WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Effect of Sulfonated Naphthalene-Formaldehyde and Polycarboxylate Based Superplasticizer on Concrete

[1]Govinda Shashikant Kakani, [2] Prof. P U Autade (Guide Prof.)

[1, 2]Department of Civil Engineering, Dr. Vithalrao Vikhe Patil Collage of Engineering Ahmednagar, Savitribai Phule Pune University

ABSTRACT

The aim of this study is to examine the effect of the types of superplasticizers (sps) on the Properties of the concrete (hpc). Three types of superplasticizers, i.e., Polycarboxylate- based (pca) sp, sulfonated naphthalene-formaldehyde with 0.5 % sodium Sulfate (lsnf) sp, and sulfonated naphthalene-formaldehyde with 16.8 % sodium sulfate (hsnf) sp, were used. The fresh, SLUMP CONE TEST, COMPRESSIVE STRENGTH TEST, ph test and bond test of the concrete were tested. Utilizing superplasticizers in the concrete increased the initial slump and the strength of the concrete, reduced the mechanical properties of the concrete. The superplasticizers- Blended concrete had the higher carbonation depth and chloride ion diffusion coefficient, The better durability properties under drying–wetting cycles than the control concrete.

Moreover, polycarbonate based superplasticizers of the lower dosage than sulfonated naphthalene-formaldehyde based superplasstcizers was used in the concrete to Achieve the same initial slump of the concrete. The concrete containing 0.5 % polycarbonate based superplasticizers had The higher slump preservation and mechanical properties, the lower water porosity, Carbonation depth, and chloride ion diffusion coefficient than that with 1.0 % sulfonated naphthalene-formaldehyde based superplasstcizers.

Keywords Types of superplasticizers, high-performance concrete, mechanical properties, durability properties

1. Introduction

Normal water reducers are well established admixtures called plasticizers in concrete technology. A conventional water reducer is capable of reducing water requirements by 10 to fifteen. Higher water reductions, by incorporating larger amounts of these admixtures, result in undesirable effects on concrete like bleeding, segregation and hardening. So, a greenhorn class of water reducers, chemically different from the standard water reducer and capable of reducing water content by about 30% has been developed. The admixtures belonging to the present class are called super plasticizers.
Superplasticizers are after all the extended version of plasticizers. At a given water /cement ratio and water content within the combination, the dispersing action of superplasticizer increases the workability of concrete, typically by raising the slump from 75 mm to 200 mm, the combo remaining cohesive. The resulting concrete is going to be placed with little or no compaction and is not subject to excessive bleeding or segregation. Such concrete is termed as flowing concrete and is helpful for putting in place very heavily reinforced sections, in inaccessible areas, in floor or road slabs, and also where very rapid placing is desired. The principal mode of action of superplasticizer is their ability to disperse cement particles very efficiently. As they're doing not entrain air, they'll be used at high dosage rates without affecting strength

1.2 Classification Of Water Reducers :

I) Plasticisers (water reducers) they are effective in reducing the water content in concrete upto 15% by maintaining workability.
II) Superplasticisers (high range water reducers) they are effective in reducing the water content upto 30 %

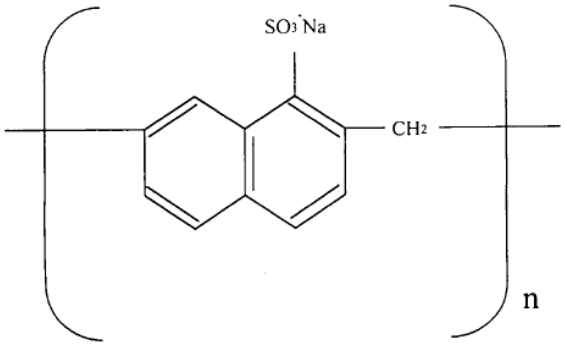
1.3. Types of Water Reducers

Several distinct types of water reducers are available based on different chemicals although they purport to have a similar function in concrete. They are all organic compounds of high molecular weight, some being synthetic and others derived from natural products

