ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 8, February 2013

Comparison and Optimization of Dosage of Different Super-Plasticizers for Self Compacted Concrete Using Marsh Cone

Nanak J Pamnani, Palakkumar D. Patel, Dr. A.K. Verma, Jayeshkumar Pitroda

Abstract: ***As mix design of Self compacted concrete is based on trial and error method, it is important to find the optimum dose of Super plasticizer in order to minimize the trials and labour. In this paper Marsh Cone has been used to decide the optimized dosage of Superplasticizers. The dosages are decided on cement slurry which is prepared using different amount of Super plasticizer for a fixed water cement ratio. The flow ability of thus prepared slurry is measured. Three different brands of polycarboxylates ether condensate (PCE) basedSuperplasticizer (SP) are selected to find out their optimum dose using marsh cone test. It seems to be easy, safe& fast method for self-compacted concrete.***

Keywords: **Self-Compacted Concrete, Marsh Cone, Super plasticizer, Fluidizing water/Cement Ratio, Compatibility.**

I. INTRODUCTION

Superplasticizers constitute a relatively new category and improved version of plasticizer, the use of which was developed in Japan and Germany during 1960 and 1970 respectively. They are chemically different from normal plasticizers. Use of Superplasticizers permits the reduction of water to the extent up to 30 per cent without reducing workability in contrast to the possible reduction up to 15 per cent in case of plasticizers. The use of Super plasticizer is practiced for production of flowing, self-leveling and self-compacting for the production of high strength and high performance concrete. They are called High Range Water Reducers (HRWR) in American literature. It is the use of Super plasticizer which has made it possible to use w/c as low as 0.25 or even lower and yet to make flowing concrete to obtain strength of the order 120 N/mm^2 or more. Self-Compacted Concrete (SCC) is highly workable concrete with high strength and high performance that can flow under its own weight through restricted sections without segregation and bleeding. SCC is achieved by reducing the volume ratio of aggregate to cementitious material, increasing the paste volume and using various viscosity enhancing admixtures and Super plasticizers. It has been noticed that all Superplasticizers are not showing the same extent of improvement in fluidity with all types of cements. Some Superplasticizers may show higher fluidizing effect on some type of cement than other cement. There is nothing wrong with either the Super plasticizer or that of cement. The fact is that they are just not compatible to show maximum fluidizing effect. Optimum fluidizing effect at lowest dosage is an economical consideration. Giving maximum fluidizing effect for a particular Super plasticizer and cement is very complex involving many factors like composition of cement, fineness of cement etc. The purpose of this research paper is to compare effect of different brands of Super plasticizers in order to select an appropriate compatible SP and also to finalise an optimum dose for these Super plasticizers to help achieving self-compacted concrete. Although compatibility problem looks to be very complex, it could be more or less solved by simple and ready field method. Incidentally these simple field tests show also the optimum dose of the Super plasticizer to the cement. Following methods could be adopted.

- Marsh cone test
- Mini slump test
- Flow table test

The Marsh cone test is a simple approach to get some data about cement pastes rheological behavior. It has already been used in cement based materials mix design in order to define the super-plasticizer saturation point, i.e. the dosage beyond which the flow time does not decrease appreciably. Marsh cone test is easy to perform and seems to give better results. The test assembly is portable making it handy at the site. Also it requires small quantity of materials. In the Marsh cone test, cement slurry is prepared and its flow ability is checked. In concrete it is the cement paste that influences flow ability. It is observed that paste theology model is useful to the SCC mix design. Although, the quantity of aggregates, its shape and texture etc. will have some influence, it is the paste that will have greater influence. The presence of aggregate will make the test more complex and often erratic. The use of paste/slurry alone will make the test simple, consistent and indicative of the fluidity effect of Super plasticizer with the cement.

II. MATERIALS& TEST METHOD

Material used in developing cement slurry is having following properties:

- **Cement:** Ordinary Portland cement of 53 grade (Sanghi brand) with Specific Gravity 3.15, available in local market.
- **Water**: Potable water was used for mixing.
- **Superplasticizers (SP):** Three different brands of polycarboxylates ether condensate (PCE) based Superplasticizers were used namely Glanium Sky 784, Viscocrete 20HE and Glanium B276 Suretec. Different dosages of Superplasticizers were used for finding the flow values of the mixes. The properties of SPs are listed in tables below.

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Table 1: SP1-BASF GLANIUM SKY 784

Aspect	Light brown liquid
Relative Density	1.10±0.01 at 25° C
pH	≥6
Chloride ion content	<0.2%

Table 2:SP2- SIKA VISCOCRETE 20HE

Aspect	Light brownish liquid
Relative Density	1.08 at 25° C
pH	4.3 ± 0.5
Chloride ion content	Chloride-free

Table 3:SP3- BASF GLANIUM B276 SURETEC

Aspect	**Light brown liquid**
Relative Density	**1.10 ± 0.02 at 25° C**
pH	**≥6**
Chloride ion content	**<0.2%**

III. MARSH CONE TEST

Apparatus: Marsh cone is a conical brass vessel, (Funnel shaped) with a smooth aperture diameter of 8 mm at the bottom. It hold son a stand with container below it. The apparatus is shown in Fig. 1, Stop Watch is needed to record the flow time (T) to empty the cone.

