International Journal of Civil Engineering and Technology (IJCIET)
Volume 8, Issue 1, January 2017, pp. 98–108, Article ID: IJCIET_08_01_011
Available online at http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=1
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

UTILIZATION OF RICE HUSK ASH AS A POZZOLAN IN SELF COMPACTING CONCRETE

Iftikhar Said

P.G Student, Department of Civil Engineering,

Iqra National University, Peshawar, Pakistan

Benish Khan

Resereach Assistant, Department of Civil Engineering,

Sarhad University of Science & Information Technology, Peshawar, Pakistan

Omair Inderyas

Lecturer, Department of Civil Engineering,

Sarhad University of Science & Information Technology, Peshawar, Pakistan

M. Abdur Rahman

Research Assistant, Department of Civil Engineering,

Sarhad University of Science & Information Technology, Peshawar, Pakistan

Shabir Ahmed

Lecturer, Department of Civil Engineering, Iqra National University, Peshawar, Pakistan

ABSTRACT

The utilization of industrial and agricultural waste can be used as a pozzolanic material in Self-consolidating concrete, as the name a concrete that completely fills the formwork under its own weight without using compaction vibrator by maintaining the homogeneity of concrete. Self-compacting concrete is to resist deformability and segregation in concrete. Deformability known as flow ability is the ability of self-compacting concrete to deform under its own weight without any obstructions. On the other hand segregation resistance is the ability to maintain the homogeneous matrix in between concrete while casting concrete.

The study explores the use of Rice Husk Ash (RHA) to increase the amount of fines and hence achieve self-compact ability in an economical way. The pozzolan used in this research was rice husk under the ASTM standard C618 (Class N). The study focuses on comparison of fresh and hardened properties of self-compacting concrete containing varying amount of 0%, 5% and 10% RHA with dosage of viscosity modifying agent of 2% to 4.5% as an admixture. The comparison is done at different dosages of super-plasticizer keeping cement, water, coarse aggregate, and fine aggregate contents constant.

The fresh properties of SCC for flow spread shows that by increasing the amount of RHA the spread decreases. The V-funnel at T=5 min showed that increase in RHA and decrease in super plasticizer high, segregation is resisted at higher content of RHA. Beside this the 10% rice husk ash *at 4% super plasticizer proved the higher compressive strength as compared to other mixes. The study concluded that the SCC produced utilizing RHA is more durable than the similar concrete utilizing commercially available admixture.*

Key words: Self-Compacting Concrete, Rice Husk Ash, Workability, Compressive Strength.

Cite this Article: Iftikhar Said, Benish Khan, Omair Inderyas, M. Abdur Rahman and Shabir Ahmed, Utilization of Rice Husk Ash as a Pozzolan in Self Compacting Concrete. *International Journal of Civil Engineering and Technology*, 8(1), 2017, pp. 98–108.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=1

1. INTRODUCTION

The utilization of industrial and agricultural waste produced by industrial processes has been the focus of waste reduction research for economic, environmental, and technical reasons. This study is concerned with the economical yet durable concrete by using natural solid waste known as rice husk ash in self - compacting concrete (SSC) or primarily called pozzolons in replacement of cement in order to overcome the overall cost of concrete as much as possible [1]. The production of SSC pozzolons may contain rice husk ash, fly ash, silica fume, bentonite and granulated blast furnace slag etc. with addition of super plasticizers.

The self-compacting or self-consolidating concrete is by definition a concrete that completely fills the formwork under its own weight without using compaction vibrator by maintaining the homogeneity of concrete. Self-consolidating concrete deforms under its own weight as a fluid does. And holds the particles of all sizes without letting them segregate into ingredients. Self-compacting concrete is versatile as it can be used in any thinkable way: precast or placed on site, using site batching plant or ready mix delivered by truck, pump or pour manually [2]. Experts across the world call self-compacting concrete one of the most revolutionary development in past several decades. Self-compacting concrete replaces the varying degrees of vibration and requirement for skilled labor with centralized quality control at production plant or mixer. This along with the ease with which self-compacting concrete can be pumped and made to travel long distances in formwork results in lower labor costs and hence an over-all economy. Durability and a better bond of concrete with reinforcement are obvious outcomes of the homogeneity without having to vibrate the concrete [3].

