IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 5 Ver. VI (Sep- Oct. 2014), PP 15-21
www.iosrjournals.org

Effect of w/c ratio on workability and mechanical properties of high strength Self Compacting Concrete (M70 grade)

V. Mallikarjuna Reddy[1], Dr. M. V. Seshagiri Rao[2]
[1]*Civil Engineering Department, GRIET, Hyderabad INDIA*
[2]*Civil Engineering Department, JNTUHCE, Hyderabad INDIA*

Abstract: *This paper presents the results of an experimental research on the workability and mechanical properties of high strength self-compacting concrete of grade M70 containing Fly ash and Micro silica as mineral admixtures. The work focused on concrete mixes having Water/Cement ratios of 0.23, 0.24, 0.25, 0.26 and 0.27, with a Packing Factor of 1.12. The Concrete mixes contains different proportions of Fly Ash, Super plasticizers, water binder ratios and constant proportions of Cement, Micro Silica, VMA, Coarse aggregate and Fine aggregate for different Water Cement ratios based on trial mixes. The percentage of Micro Silica added is 7% for all mixes based on trial mixes. The mix proportions are obtained on the basis of NAN-SU mix design. All the mixes contain Cement of 574 kg/m^3 but with different total binder content. The workability tests performed in this research were as per EFNARC. Based upon the experimental results, for water cement ratio 0.25 fresh and hardened state properties of high strength self-compacting concrete are moderate.*
Keywords: *Fly ash, High strength Self-Compacting Concrete, Micro silica, Packing Factor, Super plasticizer, VMA* and *Water Cement ratio.*

I. Introduction

Self-compacting concrete having advanced viscosity and workability properties can easily fill the moulds without the necessity of using vibrators. High volume of mineral powder is a necessity for a proper self-compacting concrete design [1]. For this purpose, mineral admixtures such as limestone powder, fly ash, micro silica, rice husk ash and blast furnace slag can be used[2,3]. In this study, the effects of water cement ratio on fresh and hardened properties of self -compacting concrete have been investigated.

It is worth noting that extensive investigations on the workability of self-compacting concrete have been made recently. Kayat et al. reported that the L-box, U-box, and J-ring tests can be used to evaluate the passing ability of self-compacting concrete and, to a certain extent, the deformability and resistance to segregation. When combined with the slump flow test, the L-box test is very suitable for the quality control of on-site Self-compacting concrete.

It is apparent that workability depends on a number of interacting factors such as water content, aggregate type, size of aggregate and grading, Fine Aggregate to Coarse Aggregate ratio(FA/CA), packing factor, kind and dosage of super plasticizers, and the fineness of cement. The main factors on self-compacting concrete are the water and super plasticizer contents of the mix since by simply adding them the inter particle lubrication is increased. In this research mix design used is based on NAN-SU method[4]. His design is based on packing factor (PF) of aggregate.PF is the ratio of mass of aggregate of tightly packed state in SCC to that of loosely packed state.

II. Materials And Mix Proportions

This part of the paper presents the specifications of the mixes used for obtaining the workability, compressive strength, split tensile strength and flexural strength of self-compacting concrete. Ordinary Portland cement (OPC 53 grade), Fly ash and Micro silica were used as cementitious materials. Natural river sand and crushed gravel with a nominal maximum size of 10 mm were used as the aggregates[5]. Chemical admixtures used were GLENIUM B233 (a new generation based on modified poly carboxylic ether) as super plasticizer [6] and Glenium Stream-2 as VMA [7]. In this research PF and FA/CA used are 1.12 and 52/48 for different w/c ratios based on trials. Proportions of Fly Ash, Super plasticizers and water binder ratios are different and proportions of Cement, Micro Silica, VMA, Coarse aggregate and Fine aggregate are constant for different Water Cement ratios. The percentages of Micro Silica and VMA added are 7% and 0.3% for all mixes based on trial mixes.

Table 1: Mix proportions of high strength self compacting concrete for different water to cement ratios.