1. ***Sulphonated naphthalene***

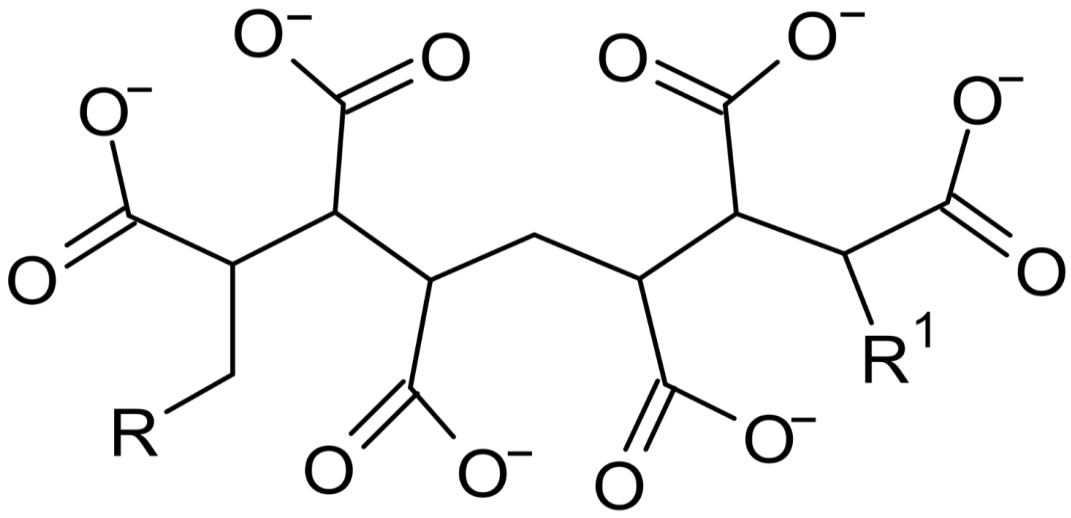
These are polymers similar in many ways to the previous category, with a simple repeating unit as shown below

Again the sodium salt is usually employed, solubility being due to the suiphonate group the value is in the range Of 5-10,giving a molecular weight of the order of 2000.



2. Polycarboxylate superplasticizers:

Polycarbonate Superplasticizers Are Comb-Shaped Polymers With An Anionic Backbone and a number of other Nonionic Pendant Chains, which usually Are Comprised Of Polyethylene Glycol. During this Study, The Synthesis Of a brand-new variety of Superplasticizer Is Presented, Which doesn't Exhibit the everyday Comb-Shaped type of PCE But is constructed Up From A Linear Polyetheramine And A Hyperbranched Poly glycerol Scaffold, Which Was Carboxymethylated within the Periphery. 1h/13c NMR And Ft-Ir Spectroscopy And Size Exclusion Chromatography Were Employed For The Characterization Of The Polymers. Furthermore, Their Dispersing Performance And"Slump Retention" Capability Were Investigated In Cement Pastes. Adsorption And Zeta Potential Measurements further As Heat Flow Calorimetry Were Conducted to achieve More Insight Into The Interaction Of The Polymers With Cement. It absolutely was Found That Such Non-Comb-Shaped Polymers Are Highly Effective Cement Dispersants. Moreover, The Hyperbranched Superplasticizers Exhibited High Robustness Toward Alkali Sulfates And Maintained The Fluidity for much longer, Compared To a standard Comb-Shaped PCE.



3 Methodology:

The Following Tests Were Conducted On The Reference Mix.

1. Slump Test
2. Compressive Strength Test
3. Chemical Test
4. Ph Test
5. Pull Out Test

The Quantity Of Materials Required For Conducting Slump Test And 28-Day Compressive Strength Test Were Calculated. The Materials (Cement, Sand, Gravel And Water) Were Weighed And Taken Separately

3.1 Slump Cone Test:

Test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. Concrete slump test is carried out from batch to batch to check the uniform quality of concrete during construction.

3.2 Compressive Strength Test:

The compressive strength of the concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether concreting has been done properly or not. Concrete compressive strength for general construction

3.3 Ph test:

- To test for ph of concrete fom 0% of admixture to 2% of admixture is used
- After the testing of admixture we found it contain chloride but in manufacturer detail its stated that it does not contain any chloride
- The maxmimum chloride content in reinforced concrete is 0.3% but in test report its content around 0.3% so we have done ph test on concrete with ph paper to see does it effect it ph value

3.4 Bond strength:

In many of admixture it specified in advantages that it increase bond strength so following testis perform to check tha***3.5 Admixture testing:***

1. Admixture testing shall be done before the use as specified in the project specification or the supplier. Some of the terms could be evaluated based on the supplier's specification as bs en 934-2-2001.
2. Some of those tests are relative density, ph value, etc. However, other parameters of the admixture shall comply with the code requirements.
3. In this project the admixture test is done in lab in pune to check its properties and copire it to the values stated by producer