Procedure: Take @ 2 kg cement, proposed to be used for the project. Take 640 ml of water (W/C 0.32%) and 0.6% Super plasticizer by weight of cement to make slurry of @ 1 liter. Mix them thoroughly in a mechanical mixer (Hobart mixer is preferable) for two minutes. Hand mixing may not give consistent results because of unavoidable lump formation which blocks the aperture.

Fig. 1 Marsh Cone Test In Process

If hand mixing is done, the slurry should be sieved through 1.18 sieves to exclude lumps. Take one liter slurry and pour it into marsh cone duly closing the aperture. Start stop watch and simultaneously open the aperture. Find out the time taken in seconds, for complete flow out of the slurry. The time in seconds is called the "Marsh Cone Time". The procedure is repeated gradually increasing the percentages of Super plasticizers in the steps of 0.1%. Similar testing is carried out for all the Super plasticizers, (SP1, SP2& SP3) and the results were analyzed to get the value of optimized doses.

Fig.2 Mixing Of Sample

Results and discussion:"T" is the time in sec taken by 1 liter of cement slurry to empty the Marsh cone which is known as "Marsh Cone Time". The time "T" for various mixes was noted and tabulated as shown in Table-4. A graph can be prepared for time "T" and dosages of Super plasticizer. The dose at which the Marsh cone time is lowest is called the saturation point. If we increase the content of Super plasticizer more than saturation point it does not affect much to the time "T". The dose is the optimum dose for that brand of cement and Super plasticizer for selected W/C ratio.

TABLE 4: Marsh Cone Time in Seconds for SP1, SP2 & SP3

SP % by cement	Time in sec (T) SP1	Time in sec (T) SP2	Time in sec (T) SP3
0.6	168	XXX	188
0.7	104	117	122
0.8	77.30	83	93
0.9	62.45	67	73
1.0	50.38	58.23	63.25
1.1	40.56	52.56	**58.47**
1.2	**38.54**	47.12	58.30
1.3	38.57	**41.03**	57.8
1.4	38	40.67	XXX
1.5	XXX	39.96	XXX

Optimum dosage of different brand SP:
SP1- BASF GLANIUM SKY 784: **1.2%**
SP2- SIKA VISCOCRETE 20HE: **1.3%**

ISSN: 2277-3754
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SP3- BASF GLANIUM B276 SURETEC: **1.1%**

The test could be carried out for various brands of cement with various brands of Super plasticizer at different W/C ratio. Alternatively W/C ratio could be taken as fixed for a Concrete Mix Design and remaining two namely the brand of cement and type of Super plasticizer could be varied to find out the optimum doses.