Mix Components	Concrete Mixes				
	M1 w/c=0.23	M2 w/c=0.24	M3 w/c=0.25	M4 w/c=0.26	M5 w/c=0.27
	Qty.(kg/m^3)	Qty.(kg/m^3)	Qty.(kg/m^3)	Qty.(kg/m^3)	Qty.(kg/m^3)
Cement	574	574	574	574	574
Fly Ash	41.00	34.30	27.60	20.90	14.20
Micro Silica	40.18	40.18	40.18	40.18	40.18
Fine aggregate	844.48	844.48	844.48	844.48	844.48
Coarse aggregate	805.32	805.32	805.32	805.32	805.32
Water	140.68	143.82	146.97	150.11	153.25
Super Plasticisers	11.07	10.95	10.83	10.71	10.59
VMA	1.722	1.722	1.722	1.722	1.722

III. Results and Discussion

In this part of the paper, the experimental results of self-compacting concrete mixes related to compressive strength, split tensile strength, flexural strength and workability are discussed for different water cement ratios. The workability tests performed in this research were as per EFNARC [8,9]. The tests done were Slump flow, V-funnel, L-box and U-box. The results of workability tests on self-compacting concrete are shown in Table 2. The results of compressive strength, split tensile strength and flexural strength are shown in Table 3. Slump Flow (SF) increases as the w/c ratio increases. When w/c increases from 0.23 to 0.27, slump flow increases by 6.9%.(Fig.1)

T500, V-funnel, T5 and U-box values are decreasing as the w/c ratio increases. When w/c ratio increases from 0.23 to 0.27, T500 time decreases by 36.6%,V-funnel time decreases by19%, T5 time decreases by16.3% and U-box value decreases by 55.56%. It is observed that workability increases as the w/c ratio increases. (Figs. 2, 3, 4 and 5)

L-box value increases as the w/c ratio increase. When w/c ratio increases from 0.23 to 0.27(17.4%), L-box ratio increases by 3.16%.It is observed that flow ability increases as the w/c ratio increases. (Fig.6)

Results of Slump flow, T500 and V-funnel tests indicate that filling ability increases as the w/c ratio increases. Results of V-funnel at T5minutes indicates that segregation resistance increases as the w/c ratio increases. Results of U-box and L-box tests indicate that passing ability increases as the w/c ratio increases. Overall it is observed that the workability increases as the w/c ratio increases. This is due to increase in water binder ratio.

Compressive strength decreases as the w/c ratio increases. When w/c ratio increases from 0.23 to 0.27, 28days Compressive strength decreases by 2.06% (Fig.7). Split tensile strength decreases as the w/c ratio increases. When w/c ratio increases from 0.23 to 0.27, 28days Split tensile strength decreases by 4.9% (Fig.8). Flexural strength decreases as the w/c ratio increases. When w/c ratio increases from 0.23 to 0.27, 28days Flexural strength decreases by16% (Fig.9). This is due to increase in water binder ratio.

The relation between the strengths and water cement ratios are as given below.

$$f_{ck} = -41.6 \left(\frac{w}{c}\right) + 91.946$$

$$f_t = -4.9 \left(\frac{w}{c}\right) + 5.243$$

$$f_{cr} = -25.2 \left(\frac{w}{c}\right) + 12.41$$

Where

f_{ck} = 28 days compressive strength in MPa.

f_t = 28 days split tensile strength in MPa.

f_{cr} = 28 days flexural strength in MPa.

$\frac{w}{c}$ = water cement ratio.

The relation between the flow values and water cement ratios are as given below.

S.F in mm = 1100 ($\frac{w}{c}$) + 397

T500 in sec = -34.4 ($\frac{w}{c}$) + 12.092

V-funnel in sec = -36.2 ($\frac{w}{c}$) + 17.008

T5 in sec = -45.7 ($\frac{w}{c}$) + 22.155

L-box ratio = 0.76 ($\frac{w}{c}$) + 0.7766

U-box ratio = -120 ($\frac{w}{c}$) + 36.2

The relation between Compressive strength and Flexural strength is as given below. (Figure 10)

$f_{cr} = 0.568\ (f_{ck}) - 40.23$

The relation between Compressive strength and Split tensile strength is as given below. (Figure 11)

$F_t = 0.12\ (f_{ck}) - 5.7678$

Table 2: Workability of the high strength self compacting concrete mixes for different w/c ratios.