3.5 Types of Water Reducers Used

Sr.No	**Chemical Type Of Water Reducer**	**Manufacturer**
1	FosrocConplastSp 500	Fosroc India Pvt Limited
2	FosroocConplastSp 440	Fosroc India Pvt Limited
3	FosrocConplastSp 430	Fosroc India Pvt Limited
4	SikamentNn	Sika India Pvt Limited
5	Auramix300	Fosroc India Pvt Limited

3.5.1 Fosroc Conplast Sp 500:

Lab Test Report Of FosrocConplast Sp 500 3.5.2

Sr No	**Test**	**Value Obtained**	**Value Stated By Manufacturer**	**Limit As Per Is 9103:1999**
1	Relative Density	1.252	1.250-1.270	+-0.02 Of Value Stated By Manufacturer
2	Ph	7.19	Minimum 6	Minimum 6
3	Colour	Dark Brown	Dark Brown	
4	Chloride Content	0.025	Nill	Within 10% Of Value

3.5.2 Conplast SP 440:

Lab test report of fosroc conplastsp 440

Sr no	**Test**	**Value obtained**	**Value stated by manufacturer**	**Limit as per is 9103:1999**
1	Relative density	1.154	1.17-1.19	+-0.02 of value stated by manufacturer
2	Ph	6.70	Minimum 6	Minimum 6
3	Colour	Dark brown	Dark brown	
4	Chloride content	0.027	Nill	Within 10% of value

3.5.3 Conplast sp 430:

Lab test report of fosroc conplast sp 430

Sr no	Test	Value obtained	Value stated by manufacturer	Limit as per is 9103:1999
1	Relative density	1.151	1.17-1.19	+-0.02 of value stated by manufacturer
2	Ph	6.90	Minimum 6	Minimum 6
3	Colour	Dark brown	Dark brown	
4	Chloride content	0.029	Nill	Within 10% of value

Lab test report OF 3.5.5 Auramix 300

Sr no	Test	Value obtained	Value stated by manufacturer	Limit as per is 9103:1999
1	Relative density	1.156 g/cm2	1.165	+-0.02 of value stated by manufacturer
2	Ph	7.42	Minimum 6	Minimum 6
3	Colour	Brown	Brown	+- 5% of value stated by manufacturer
4	Chloride content	0.030	Max 0.2	Within 10% of value

4. Results and Discussion

4.1 Slump Cone Test:

Test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. Concrete slump test is carried out from batch to batch to check the uniform quality of concrete during construction.

Table 4.1.1 Result Of Slump Test With Admixture CONPLAST SP 500

Sr. No	Cement Grade	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement)	Slump Observed (Mm)
S 0	**M40**	**0**	**110**
S 0.5		**0.5**	**134**
S 0.7		**0.7**	**150**
S 0.9		**0.9**	**168**

Table 4.1.2 Result Of Slump Test With Admixture CONPLAST SP 440

Sr. No	Cement Grade	Optimum Dosage Of Snf Based Superplasticizer (Sp)(% Weight Of Cement)	Slump Observed (Mm)
S 0	**M25**	0	95
S 0.5		0.5	**120**
S 0.7		0.7	140
S 0.9		**0.9**	170

Table 4.1.3 Result Of Slump Test With Admixture CONPLAST SP 430

Sr. No	Cement Grade	Optimum Dosage Of Snf Based Superplasticizer (Sp)(% Weight Of Cement)	Slump Observed (Mm)
S 0	M25	0	95
S 0.5		0.5	120
S 0.7		0.7	140
S 0.9		0.9	170

Table 4.1.4 Result Of Slump Test With Admixture SIKAMENT NN

Sr. No	Cement Grade	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement)	Slump Observed (Mm)
S 0	M25	0	72
S 0.5		0.5	90
S 0.7		0.7	110
S 0.9		0.9	135

Table 4.1.5 Result Of Slump Test With Admixture Auramix 300

Sr. No	Cement Grade	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement)	Slump Observed (Mm)
S 0	M25	0	40
S 0.5		0.5	65
S 0.7		0.7	100
S 0.9		0.9	135

Discussions:

For CONPLAST SP 500:

As For Slump Cone Test Slump Value Increses As We Increases Percentage Of Admixture In Concrete

For CONPLAST SP 440:

As For Slump Cone Test Slump Value Increses As We Increases Percentage Of Admixture In Concrete Slump Value At 0% Admixture Is 95,At 0.5% Admixture 120 At 0.7% Is 140 And At 0.9% Is 170 Mm

For CONPLAST SP 430:

As For Slump Cone Test Slump Value Increses As We Increases Percentage Of Admixture In Concrete Slump Value At 0% Admixture Is 85,At 0.5% Admixture 105 At 0.7% Is 140 And At 0.9% Is 170 Mm

