Journal of Academia and Industrial Research (JAIR)
Volume 4, Issue 1 June 2015

ISSN: 2278-5213

RESEARCH ARTICLE

Effect of Fly Ash Replacement with Surkhi on Workability of Self-compacting Concrete

Aparajita Ranjan[1*], Vikas Srivastava[2] and Rakesh Kumar[3]
[1,2]Dept. of Civil Engineering, SHIATS (Formerly AAI-DU), Allahabad-211007; [3]Dept. of Civil Engineering, MNNIT, Allahabad-211004, India
civil.eng.ap@gmail.com*; +91 8115901187

Abstract

This study presents the experimental results carried out to determine the properties of self-compacting concrete. In the present investigation, self-compacting concrete was made using fly ash, cement, fine aggregate, coarse aggregate and water. Initially fly ash proportions was kept 32% of total powder content however, fly ash is replaced subsequently by Surkhi up to 100% at an interval of 25%. Total powder content was kept constant (660 Kg/m^3) at a water powder ratio of 0.36 throughout the study. The workability tests utilized in this research were the slump flow, J-Ring test, V-funnel, U-tube filling height and L-box which can be used to evaluate the passing ability of self-compacting concrete. A comparative study of concrete mix is carried out to find the effect on workability of SCC replacing fly ash with Surkhi.

Keywords: Fly ash, Surkhi, cement replacement, self-compacting concrete, workability.

Introduction

Self-compacting concrete (SCC) is the new example of high performance concrete characterized by its ability to spread and self-consolidate in the formwork exhibiting any significant separation of constituents. Elimination of vibration for compacting concrete while placing through the use of SSC results to substantial advantages in terms of to better homogeneity, enhancement of working environment and improvement in the productivity by increasing the speed of construction. Understanding of this concrete flow property is a matter of concern to many researchers. Flow properties of concrete at green stage are significantly governed by paste content, aggregate volume and dose of admixture. SCC is an innovative concrete that does not require vibration for placing and compaction. It has ability to flow under its own weight, completely filling form work 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. SCC has many advantages such as (i) from the contractors point of view costly labour operations are avoided improving the efficiency of the building site, (ii) The concrete workers avoid poker vibration which is huge benefit for their working environment and (iii) When vibration is omitted from casting operations, the worker experience a less strenuous work with significantly less strenuous work with significantly less noise and vibration exposure. SCC is considered to increase the durability as compared to vibrated concrete (this is due to the lack of damage to the internal structure), which is normally associated with vibration. Maghsoudi *et al.* (2010) executed the three different methods and the modulus of elasticity of self-compacting light weight concrete (SCLWC) are obtained. It was found that a brittle mode of failure is governed in SCLWC. Singh *et al*. (2013) observed that the workability of SCC decreased with increase in proportion of rice husk ash in the mixes because the dosage of super-plasticizer needs a check to avoid segregation in the form of bleeding. Okamura and Ouchi (2003) established a rational mix design method and self-compacting concrete testing methods was carried out from the view point of making self-compacting concrete. All the tests of SCC performed in this study as per EFNARC guidelines and specifications. Kyayat (1999) reviewed the benefits of using self-consolidating concrete to facilitate the casting of densely reinforced sections and improve productivity and on-site working conditions. Workability requirements necessary to secure self-consolidation and the principle involved in proportioning such highly flowable concrete are discussed. Mazloomand and Ranjbar (2010) presented the relation between the compressive strength and workability of concrete mixes and found it linear when the w/c ratio and other mix proportions were constant. Ramanathan *et al.* (2012) concluded that the use of mineral admixtures improved the performance of self-compacting concrete in fresh state and also avoided the use of viscosity modifying admixtures. This study presents the experimental results of study carried out to determine the properties of self-compacting concrete.

Materials and methods

Cement: Ordinary Portland cement (OPC) (43 Grade) was used throughout the investigation. Physical properties of cement used are given in Table 1.

Fine aggregate: Local Yamuna sand confirming the Zone-II was used as fine aggregates.

Table 1. Physical properties of cement.

Properties	Experimental	Codal requirement (IS:8112-1989 specifications)
Normal consistency (%)	29%	-
Initial setting time	60min	(Not less than 30 min)
Final setting time	215min	(Not more than 600 min)
Soundness of cement (Le-chatelier expansion)	0.7mm	(Not more than 10 mm)
Fineness of cement (% retained on 90 µ IS sieve)	4.33%	10%
Specific gravity of cement	3.15	3.15
Compressive strength (3 d)	24.0	16.0 N/mm^2 (min)
Compressive strength (7 d)	35.2	22 N/mm^2 (min)
Compressive strength (28 d)	45.4	43 N/mm^2

Table 2. Physical properties of fly ash.

Physical properties	Test result
Color	Grey (blackish)
Specific gravity	2.12
Fineness modulus (% retained on 90 µ IS sieve)	0.88

Table 3. Physical properties of surkhi.

Physical properties	Test result
Color	Reddish orange
Specific gravity	2.65
Fineness modulus (% retained on 90 µ IS sieve)	0.70

Specific gravity, bulk density and fineness modulus were 2.8,1760 Kg/m^3 and 3.12 respectively.

Coarse aggregate: Locally available crushed stone aggregates of (10 mm) nominal maximum size with specific gravity, bulk density and fineness modulus were 2.68,1410 Kg/m^3 and 6.54 were used respectively.

Fly ash: Class F fly ash produced from NTPC Unchahar was used as an additive accord. As per IS-456(2000), cement is replaced by 30% of fly ash by weight of cementitious material (Fig. 1). Physical properties of fly ash are given in Table 2.