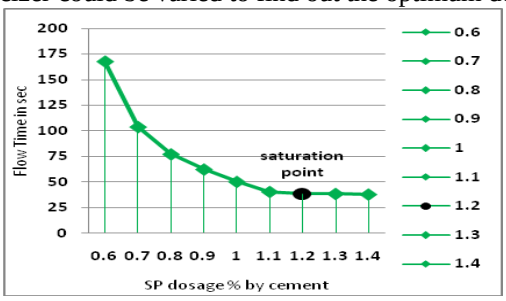

Fig. 3 Optimization of SP1

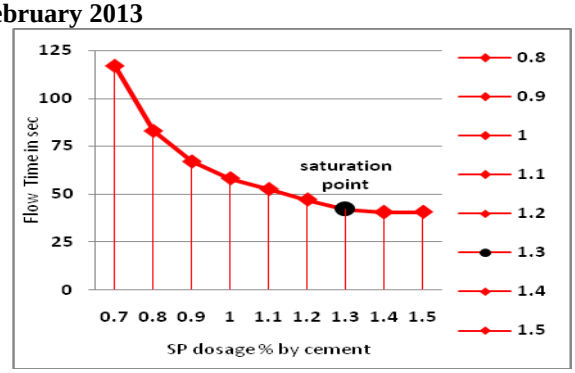

Fig. 4 Optimization of SP2

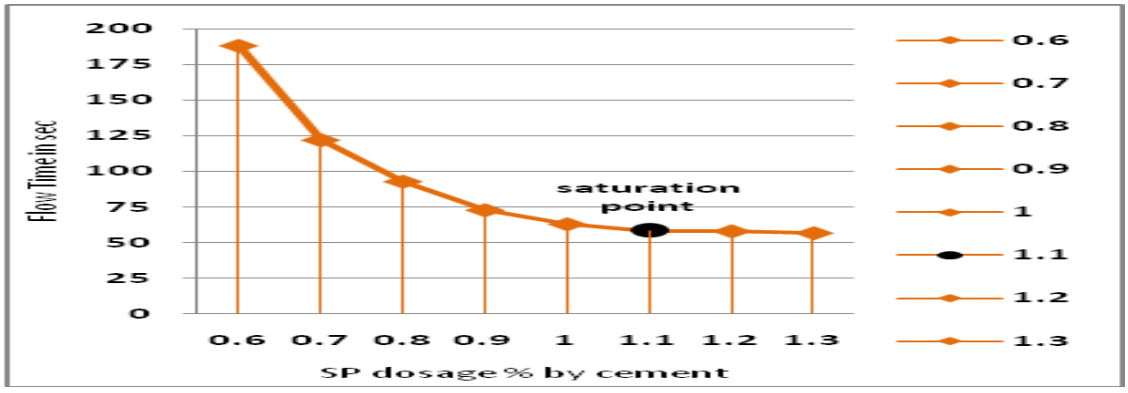

Fig. 5 Optimization of SP3

IV. CONCLUSION

- For a selected water cement ratio (0.32) the optimum dose are 1.2%, 1.3% and 1.1% for SP1, SP2 & SP3 respectively.
- The optimum doses inferred from the above tests fall within the range recommended by manufactures.
- It can be inferred from experiment that all the three SPs are compatible with the cement used for the project.
- As SP3 i.e. Glanium B276 Supertec gives the minimum %age of dose for the sample, and the rate of SP1 & SP3 does not differ much, SP3 can prove more economical.
- Marsh cone test can be effectively used as useful tool for optimization of doses of Super plasticizer.

V. ACKNOWLEDGMENT

We sincerely thanks to Dr. F.S. Umrigar, Principal, BVM Engineering College, Vallabh Vidyanagar for providing us infrastructural facilities. We are also thankful Engineering experts Mr. Kamleshwarrier, BASF India Limited (Construction Chemical Division), Baroda. Mr. Jaymikpatel, BASF India Limited (Construction Chemical Division) Ahmedabad &Mr. ChiragPatel, Design Cell, Vallabh Vidyanagar – Gujarat – India for their sincere support.

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ISSN: 2277-3754
ISO 9001:2008 Certified
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Volume 2, Issue 8, February 2013

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AUTHORS BIOGRAPHY

Born in 1966, Prof. Nanak J. Pamnani has completed his graduation in Civil Engineering in 1988 from Birla Vishvakarma Mahavidhyalaya, Sardar Patel University (SPU), and India with first class, distinction and secured 2nd rank in university. He cleared GATE (Graduate Aptitude Test in Engineering) with flying colors and earned his Master's degree in Structural Engineering from Faculty of Technology, M.S. University, and Vadodara, India in 1992. Later he has studied Master's in Valuation (Real Estate) from Sardar Patel University, VallabhVidhyanagar, India. At present he is pursuing his PhD in Structural engineering from SICART, SPU, and India. After his graduation, He has designed projects in India and abroad. His professional experience is @20 years. He joined College of Architecture, VallabhVidhyanagar in 1994 and served there for 17 years. At present he is faculty in Institute of Technology and Management (ITM) Universe, Vadodara, Gujarat as Associated Professor in Department of Civil Engineering. He has academic experience of @18 years. He has 05 National publishing to his credit and guided 18 undergraduate and 5 post graduate projects. He is life time member of Indian Society for Technical Education (ISTE) and Institute of Engineers, India. He is also member of Bahrain Engineering Bureau.

Patel PalakkumarDipakbhai was born in 1988 in Sarbhan Town, Bharuch, and Gujarat. He received his Bachelor of Engineering degree in Civil Engineering from the Government Engineering College Dahod (GECD), Gujarat University, and Ahmedabad in 2011. At present he is Final year student of Master's Degree in Construction Engineering & Management at Birla Vishwakarma Mahavidyalaya, Gujarat Technological University (GTU).

Prof. A. K. Verma has completed his graduation in Civil Engineering, and Post-Graduation and Doctorate in Geotechnical Engineering. Prof. Verma joined Birla Vishvakarma Mahavidyalaya, Department of Structural engineering in 1986 and today he serves as Professor and Head of Structural Engineering department. His has been teaching since last 28 years. He has fetched 2 grants worth Rs. 13.25 lcs under AICTE MODROB and R & D grant. Apart from academics, he is involved in consultancy activities for Research and Testing work in the Department. Prof. Verma has published @ 50 papers at National level and 6 international publications. He has presented 12 national and 2 international papers. He has guided 03 PhD scholars and 23 master level projects. He is registered PhD guide for S.P. University (SPU) and Gujarat Technical University (GTU). He is life member of Indian Society for Technical Education (ISTE) and Indian Geotechnical Society (IGS).

Prof. Jayeshkumar R. Pitroda was born in 1977 in Vadodara City. He received his Bachelor of Engineering degree in Civil Engineering from the Birla Vishvakarma Mahavidyalaya, Sardar Patel University in 2000. In 2009 he received his Master's Degree in Construction Engineering and Management from Birla Vishvakarma Mahavidyalaya, Sardar Patel University. He joined Birla Vishvakarma Mahavidyalaya Engineering College as a faculty where he is Assistant Professor of Civil Engineering Department with a total experience of 12 years in field of Research, Designing and education. He is guiding M.E. (Construction Engineering & Management) Thesis work in field of Civil/ Construction Engineering. He has papers published in National Conferences and International Journals.