and Jab, J.P., compressive strength of concrete subjected to elevated temperatures, The Indian concrete journal, August 1999, vol. 73, No.8, pp. 503-506
[3] Chakrabarti, s.c. and Jatu, AK., Strength properties of concrete at elevated temperature-A review, Indian Concrete journal, August 1999, Vol. 73, No.8, pp.495-501.

[4] Malhoira, V.M. and Mehta, F.K, Guest editorial comments: HVFA concrete for sustainable development, The Indian concrete journal, November 2004, Vol. 78, No.11, pp.3-4.
[5] Ali S. Al-Harthy, Ramzi Taha, Faisal Al-Maamary. "Effect of cement kiln dust (CKD) on mortar and concrete mixtures" Construction and Building Materials 17 (2003) 353–360.
[6] Ravindrarajah, R. Sri, "Usage of cement kiln dust in concrete', International Journal of Cement Composites and Lightweight Concrete", 4 (2) (1992) 95-101.
[7] Uysal M, Sumer M. Performance of self-compacting concrete containing different mineral admixtures. Constro Build Mater 2011;25:4112–20.
[8] Galle C, Sercombe J, Pin M, Areier G, Bouniol P. Behaviour of high performance concrete under high temperature (60—450 'C) for surface long-term storage: thermo-hydro-mechanical residual properties. In: Proceedings of the MRS Conference Sydney, Australia. 200t).
[9] Noumowe A, Dchiclci 0. Effect of elevated temperature from 200 to 600 'C on the permeability of high performance concrete. In: Proceedings of the 6th international symposium on utilization of high strength/performance concrete, vol. I – Leipzig. Germany. 2002.