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Effect of Superplasticizer on Fresh and Hardened Properties of Concrete

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Abstract

In recent years, significant attention has been given to use superplasticizer as a chemical admixture on concrete. However, the use of chemical admixtures in concrete is a common solution to achieve high performance concrete. The past researchers have been underscored the use of chemical admixtures imparts the desirable properties to concrete in both fresh and hardened state. This paper has been made an attempt to study the influence of superplasticizer dose of 0.6, 0.8, 1.2, 1.8 and 2.5 percentage on performance of concrete. The experimental tests for fresh and hardened properties of concrete for M35 grade are studied and the results are compared with normal concrete. The tests considered for study are, slump test and compressive strength test The results show that the increase of superplasticizer dose in concrete leads to gain of good ability in addition to slump. Moreover, there is also slightly increase in compressive strength than that of normal concrete.

Keywords

Compressive Strength, Superplasticizer, Concrete, Workability

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1. Introduction

In the world, about 90-95 percent of the construction materials market for both structural and non-structural applications is made of concrete compared with other materials used for similar functions. Concrete, generally, is a product made from cement, water and aggregates and an additional material known as admixture, is sometimes added to modify certain properties of concrete. Cement is the chemically active constituent but its reactivity is only brought into effect upon mixing with water. The aggregate plays no important roles in chemical reaction but its usefulness arises because it is an economical filler material or hard composite material with good resistance to volume changes which take place within the concrete after mixing, besides improving durability of concrete.

In hardened state, concrete is a rock like material with a high compressive strength. In its plastic state, concrete may be moulded into any form of shapes, it may be used to advantages architecturally or solely for decorative purposes. Concrete has low tensile strength, and hence, this is the reason why it is used with steel bar to resist any tensile forces in the reinforced concrete. However, concrete is usually used in building for foundations, columns, beams and slabs, in shell structures, bridges, sewerage treatment plants, roads, cooling towers, railway sleepers and so on. In precast concrete industry, concrete is widely used as concrete blocks, cladding panels, pipes, piles and lamp posts (1).

Nowadays, more than 70% of in-situ concrete in the world is produced by the ready mixed concrete industry. The ready mixed concrete producers are using a superplasticizier (SP) admixture which is readily available from various manufacturers. Superplasticiser (SP) is used to increase the workability without changing the water/ cement ratio. Or, it

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can be used to increase the ultimate strength of concrete by reducing water content while maintaining adequate workability.

Superplasticizer is a type of water reducers; however, the difference between superplasticizer and water reducer is that superplasticizer will significantly reduce the water required for concrete mixing (2). Generally, there are four main categories of superplasticizer: sulfonated melamine-formaldehyde condensates, sulfonated naphthalene-formaldehyde condensaes, modified lignosulfonates and others such as sulfonic- acid esters and carbohydrate esters. Effects of superplasticizer are obvious, i.e. to produce concrete with a very high workability or concrete with a very high strength. Mechanism of superplasticizer is through giving the cement particles highly negative charge so that they repel each other due to the same electrostatic charge. By deflocculating the cement particles, more water is provided for concrete mixing (2). For general usage, dosage of superplasticizer is between 1- 3 l/m3. However, the dosage can be increased to as high as 5- 20 l/m3. Since concentration of superplasticizer is different, any comparison of performance should be made on the basis of the amount of solids, and not on the total mass. Effectiveness of a given dosage of superplasticizer depends on the water/cement ratio. Effectiveness increases when w/c decreases. Compatibility with actual cement is one of the most important parameters that needed to be considered, and it is not recommended that the cement and superplasticizer conform the standard separately (2).

There are few advantages obtained when superplasticizer is used: produce high workability concrete with constant cement content and strength, with objective for easy placing and compaction; produce concrete with normal workability, but lower water requirement; production of concrete with combination of high workability and low water content; and designing a normal strength and workability concrete with less cement content (3). Usage of superplasticizer becomes famous nowadays since it possesses advantages for both fresh and hardened concrete. The utilization of superplasticizer will have positive effects on properties of concrete, both in the fresh and hardened states (4). In the fresh state, utilization of superplasticizer will normally reduce tendency to bleeding due to the reduction in water/ cement ratio or water content of concrete. However, if water/ cement ratio is maintained, there is tendency that superplasticizer will prolong the time of set of concrete as more water is available to lubricate the mix. In the case of hardened concrete the use of superplasticizer will increase compressive strength by enhancing the effectiveness of compaction to produce denser concrete. Risk of drying shrinkage will be reduced by retaining the concrete in liquid state for longer period of time. In addition, rate of carbonation become slower when water/ cement ratio is decreased with the presence of superplasticizer (4).

