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Experimental Studies on Property of Concrete due to Different Ingredient based Super Plasticizer

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Abstract— As civil engineer's maintaining our duty to discover method of making concrete at lowest water cement ratio while maintain a required workability. It is now possible with the advent of super plasticizers. Today new applications of admixture have been brought into the market for production of high strength and flowing concretes. These super plasticizers were also suitable for use with other cement material like FLY ASH and PPC. The effects of super plasticizer on fresh and hardened concrete were investigated. The experiment program included test on workability, slump loss and compressive strength. In this experimental works we are comparing the properties of super plasticizer based concrete with that of without super plasticizer added concrete. Super plasticizer permitted a significant water reduction while maintain the same workability.

In these research program three different families of super plasticizers has been used.

Rheobuild 1125(Sulphonated naphthalene polymer based)
Glenium 140 (Polycarboxylic ether polymers)
Pozzolith 225 (Modified lignosulphate)

Two design ratios of M20 and M40 grade were used for mix proportioning of concrete constitute by weight. The water cement ratio were maintained as 0.55, 0.40, to study the effect of these super plasticizer on various properties of concrete. The dosages of super plasticizer were adopted as 0.25% by weight of cement. To study the effect of super plasticizer the experiment has been divided into four series namely workability series, water reduction series and cement saving series, compressive strength.

Index Terms—**Super plasticizers, mix proportioning, compressive strength, slump loss, workability, cement reduction.**

I. Introduction

The earliest known published reference to the use of small amounts of organic material to increase the fluidity of cement containing composition was made in 1932 where polymerized naphthalene formaldehyde sulphonate salts were claimed as useful in this role. This was followed during the mids 1930s to early 1940s by numerous disclosures regarding the use of lignosulphonate and improved composition In recent years, construction agencies in North America, Great Britain and other countries have evinced great interest in the use of super plasticizers, super fluidifiers, sipper water reducers or high range water reducers. The super plasticizers' (SP) are referred to as high range water reducing admixture by ASTMC494, which mainly disperses the water in concrete matrix. This property is some time called as Dispersion-fluidification property of concrete admixture. According to the United Nations, there will be at least 20 megacities of more than 10 millions habitants in the year 2025. These cities will require large amounts of construction material for buildings and municipal infrastructures as well as for facilities necessary to handle food, drinking water and sewage. With an annual production of approximately 7 billion tons, Portland cement concrete is the most commonly used construction material throughout the world and it is expected that its use will continue to expand significantly in the next few years. Mostly due to its relative low cost, easy availability and versatility, Portland cement concrete has found many useful applications, from massive dams to high-rise buildings.

The super plasticizers are classified in the following four major groups;

Sulphonated Naphthalene Formaldehyde polymer based (SNF).
Polycarboxylic ether polymers.(PCEP)
Modified Lignosulphonate (MLS).
Others

Today super plasticizers are used in all important projects across the world in high raise buildings, pre stressed concrete, slender components with congested and densely packed reinforcement, beams and slabs pre-cast elements and long slender columns. The super plasticizer affect the various properties of concrete both in fresh and hardened forms mainly due to the following facts as commented by

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M.Collperdi in Concrete Admixtures Hand Book;

(i) Reduction in interfacial tension.
(ii) Multilayered adsorption of Organic molecule.
(iii) Release of water trapped amongst the cement particles.
(iv) Retarding effect of cement hydration.
(v) Change in morphology of hydrated cement.

