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Evaluating The Effects of Using Superplasticizer RHEOBUILD® 600 on The Workability and Compressive Strength of Normal Concrete

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Abstract

This study has been undertaken as an attempt to examine the use of different super plasticizer dosage (0.5, 0.7, 0.9, 1.1 and 1.2) percentage of the weight of cement on the performance of the concrete and estimate the best ratio of super plasticizer. The laboratory experiments for both plastic and hardened properties of concrete for concrete mix grade 25 were determined and the effects were contrasted against normal concrete mixture. The tests performed for this study are slump test and compressive strength test .The findings demonstrate that with the raise of superplasticizer dose in concrete will lead to an improvement in the properties of concrete.

The experimental calculations display a significant increase in the rate of compressive strength in comparison with the normal mix. The compressive strength increased about (47.43) % in comparison with the normal mix. Also, the experimental results showed the optimum ratio of the superplasticizer is (0.7)% of the weight of cement.

Keywords: Compressive Strength, Superplasticizer, Concrete, Workability, Admixture.

الخلاصة

لقد تم إجراء هذه الدراسة كمحاولة لدراسة تأثير جرعة الملدن المتفوق بالنسب التالية (0.5، 0.7، 0.9، 1.1 و 1.2) على سلوك الخرسانة اضافة الى ذلك تقدير أفضل نسبة يمكن اضافتها من الملدن المتفوق . و تم اجراء الاختبارات التجريبية على العينات في الحالتين الطرية و الصلبة للخرسانة و تم مقارنة النتائج مع عينة خالية من المضاف (الملدن المتفوق). التجارب المختبرية التي تم اعتمادها في هذا البحث هي كالتالي: اختبار الهطول، اختبار الانضغاط ، حيث بينت النتائج ان زيادة نسبة الملدن المتفوق في الخرسانة يؤدي الى تحسن في خواص الخرسانة.

النتائج المختبرية بينت زيادة بالغة بمقاومة الانضغاط في العينات التي تحتوي على الملدن مقارنة مع العينة التي تخلو منه، وازدادت قوة الانضغاط بحوالي (47.43)٪ مقارنة مع المزيج الطبيعي. كما اظهرت النتائج التجريبية ان النسبة المثلى الملدن المتفوق هي (0.7٪)

الكلمات المفتاحية: مقاومة الانضغاط ، الملدن المتفوق ، الخرسانة، الفعالية، المضاف.

I. Introduction

Concrete is the most used building material across the globe. The general composition of concrete is cement , fine aggregate, coarse aggregate and water and an additional material known as admixture. Due to the increasing demand on the use of concrete in different circumstances, therefore, the current orientation is to develop a special high performance concrete (HPC) that present a special performance and uniform characteristics which are commonly hard to achieve with conventional concrete (Mehta, 1999; Mehta and Monteiro, 2006). The producers of ready mixed concrete are using a superplasticizer(SP) admixture which is easily accessible from numerous companies. superplasticizer(SP) is being used mainly to enhance the possibility of work for the concrete mix without modifying the ratio of water to cement (W/C), Or else, It can be adopted to amplify the final strength of the concrete by cutting down the amount of water needed for the mixture while sustaining suitable workability (Alsadey,2015).

Superplasticizer is an example of water reducing agent; however, the major disparity between superplasticizer and a water reducer is the fact that superplasticizer reduces the water necessary for concrete mixture substantially (Neville, 2005).

Superplasticizers help to achieve faster placing and completion of concrete and eliminates to a great deal the risk of both segregation of aggregates and bleeding, therefore, the processes of pumping concrete become much smother (Malagavelli and Paturu, 2012). The usage of admixtures is spreading quickly in the construction industry for the fact that admixtures can present both physical and economic benefits to the building materials saying that, the use of admixture can never substitute or can be the solution for a lacking quality concrete mix (Alsadey, 2013; Alsadey, 2012).

The main purpose of this work is to determine the best ratio of the admixture to be added to the concrete to give better strength and workability.