The main purpose of self-compacting concrete is to resist deformability and segregation in concrete. Deformability known as flow ability is the ability of self-compacting concrete to deform under its own weight without any obstructions. On the other hand segregation resistance is the ability to maintain the homogeneous matrix in between concrete while casting concrete. These two main properties can be reiterated from European Federation of National Associations Representing for Concrete (EFNARC) guidelines [4]. Casting of SSC involve high range water reducing admixtures to develop enough deformability and to resist segregation resistance by adding chemical viscosity modifying admixture (VMA) generally known as super plasticizers.

Rice husk ash is an agro-industrial waste product produced as a result of burning the outer cover of rice grain, called rice husk, which has a great fuel value. In crop season 2005-06 about 5.5 million tons of rice were produced in Pakistan. The excessive amount of burned rice husk ash possibly has no use at all and disposing it is also a concern problem. Rice husk is composed of both organic and inorganic matter. The major inorganic matter is silica. Rice plant takes up silicon component from soil and deposits it as an outer covering of the grain as silica. When burnt, organic matter is decomposed and the silica rich inorganic residue is left behind.

2. LITERATURE REVIEW

For achieving SCC mixes various methods have been used. In the previous studies the “Okamura” [5] fixed the amount of coarse aggregate and fine aggregate contents to achieve the self-compacting concrete.

By doing so the water cement ratio amount and super plasticizer dosage were adjusted for different mixes. In another pervious study “M Ouchi” [6] suggested about the workability of concrete by anticipating an index for ratio of funnel speed to flow area to estimate the amount of super plasticizer and viscosity of mortor. Another study from “Nansu” [7] used material properties to determine the cementations binders, mixing water, amount of aggregates, and super plasticizer dosage.

From the studies it was observed that when rice husk is burn between 550 to 800C° the resulting ash is amorphous and highly reactive (lechatelerite). Above this temperature, the ash structure rearranges to form crystalline silica (transition: quartz) at about 900C°, crystallization is complete and silica is wholly crystalline (cristobalite and tridymite). RHA melts at 1440C°. Two main issues associated with RHA are its unburnt carbon dependent water demand and amorphous content dependent reactivity. Like every ash, RHA may be collected from the bottom residue or collected from catchers [8]. When RHA is in crystalline form, it have little reactivity and high health hazards, so at that time we cannot use it. Exposure to the crystalline RHA causes silicosis. Besides, crystalline RHA is also carcinogenic. The presence of unburnt carbon, greatly increases water demand and reduces silica content of the ash. The unburnt carbon is identifiable by dark color of RHA. Ideal RHA should have very little LOI (Loss on ignition value). Stoker fired boilers produce more crystalline ash than suspension firing boilers. Conditions for ideal amorphous RHA are prolonged burning at temperature below 800C°. Typically, RHA contains silica above 90% which is highest among similar agro-industrial waste ashes. Owing to this silica content, amorphous RHA is highly pozzolanic.

3. EXPERIMENTAL WORK

The materials were collected from different queries and industries through-out the country. Materials used for this study were cement, coarse aggregates, fine aggregates, water, and admixture and risk husk ash [9], [10]. The concrete mix uses a single batch of cement supply to minimize variation of results. Aggregates of well graded type and free from impurities were checked and certain standards were compiled in the course of this study. A set of different material tests were performed using ASTM Standards [11] whose detail is tabulated in table I, Sieve Analysis of fine aggregate, sieve analysis of coarse aggregate, chemical properties of rice husk ash, Sieve Analysis of RHA and effect of normal consistency of different percentage of RHA are tabulated in table II, table III, table IV, and table V and table VI respectively. Whereas the graphical representation of Gradation curve from sieve Analysis of fine aggregate, Gradation curve from sieve analysis of coarse aggregate and Gradation curve from sieve Analysis of RHA is shown in figure 1, figure 2 and figure 3 respectively.