For SIKAMENT NN:

As For Slump Cone Test Slump Value Increses As We Increases Percentage Of Admixture In Concrete Slump Value At 0% Admixture Is 72,At 0.5% Admixture 90 At 0.7% Is 110 And At 0.9% Is 135 Mm

For AURAMIX 300:

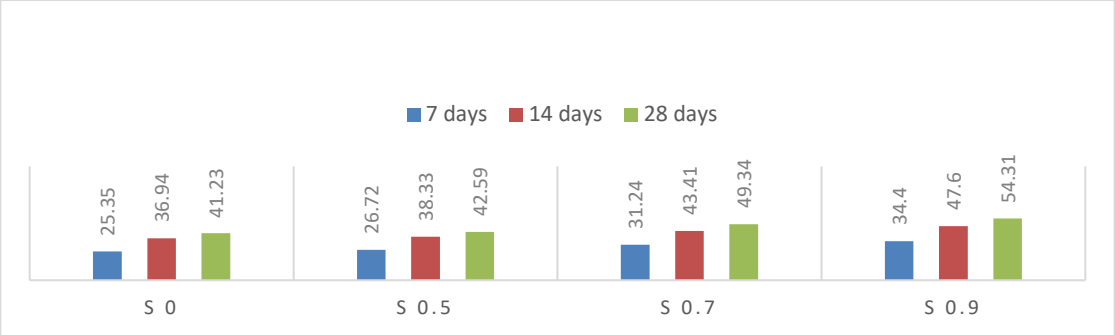
As For Slump Cone Test Slump Value Increses As We Increases Percentage Of Admixture In Concrete Slump Value At 0% Admixture Is 40,At 0.5% Admixture 65mm At 0.7% Is 100mm And At 0.9% Is 135 Mm

4.3 Compressive Strength Test:

The compressive strength of the concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether concreting has been done properly or not. Concrete compressive strength for general construction

Table 4.3.1 Result of Compressive Strength with Admixture CONPLAST SP 500

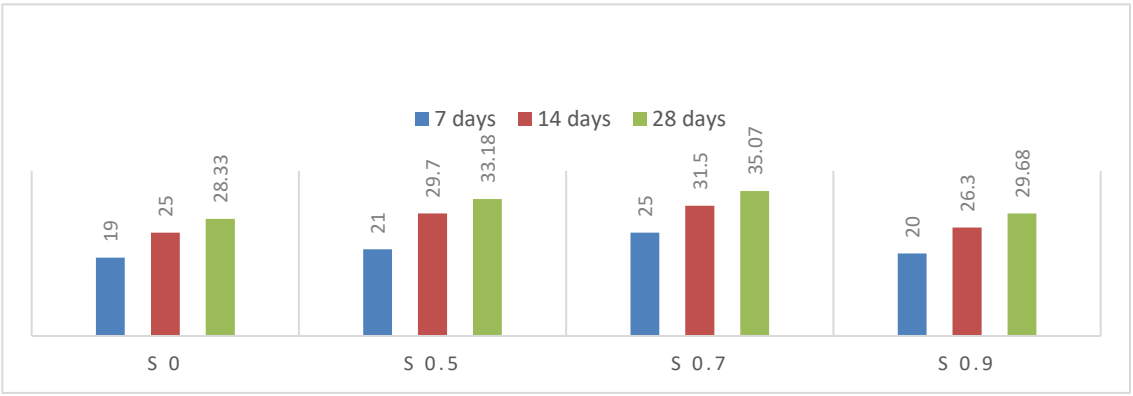
Sr.No	Compressive Strength @ 7 Days (Mpa)	Compressive Strength @ 14 Days (Mpa)	Compressive Strength @ 28 Days (Mpa)
S 0	25.35MPA	36.94MPA	41.23
S 0.5	26.72MPA	38.33MPA	42.59
S 0.7	35.24mpa	43.41Mpa	49.34
S 0.9	37.2mpa	47.6Mpa	50.80



1 Result of Compressive Strength with Admixture CONPLAST SP 500

4.3.2 Result of Compressive Strength with Admixture CONPLAST SP 440

Sr.No	Compressive Strength @ 7 Days (Mpa)	Compressive Strength @ 14 Days (Mpa)	Compressive Strength @ 28 Days (Mpa)
S 0	19MPA	25MPA	28.33MPA
S 0.5	21MPA	29.7MPA	33.18MPA
S 0.7	25mpa	31.5MPA	35.07MPA
S 0.9	20Mpa	26.3MPA	29.68MPA



