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INFLUENCE OF WATER SOURCE ON COMPRESSIVE STRENGTH OF HIGH STRENGTH CONCRETE

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ABSTRACT: - This research studies the influence of water source on the compressive strength of high strength concrete. Four types of water source were adopted in both mixing and curing process these are river, tap, well and drainage water (all from Iraq-Diyala governorate). Chemical analysis was carried out for all types of the used water including (pH, total dissolved solids (TDS), Turbidity, chloride, total suspended solid (TSS), and sulfates). Depending on the chemical analysis results, it was found that for all adopted sources the chemical compositions was within the ASTM C 1602/C 1602M-04 limits and can be satisfactorily used in concrete mixtures.

Mixture of high strength concrete for compressive strength of (60 MPa) was designed and checked using water-to-cement ratio of 0.37, 400.5 kg cement with 10% replacement of SF (Silica Fume), 607 kg sand, 1147 kg gravel and 0.85 lit /100 kg of cement of SP (Supper Plasticizer). Five ages were adopted to measure the compressive strength these are (7, 14, 28, 60, 90 and 120) days.

The results indicated that the strength of concrete at different ages was affected by the adopted water source especially on the period (28-90) days. There was a reduction on the compressive strength varies between (3-8.5) % and (3-1.5) % for both river and well water source which is belong to the effect of chlorides.
Keywords: *high strength concrete, mixing water, absorption, strength.*

1- INTRODUCTION

Water can be consider as the most important source of life continuity, so it is very important to avoid the waste of water. For both mixtures and curing of concrete, numerous sources of non-tap water were tested such as sea and al-kali waters, mine and mineral waters, waters containing sewage and industrial wastes, and oily and brackish waters from oil wells (Cebeci, O.Z., Saatci, A.M.,1989, Mujahed, F.S., 1989, , Ahmad, S.,1991, Taha et al, 2005)

Concrete usually mixed using potable water due to its well-known specifications and chemical composition. In the international codes, only 10% reduction in the compressive strength of concrete cubes made of untried water is allowed compared with that made with tap water (Taha et al, 2010). The graphing of the sound conclusion regarding the use of non-fresh water is difficult because the differences in the impurities types that exist in each water types (Neville, A., 2000),

El-Nawawy, O.A. 1991, presented a study on the influence of using water obtained from municipal sewage treatment plant in concrete mixing. The chemical analysis of the adopted water showed that the total dissolved solids, chloride and sulphate contents exceed the standard limits in mixing water. Different proportion of treated and portable water were studied, up to 40% was within the standard limits of mixing water. The results indicated that the compressive strength reduced by 10% in a case of treated to portable proportion equal to 20%.

Chini et al, 1999, investigated the satisfaction of using wastewater in both aggregate irrigation and patch water. Two source of wastewater were used in the research, the first type was within the standard limits of both FDOT and AASHTO M 157 specifications while the second type was not meet the limit of FDOT specification. The research showed that the two types has no significant effect on the concrete compressive strength and recommended to supplement the FDOT specification.

Al-Jabri et al. 2010, studied the influence of wastewater on high compressive concrete properties, different percentage of (wastewater / tap water) replaced were used ranged between 25-100%. The research result detected that the chemical composition of the used wastewater is within the limit of the ASTM requirement even that its higher than the tap water and that there is no significant effect on the compressive strength of concrete in a case of using wastewater instead of tap water.

2. MATERIAL

2.1 Cement

An Ordinary Portland Cement (Type–I), Tassluga, was used for all specimens. The results of chemical analysis and physical test are shown in Table 1 and Table 2, respectively. The results of both chemical and physical test were compared with Iraqi Specification No. 5 / 1993.

2.2 Fine Aggregate

Al-Ukhaider sand of (4.75 mm) maximum size was used as fine aggregate in concrete mixes for all specimens. Sieve analysis of the used sand is shown in Table 3 both with the limit of Iraq Specification No. 45/1993 while the physical properties are shown in Table 4. According to the limit of Iraq Specification the used sand can be classified as Zone 2.

