*Int. J. Chem. Sci. : 2 (1), 2004, 1–8*

# REVOLUTIONARY CHEMICALS : SUPERPLASTICIZERS

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## ABSTRACT

One of the important advances in the field of concrete industry is the miraculous application of high– range water–reducing admixture or as they sometimes called, Superplasticizers. These admixtures are known in the US as high–range water–reducers and called Type F by ASTM. They are variously known as superfluidizers, superfluidifiers and super water–reducers. The use of superplasticizers has become a quite common practice. This class of water reducers was originally developed in Japan and Germany in the early 1960's; these were introduced in the United States in the mid 1970's. These new admixtures have changed construction practices. High–range water–reducers may be considered functional admixtures rather than chemical admixtures. They are powerful dispersing agents and have little effect on the water/cement reaction. They, therefore, can be used in relatively high dosages. Most of the commercial formulations belong to one of the four families namely SMF, SNF, MLS and polycarboxylates. Superplasticizers are used to produce flowing concrete in situations where placing in inaccessible locations, in floor or pavement slabs, toppings, walls, columns or where very rapid placing is required.

**Key words** : Superpasticizers, SMF, SNF, MLS

## INTRODUCTION

Admixtures are the materials that are added to concrete at some stage in its making to give to the concrete new properties either when fluid or plastic and /or in the set or cured condition. They differ from additives, which are the materials added to the cement during its manufacture either as an aid to production or when cement is to be used to make concrete with special properties.

With the present trend in cement price, it is probably timely that users and manufacturers of concrete should take a keen and informed interest in the part that admixtures could play in making the best use of the cement paid for. One of the important class of admixtures are superplasticizers. The main purpose of using superplasticizers is to produce flowing concrete with very high slump in the range of 7–9 inches (175–225 mm) to be used in heavily reinforced structures and in placements, where adequate consolidation by vibration cannot be readily achieved. The other major application is the production of high–strength concrete at w/c ratio ranging from 0.3 to 0.4[1]. They increase the slump to make the concrete easier to place. Superplasticizers disperse particles of cement throughout a concrete mix. The effect is the same as adding water, but without the detrimental side effects. In addition, they reduce water in the mixture to gain higher earlier strengths. Upon addition of superplasticizers, the resultant concrete show a more dense microstructure resulting in higher mechanical strength, higher resistance to environmental attack and enhanced durability. When combined with low initial slump concrete, superplasticizers produce a workable mix with higher earlier strength .

Superplasticizers are linear polymers containing sulphonic acid groups attached to the polymer backbone at regular intervals[2]. Most of the commercial formulations belong to one of the four families[3] :–

Sulfonated melamine– formaldehyde condensates (SMF)

Sulfonated naphthalene– formaldehyde condensates (SNF)

Modified lignosulfonates (MLS)

Polycarboxylate derivatives.

The sulfonic acid groups are responsible for neutralizing the surface charges on the cement particles and causing dispersion,. thus releasing the water tied up in the cement particle agglomerations and thereafter reducing the viscosity of the paste and concrete.[4]

ASTM C 494 was modified to include high–range water–reducing admixtures in the edition published in July 1980. The admixtures were designated Type F water–reducing, high–range admixtures and Type G water–reducing, high–range, and retarding admixtures.[5]

## Present work

It consists of general treatment of "superplasticizers " as an important engineering material, its effect on concrete properties, such as water reduction, 28 days compressive strength, slump loss, effect of dosage on 7 and 28 days compressive strength.

## Materials and experimental methods

To carry out the experimental work, "superplasticizer" was used. They provide concrete of high workability and good cohesion power. It works by activating repulsive forces between cement and fine sand. It improves the cohesion of the concrete. Accelerating admixtures contain calcium chloride although other materials such as triethanolamine, calcium nitrite, calcium formate, lithium oxalate and certain aluminates also have an accelerating effect.[6] Retarders slow down the rate of setting of cement and as with retarding /water reducing admixtures, they assist in hot weather concreting and in the casting and consolidating of large number of pours without the formation of cold joints. They do this by extending the vibration time.[7]

Retarders include unrefined lignosulphonates containing sugars which are, of course, the component responsible for retardation, modifications and derivatives of the first group, hydroxycarboxylic acids and their salts for instance sodium tartarate, carbohydrates, heptonates, which are related to the sugars and starches. Water reducers include polyhydroxy compounds. Air entraining admixtures are natural wood resins, their soaps, certain fats and oils and lignosulphonates.

To study the effect of addition of admixtures on various properties of cement, tests were carried out in the laboratory. Properties like reduction in water requirements, slump loss, compressive strength were studied.

The 28 days compressive strength, slump loss, reduction in water requirements were determined as per the standard methods[6] and the Indian Standard Specifications for admixture for concrete, IS:7861(Part II)–1981.