Workability Tests	Concrete Mixes				
	M1 w/c=0.23	M w/c=0.24	M3 w/c=0.25	M4 w/c=0.26	M5 w/c=0.27
Slump flow (mm)	655x655	660x660	665x665	680x680	700x700
T 500(sec)	3.94	3.88	3.82	3.32	2.5
V-funnel(sec)	8.5	8.35	8.1	7.95	6.89
V-funnel T_5 min (sec)	11.89	10.92	10.66	10.23	9.95
L-box(h2/h1)	0.95	0.959	0.969	0.975	0.98
U-box (mm)	9	7	6	5	4

Table 3: Development of compressive strength, split tensile strength and flexural strength for different w/c ratios.

Concrete Mix	Compressive strength (N/mm^2.)		Split tensile strength (N/mm^2.)		Flexural strength (N/mm^2.)	
	7days	28days	7days	28days	7days	28days
M1 w/c=0.23	61.64	82.22	3.72	4.09	5.92	6.58
M2 w/c=0.24	59.73	82.07	3.62	4.08	5.84	6.42
M3 w/c=0.25	55.11	81.62	3.43	4.04	5.72	6.18
M4 w/c=0.26	52.53	81.29	3.4	3.99	5.46	5.76
M5 w/c=0.27	52.48	80.53	3.37	3.89	5.184	5.65

