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Dosage Limit Determination of Superplasticizing Admixture and Effect Evaluation on Properties of Concrete

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Abstract— Superplasticizers are commonly known as High Range Water Reducers because it permits low water cement ratio as well as the workability also affected. In very recent decades, superplasticizers creates milestone in the advancement of chemical admixtures for Portland cement concrete. The dramatic effect of superplasticizer (SP) on properties of fresh and hardened concrete has studied and the properties of concrete inspected are compressive strength and slump test. To determine the optimum dosage for the admixture, an experimental investigation conducted and the effect of over dosage of the SP admixture experimented, together with one control mixed. The viscosity of grout and hence the workability of concrete influenced by the dosage of superplasticizer. From dosages of admixture, the difference between concrete mixes comes, which used at amounts 400 ml/100 kg, 600 ml/100 kg, 800 ml/100 kg, 1000 ml/100 kg and 1200 ml/100 kg of cement were prepared. By dosage 1.0% of SP, compressive strength is improved and after 28 days curing it is 57 N/mm^2, which is higher than that of control specimen. This paper shows that, the optimum amount of admixture must be 1.0 %. Over dosage of SP found to deterioriate the properties of concrete with indication of lower compressive strength.

Index Terms— Admixture, Compressive Strength, Concrete, Dosage, Superplasticizer, Workability, Water reducer

1 Introduction

In recent decade High Performance Concrete (HPC), a new term become very attractive to civil engineering professionals and material scientists of this sector. HPC possess higher workability, higher strength, and high modulus of elasticity, higher density, higher dimensional stability, low permeability and resistance to chemical attack. HPC has been increasingly applied in the tall building construction as well as construction of bridges and off-shore structures. In HPC along with Cement, Fly ash, Slag, Coarse aggregate, Fine aggregate one of the important parameter is 'Superplasticizer (SP)'. During the last 35 years, the most important advancement in concrete technology has been the use of superplasticizers. Superplasticizers constitute a relatively new category as well as improved version of plasticizer. The conventional method is to obtain higher workability is improving the gradation increasing the cement content. But it creates difficulties in field for a given set of conditions. That's why; in site most of the cases extra water uses which can do a lot of harm in strength and durability of concrete. In this case superplasticizers are the final solution and for reducing the water requirement to make concrete of higher workability or flowing concrete, now throughout the world the SP used for almost all the reinforced concrete structure and even for mass concrete.

According to the ASTM C-125-97a standards, an admixture is a material which is uded as an ingredient of mortar or concrete other than hydraulic cement, water and aggregates. It is added to the batch immediately before or during mixing.

According to Yamakawa, both in the fresh and hardened states, the utilization of SP will have accelerating & significant effects on properties of concrete. Due to the reduction in water/ cement ratio or water content of concrete, in the fresh state, dosage and use of superplasticizer will normally reduce tendency to bleeding. The action of SP is mainly to fluidity the mix and improves the workability of concrete, mortar or grout. The superplasticizer will prolong the setting time of concrete, if water/ cement ratio is maintained. Because of more water is available to lubricate the mix. For producing denser concrete, by increasing the effectiveness of compaction the use of superplasticizer will increase compressive strength in the case of hardened concrete. If concrete is retained in liquid state for longer period the overall risk of drying shrinkage can be lowered in huge extent. Most importantly if SP is present, the water/cement ratio is lowered and it results slow rate of carbonation.

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2 Obejectives Of The Study

This study is carried, (I) to determine the optimum dosage limit of concrete superplasticizer for normal concrete and (II) to investigate the effects of superplasticizer on properties of concrete.

3 Experimental Procedure And Approach

This experimental study was based on normal strength concrete with characteristic strength of 35 N/mm^2 at 28 days. As a binder material Ordinary Portland Cement (OPC) was used and granite coarse aggregate of 20mm sieve size well as Sylhet sand also used.

Sikament® R2002 used as superplasticizer because it is a high range water reducing admixture as well as non-hazardous and non toxic under relevant safety and health issue. Sikament® R2002 is a highly effective super plasticizer with a set retarding effect for producing free flowing concrete in hot climates. It is also a substantial water reducing agent for promoting high early and ultimate strengths. It complies with ASTM C-494 Type G and B.S. 5075 Part 3. Sikament® R2002 is basically Modified Synthetic Dispersion and having Brown Liquid appearance. It can be added separately to the freshly mixed concrete or directly to the mixing water prior to its addition to the aggregates. Sikament® -R2002 is compatible with all types of Portland Cement, including SRC (Sulfate Resisting Cement).

Without any admixture, one control specimen (S) was prepared for comparing. For investigating the effects of superplasticizer on concrete properties, five additional mixes was prepared using admixture dosage of 400, 600, 800, 1000, and 1200 ml/ 100 kg of cement and named as S1, S2, S3, S4 and S5. To assess the workability of the concrete mixes Slump test were conducted. To determine the compressive strength concrete cube used which was cured for 28 days. As per BS 1881: Part 111: 1983 code, for hardened concrete test water curing temperature was 27 ± 2ºC for all samples. Overall six specimens (concrete cube) with the dimension of 150 mm x 150 mm x 150 mm were fabricated at laboratory.