## RESULTS AND DISCUSSION

The high–range water–reducers affect the following properties of concrete–

**Water requirements :** Being powerful dispersants and having little chemical effect on the cement/water reaction, high–range water–reducers can be used in relatively high dosages. Water reduction will be in proportion to the dosage of high–range water–reducers as shown in the Figure 1. Water reduction of 20 to 30 % are quite common. There is evidence that beyond a particular dosage, further water reduction may not be possible.

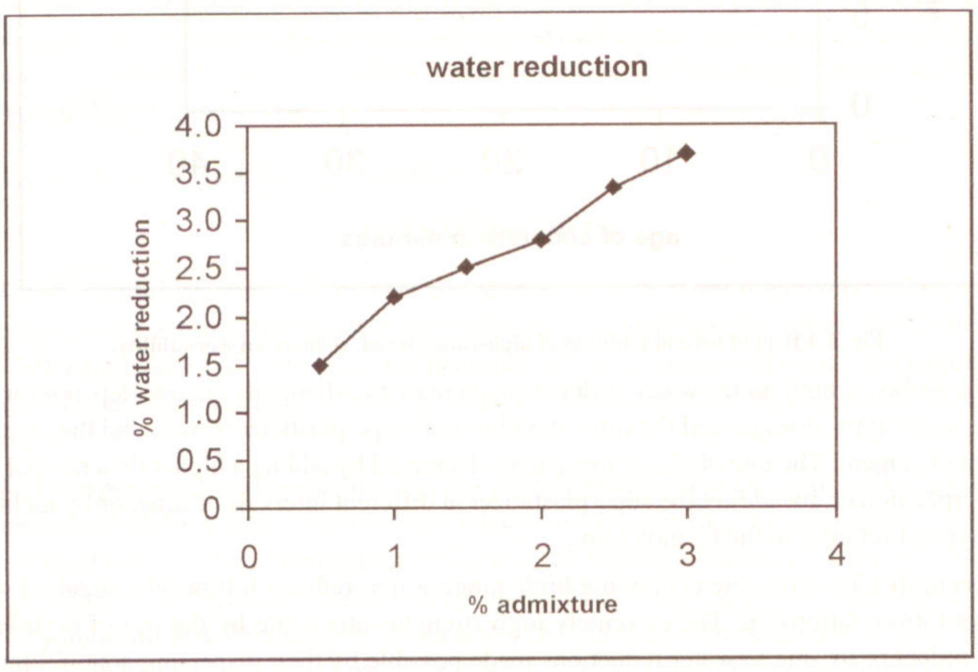


**Fig. 1. Effect of addition of admixture on water reduction**

The capability of superplasticizers to reduce water requirements by 20 to 30 % without affecting the workability leads to the production of high–strength concrete and lower permeability.[8]

**Workability :** A high–range water–reducer added to 0 (zero) slump concrete will render the concrete workable and placeable with conventional equipment. 0 (zero) to 1 cm slump concrete can be turned into 5 to 10 cm slump concrete depending on the high–range water–reducer used and the dosage. The time of addition of the high–range water–reducer will effect the workability obtained as shown in the Figure 2; the earlier the addition, the more efficient the high–range water–reducer in regard to workability.