2 Result of Compressive Strength with Admixture CONPLAST SP 44

Table 4.3.3 Result of Compressive Strength with Admixture CONPLAST SP 430

Sr.No	Compressive Strength @ 7 Days (Mpa)	Compressive Strength @ 14 Days (Mpa)	Compressive Strength @ 28 Days (Mpa)
S 0	25.35MPA	25.12MPA	29
S 0.5	30MPA	25.70MPA	32
S 0.7	32MPa	27Mpa	33.80
S 0.9	28	28	34.10

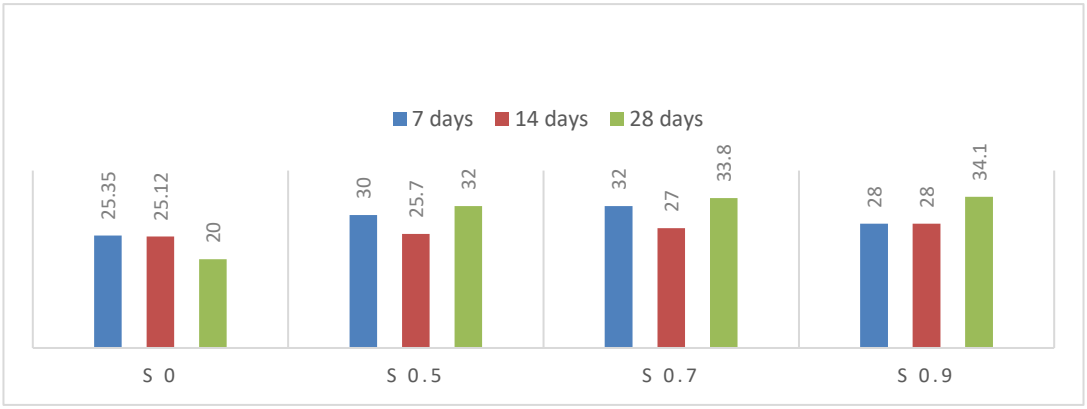


Table 4.3.4 Result of Compressive Strength with Admixture SIKAMENT NN

Sr.No	Compressive Strength @ 7 Days (Mpa)	Compressive Strength @ 14 Days (Mpa)	Compressive Strength @ 28 Days (Mpa)
S 0	20.35MPA	30.20MPA	34.09MPA
S 0.5	23MPA	28.33MPA	32.86MPA
S 0.7	23.56MPA	29.41Mpa	34.27MPA
S 0.9	20Mpa	29.13MPA	33.03MPA

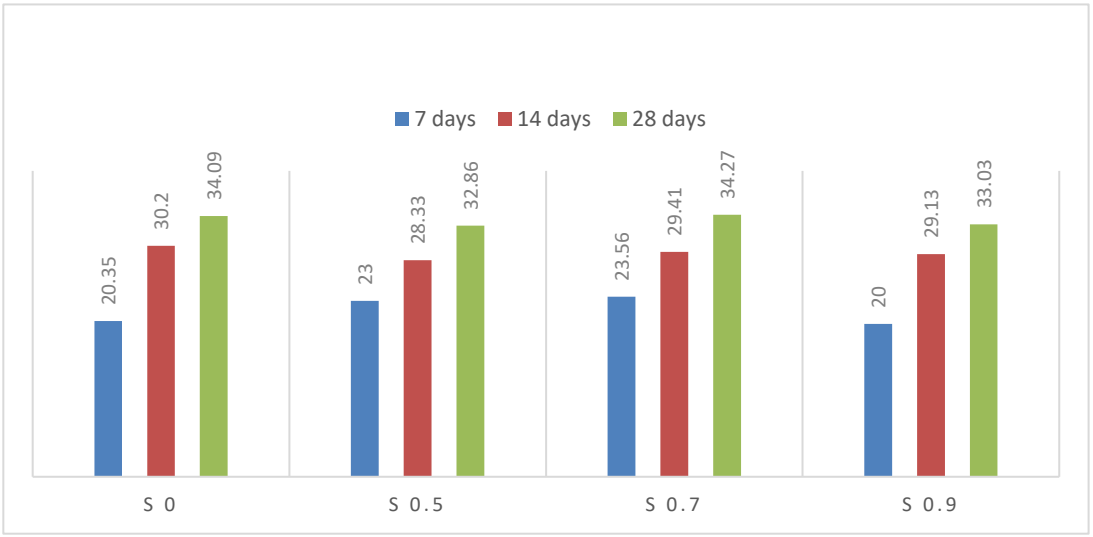
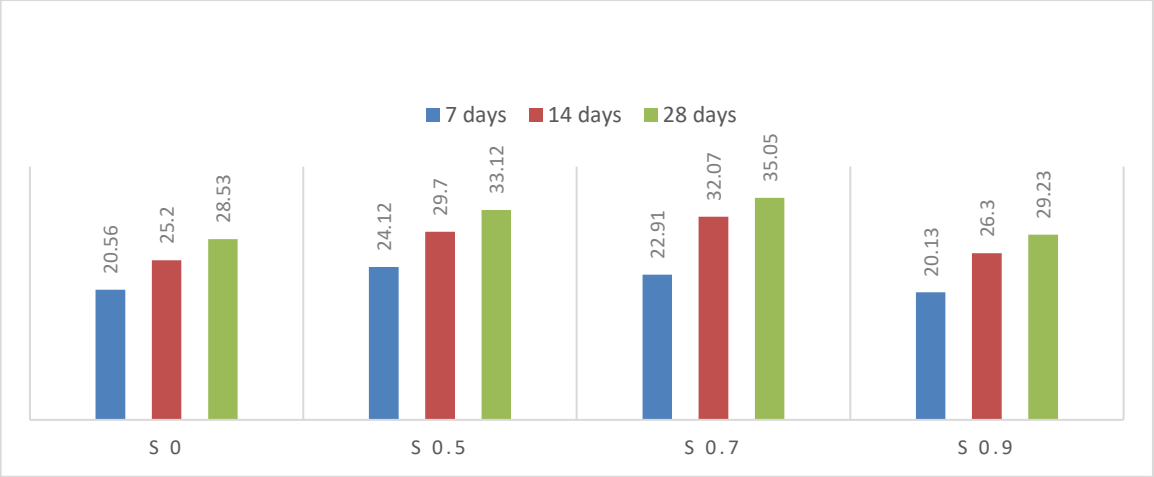