4 Results And Discussions

4.1 Superplasticizer Effect on Slump Test

The results for slump loss of superplasticized concrete summarize in Table 1. The data of Dimension, SP ratio in percentage and slump in mm were recorded. It showed a relation between dosages of SP and slump loss. And then, the value of slump loss at different specific dosages of SP is then plotted as in two graph as shown in Figure 1 and 2, in Y axis the slump (mm) and in X axis ratio of superplasticizer (%).

TABLE 1

Slump Loss for Superplasticized Concerete

Concrete Mix	Dimension (mm) L x B x H	Sikament® R2002 ratio %	Slump (mm)
Control (S)	150x150x150	0.0	95
400 ml/100 kg of cement (S1)	150x150x150	0.4	105
600 ml/100 kg of cement (S2)	150x150x150	0.6	120
800 ml/100 kg of cement (S3)	150x150x150	0.8	140
1000 ml/100 kg of cement (S4)	150x150x150	1.0	150
1200 ml/100 kg of cement (S5)	150x150x150	1.2	170

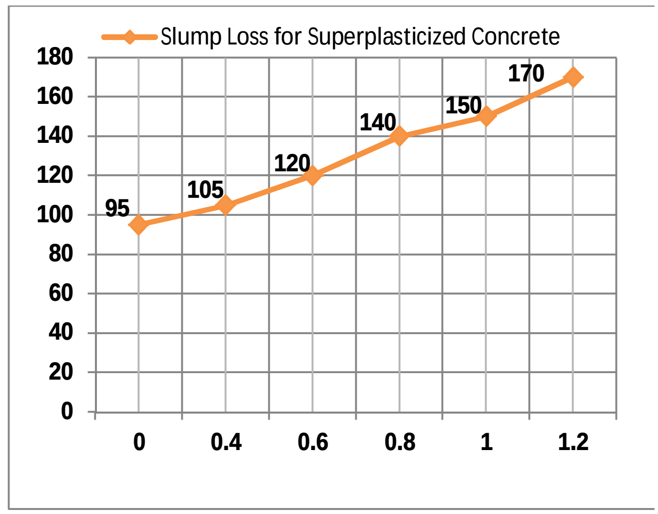

Fig.1. Effect of SP dosage on slump loss (Line Graph)

The above (Fig. 1) Graphs show slump in mm against of different dosages of Superplasticizers. At Figure 1 (Line Graph) it is clear that with the increase of Superplasticizer the slump (mm) also increases. Another Column graph is plotted here to understand the Slump loss condition in total six specimens. "S" specimen is control specimen here that's why it does not fabricate with any SP. But S1, S2, S3, S4 and S5 contains SP (Sikament® R2002) in a ratio 0.4, 0.6, 0.8, 1.0 and 1.2 consecutively using admixture dosage of 400, 600, 800, 1000, and 1200 ml/ 100 kg of cement. At maximum dosage the slump value in mm also maximum and it shows higher value at specimen S5. However, the action of Superplasticizer will help to fluidity the mix for a longer time and it finally results reducing the slump loss during the transportation of concrete to the site. It is visible that, over dosage of these sorts of admixtures will result high slump losses. So, it will not give true slump that as what we expect and desire.

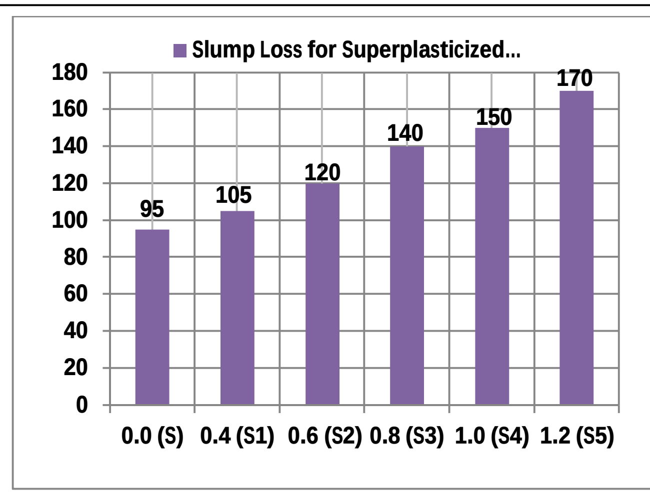

Fig. 2. Effect of SP dosage on Slump Loss (Column Graph)

4.1 Effect of Superplasticizer on Compressive Strength

Compressive strength of concrete with different dosage of superplasticizer is shown in Table 2. This test performed on 28 days. The values and fluctuation of compressive strength at different specific dosage of superplasticizer are then shown in a graph in Figure 3.