Table I Physical Properties of Materials & their Test Results

S#	Material Tests	Material Test Results
1	Type of Cement (ASTM C 150)	Type I
2	Specific Gravity of Cement	3.14
3	Consistency of Cement (ASTM C 187)	29.3%
4	Initial & Final Setting Time of Cement Initial	Initial 180 min
5	Sieve analysis of coarse aggregate (ASTM C136-	Max Nominal size
6	Sieve analysis of fine aggregate (ASTM C136-06)	Fineness Modulus 2.36
7	Specific gravity of coarse aggregate (ASTM C127-	Bulk Specific Gravity (SSD)
8	Specific gravity of fine aggregate (ASTM C128-	Bulk Specific Gravity (SSD)
9	Specific gravity of Risk husk Ash	2.4
10	Water absorption of coarse aggregate (ASTM	0.98%
11	Dry roded bulk density of coarse aggregate (ASTM	1602 kg/m^3
12	Dry roded unit weight of fine aggregates (ASTM	1956 kg/m^3

TABLE II Sieve Analysis of Fine Aggregate (ASTM C 136)

ASTM Sieve N0.	Mass Retained (gram)	Percentage Retained	Cumulative Percentage Retained	Cumulative Percentage Passing	ASTM Range (C 33)
8	0	0.0	0.0	100.0	80 to 100
16	87	16.0	16.0	84.0	50 to 85
30	160	29.4	45.3	54.7	25 to 60
50	172	31.6	76.9	23.1	5 to 30
100	114	20.9	97.8	2.2	0 to 10
Pan	12	2.2	100.0	0.0	
Total	545		236.0		

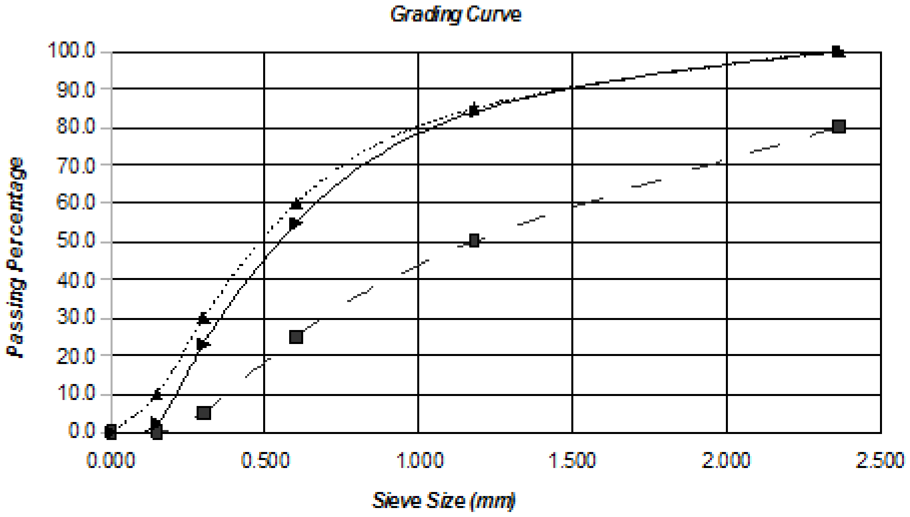

Figure 1 Gradation Curve of fine Aggregate

TABLE III Sieve Analysis of Coarse Aggregate (ASTM C 136)

Sieve Size mm	Mass Retained gram	Percentage Retained	Cumulative Percentage Passing	Cumulative Percentage Retained	ASTM Range
19	0	0.0	100	0.0	90 to 100
12.5	377	12.5	87.52894476	12.5	-
9.5	1840	60.9	26.66225604	73.3	20 to 55
4.75	796	26.3	0.330797221	99.7	0 to 10
2.36	8	0.3	0.066159444	99.9	0 to 5
Pan	2	0.1	0	100.0	-
Total	3023				