II. Materials and methods

This research was conducted using Ordinary Portland Cement OPC (Type I), which meets the terms with the Iraqi specification (IQS) No. 5/1984. The used cement has the best chemical constituents and physical characteristic. Normal sand from **(**Al-Akaidur**)** region and rounded coarse aggregate from Al-Nebai quarry of maximum aggregate size 14 mm are used as fine and coarse aggregates, respectively. Which are both meeting the terms with the Iraqi specifications (IQS) No. 45/1984. The properties of both coarse and fine aggregates are given in Table 1. Ordinary tap water was used in this work for the making processes and also the curing process of all the samples.

(RHEOBUILD® 600) is a ready-to-use superplasticizer, known to be a high range water-reducing compound designed to produce elevated slump concrete with workability retain in properties.

Table 1: Physical and Chemical Properties of Fine and coarse Aggregate (According to IQS No. 45/1984)

Physical properties	Fine aggregates	Coarse aggregate
Specific Gravity	2.60	2.65
Sulfate content	0.08 %	0.03 %
Absorption	0.75 %	0.5 %
Clay content	0.83 %	0.2 %

Table 2: superplasticizer used in this study (BS 5075: Part 1,1982)

Type	Superplasticizer RHEOBUILD® 600
Form	Liquid
Active ingredients	Lignosulphonate
Containing air entraining properties	None
Shelf life	2 years
Specific gravity	1.15
Safety precautions	Non- toxic
Curing efficiency	Nil

III. Mix Design

The mix design of concrete was based on the American method (ACI 211-1) and the details of the mixes are shown in (Table 3). Six mixes are prepared to evaluate the influence of the superplasticizer on the properties of fresh and hardened concrete. The experimental program contained of 36 (Cubes**)** separated into six groups. All set were formulated in control mix in w/c = 0.43. The required strength of 25 N / mm2 in 28 days was adopted in this study. Three samples from each mixture set were tested at the age of 7 and 28 days for compressive strength.

Table 3: Details of mix proportion

Concrete Mix Grade 25 KN/ mm^2			
Mix No.	Cube Sample Name	W/ C ratio	SP (%)
1	Conventional	0.43	Zero
2	SP1	0.43	0.5
3	SP2	0.43	0.7
4	SP3	0.43	0.9
5	SP4	0.43	1.1
6	SP5	0.43	1.2
Material	Cement (Kg/ m^3)	Sand (Kg/ m^3)	Gravel (Kg/ m^3)
Amount	410	640	1250

Superplasticizer Modified Concrete (SPC):

In this research, superplasticizer modified concrete compositions containing (0.5%, 0.7%, 0.9%, 1.1% and 1.2%) superplasticizer by weight of cement were arranged. Cubes were cast using these superplasticizer modified concrete in order to test their compressive strength.

Sample Preparation: with the help of mechanical mixer, all concrete mixes were arranged. Cube specimens of 15 ×15×15 cm were cast. The casted samples had been placed in a chamber with 30ºC temperature and 90% humidity to be cured. Superplasticizer enhanced concrete cubes were tested at 7 and 28 days of age in order to calculate the compressive strength for each cube.

Testing methodology

The compressive strength of all concrete compositions was established according to BS 1881: Part 116 (1983) and ASTM C 39-86(1986)**.** The compressive strength tests were performed by the use of a Compression equipment. From each mixture three cube samples were tested for compressive strength. For the purpose of this research this research, the average value of samples had been registered.

Physical Properties

A. Fresh Concrete

(1) Workability Tests

Slump Test (mm):

Table 4 shows the results of the slump test for the different mixes of the concrete and the superplasticizer. The data were registered, and the relation between doses of superplasticizer and the slump readings can be observed, according to BS 1881: Part 102 (1983).

Details of specimens used for mix design proportion of 1:1.5:3 with constant water cement ratio: 150mm x 150mm x 150mm Cube specimens for Compressive strength.