TABLE 2
Compressive Strength for Superplasticized Concerete

Concrete Mix	Dimension (mm) L x B x H	Sikament® R2002 ratio %	Compressive Strength (N/mm²)
Control (S)	150x150x150	0.0	44
400 ml/100 kg of cement (S1)	150x150x150	0.4	45
600 ml/100 kg of cement (S2)	150x150x150	0.6	52
800 ml/100 kg of cement (S3)	150x150x150	0.8	54
1000 ml/100 kg of cement (S4)	150x150x150	1.0	57
1200 ml/100 kg of cement (S5)	150x150x150	1.2	43

After conducting the experiment, a graph of compressive strength versus dosage of superplasticizer is shown at Figure 3.

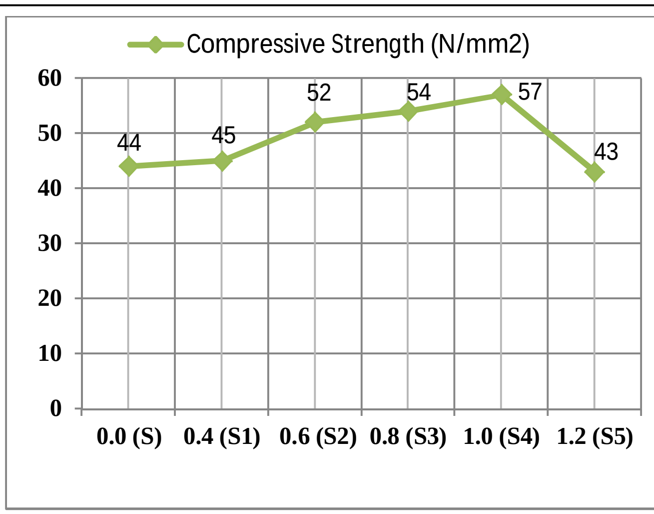

Fig. 3. Compressive Srength of Concrete with Different Dosages of Superplasticizer

From the graph, it is clear that the strength gains continuously for addition of chemical admixture and the compressive strength is increasing with the increment of superplasticizer dosage. It also visible from experiment that superplasticizer has a lowest and highest dosage value corresponding to compressive strength. Continuous addition of superplasticizer agent may not be able to increase the compressive strength of concrete continuously; rather high dosage reduces the strength significantly. Most importantly, the strength condition is so frustrating that the strength becomes lower than the control specimen, which has no superplasticizer at all. It is true that if dosage increases the compressive strength also increased. But excessive addition of SP disturbed the hydration process because extra addition of SP (Over dosage) provides more water to mix the concrete. Over dosage results also acceleration of deflocculation of cements particles. Moreover, the entrapped water increasing with the increasing of dosage and it creates hydration of cement.

For using of admixture there is a maximum limit which can be termed as optimum limit, though increment in dosage of superplasticizer admixture is increasing the compressive strength of concrete. But, if the dosages pass or cross this specific limit that means over dosage state, increase in dosage does not increase the strength and it only reduce the compressive strength. This phenomenon occur because excessive usage of SP will cause bleeding and segregation. And finally it affects the cohessiveness as well as uniformity of the concrete. That's why compressive strength will reduce if the used dosage is greater than the optimum dosage.

From the observation of the efficiency of compressive strength it is seen that, compressive strength of concrete specimen is increased at S1, S2, S3 and S4 when dosing with SP and it increasing 1 N/mm², 8 N/mm², 10 N/mm² and 11 N/mm² respectively from the compressive strength of control specimen (S). But at concrete specimen S1 which have dosage value 400 ml/100 kg of cement, does not increase compressive strength in a significant manner from the Control specimen (S) rather than 1 N/mm². On the contrary, from the highest ultimate strength (28 days aged), optimum maximum dosage of superplasticizer is determined.

From Figure 3, we can observe that maximum or optimum dosage for the admixtures is 1.0% i.e, 1000 ml/100kg of cement which is obtained from specimen S4. The compressive strength is decreasing if the dosage of SP is fluctuating i.e, higher or lower from this limit. With very small interval of dosage the more accurate and specific result may obtained. It also results High Performance Concrete without showing any retarding properties.

5 Conclusion

This paper was conducted to determine the dosage limit as well as optimum dosage determination. Various effects of superplasticizer on properties of concrete (workability & compressive strength) with characteristic strength of 35 N/mm² also studied.

- From the results of the study, it is decided that by addition of superplasticizer the workability of concrete can be enhanced.

- By using the proper chemical admixtures slump loss can be reduced to a great extent. In superplasticizer concrete effect is too high.
- Up to a specific limit (1.0%) with the increment of superplasticizer dosage the compressive strength is improved and it is compared with a control specimen which fabricated without any SP.
- The effective minimum dosage is 600 ml/100 kg of cement and maximum effective dosage is 1000 ml/100kg of cement.
- The effective range of dosage is 0.6-1.0%.

6 ACKNOLEDGMENT

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