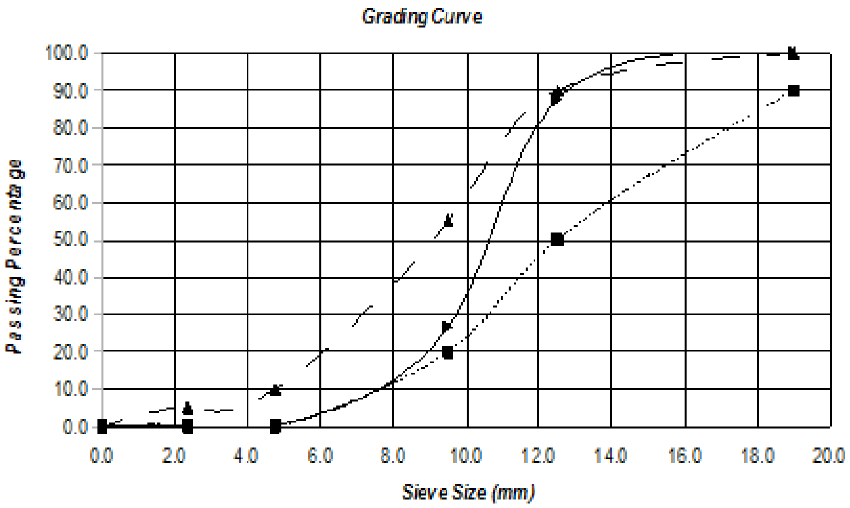

Figure 2 Gradation Curve of Coarse Aggregate

TABLE IV Chemical Analysis of Rice Husk Ash

Constituents	**Raw**	**Sieved**
	% by weight	**% by weight**
SiO_2	77.19	77.27
TiO_2	0.379	0.432
Al_2O_3	6.19	6.87
Fe_2O_{3T}	3.65	4.18
MnO	0.135	0.155
MgO	1.455	1.76
CaO	2.88	3.10
Na_2O	0.00	0.00
K_2O	1.815	2.10
P_2O_5	1.107	1.353
LOI (1000°C)	5.429	2.938

TABLE V Sieve Analysis of Rice Husk Ash

Sieve Opening Size um	**Mass Retained gram**	**Percentage Retained**	**Cumulative Percentage Retained**	**Cumulative Percentage passing**
425	12.0	12.1	12.1	87.88
250	16.0	16.2	28.3	71.72
150	20.3	20.5	48.8	51.21
75	20.8	21.0	69.8	30.2
Pan	29.9	30.2	100.0	0.0
Total	99			

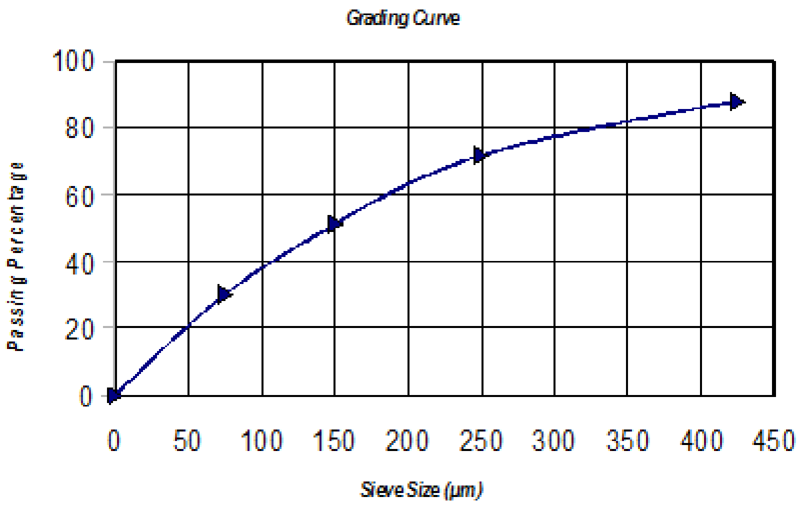

Figure 3 Gradation curve of Rice Husk Ash

TABLE VI Effect on Normal Consistency and Setting Times

Scheme	Normal Consistency (% by wt. of binder)	Setting Time	
		Initial Setting Time (Minutes)	Final Setting Time (Minutes)
Pure Cement	29.2	184	434
5% RHA	31.4	154	409
10% RHA	34.7	79	349
15% RHA	36.7	-	-

3.1. Mix Design

The mix design followed for this study was devised from the previous study of SSC provided by Professor Okamura by utilizing concrete materials and modifying water cement ratio and dosage of super plasticizer using EFNARC guideline [5]. There were 18 mixes in total which subdivided into three groups: Control Concrete, 5% RHA, and 10% RHA. For each of the group, dosage of super plasticizer was varied from 2% to 4.5% with an increment of 0.5%. The mix proportions are designated by specific names which are explained in the table VII below:

Table VII Mix proportions of SCC for various Percentages of RHA & SP

Mix Name	Water Kg/m3	Cement Kg/m3	RHA Kg/m3	Fine Aggregate	Coarse Aggregate Kg/m3	Sika (SP) %	Visco %	W/C Ratio
CC2	200	500	0	875	750	2	2	0.40
CC2.5	200	500	0	875	750	2.5	2	0.40
CC3	200	500	0	875	750	3	2	0.40
CC3.5	200	500	0	875	750	3.5	2	0.40
CC4	200	500	0	875	750	4	2	0.40
CC4.5	200	500	0	875	750	4.5	2	0.40
5R2	200	500	25	875	750	2	0	0.38
5R2.5	200	500	25	875	750	2.5	0	0.38
5R3	200	500	25	875	750	3	0	0.38
5R3.5	200	500	25	875	750	3.5	0	0.38
5R4	200	500	25	875	750	4	0	0.38

5R4.5	200	500	25	875	750	4.5	0	0.38
10R2	200	500	50	875	750	2	0	0.36
10R2.5	200	500	50	875	750	2.5	0	0.36
10R3	200	500	50	875	750	3	0	0.36
10R3.5	200	500	50	875	750	3.5	0	0.36
10R4	200	500	50	875	750	4	0	0.36
10R4.5	200	500	50	875	750	4.5	0	0.36

4. EXPERIMENTAL RESULTS & DISCUSSION

The tests done may be bifurcated into two main divisions: Tests conducted on conventional concrete and self-compacting concrete on both fresh and hardened Properties. For workability of concrete, following tests were selected as a measure for each of the property of concrete; for filling ability “slump flow spread and V-funnel tests”, for passing ability “L-box test”, for segregation resistance “V-funnel at t=5 minutes”. The results for the tests are shown in the table VIII.

Table VIII Test Results of Fresh Properties of Concrete

EFNARC Range	**SPREAD mm**	**L-BOX Blocking Ratio**	**V-FUNNEL**	
			T_0 Seconds	**T_5 Seconds**
	650 to 800	**0.8 to 1**	**6 to 12**	**T_0 to T_0 +3**
CC2	695	1	7.36	7.88
CC2.5	695	1	6.27	6.95
CC3	765	1	4.99	5.74
CC3.5	792	1	4.1	4.0
CC4	782	1	3.01	3.03
CC4.5	797	1	2.03	2.02
5R2	NTP	NTP	NTP	NTP
5R2.5	NTP	NTP	NTP	NTP
5R3	610	0.23	7.71	9.08
5R3.5	649	1	6.1	10.01
5R4	700	1	4.02	5.0
5R4.5	750	1	3.0	4.5
10R2	NTP	NTP	NTP	NTP
10R2.5	NTP	NTP	NTP	NTP
10R3	NTP	NTP	NTP	NTP
10R3.5	596	stuck	14.1	stuck
10R4	661	0.88	6.0	8.99
10R4.5	701	0.94	8.99	12.55

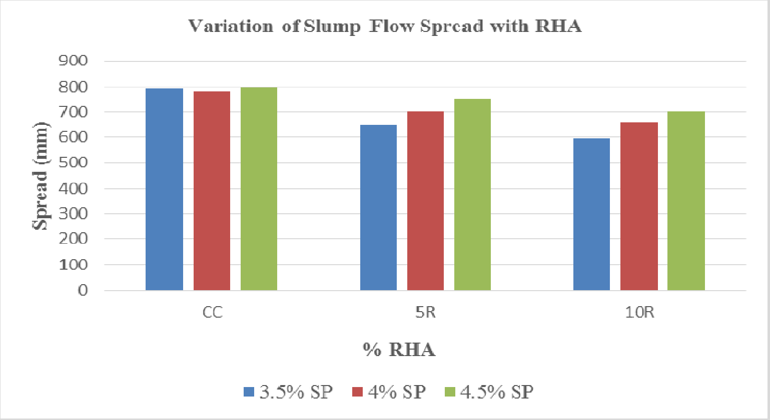

Figure 4 Variation of slump flow spread with % RHA

From the figure 4. It can be seen that all the slump spreads were within the recommended range of EFNARC i.e. 650 to 800 except one mix which is 595 at 10R3.5. It can also be observed that increasing the amount of RHA, the spread decreases. Beside this in a mix, the spread increases with the amount of super-plasticizers due to high flow ability incorporated by it.