A. Chemistry of super plasticizer:

Until the early 1930's, the composition of Portland cement concrete consisted primarily of cement, water and aggregates. The accidental discovery of the benefits of air entrainment in concrete by chemical admixtures in the 1940's was the first major breakthrough in concrete technology. This finding rapidly led to the development of several chemical products and admixtures that enhanced various properties of concrete such as workability, setting time and early strength. In the early 1960's, high-range water reducers or superplasticizers were developed and introduced into the concrete technology market. Superplasticizers are chemical admixtures that can be considered to pertain to the category of polymeric dispersants. In terms of chemical structure, superplasticizers can be broadly classified into two general categories. The first categories, the sulfonates-based superplasticizers, are the most important group of superplasticizers currently in use in the concrete industry. The first and most widely accepted compounds of this group are the poly-b-naphthalene sulfonates (PNS), the molecular structure of which is illustrated in. The synthesis of PNS superplasticizers involves several steps. It begins with the sulfonation of molten naphthalene with concentrated sulfuric acid at high temperature and pressure for several hours, followed by condensation of the b-naphthalene sulfonates with formaldehyde, neutralization with a suitable alkali and filtration to eliminate calcium sulfate. The resulting product is clear dark-colored liquid containing between 30 and 40% solids. Poly melamine sulfonates (PMS) are a second family of sulfonates superplasticizers that are also widely used in the concrete industry. Typical molecular structure of PMS is illustrated in and, as for the PNS described above; the synthesis of this superplasticizer involves several steps. First, formaldehyde reacts with the amino groups of melamine in alkaline conditions, yielding an addition product containing one or more methylol groups (CH2OH), depending on the formaldehyde/melamine ratio. Sulfonation of one of the methylol groups is then performed using sodium bisulfite under the same alkaline conditions. Polymerization of the sulfonates monomeric units is then initiated by mild heating under slightly acidic conditions. Finally, when the desired degree of polymerization has been obtained, the reaction is stopped by increasing the pH to slightly basic pH values and the final product is filtered to eliminate any non-desirable byproducts. Organic polymers bearing carboxylic acid groups constitute the second category of superplasticizers. Several polycarboxylate polymers and in particular poly acrylates have been proposed as concrete superplasticizers since the early 1980's. Poly acrylate polymers are prepared by a free radical addition polymerization of acrylic monomers. The polymerization reaction between the monomeric units, typically acrylic acid (CH2=CH-COOH) or meth acrylic acid (CH=C (CH3)-COOH) and ester derivatives of these monomers, is initiated by a free radical initiator species, typically a peroxide. The acrylic free radical reacts with an acrylic monomer to form a dimer free radical which, in turn, reacts with a third monomer and so on. This chain reaction propagates until the free radical species are quenched by free radical scavengers to form inactive terminal products. The average molecular weight of the final product depends on the concentration of the free radical initiator, higher concentration resulting in more polymers of lower average molecular weight.

B. SUPERPLASTICIZERS AND MINERAL ADMIXTURES

As stated before, the Portland cement industry is one of the most important contributors of anthropogenic CO2 released in the atmosphere. Portland cement is also the most energy intensive component of a concrete mixture and therefore its partial replacement by silica fume, fly ash or other cementitious by-products from thermal power production and metallurgical operations might result in a significant energy savings and in an important reduction of global CO2 emissions. In recent years, several investigations have been performed that were aimed at the development of concrete in which a significant proportion of cement (typically between 20 and 60%) was replaced by these industrial by-products.

C. Mode of action of superplasticizers:

It has long been known that the strength of any given concrete is inversely related to the water/cement ratio, i.e. the lower the water content of the concrete, the stronger it is. Water is an essential ingredient of concrete where it plays two basic roles: 1) it gives concrete the required rheological properties and 2) it participates in the reactions of hydration. The ideal concrete should thus only contain the minimal quantity of water necessary to develop the maximum possible strength of cement while providing sufficient workability for placement. However, since cement particles have a strong tendency to flocculate when they are brought in contact with water, it is necessary to add more water than is necessary in order to obtain a certain level of workability. Since this additional water will never be used in the hydration reactions, it will generate porosity within the hydrated cement paste, resulting in a weakening of the mechanical properties of concrete and in a decrease of its durability. Superplasticizers are powerful dispersing agents. As with most dispersing agents in aqueous solutions, they first act by being adsorbed onto the surface of cement particles. As illustrated in a significant proportion of the added superplasticizer is adsorbed onto cement particles at concentration commonly used in concrete. A schematic description of the adsorption mechanism is shown.Adsorption of negatively charged PNS on the surface of cement particles that are also negatively charged is made possible by the presence of calcium ions that have been solubilized from the

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cement.

Following adsorption of the superplasticizer, several physic-chemical effects might take place in the cement paste. For instance, the adsorbed superplasticizer molecules might contribute to minimize interactions between the particles through electrostatic repulsive forces or to the induction of short-range repulsive forces due to steric hindrance between polymer layers.

Superplasticizer molecules might also adsorb preferentially onto the aluminate phases of cements (particularly C3A) and compete with SO_4^{2} ions in the reactions that control the early hydration of C3A.