Different types of superplasticizer will normally have different effects on properties and performance of concrete. (5) carried out an investigation to study the effect of two types of superplasticizers- acrylic polymer (AP) and sulfonated naphthalene (SN) on concrete containing high volume of fly ash. From the investigation, they concluded that AP- based superplasticizer performs significantly better than the SN- based superplasticizer, where it provides higher slump level, lower slump loss and higher water reduction. In addition, concrete containing AP- based superplasticizer gives higher compressive strength and durability performance (in terms of CO2 and chloride penetration). Hence, addition of AP- based superplasticizer not only improves the slump loss problem of the concrete, but also it does not cause any reduction in the early strength development of hardened concrete. However, the influence of a superplasticizer by the name of (Mighty 2000) in addition, they confirmed that slump of fresh concrete can be optionally controlled in all mix- designs if reactive polymer is added. Since workability of low water/cement ratio concrete is difficult to control, addition of reactive polymer can usefully maintain the initial slump of ready mixed concrete (6). In addition, they claimed that superplasticizer can really produce a good quality concrete by increasing the density of concrete, through significant reduction in water requirement and slump loss.

The reason for widespread usage of admixtures is that admixtures are able to impart considerable physical and economic benefits with respect to concrete. However, usage of admixture is not remedy for poor quality of concrete due to the use of incorrect mix proportion, poor workmanship in concrete mixing and the problems caused by low quality raw materials selection (7, 8).

2. Objectives of Study

The aim of this paper is to produce concrete using Ordinary Portland Cement and Superplasticizer. In order to achieve this aim, several objectives are set out:

1. Effect of Superplasticizer on strength development of conventional concrete.

2. Effect of Superplasticizer on workability of conventional concrete.

3. The optimum Superplasticizer added to achieve the better strength and workability of concrete.

3. Experimental Investigation

3.1. Materials Used and Properties

The materials used for this study are cement, fine and coarse aggregates. However, a chemical admixture (superplasticizer) is added in order to change the characteristics of concrete for certain applications. Since the materials are important in determining the quality of produced concrete, they should be properly selected and chosen before the beginning of the experiment.

3.1.1. Cement

The cement used in this study is a product from Cement Industries of Libya, with a brand name blue lion. This type-I cement complies strictly with BS 12: 1991 where it is widely used in general construction, for example buildings, bridges and other precast concrete products. It is available in 50 kg bag.

3.1.2. Fine and Coarse Aggregates

Aggregate is important because it occupies about three-quarters of the volume of concrete. Usually, there are two types of aggregate used in concrete, which are fine and coarse aggregates. Many parameters needed to be considered in selection of aggregate, for instance, types of aggregate, size and shape of the particle, and the strength of the aggregate. All aggregate must be free from dust as the dust may affect the bonding between the aggregate and cement particles. The fine aggregate used in this investigation is sea sand. Lastly, coarse aggregate used in this study is crashed stone with a maximum size of 20 mm. In addition, aggregates should be cleaned before mixing to wash away the fine particles that stick on the surface of the aggregate.

3.1.3. Superplasticizer

The superplasticizer used in this study is Liboment – 163. It is a new superplasticizer, which not only suitable for prestressed concrete, but also for other types of concrete. One of its benefits is that it can improve both early and final strength. In addition, slump retention and workability of concrete also enhanced by using Liboment – 163.

3.2. Concrete and Mix Proportion

In order to study the effect of superplasticizer on the properties of fresh and hardened concrete, sex mixes are prepared. After design calculation, water/cement required to obtain slump range 60 mm is 0.475. However, as the aggregate used in the experiment is in wet condition, the weight of mixing water had to be decrease by the amount required for absorption by the aggregates (Building Research Establishment, 1988). On the hand, when SP is added to the mixes were prepared by adding SP dosages of 600, 800, 1200, 1800 and 2500 ml/100kg of cement, the slump becomes higher than normal concrete. Therefore, details of the mixes are given in Table 1.

Table 1. Mix Proportions of Concrete

Mix No	Concrete Mix Grade 30 N/mm^2		
	Type of Concrete	W/C %	SP %
1	Conventional	0.475	0.0 %
2	SP	0.475	0.6 %
3	SP	0.475	0.8 %
4	SP	0.475	1.2 %
5	SP	0.475	1.8 %
6	SP	0.475	2.5 %

4. Experimental Results and Discussion

4.1. Physical Properties of Fresh Concrete

(1) Workability Test

The results for slump loss of superplasticizer concrete are shown in Table 2. The data are recorded and being shown to observe the relation between dosages of superplasticizer and slump loss. The values of slump loss for different dosages of superplasticizer is then plotted as a graph as shown in Figure 1.