Table 4.3.5 Result of Compressive Strength with Admixture AURAMIX 300

Sr.No	Compressive Strength @ 7 Days (Mpa)	Compressive Strength @ 14 Days (Mpa)	Compressive Strength @ 28 Days (Mpa)
S 0	20.56	25.2	28.53
S 0.5	24.12	29.7	33.12
S 0.7	22.91	32.07	35.05
S 0.9	20.13	26.3	29.23



Discussions:

For CONPLAST SP 500:

In Case Of Admixture fosroc conplast Sp500 M40 Grade Concrete Concrete With Out Any Dosages Achive 41.23 Mpa After 28 Days As We Add Admixture 0.5% Compressive Strength Is 42.59at 28 Days , At 0.7% Admixture The Compressive Strength Is 49.34 Mpa At 28 Days an At 0.9% Of Admixture The Compressive Strength Is 50.80 Mpa At 28 Days

For CONPLAST SP 440:

In Case Of Admixture fosroc conplast Sp440 M25 Grade Concrete Concrete With Out Any Dosages Achive 28.33 Mpa After 28 Days As We Add Admixture 0.5% Compressive Strngth Is 33.8 Mpa At 28 Days , At 0.7% Admixture The Compressivve Strength Is 35.07 Mpa At 28 Days an At 0.9% Of Admixture The Compressive Strength Is 29.68 Mpa At 28 Days

For CONPLAST SP 430:

In Case Of Admixture FosrocConplast Sp430 M25 Grade Concrete Concrete With Out Any Dosages Achive 29 Mpa After 28 Days As We Add Admixture 0.5% Compressive Strngth Is 32 Mpa At 28 Days , At 0.7% Admixture The Compressivve Strength Is 33.80 Mpa At 28 Daysan At 0.9% Of Admixture The Compressive Strength Is 34.10 Mpa At 28 Days

For SIKAMENT NN:

In Case Of Admixture SikamentNn M25 Grade Concrete Concrete With Out Any Dosages Achive 34.09 Mpa After 28 Days As We Add Admixture 0.5% Compressive Strngth Is 32.86 Mpa At 28 Days , At 0.7% Admixture The Compressivve Strength Is 34.27 Mpa At 28 Daysan At 0.9% Of Admixture The Compressive Strength Is 33.03 Mpa At 28 Days

For AURAMIX 300:

In Case Of Admixture Auramx 300 M25 Grade Concrete Concrete With Out Any Dosages Achive 28.53 Mpa After 28 Days As We Add Admixture 0.5% Compressive Strngth Is 33.12 Mpa At 28 Days , At 0.7% Admixture The Compressivve Strength Is 35.05 Mpa At 28 Daysan At 0.9% Of Admixture The Compressive Strength Is 29.23 Mpa At 28 Days