FIGURES

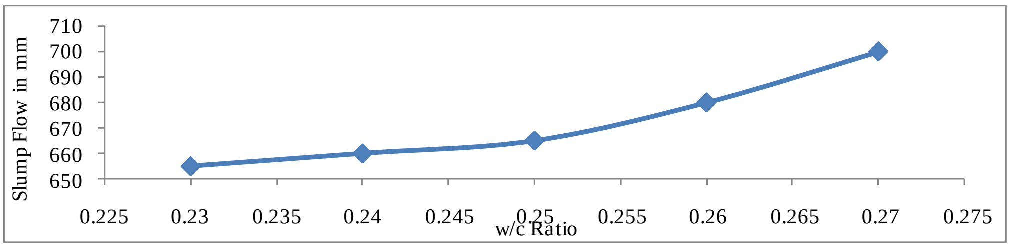

Figure 1: w/c ratio Vs slump flow

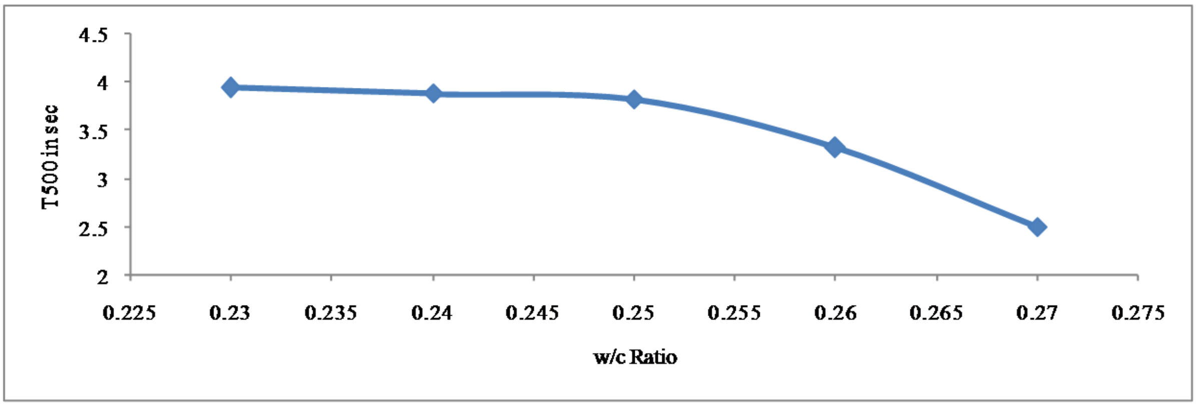

Figure 2: w/c ratio Vs T500

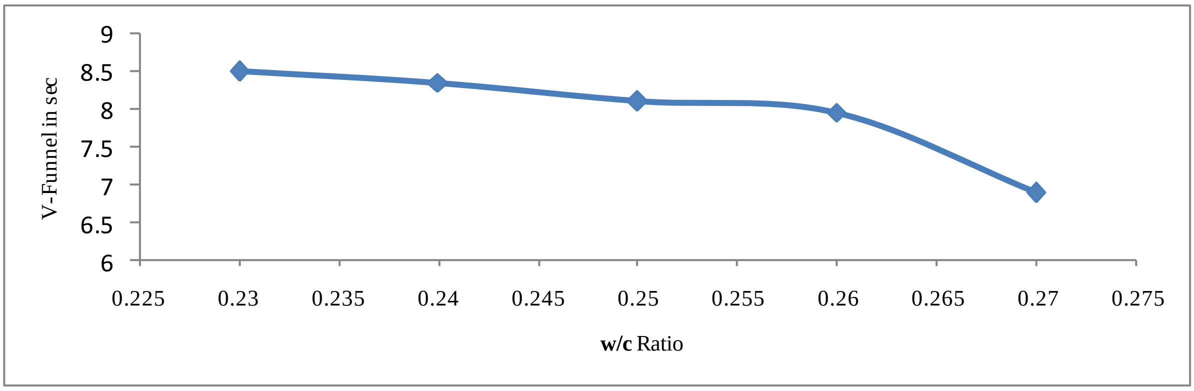

Figure 3: w/c ratio Vs V-Funnel

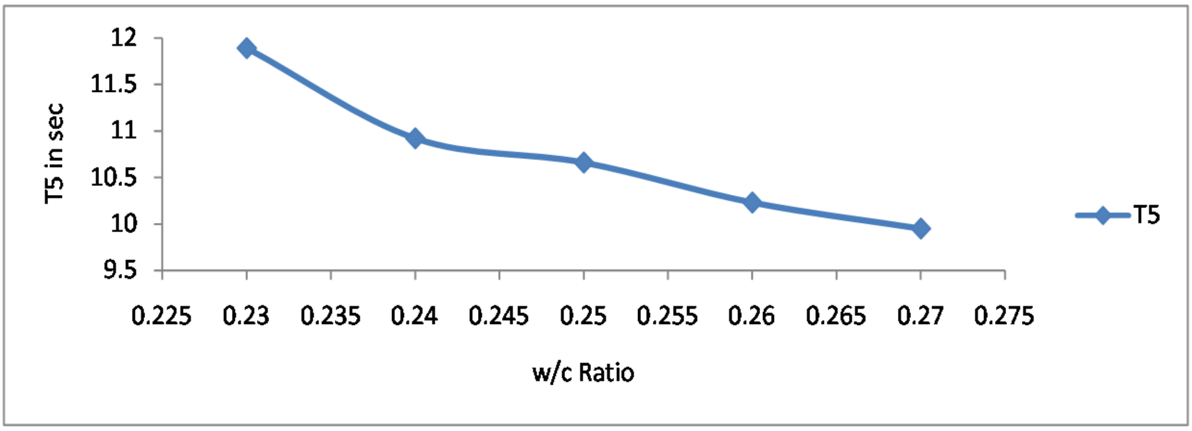

Figure 4: w/c ratio Vs T_5

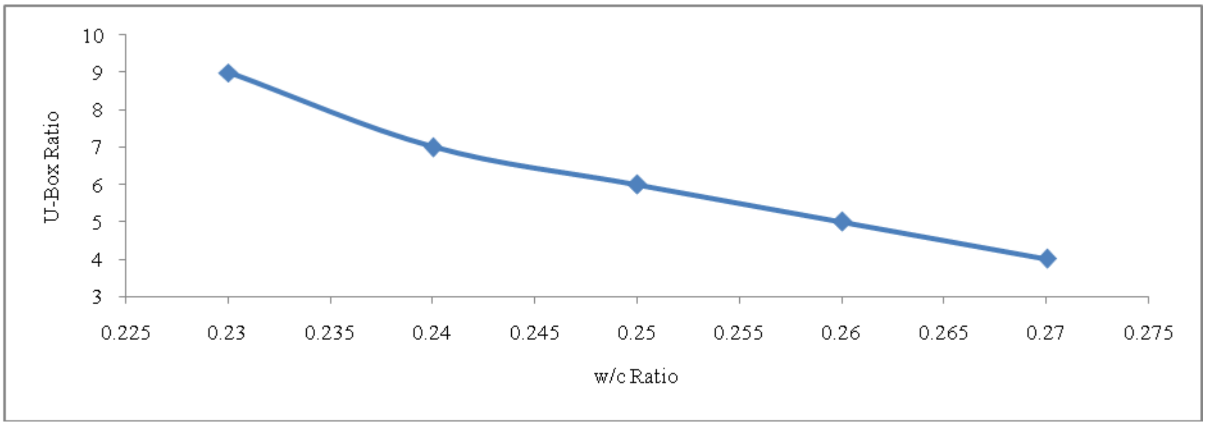

Figure 5: w/c ratio Vs U-Box Ratio

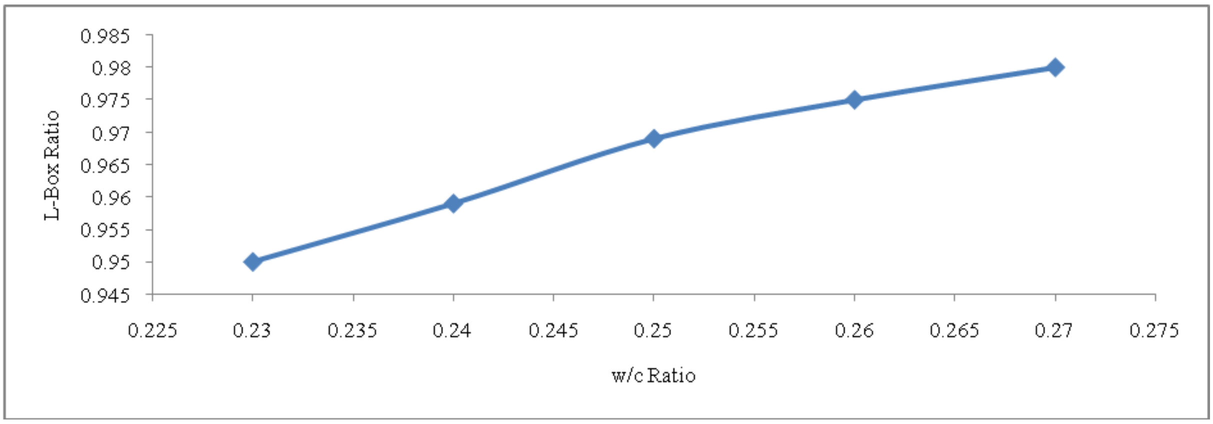

Figure 6: w/c ratio Vs L-Box ratio

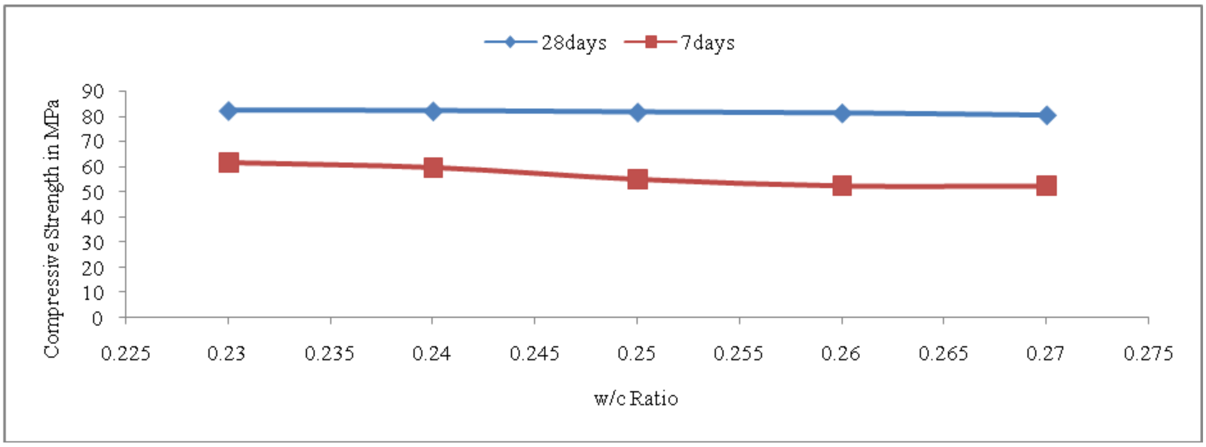

Figure 7: w/c ratio Vs Compressive Strength

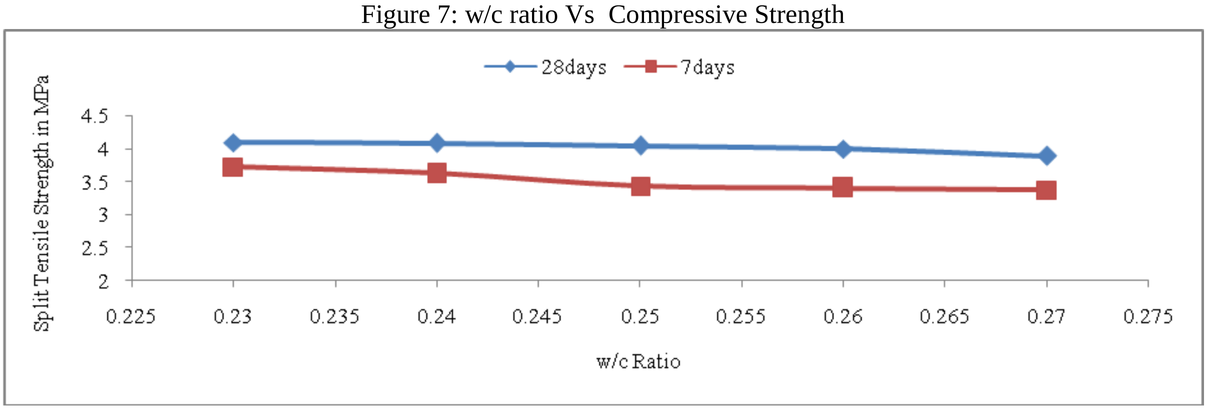

Figure 8: w/c ratio Vs Split Tensile Strength

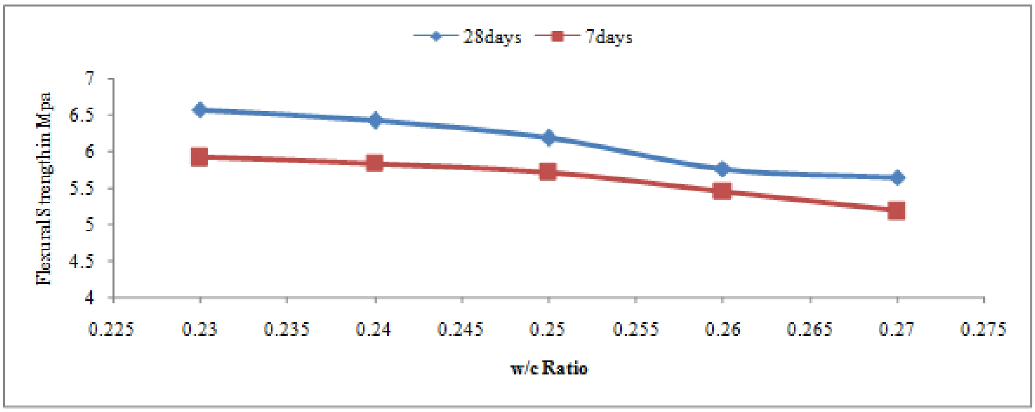

Figure 9: w/c ratio Vs Flexural Strength

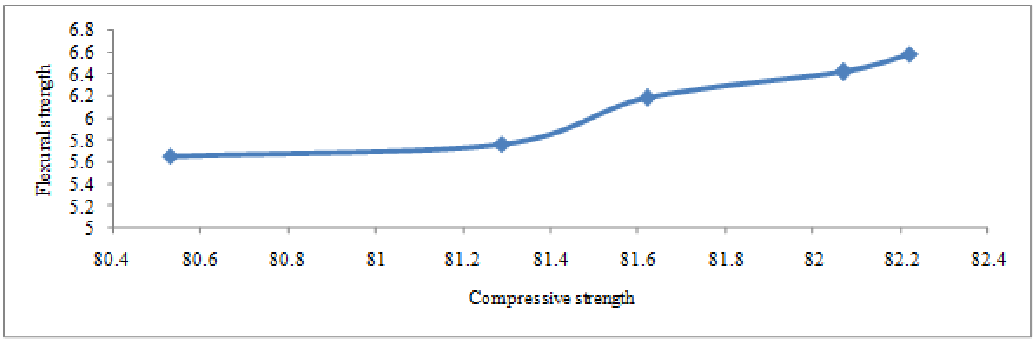

Figure 10: Compressive strength Vs Flexural Strength

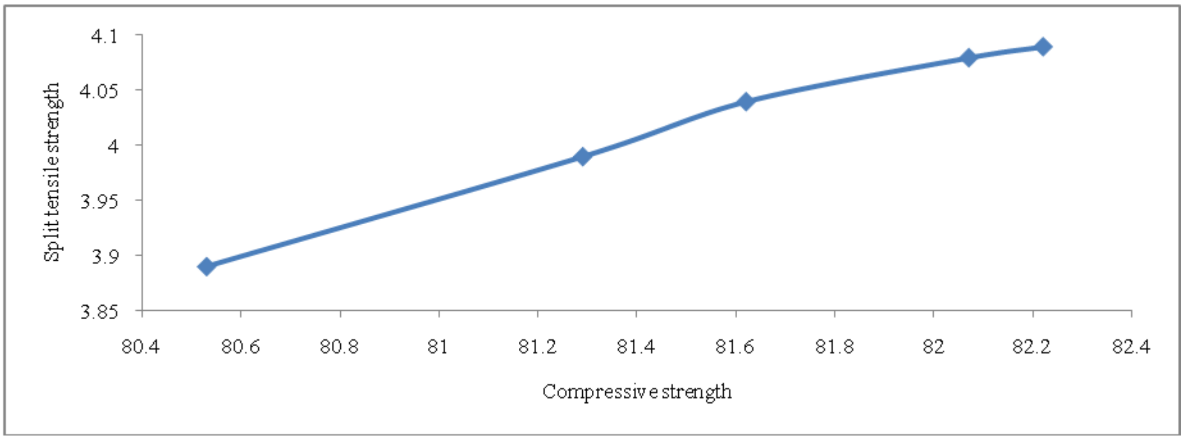