II. EXPERIMENTAL DETAILS

Material used:

Cement: Portland pozzolona cement was used.

Fine Aggregates: Fine aggregate consisting of natural sand obtained from shivnath river, as supplied to the construction sites as used.

Coarse Aggregates: Locally available coarse aggregate obtained from nandani quarry, consisting of naturally crushed rock of nominal maximum size 0f 20mm and down with the existing grading, as supplied to construction site was used.

Series No 1

Design of grade M20 and M40 mixes prepared in the lab as per IS 10262:2009. Four mixes with each type of super plasticizers have been developed for the 12 mixes.

Series No 2

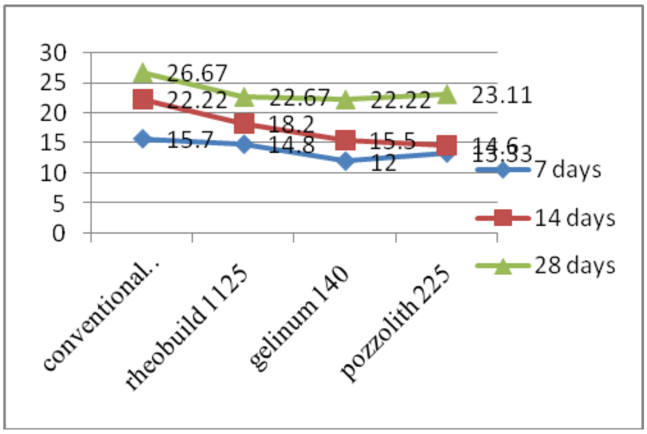
To investigate the effect of Super plasticizers on workability slump tests were carried out and to check the slump loss within time is observed.

Series No 3

To investigates effect on compressive strength cubes [6*6*6] were tested at the ages of 7, 14, 28 days. The results are shown in Table.

III. RESULT AND ANALYSIS

A. Table I Test result of the graph showing compressive strength at constant w/c ratio of M20 grade concrete



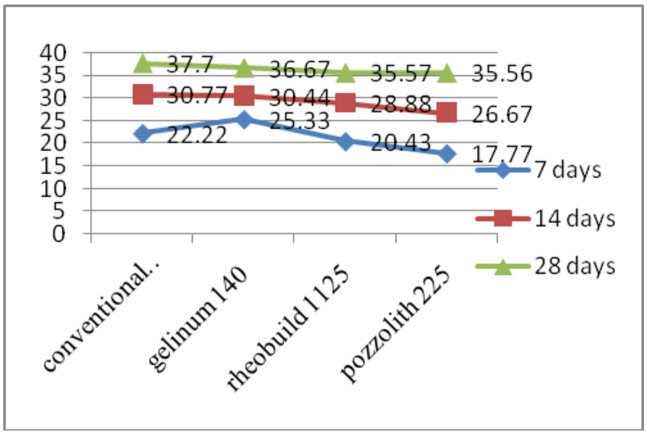
From this graph the following points to be pointed out:

Conventional concrete has got the7 days strength more than any other type of superplasticizers and conventional concrete.

Conventional concrete give the higher strength than any other concrete using superplasticizer at 14 days.

Conventional concrete give the target mean strength at 28 days and also highest strength comparing three different types of superplasticizers.

B. Table II Test result of the graph showing compressive strength at constant w/c ratio of M40 grade concrete



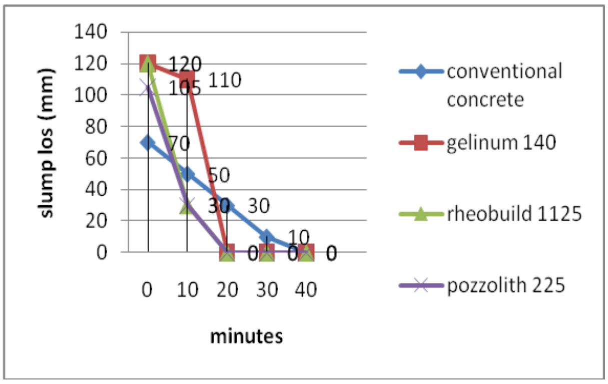
From this graph the following points to be pointed out:

Glenium140 has got the7 days strength more than any other type of superplasticizers and conventional concrete.