4.4 Ph test:

Table 4.4.1 Result of Ph test with Admixture CONPLAST SP 500

SR.NO	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement	Ph Value
S 0	0%	12
S 0.5	0.5%	12
S 1	1%	11

Table 4.4.2 Result of Ph test with Admixture CONPLAST SP 440

SR.NO	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement	Ph Value
S 0	0%	12
S 0.5	0.5%	12
S 1	1%	12

Table 4.4.3 Result of Ph test with Admixture CONPLAST SP 430

SR.NO	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement	Ph Value
S 0	0%	12
S 0.5	0.5%	12
S 1	1%	12

Table 4.4.4 Result of Ph test with Admixture SIKAMENT NN

SR.NO	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement	Ph Value
S 0	0%	12
S 0.5	0.5%	12
S 1	1%	12

Table 4.4.5 Result of Ph test with Admixture AURAMIX 300

SR.NO	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement	Ph Value
S 0	0%	12
S 0.5	0.5%	12
S 1	1%	12

Discussion:

For CONPLAST SP 500:

Ph value of concrete before and after mixture of admixture is same its between 11 to 12

For CONPLAST SP 440:

Ph value of concrete before and after mixture of admixture is same its between 11 to 12

For CONPLAST SP 430:

Ph value of concrete before and after mixture of admixture is same its between 11 to 12

For SIKAMENT NN:

Ph value of concrete before and after mixture of admixture is same its between 11 to 12

For AURAMIX 300:

Ph value of concrete before and after mixture of admixture is same its between 11 to

4.5 Bond strength:

In many of admixture it specified in advantages that it increase bond strength so following testis perform to check that

Sr.No	Cement Grade	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement	Ultimate Bond Stress
			Σbu = Pb / (Π X D X L)
SAMPLE 1	M25	0%	65.06
SAMPLE 2	M25	1%	80.64

Table 4.5.1 Result of Bond strength with Admixture CONPLAST SP 500

Sr.No	Cement Grade	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement	Ultimate Bond Stress $\Sigma_{bu} = P_b / (\Pi X D X L)$
SAMPLE 1	M25	0%	65.06
SAMPLE 2	M25	1%	80.64

Table 4.5.2 Result of Bond strength with Admixture CONPLAST SP 440

Sr.No	Cement Grade	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement	Ultimate Bond Stress
SAMPLE 1	M25	0%	61.87
SAMPLE 2	M25	1%	74.47

Table 4.5.3 Result of Bond strength with Admixture CONPLAST SP 430

Sr.No	Cement Grade	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement	Ultimate Bond Stress
SAMPLE 1	M25	0%	53.37
SAMPLE 2	M25	1%	60.72

Table 4.5.4 Result of Bond strength with Admixture SIKAMENT NN

Sr.No	Cement Grade	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement	Ultimate Bond Stress
SAMPLE 1	M25	0%	51.06
SAMPLE 2	M25	1%	60.64

Table 4.5.5 Result of Bond strength with Admixture AURAMIX 300

Sr.No	Cement Grade	Optimum Dosage Of SNF Based Superplasticizer (SP)(% Weight Of Cement	Ultimate Bond Stress
SAMPLE 1	M25	0%	56.75
SAMPLE 2	M25	1%	68.12

Discussions:

For CONPLAST SP 500:

In Case Of Bond Test Bond Strength Is Increses At Optimum Dosages Of Admixture Compaire To Concrete With Out Any Admixture Over Dosages Of Admixture May Result In Low Bond Stength In Case Of Sp 500 Bond Strength At 0% Admixture Is 65.06 And At 1% Is 80.64

For CONPLAST SP 440:

In Case Of Bond Test Bond Strength Is Increses At Optimum Dosages Of Admixture Compaire To Concrete With Out Any Admixture Over Dosages Of Admixture May Result In Low Bond Stength In Case Of Sp 440 Bond Strength At 0% Admixture Is 61.87 And At 1% Is 74.47

For CONPLAST SP 430:

In Case Of Bond Test Bond Strength Is Increses At Optimum Dosages Of Admixture Compaire To Concrete With Out Any Admixture Over Dosages Of Admixture May Result In Low Bond Stength In Case Of Sp 440 Bond Strength At 0% Admixture Is 53.37 And At 1% Is 60.72

For SIKAMENT NN:

In Case Of Bond Test Bond Strength Is Increses At Optimum Dosages Of Admixture Compaire To Concrete With Out Any Admixture Over Dosages Of Admixture May Result In Low Bond Stength In Case Of Sp 440 Bond Strength At 0% Admixture Is 51.06 And At 1% Is 60.64 Kn