Table4: Slump test results

S.No	Cube Sample name	% of SP	Weight of SP in mix (gm)	Slump Value (mm)
1	Conventional	0	0	20
2	SP1	0.5	20.50	28
3	SP2	0.7	28.70	40
4	SP3	0.9	36.90	95
5	SP4	1.1	45.10	132
6	SP5	1.2	49.20	180

Compaction Factor Test:

Table 5 shows the results of the compaction test for the different mixes of the concrete and the superplasticizer. The data were registered, and it could be observed the relation between doses of superplasticizer and compaction.

Table5: compaction factor test results

S.No	Cube Sample name	% of SP	Weight of SP in mix (gm)	Compaction test
1	Conventional	0	0	0.880
2	SP1	0.5	20.50	0.900
3	SP2	0.7	28.70	0.900
4	SP3	0.9	36.90	0.909
5	SP4	1.1	45.10	0.906
6	SP5	1.2	49.20	0.980

B. Hardened Concrete

Compressive Strength:

The compressive strength test was determined according to (BS 1881: Part 116 , 1983; ASTM C 39-86,1986). Cubes of (150x150x150) mm has been tested by using a hydraulic powered compression machine of (1300) kN. An average of three cubes from each mixture were assumed for each test.

The table below illustrates the change in the compressive strength of the concrete with a change in the dosage of the superplasticizer. This test was done on cubes with the ages of 7 and 28 days.

Table6: compression strength test results

S.No	Cube Sample name	% of SP	7 Days strength, N/mm2	28 Days strength, N/mm2	Density Kg/m^3
			Average of 3 samples		
1	Conventional	0	20.82	31.37	2.41
2	SP1	0.5	28.33	42.32	2.39
3	SP2	0.7	27.52	46.25	2.39
4	SP3	0.9	26.28	38.85	2.42
5	SP4	1.1	27.77	36.15	2.41
6	SP5	1.2	26.43	37.38	2.42

IV. Discussions

This research has been established to calculate the optimum amount of admixture (superplasticizer) to add to the concrete mix, the strength of which is 25 Mpa. The tested properties were slump test(workability), compressive strength at 7 and 28 days ages ,and compaction factor. The results obtained from this research shows the following:

The addition of superplasticizer to the concrete showed an increase in the slump with respect to the normal mix. The slump increased from (20mm) to (180mm), as a result, we can conclude that the workability of concrete increase when the ratio of superplasticizer increased the compaction factor approaches to the 1.0.

The compressive strength of concrete increased in all concrete mixes which contain of superplasticizer. Based on the above results obtained from the tests showed that the optimum ratio of superplasticizer is (0.7%) from the weight of cement, where this percent showed the highest compressive strength at 28 days with a value of (46.25 N/mm^2)

V. Conclusions

1- Conclusion

Considering the outcomes achieved by performing the laboratory experiments, the following conclusions can be drawn:

The workability of concrete can be increased with the increase in the dosage of superplasticizer. Slump and compaction factor increased by using the superplasticizer. The compressive strength is improved by superplasticizer in comparison with control mix (without any additive).

2- Recommendations for Future Research

1- Since superplasticizer increased the concrete's workability, then as a Next step for future research consideration should be given to examine the influence of the added superplasticizer to a concrete mixture including a mineral admixtures for example, silica fume , fly ash and metakaolin.

2-Using the same type of superplasticizer with ultra-high strength concrete (100 – 150 MPa) to evaluate the effect on the properties of concrete.

3- Using another type of superplasticizer.

4- Studying the effects that superplasticizer might have on the other properties of concrete.