Table 2. Workability Test Results for Various Concrete Mixes

Concrete mix	SP %	Slump loss (mm)				
		0 min	30 min	60 min	90 min	120 min
Mc 1	0.0	65	25	0		
MS 2	0.6	70	25	8	0	
MS 3	0.8	95	25	10	0	
MS 4	1.2	125	45	18	0	
MS 5	1.8	130	55	25	10	0
MS 6	2.5	140	55	35	20	0

Graph in Figure 1 show slump against elapse of time for different dosages of superplasticizer. From the graph, it is clear that slump reduces with time. It is acceptable since continuous hydration process will produce calcium silicate hydrate to fill the pores between the cement particles and aggregate. As a result, setting of the concrete will reduce the fluidity of concrete, hence, reduce the slump too. When observation is done on the content of superplasticizer, increase in dosage of the chemical admixture will decelerate the rate of setting of concrete, since the superplasticizer will help to retain the concrete in liquid state for a longer time, and hence, reduce the slump loss during the transportation of concrete to the site. However, over dosage of the admixture will lead to high slump loss, which will not give true slump that as what we expect and desire. Finally, comparisons are made between the SP and normal concrete the setting time for superplasticizer concrete is longer than the normal concrete. After 90 minutes, concretes with superplasticizer dosage present zero slump. On the other hand, As a result, conclusion is made that superplasticizer is more effective in retaining the slump of the concrete than the normal concrete.

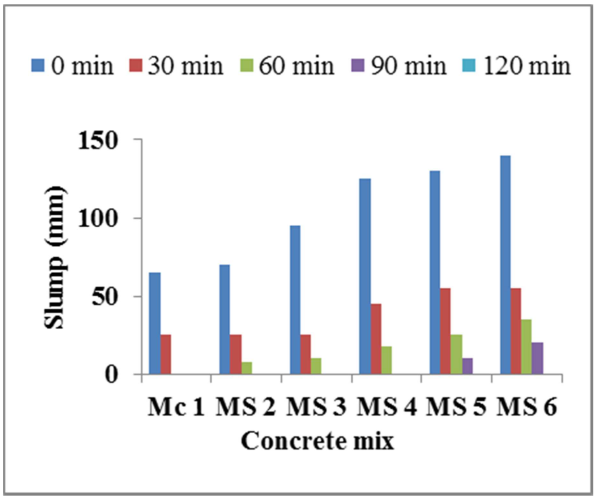

Figure 1. Workability test results for various concrete mixes

4.2. Physical Properties of Hardened Concrete

(1) Compressive Strength

Compressive strength of concrete with different dosage of superplasticizer is shown in Tables 3. This test is performed on 28 days. The values of compressive strength for the different dosage of superplasticizer are higher than normal concrete. After conducting the experiment, graph of compressive strength compares with normal concrete is plotted. From the Figure 2, continuous strength gain for chemical admixture is observed by the increase in compressive strength with dosage. In addition, when we observe the effect of dosage of the admixture present different behaviours on the compressive strength of concrete. At very low dosage addition of superplasticizer not able to increase the compressive strength of concrete, on the other hand, the superplasticizer, increase in dosage will increase the compressive strength. Since addition of superplasticizer will provide more water for concrete mixing, not only the hydration process will not be disturbed, but, it is accelerated by the additional water from deflocculation of cement particles. Hence, increase in dosage will increase the entrapped water and promote hydration of cement.

Table 3. Compressive strength of various concrete mixes at 28 days

Concrete Mix	SP %	Compressive Strength N/mm² 28 Days
Mc 1	0.0	37.68
MS 2	0.6	37.17
MS 3	0.8	40.24
MS 4	1.2	36.75
MS 5	1.8	36.75
MS 6	2.5	36.17

Though increment in dosage of admixture will enhance the compressive strength, there is still an optimum limit for the usage of admixture. When the dosages go beyond this limit, increase in dosage will only reduce the compressive strength. This phenomenon occur since over dosage of superplasticizer will cause bleeding and segregation, which will affect the cohessiveness and uniformity of the concrete. As a result, compressive strength will reduce if the used dosage is beyond the optimum dosage. If observation is done on the efficiency in increasing compressive strength, superplasticizer performs better than normal concrete. For compressive strength of concrete containing superplasticizer exceeded 2.56 MPa, and this value is higher than the compressive strength of the control, However, for compressive strength of superplasticizer concrete give acceptable result, where the compressive strength achieve exceeds 40.24 MPa, which is higher than the desired characteristic strength of 30 MPa. Howevr, the optimum dosage of superplasticizer is found based on the highest ultimate strength that they present at age 28 days. From the graph, we can observe that optimum dosage for the superplasticizer concrete is 800 ml/100kg of cement. Dosage with lower or higher than this optimum value will reduce the compressive strength. For more accurate and precise result, more dosages should be done with smaller interval for a better fit curve.