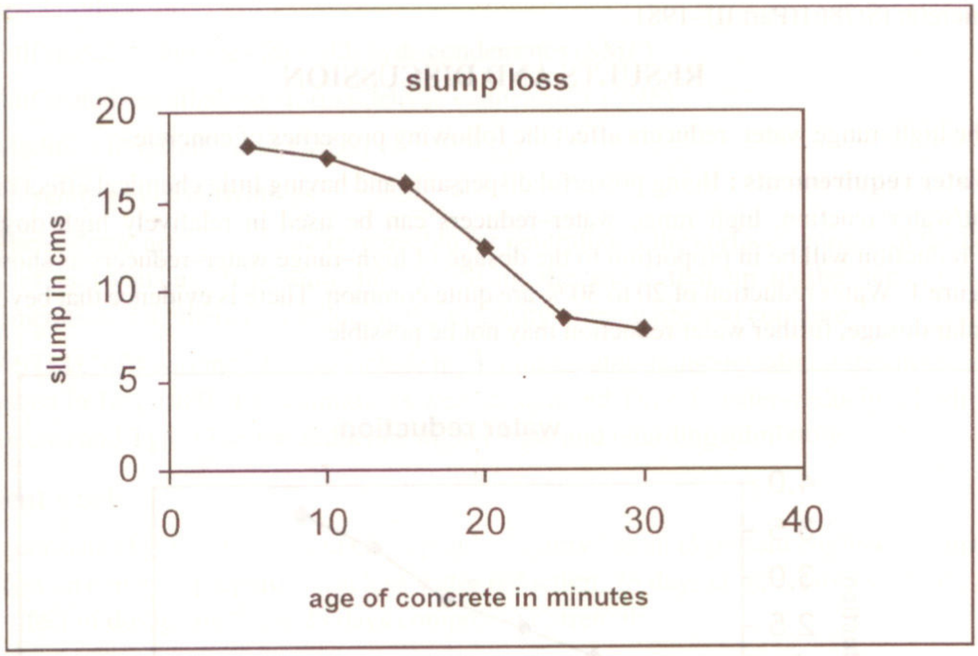


**Fig. 2. Effect of time of addition of high-range water-reducer on workability.**

The ability of high–range water–reducers to increase the slump of concrete depends on such factors as the type, dosage, and the time of addition of superplasticizers, w/c, and the nature or amount of cement. The rate of slump loss can be decreased by adding a higher than normal dose of superplasticizer, by adding the superplasticizer at different intervals of time, or by including some type of retarder in the formulation .

**Strength :** The concrete containing high–range water–reducer follows the standard water /cement ratio relationship. The extremely high strengths attainable by the use of high–range water–reducers are due to water reductions made possible by their dispersing action. Figure 3 shows relationship between compressive strength at 28 days of plain concrete and that of

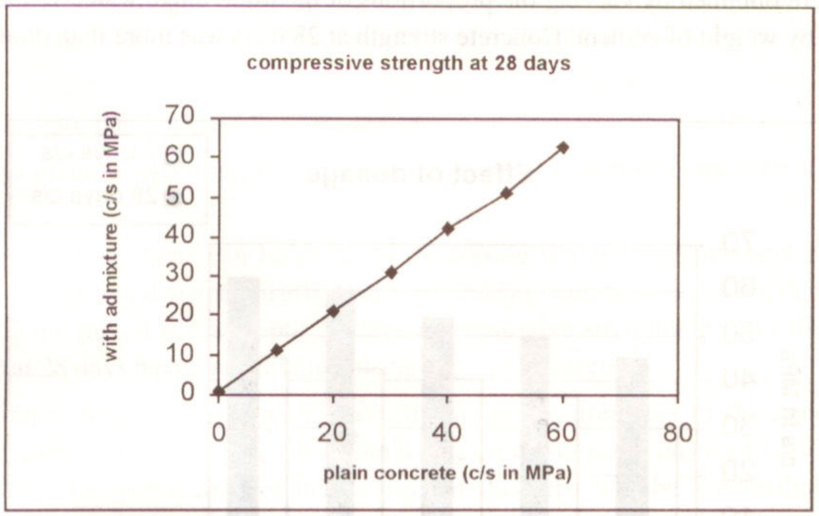


**Fig .3. Relationship between compressive strength at 28 days of plain concrete and concrete with high–range water–reducer.**

concretes containing 5 different high–range water–reducers plotted at equal water/cement ratios.

The strengths are equivalent, however, the concretes containing high–range water–reducers had 2 to 4 times the slump of plain concrete. At constant slump, compressive strength will be proportioned to the dosage of high–range water–reducers as shown in Figure 5.

Figure 4 illustrates the effect of high–range water–reducer on water reduction and strength. In this test series, 14 concretes were proportioned to obtain a 7 to 10 cm slump. The water

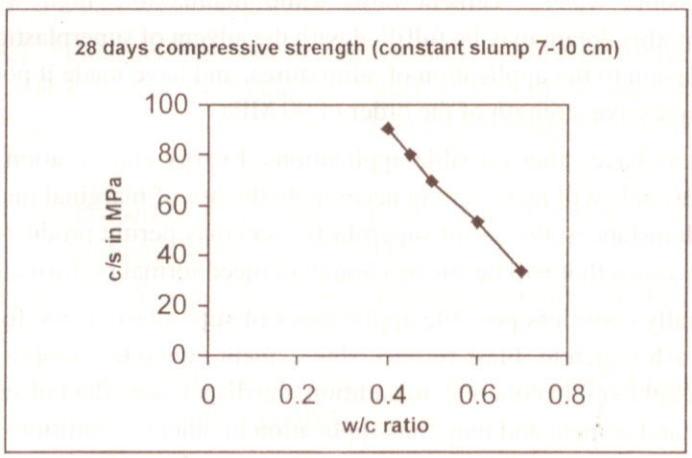


**Fig. 4. Effect of high–range water–reducer on water reduction and strength.**

reductions were obtained by varying the proportions of the high–range water–reducers from 0 (zero) to 2 % by weight of cement. Concrete strength at 28 days was more than doubled.