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Nomenclature

Symbol	Definition
SP	Superplasticizer
ASTM	American Society for Testing and Materials

Table7: Chemical composition and main compounds of cement (according to IQS No.5/1984) *

Composition	Chemical Compound	% {by weight}	(IQS NO5/1984) Limits
Lime	Cao	62.23	------------------------
Silica	SiO2	19.50	------------------------
Alumina	Al2O3	4.56	------------------------
Iron oride	Fe2O3	3.56	------------------------
Sulfate	SO3	2.59	<= 2.5 % if C3A < 5% <= 2.8 % if C3A > 5%
Magnesia	MgO	2.95	<= 5%
Free lime	Free CaO	1.12	------------------------
Loss on ignation	l.O.I.	4.00	<=4 %
Insoluble residue	I.r.	1.23	<= 1.5 %
Lime saturation factor	l.s.F.	0.95	0.66 -1.02

Main compounds (Bogues equs)	% weight of cement
Tricalcium-silicate (c3s)	57.47
Dicalciums-silicate (c2s)	12.55
Tricalcium-aluminate (c3a)	6.06

*__The test is made in the Environmental Laboratory in Al-mustaqbal University College.__

Table 8: Physical properties of cement (according to IQS No.5/1984) *

Physicals properties	End Results	(IQS NO.5/1984) Limits
Setting time (Vacates test) primary, min last,min	120 235	>= 45 min <= 600 min
Blaine fineness apparatus , m^2/kg	310	>= 230 m^2/kg
Compressive strengths, Mpa 3 days 7 days	19,0 28.0	>= 15 Mpa >= 23 Mpa

*** Physical tests were performed in the laboratory of construction materials**

Al-mustaqbal University College.

Table 9: Grading of Fine Aggregate (according to IQS No.45/1984)*

Sieves sizes	Fine aggregate	Limits of IQS NO. 45/1984 for Zone 2
10 mm	100	100
4.75 mm	99	100-90
2.36 mm	90	100-75
1.18 mm	81	90-55
600 micron	52	59-35
300 micron	25	30-8
150 micron	6	10-0