For AURAMIX 300:

In Case Of Bond Test Bond Strength Is Increses At Optimum Dosages Of Admixture Compaire To Concrete With Out Any Admixture Over Dosages Of Admixture May Result In Low Bond Stength In Case Of Auramix 300 Bond Strength At 0% Admixture Is 56.75 And At 1% Is 68.12 Kn

5. Conclusions

- Generally All Mixes Containing Admixtures Achieved Higher Strength Than The Control Mix Without Any Admixtures. The Presence Of

Admixture Caused A Reduction In Shrinkage.

- Slump Value Increases As Dosages Of Admxture Increases
- Based On The Preliminary Results Of This Investigation, It Is Strongly Recommended To Use Higher Dosage Of Admixture, Than Those Used In The Present Work So That So Adequate Slump Can Be Obtained. In The Present Work The Dosages Used Were Those Recommended By The Manufacturer But The Low Water To Cement Ratio In The Mixes Exacerbated The Effect And Dosages Of Admixtures Above Those Recommended Should Be Used

References

1. J.Derle Thorpe And William A.Cordon, "Potential Of Water Reducing Admixtures", Concrete International, March 1983, P 32 To 38
2. GajananM.SabnisAndA.Gharbanpoor, "Structural Properties Of Superplasticized Concrete" Indian Concrete Journal, July 1983, P 179 To 185.
3. V.Ramakrishnan, William V.CoyleAndS.S.Pande "Workability And Strength Of Superplasticised Concrete", Indian Concrete Journal, January 1980, P 23 To 27.
4. K. Ganesh Babu, B.V.Subramanyam, M.NeelamegamAnd N.P. Rajamane, "Strength And Behaviour Of Superplasticized Concretes", Indian Concrete Journal, June 1982, P 159 To 163.
5. N.Chitharanjan, "Workability Agent As A Cement Saver", Indian Concrete Jounral, Dec 1987, P 325 To 329.
6. G. Corrandini, G. Scoccia, R. VolpaAnd S. Tavano, "Statistical Evaluation Of Mechanical Properties Of Superplasticised Concrete", Cement And Concrete Research, Vol 14, 1984, P 375 To 385.
7. P.BararAnd A.C. Sood, "A New Generation Superplasticiser", Civil Engineering And Construction Review, March 1989, P 44 To 47.
8. V. Kumar, B.N.RoyAndA.S.R.Sai, "Effect Of Superplasticiser On Concrete", Indian Concrete Journal, Jan 1989, P 31 To 42.
9. Samir Surlaker, "Admixtures And Curing For Concrete Durability", Civil Engineering And Construction Review, March 1989, P 24 To 29.
10. N.C. Rawal & M.K. Rawal, "Advantages Of Using Superplasticisers In Concrete", Civil Engineering And Construction Review, Aug 1993, P 37 To 43
11. Kaushal Kishore, "High Strength Concrete", Ici Bulletin No.5 1, April-June 1995, P 25 To 31
12. T.B. Viswanath, "Evaluation, Selection And Uses Of Water Reducing Admixtures At Chamera Hydro Electric Project", Institution Of Engineers (India) Journal - Cv, Feb 1994, P 202 To 207.
13. Dr. N.C. RawalAndM.K.Rawal, "Performance Of Chemical Admixtures Developed In India" Civil Engineering And Construction Review, May 91, P28 To 31.
14. K.B. Prakash And Dr.K.T. Krishnaswamy, "Effect Of Repeated Dosages Of Superplasticisers On The Properties Of Concrete Produced From High Grade Cements", Civil Engineering And Construction Review, May 1996, P 29 To 37.
15. T.Manjrekar, "Use Of Superplasticisers : Myths And Reality", The Indian Concrete Journal, June 1994, P 317 To 320.
16. A.M. Chalibal, "SuperplasticisersIn Concrete", Civil Engineering And Construction Review, Aug 1991, P 33 To 37.
17. IrshadMasoodAndS.K.Aggarwal, "Use Of Superplasticisers In Cement Concrete-Present Status And Future Prospects In India", Civil Engineering And Construction Review, Aug 1993, P 12 To 17.
18. M.K. Rawal, "Role OfSuperplasticiser In Concrete", Civil Engineering And Construction Review, April 1998, P 57 To 59.
19. D.Ghanti, "Construction Chemicals And Their Utilities", Civil Engineering And Construction Review, Aug 1993, P 25 To 28.