Conventional concrete give the higher strength than any other concrete using superplasticizer at 14 days.

Conventional concrete give the target mean strength at 28 days and also highest strength comparing three different types of superplasticizers.

***C.** Table III Combination of graph showing the result of slump loss at every 10 min for grade M20 by using three different families of superplasticizer and a conventional concrete:*



This is the graph showing combination of three super plasticizer and conventional concrete showing there slump loss at every 10 min, from this graph it is shown that Rehobuild1125 show maximum slump at 0min but is not workable , after 20 min its workability fall to zero. But the conventional concrete is workable for 30 min.

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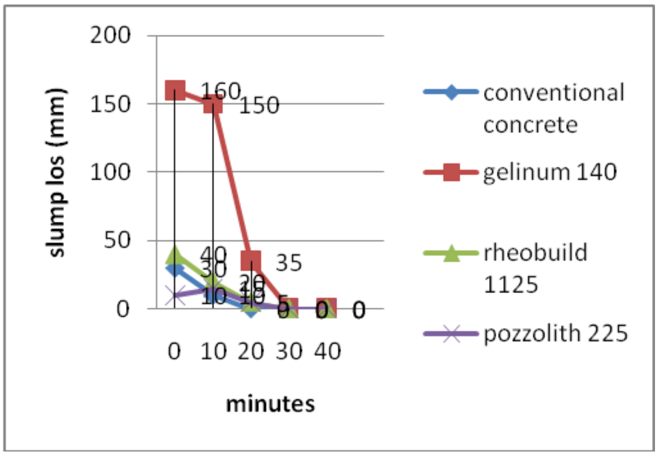
D. Table IV Combination of graph showing the result of slump loss at each 10 min for grade M40 by using three different families of superplasticizer and a conventional concrete



This is the graph showing combination of three superplasticizer and conventional concrete showing there slump loss at every 10 min, from this graph it is shown that rehobuild1125 show maximum slump at 0min but is not workable , after 20 min its workability fall to zero. But the conventional concrete is workable for 30 min

E. Table V Test result showing effect of superplasticizer on water reduction and compression strength at constant workability for grade M20

Superplasticizer used	Water-cement ratio	Water reduction	Slump(mm)	Compressive strength (N/mm²)		
				7 days	14 days	28 days
Rheobuild 1125	0.55	29 %	10	12.0	15.5	22.22
Glenium 140	0.55	29 %	10	14.8	18.2	22.67
Pozzolith 225	0.55	29 %	5	13.3	14.6	23.11

Glenium 140 has got the highest strength in 7 days compressive strength than any other superplasticizer concrete. 14 days compressive strength is higher for Glenium 140.In 28 days the result is totally different, Pozzolith 225 has got the strength higher than any other superplasticizer concrete.

F. Table VI Test result showing effect of superplasticizer on water reduction and compression strength at constant workability for grade M40

Superplasticizer used	Water-cement ratio	Water reduction	Slump (mm)	Compressive strength (N/mm²)		
				7 days	14 days	28 days
Rheobuild 1125	0.40	29%	10	20.43	28.88	35.57
Glenium 140	0.40	29%	0	25.33	30.44	36.67
Pozzolith 225	0.40	29%	0	17.77	26.67	35.56

Glenium 140 has got the highest strength in 7 days compressive strength than any other superplasticizer concrete. In 14 days compressive strength is higher for Glenium 140. In 28 days the result is totally different, Glenium 140 has got the strength higher than any other superplasticizer concrete.

IV. CONCLUSION

This paper was conducted to study the effect of superplasticizer on properties of concrete with characteristic strength of 20 and 40 N/mm². The properties investigated were workability (Slump), and compressive strength. On the basis of observation on test result it can be stated that properties of concrete in fresh and hardened stages have been improved with the addition of three types of superplasticizer for all nominal mixes of concrete, the Glenium 140 have shown however more pronounced in terms of increase in the compressive strength, workability, water reduction, cement saving requirements of concretes. From the results of the study the workability of concrete can be increased by addition of superplasticizer. However, very high dosages of SP tend to impair the cohesiveness of concrete. Slump loss can be reduced by using the chemical admixtures. However, effectiveness is higher for superplasticizer concrete.

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