2.3 Coarse Aggregate

Graded crushed gravel of (14 mm) maximum sized from Al Niba'ee region was used in all specimens. Grading and physical properties of the coarse aggregate are shown in Table 5 and Table 6, respectively. Conformed to Iraq Specification No. 45/1993.

2.4 Water

Four sources of water was adopted in this study these are:

- River water (Tigris).
- Well water.
- Drainage water.
- Tap water.

These types were chemically analyzed for certain contaminations that may affect concrete mixes. The measurements included: sulfate content (as SO_3), chloride content (as Cl), total dissolved solids (TDS), total suspended solids (TSS) and water Turbidity. PH was also measured for all used types. The result of the chemical test are shown in Table 7.

2.5 Silica Fume

Silica fume conformed to EN 13263, product of Sika, was used as an additives (pozzolanic material) to produce the HPC for all specimens. The chemical composition and ASTM C1240-03 requirements of silica fume are listed in Table 8 and Table 9.

2.6 Superplasticizer

A new generation of modified polycarboxylic ether that complies with ASTM C494-05 types A and F (GLENIUM51) was the super plasticizer that used as a superplasticizer to modify the workability of high strength concrete. Table 10 gives the technical description of GLENIUM51.

3. EXPERIMENTA PROGRAM

The mix proportion of the high strength concrete adopted in this study is illustrated in Table 11 for a slump of (100 mm). A rotating pan was used to mix the constituents materials according to ASTM C192-98 requirements and a vibrating table was used to compact the mixtures. Demoulded of the specimens were after 24 hours, cured in the same type of mixed water and then tested at room temperature. Three cubs (150x150x150 mm) were tested to evaluate the compressive strength at the adopted ages (7, 14, 28, 60, 90 and 120 days) for each types of used water.

4. RESULTS AND DISCUSSION

The chemical analysis for all types of used water, Table 7, appears that there is a percentage of difference between them and it was detected that the result was within the ASTM requirements for all substances (ASTM T26-79 1996). The results of the chemical analysis indicate that pH values were within the acceptable range (4.5-8.5). All the used water types were of acid pH especially the river source (pH = 7.4). The standard endorses that the containing of total dissolved solids in water should be less than 2,000 ppm to be used satisfactorily in making concrete. In this research the range of total dissolved solids was (386-480) ppm, which is acceptable since it is below the standard requirement. Also, the maximum chloride concentration of 125 ppm was less than the threshold limit of (1000 ppm).The chemical composition of the adopted water sources shows that sulfate content in tap water is higher than the other sources which belongs to Alum material ($Al_2(So_4)_3.18H_2O$) that added to tap water in the treatment process.

The trading lines of the compressive strength- time relation indicate that for both river and well water source there was a reduction in the compressive strength especially on the period (28-90) days by about (8.5-3) % and (3-1.5) % respectively, Fig. 1. It's well-known that the chemical reaction and effect of the additives materials (Silica Fume) started approximately after 90 days of concrete mixing. For this reason the reduction in the compressive strength for both river and well sources was modified after 90 days.

5. CONCLUSIONS

The main conclusions drawn from the effect of water type on the compressive strength of concrete are:

1. Generally, the chemical composition of the adopted water sources is greater than tap water. However, all the adopted sources were within the standard limits of ASTM.
2. There was a reduction in the compressive strength for both river and well sources by (3-8.5) % and (1.5-3) % respectively due to the effect of chlorides.
3. The effect of the additive material (Silica Fume) modified the reduction of the concrete compressive strength.
4. All the water sources that used in this research are suitable for using in site instead of tap water.