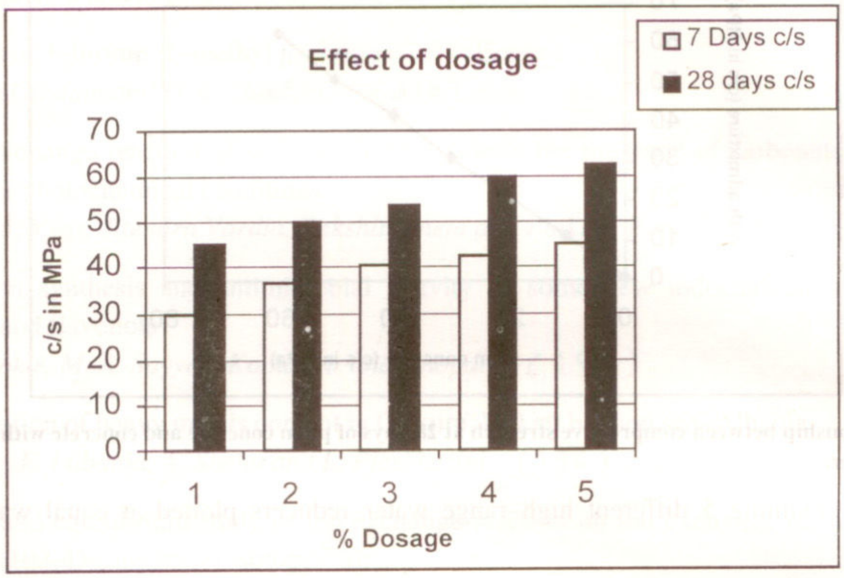


**Fig. 5. Effect of dosage of high–range water–reducer on compressive strength, at constant slump**

## CONCLUSION

It has long been a concrete technologist's dream to discover a method of making concrete at the lowest possible water : cement ratio while maintaining high workability. To a considerable extent, this dream may be fulfilled with the advent of superplasticizers. They have added a new dimension to the application of admixtures, and have made it possible to produce concrete with compressive strength of the order of 90 MPa.

Superplasticizers have other possible applications. Energy conservation and diminishing supplies of raw materials will increasingly necessitate the use of marginal quality cements and aggregates. In such instances, the use of superplasticizers may permit production of concrete at low water : cement ratios that will be strong enough to meet normal performance requirements.

There are literally countless possible applications of superplasticizers, for example, in the production of fly ash concrete, blast furnace slag cement concrete, composites with various types of fibres and lightweight concrete. In addition, the dispersing effect of superplasticizers is not limited to Portland cement and may find application in other cementitious systems.

The above discussion provides information relevant to the various categories and properties of superplasticizers for concrete. The functions of superplasticizers can be summarized as follows–

(i) To increase the workability of the concrete .

(ii) For a given workability, the amount of water that is water : cement (w/c) ratio can be reduced .

(iii) Cement reductions can be made by increasing the aggregate/cement ratio to effect economies without any detrimental effect on workability or compressive strength in comparison with the original mix at periods upto 28 days. Compressive strengths greater than 14,000 psi (96.5 MPa) at 28 days have been attained using superplasticizers.[8]

The water reducing admixtures reduces the water requirements of the concrete thereby increasing the strength of concrete. They find its use on seashores or on construction sites at sea. It is hoped that the publication of information of this type will be a contributive factor in encouraging the useful application of these materials both on site and in the precast yard to facilitate methods of working and to effect economies in the industry.

## ACKNOWLEDGEMENT

The authors are thankful to Department of Applied Chemistry, MANIT, Bhopal for their support and assistance.

## REFERENCES

1. V. S. Ramachandran and V. M. Malhotra, "Superplasticizers. In Concrete Admixtures Handbook: Properties, Science and Technology", Ed. V. S. Ramachandran. Park Ridge, N. J., Noyes publication (1984) pp. 211–68.
2. G. J. Verbeck, "Field and Laboratory Studies of the Sulfate Resistance of Concrete". In Performance of Concrete Resistance of Concrete to Sulfate and Other Environmental Conditions", Thorvaldson Symposium, Toronto, University of Toronto Press, (1968) pp. 113–24.
3. A. M. Neville, "Properties of concrete", ELBS with Addison Wesley Longman, Ltd, England, Fourth Edition, (1996) pp. 255–263.
4. S. Mindess and J. F. Young, "Concrete". Englewood Cliffs, N. J., Prentice–Hall, Inc. (1981).
5. R. Mielenz, "History of Chemical Admixtures for Concrete", Concrete International: Design and Construction, **6(4)**, 40 (1984).
6. M. L. Gambhir, "Concrete Manual", Dhanpat Rai and Sons Pvt Ltd., New Delhi (2002).

7. A. M. Neville and J. J. Brooks, "Concrete Technology", ELBS with Addison Wesley Longman Group, England, Fourth Edition, (1994) pp. 147–161.

8. "Admixtures and Ground Slag for Concrete", (1990), Transportation Research Circular No. 365 (December) . Washington: Transportation Research Board, National Research Council.

*Accepted : 12.1.2004*