*** Grading tests were conducted in Construction Materials Laboratory ofAl-mustaqbal University College.**

Figure. 1: slump test

Figure.2: specimens preparation

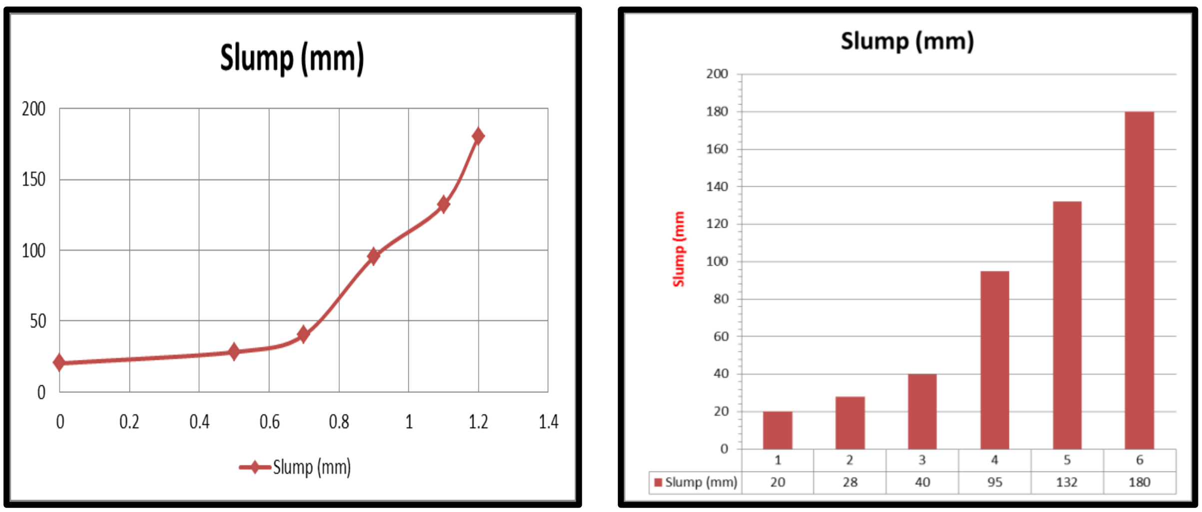

Figure. 3: slump with different (SP) mixing ratios

Figure.4 : Cube samples during compression test

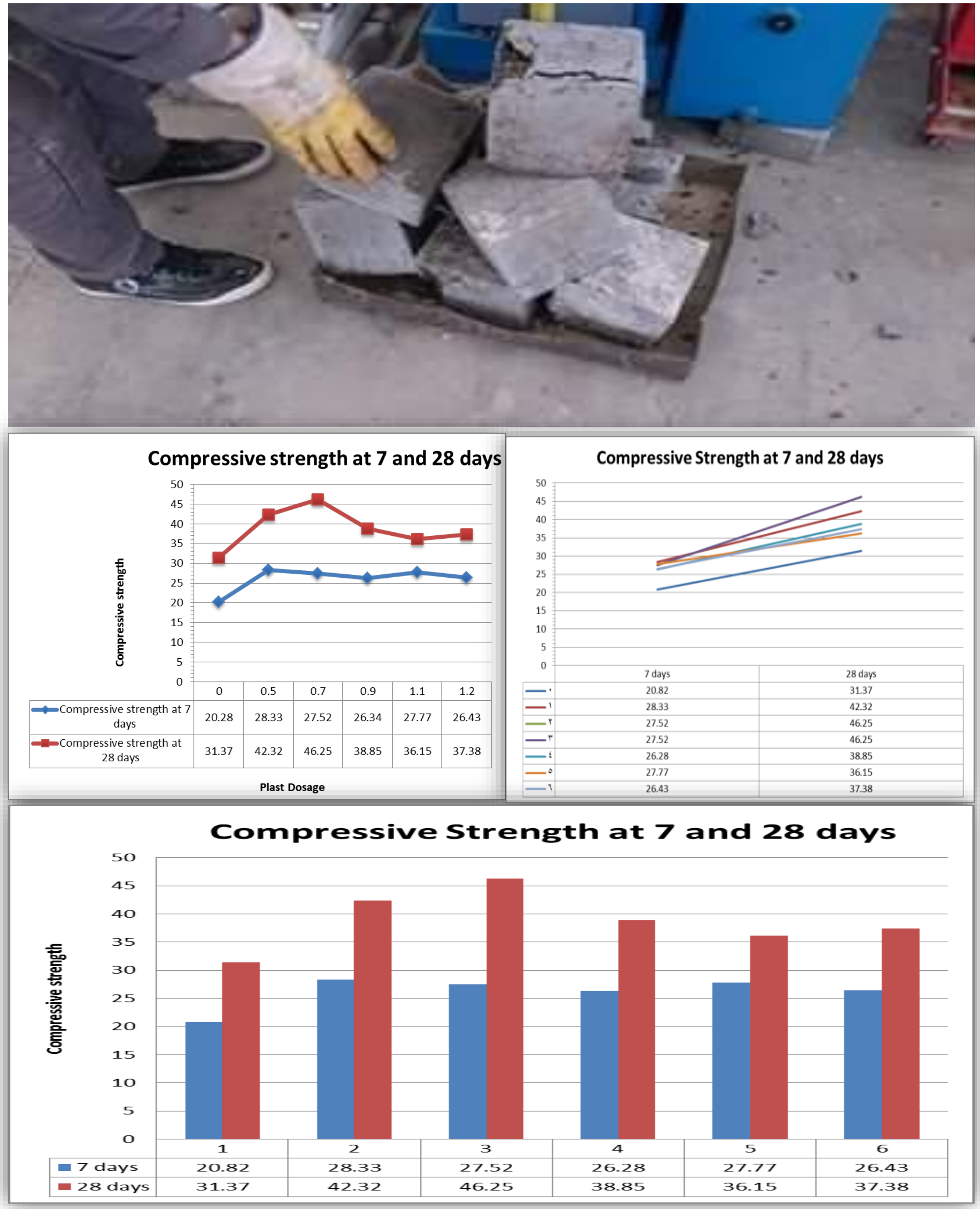

Figure.5 : compressive strength at 7 and 28 days for different (SP) mixing ratios