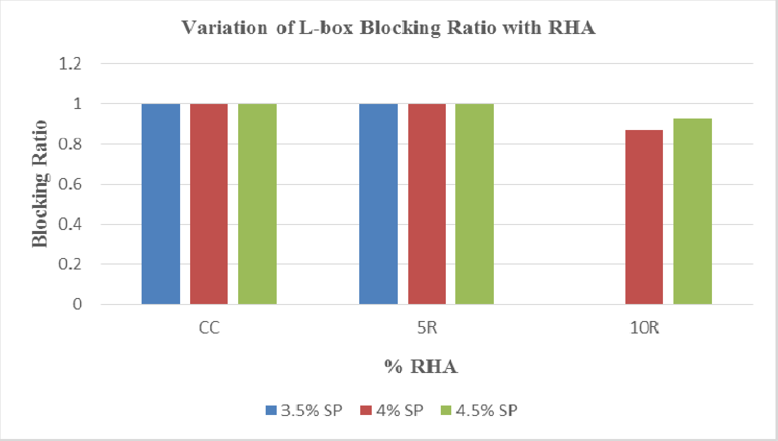

Figure 5 Variation of L-box blocking ratio with % RHA

From the figure 5, it is observed that all of the mixes were within the range of EFNARC except 10R3.5 However, this mix was not classified as self-compacting anyways. However, the mixes with 10% RHA had a slightly less blocking ratio than other CC and 5%RHA mixes.

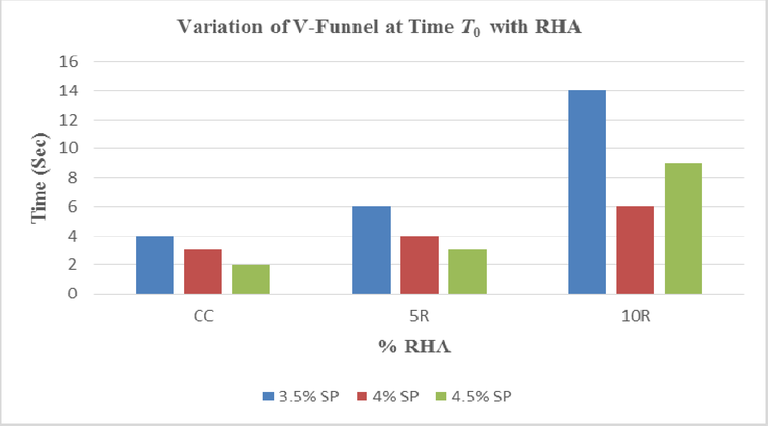

Figure 6 Variation of V-funnel at time T_0 with % RHA

From the figure 6, the flow ability of the mixes were measured through V-funnel tests, it can be clearly seen that most of them were just approaching and below to EFNARC limits. Three of the 6 mixes explored show V-funnel time values satisfying EFNARC guidelines. This shows that with the increase in RHA, the V-funnel times increased showing improving viscosity.

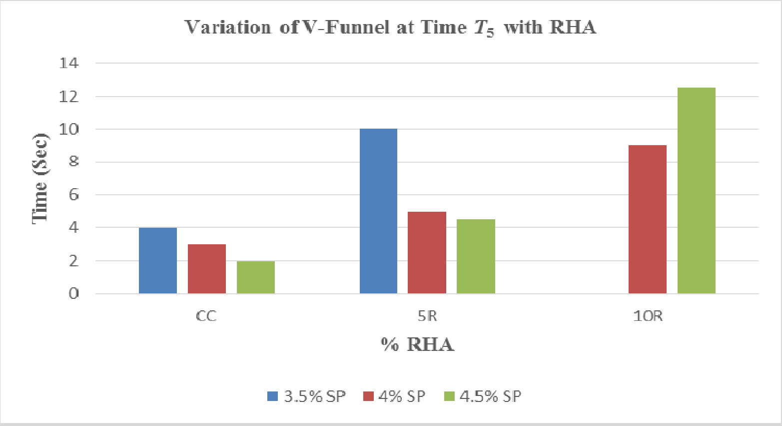

Figure 7 Variation of V-funnel at time T=$_5$ with % RHA

From the figure 7, it is observed that results of V-funnel at T=5 min are quite inspiring. Almost all of the results obtained within the EFNARC limit or nearly above it. This proves that with increase in RHA and decrease in super plasticizer, the values of time incline to the upper limit. This means high segregation resistance at higher content of RHA.