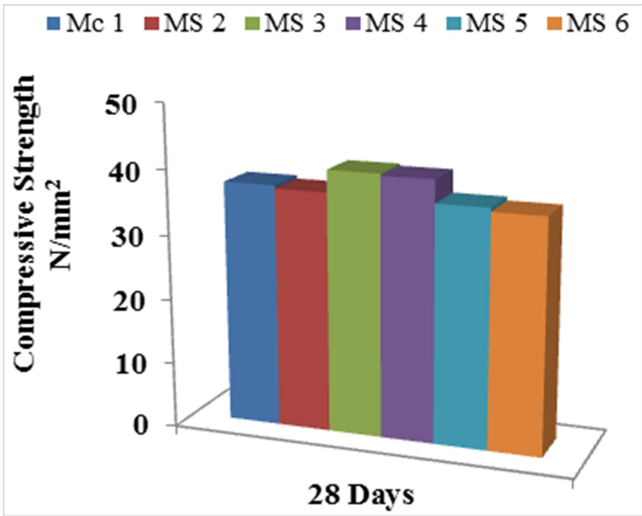

Figure 2. Compressive strength of various normal concrete mixes at 28 days

5. Conclusion and Recommendation

An investigation has been performed to study the effects of superplasticizer on properties of concrete with characteristic strength of 30 MPa. The properties investigated were workability (slump), workability retention and compressive strength. However, the conclusion, which follow are drawn based on experimental results and observations presented earlier in the study. These conclusions are of necessity specific to this study, being related to type of superplasticizer, environmental condition during testing, testing method, etc. Nevertheless, the findings of this investigation should provide a significant contribution towards the knowledge on the effect of superplasticizer on properties of concrete. The main conclusions of the study together with recommended future work are presented in the following sections.

5.1. Conclusions

Properties of concrete containing superplasticizer had been successfully studied. From the results of the study presented earlier, the following conclusions are offered:-

➢ The workability of concrete can be increased by addition of superplasticizer. However, very high dosages of superplasticizer tend to impair the cohesiveness of concrete.

➢ Slump loss can be reduced by using the superplasticizer admixture. However, effectiveness is higher for superplasticizer concrete than normal concrete.

➢ Compressive strength is improved by superplasticizer. On the other hand, its ultimate strength is higher than the desired characteristic strength.

5.2. Recommendation

The following are few recommendations that can be done to further enhance the usefulness of the experiment:

➢ Inclusion of both chemical and mineral admixtures

- Since superplasticizer help to increase workability of concrete, its usage on concrete containing mineral admixtures such as silica fume or fly ash and metakaolin should be studied in depth to determine whether ultra-high strength concrete (100 – 150 MPa) can be produced using these chemical admixtures

➢ Effects of various types of admixtures

- Since different kinds of admixture will react differently when contacts with cement even though they are categorized in the same type, therefore, study should be done to determine which admixture perform better under certain exposure condition.

➢ Determination of accurate optimum dosage

- Since there are only 5 dosages of admixture used, accurate optimum dosage of admixture is difficult to estimate. For this reason, more concrete mixes that contain different dosages of admixtures should be prepared in order to obtain the precise optimum dosage of admixture through the best fit line drawn on the graph.

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References

[1] Jackson, N.; and Dhir R.K. (Eds.). 1996. Civil engineering materials. 5th ed. McMillan, London, UK.

[2] Neville A.M, 2005. Properties of concrete, Pearson. Prentice Hall, p 255- 262

[3] Ramachandran V. S., Beaudoin J. J.and Shihua., 1981. Concrete science . Heyden & Son Ltd. p. 91,130- 138, 145,

[4] Yamakawa C., Kishitani K., Fukushi I. and Kuroha K., 1990. Slump control and properties of concrete with a new superplasticizer. II: High strength in- situ concrete ork at Hikariga- oka Housing Project, Chapman and Hall. p. 94.

[5] Borsai A.., 1994. Effect of superplasticizer type on the performance of high- volume fly ash concrete.

[6] Fukuda M., Mizunuma T. Iumi T. and Iizuka M., 1990. Slump control and properties of concrete with a new superplasticizer. Chapman and hall.

[7] Salahaldein Alsadey*, 2013 " Effects of Superplasticizing and Retarding Admixtures on Properties of Concrete " International Conference on Innovations in Engineering and Technology (ICIET), Bangkok (Thailand).

[8] Salahaldein Alsadey*, (2012) " Effects of Superplasticizing Admixture on Properties of Concrete" Paper presented at International Conference on Transport, Environment and Civil Engineering (ICTECE' 2012). Kuala Lumpur (Malaysia), August 25-26,2012.

[9] Building Research Establishment Report, 1988. Design of normal concrete mixes.

[10] British Standard Institution, BS 1881 : Part 3 (1970)." Methods of Making and Curing Test Specimens".

[11] British Standard Institution, BS 1881: Part 102 (1983). "Methods for Determination of Slump".

[12] British Standard Institution, BS 1881 : Part 116 (1983). "Methods for Determination of Compressive Strength of Concrete Cube".