Figure 11: Compressive strength Vs Split Tensile Strength

IV. Conclusion

The following conclusions are drawn from the study on the effect of water cement ratio on workability and mechanical properties of high strength self compacting concrete with fly ash and micro silica as mineral admixtures.

- Required minimum slump is achieved for a w/c ratio of 0.23 with optimum strength for M70 grade high strength self compacting concrete. This is due to low water binder ratio.
- Required minimum strengths are achieved for a w/c ratio of 0.27 with optimum slump for M70 grade high strength self compacting concrete. This is due to high water binder ratio.
- For a w/c ratio of 0.25 fresh and hardened state properties of high strength self-compacting concrete are moderate.
- These values are obtained for a Packing Factor of 1.12 with addition of 7% Micro Silica.

References

[1]. Okamra H. and Ouchi, M. "Self-compacting concrete". Journal of advanced concrete technology, 2003, Vol.1, No.1, pp 5-15
[2]. Anne-Meike Poppe an Geert De Schutter. "Cement hydration in the presence of high filler contents". Cement and Concrete research 2005, Vol.35, pp 2290-2299.
[3]. Khatri, R.P. and Sirivivatnanon, V. "Effect of different supplementary cementitious materials on mechanical properties of high performance concrete," Cement and Concrete Research, 25, 1, 1995, 209-220.
[4]. Nan Su, Kung –Chung Hsub and His-Wen Chai. " A simple mix design method for self compacting concrete". Cement and Concrete Research, 2001, Vol.31, pp 1799-1807.
[5]. S. Venkateswara Rao, M. V. Seshagiri Rao and P. Ratihish Kumar. "Effect of size of aggregate and fines on standard and high strength self-compacting concrete", Applied science research, 6(5): 433-442, 2010.
[6]. Felekoglu, B. and Sarikahya, H. "Effect of chemical structure of polycarboxylate-based super plasticizers on workability retention of self-compacting concrete," Construction and Building Materials, 22, 2008, 1792-1980
[7]. Lachemia M., Hossiana K.M.A, Lambrosa V., Nkinamubanzib and Bouzoubaa N. "Performance of new viscosity modifying admixtures in enhancing the rheological properties of cement paste". Cement and concrete research, 2004, Vol.34, pp 185-193.
[8]. European Project Group, Specification and guidelines for self-compacting concrete, United Kingdom,EFNARC, 2002.
[9]. Hemant Sood, Khitoliya R.K. and Pathak .S., " Incorporating European Standards for testing self compacting concrete in Indian conditions". International Journal of Recent Trends in Engineering May 2009, Vol.1, No.6, pp 41-45.