The compressive strength was determined for 7 and 28 days. The variation of compressive strength with different % RHA of 7 and 28 days strength with different dosage of super-plasticizers are tabulated in below table IX;

Table IX Test Results of Compressive strength of Concrete Specimens

Specimen	**Compressive Strength**			
	7 days		**28 days**	
	MPa	**Psi**	**MPa**	**psi**
CC2	19.2	2790	33.0	4780
CC2.5	16.9	2450	30.4	4415
CC3	13.2	1908	30.9	4475
CC3.5	10.5	1522	28.4*	4125*
CC4	6.8	983	18.3*	2655*
CC4.5	1.2	180	8.6	1250
5R2	NTP	NTP	NTP	NTP
5R2.5	NTP	NTP	NTP	NTP
5R3	32.1	4650	47.4	6880
5R3.5	25.2	3657	38.0	5505
5R4	21.4	3100	37.8	5485
5R4.5	11.9	1719	22.2	3220
10R2	NTP	NTP	NTP	NTP
10R2.5	NTP	NTP	NTP	NTP
10R3	NTP	NTP	NTP	NTP
10R3.5	22.5	3260	36.2	5250
10R4	36.8	5330	41.4	6000
10R4.5	36.5	5287	48.5	7035

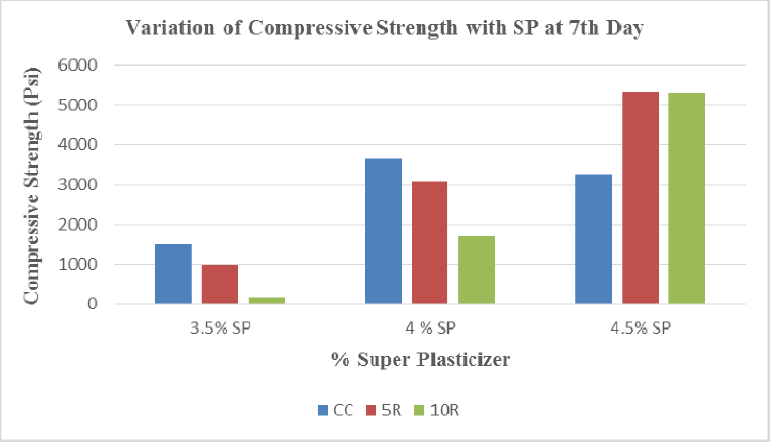

Figure 8 Variation of Compressive Strength at 7th Day with different % SP

The figure 8. demonstrate the compressive strength of SSC specimens with different %age of super plasticizer at 7th day. It was observed that the compressive strength of all three types of specimens i.e. CC, 5R and 10R with increase in % of super plasticizer except 4.5% SP. At 4.5% SP the result is totally opposite to other conditions at 7th day. At that stage the compressive strength of all three types of specimens increases.

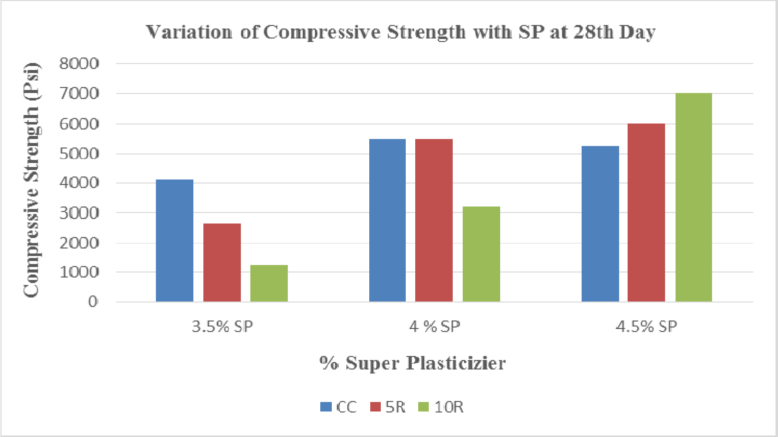

Figure 9 Variation of Compressive Strength at 7th Day with different % SP

The figure 9. demonstrate the compressive strength of SSC specimens with different %age of super plasticizer at 28th day. It showed that with the increase in dosage of super plasticizer, the strength of concrete is increasing for all three specimens CC, 5R, and 10R. The reason for this is that for same water content more water is available for hydration due to increase in SP percentage. However, in mix with 10% RHA, the strength gain is higher than all other mixes with increase in %age of SP, this is due to improved workability and sufficient self-compaction of concrete.