Surkhi: Surkhi is brick powder used as pozollanic material. In the present investigation, 1st class brick dust was used to replace fly ash present in cement with different replacement level (0, 25, 50, 75 and 100%). Physical properties of fly ash are given in Table 3.

Water: Potable water for mixing and curing of concrete specimens was used.

Super plasticizer: Modified poly-carboxylates type super plasticizer of commercial name Sika Viscocrete 20-HE manufactured by Sika. Relative density of super plasticizer was 1.08 at 30°C.

Experimental design: Okamura method was used for mix design of self-compacting concrete. Okamura and Ozawa (1995) have proposed a simple mix proportioning system assuming general supply from ready mixed concrete plants.

Fig. 1. Fly ash.

Fig. 2. Surkhi (Brick powder).

The coarse and fine aggregate contents are fixed so that self-compactability can be achieved easily by adjusting the water powder ratio and super plasticizer dosage only. The coarse aggregate content in concrete is fixed at 50% of the solid. The fine aggregate content is fixed at 40% of the mortar. The water powder ratio in volume is assumed at 0.9 to 1.0 depending on the properties of the powder. The super plasticizer dosage and the final water-power ratio are determined so as to ensure self-compactability. The mix produced by the Okamura method is most efficient, suitable for local materials the most and it saves time and materials by minimizing the number of concrete mixes. Mix design of SCC is given in Table 5.

Table 4. Typical acceptance criteria for self-compacting concrete (EFNARC, 2001).

Methods	Typical range of value	
	Minimum	Maximum
Slump flow BY Abram cone (mm)	650	800
T_{50cm} slump flow (sec)	2	5
J-Ring (mm)	0	10
V- Funnel (sec)	6	12
Time increase at V-funnel at T_{5min} (sec)	0	3
L-box test (h_1/h_2)	0.8	1.0
U-tube filling height (h_1-h_2) mm	0	30

Table 5. Mix Design of SCC.

Material	Cement (kg)	Fly ash (kg)	Coarse aggregate (kg)	Fine aggregate(kg)	Super plasticizers (kg)	Water (kg/m^3)
Quantity per cubic meter	500	160	703	794	264	3.5
Ratio	1	0.32	1.4	1.59	0.016	0.52

Table 6. Workability of SSC by replacing fly ash with different percentages of surkhi.

Methods	Different dose of super plasticizer (SP) with different % of fly ash replacing with surkhi				
	SCC-0	SCC-25	SCC-50	SCC-75	SCC-100
	SP-1.4%	SP-1.6%	SP-1.7%	SP-1.8%	SP-2%
Slump flow BY Abram cone (mm)	780	730	690	655	650
T_{50cm} slump flow (sec)	3	3	4	5	5
J-Ring (mm)	8	6	4	1	0
V- Funnel (sec)	6	7	9	11	12
Time increase at V-funnel at T_{5min} (sec)	1	1	2	3	3
L-box test (h_1/h_2)	1	1	0.9	0.8	0.8
U-tube filling height (h_1-h_2) mm	20	15	8	5	2

Results and discussion

Workability of self-compacting concrete is defined in terms of three properties normally filling ability, passing ability and fluidity. Workability of SCC is to flow and consolidate under its own mass. It is seen from Table 6 that on increasing the dose of surkhi at partial replacement of fly ash, dose of super plasticizers also required to be increase which shows increase in workability with increase in proportion of surkhi. It may be due to the fact that water absorption of surkhi is substantially higher than that of fly ash which leads to the more absorption of available water resulting in lower workability. Fly ash comprise spherical particles which requires less for lubrication however, surkhi comprises angular particle resulting in higher water demand for lubrication. Specific gravity of surkhi more than that of fly ash on equal weight base volume of surkhi would be less than that of fly ash that may lead to more void in concrete. Water available for lubrication may be entrapped in void resulting in lower workability.

Conclusion

1. At 0.36 w/b ratio, slump flow test, U-box test results were found to be satisfactory, i.e. passing ability; filling ability and segregation resistance are within the specified range.
2. The workability is found to be decreasing with increase in replacement level.
3. Beyond 25% replacement level and increasing dose of super plasticizer, delayed setting of SCC is observed. It may be due to the low reactivity of fly ash.

References

1. EFNARC. 2001. EFNARC specification and guidelines for self compacting concrete Feb, 2001.
2. Kyayat, K.H. 1999. Workability, testing, and performance of self-consolidating concrete. *ACI Mater. J.* 96(3): 346-353.
3. Maghsoudi, A.A., Mohamadpour, Sh. and Maghsoudi, M. 2011. Mix design and mechanical properties of self compacting light weight concrete. *Int. J. Civil Engg.* 9(3): 230-236.
4. Mazloom, M. and Ranjbar, A. 2010. Relation between the workability and strength of self-compacting concrete. 35th Conf. on Our world in concrete and structures, Singapore.
5. Okamura, H. and Ouchi, M. 2003. Self-Compacting Concrete 2003. *J. Adv. Concret. Technol.* 1(1): 5-15.
6. Ramanathan, P., Baskar, I., Muthupriya, P. and Venkatasubramani, R. 2013. Performance of self-compacting concrete containing different mineral admixtures. *KSCE J. Civil Engg*. 17(2): 465-472.
7. Singh, D.S., Khan, S.P. and Rizwan, K.S. 2013. Workability of self-compacting concrete containing rice husk ash. UKIERI Concrete Congress-Innovations in Concrete Construction, pp.196-200.