5. CONCLUSION

Based on the experimental results the following conclusions were drawn;

- From the fresh properties of SCC for flow spread it was observed that by increasing the amount of RHA, the spread decreases. In a mix, the spread increases with the amount of super-plasticizers due to high flow ability incorporated by it. On the other hand the test results of V-funnel at T=5 min are quite encouraging. With increase in RHA and decrease in super plasticizer, the values tend to approach the upper limit which proves that high segregation is resisted at higher content of RHA.

- From the compressive test results it was observed that SCC under all super plasticizer dosage has higher strength than conventional concrete. It is concluded from test results of 28th day compressive strength that with the increase in dosage of super plasticizer, the strength of concrete is increasing for all three specimens CC, 5R, and 10R. The 10% rice husk ash at 4% super plasticizer proved the higher compressive strength as compared to other mixes.

6. ACKNOWLEDGMENTS

The authors are thankful to “Dr. Mehboob Alam” Head of Civil Engineering department, “Engr. M. Zeeshan Ahad” MS/Ph.D Coordinator, of Iqra National University Peshawar Pakistan-25000, and Professor Dr. Sher Afzal Khan, Chairman Civil Engineering Department of Sarhad University of Science & Information Technology Peshawar, for their kind support and encouragement.

REFERNENCES

[1] Sua-iam, G. and N. Makul, “Utilization of high volumes of unprocessed lignite-coal fly ash and rice husk ash in self-consolidating concrete." Journal of Cleaner Production 78: 184-194, 2014.

[2] Lea, F.M. "The chemistry of cement and concrete." third edition, 1998, Arnold. London.

[3] Wallevik, O., and Nielsson, I. “Self-compacting concrete- a rheological approach.” Proc. International Workshop on Self-compacting concrete,1998, Kochi University of technology, Japan.

[4] Specifications and Guidelines for Self-compacting Concrete. European Federation of National Trade Associations representing producers and applications of specialist building products (EFNARC), 2002.

[5] Okamura, H, “Self-Compacting High-Performance Concrete”, Concrete International, Vol. 19, pp. 50-54, 1997.

[6] M Ouchi, Hajime Okamura “Effect of Super plasticizer on Self-Compatibility of Fresh Concrete,” Journal of Transportation Research. Board, pp 37-40, 1997.

[7] Nan Su, Kung-Chung Hsu, His-Wen Chai, “A Simple Mix Design Method for Self-Compacting Concrete,” Cement and Concrete Research pp1799, 31, 2001.

[8] S.A. Memon, M.A Sheikh, H.Akbar, “Production of Low Cost Self-Compacting Concrete Using Rice Husk Ash” First International Conference on Construction in Developing Countries (ICCIDC–I) “Advancing and Integrating Construction Education, Research & Practice” August 4-5, 2008, Karachi,, Pakistan.

[9] Neville, A.M. "Properties of concrete." fourth edition, Neville, A.M. 2006, Dorling Kindersley (India), Pvt Ltd, Patparganj, Delhi, India.

[10] Shetty, M.S. “Concrete Technology- Theory and Practice" fifth edition. 2004, S. Chand and Company Ltd. Ram Nagar, New Delhi. 110 055. India

[11] American Society of Testing and Materials manual ASTM, for standard procedures of cement, aggregates and concrete, 2006.

[12] Shashikant Srivastava, Mohd Arif Ansari, P. K. Meht a and Vikas Srivastava, Flyash as Partial Replacement of Portland Pozzolana Cement in Concrete: an Experimental Investigation. *International Journal of Civil Engineering and Technology (IJCIET),* 7(6), 2016, pp.207 – 214.

[13] Abdullah Anwar, The Influence of Waste Glass Powder as a Pozzolanic Material in Concrete. *International Journal of Civil Engineering and Technology (IJCIET)*, 7(6), 2016, pp.131 – 148.