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Table 1. Chemical composition of cement.*

No.	Compound Composition	Chemical Composition	% Weight	Iraqi Specification No. 5 / 1993
1	Silica	SiO_2	20.28	---
2	Alumina	Al_2O_3	5.00	---
3	Iron Oxide	Fe_2O_3	3.44	---
4	Lime	CaO	63.80	---
5	Magnesia	MgO	2.33	5 (max)
6	Sulfate	SO_3	2.4	2.8 (max)
7	Insoluble residue	I.R	1.27	1.5 (max)
8	Loss on ignition	L.O.I	3.00	4.0 (max)
9	Tricalcium aluminates	C_3A	0.58	---
10	Lime saturation factor	L.S.F	0.93	0.66 – 1.02
11	Tricalcium alumina ferrite	C_4AF	Not available	---
12	Tricalcium silicate	C_3S	Not available	---
13	Dicalcium silicate	C_2S	Not available	---
14		Fe_2O_3- Al_2O_3	Not available	---

*All the test were conducted by the National Center of Laboratories and Researches (Baghdad).

Table 2. Physical properties of cement.*

No.	Physical Properties	Test Result	Iraqi Specification No. 5 / 1993
1	Specific surface area (Blaine Method) m^2/kg	392	230 (min)
2	Setting time (Yicale's Method) Initial time setting : (hour: mint) Final time setting : (hour: mint)	 2:25 3:50	 00:45 (min) 10:00 (max)
3	Autoclave Expansion %	0.08	0.80 (max)
4	Compressive Strength, Mpa 7 days 28 days	 21.41 27.81	 15.00 (min)\ 23.00 (min)

*All the test were conducted by the National Center of Laboratories and Researches (Baghdad).

Table 3. Grading of the fine aggregate.

Sieve size (mm)	% Passing by Weight	Limit of Iraqi Specification No. 45 / 1993			
		Zone 1	Zone 2	Zone 3	Zone 4
10	100	100	100	100	100
4.75	100	90-100	90-100	90-100	95-100
2.36	91.8	60-95	75-100	85-100	95-100
1.18	76.5	60-90	55-90	75-10	90-100
0.60	51	30-70	35-59	60-79	80-100
0.30	12.2	5-34	8-30	12-40	15-50
0.15	2.7	5-20	0-10	0-10	0-15
$75x10^{-3}$	2.66	5 max			

Table 4. Physical properties of the fine aggregate.*

No.	Physical Properties	Test Result	Iraqi Specification No. 45 / 1993
1	Specific gravity	2.63	---
2	Sulfate contained %	0.22	0.5 (max)
3	Absorption	---	---

*All the test were conducted by the National Center of Laboratories and Researches (Baghdad).

Table 5. Grading of the coarse aggregate.

Sieve Size (mm)	% Passing by Weight	Limit of Iraqi Specification No. 45 / 1993
37.5	100	100
19	97.1	95-100
9.5	51.4	30-60
4.75	6.8	0-10

Table 6. Physical properties of the coarse aggregate.*

No.	Physical Properties	Test Result	Iraqi Specification No. 45 / 1993
1	Specific gravity	2.63	---
2	Sulfate contained %	0.04	0.1 (max)
3	Absorption	0.7	---

*All the test were conducted by the National Center of Laboratories and Researches (Baghdad).

Table 7. Chemical analysis of used water.*

No.	Chemical Test	Standard Unit	Results				ASTM C 1602/C 1602M-04
			Tap	Well	Rive	Drainage	
1	TSS	ppm**	< 0.1	4	7	15	----
2	TDS	ppm	417	459	386	480	2000
3	Sulfate	ppm	0.2	0.1	0.1	0.2	3000
4	Chloride	ppm	50	125	125	100	1000
5	PH	---	7.2	7.72	7.7	7.4	(4.5-8.5)
6	Turbidity	NTV	4.81	11.6	10.4	4.67	---

*All the test were conducted by the Sanitary Laboratory/ Civil Engineering Dept. /Baghdad University.
**ppm= part per million part

Table 8. Chemical composition of silica fume.*

No.	Compound Composition	Chemical Composition	% Weight
1	Silica	SiO_2	92.03
2	Alumina	Al_2O_3	0.18
3	Lime	CaO	0.70
4	Iron Oxide	Fe_2O_3	1.10
5	Magnesia	MgO	2.10
6	Sulfate	SO_3	0.85
7	Loss on ignition	L.O.I	3.78

*All the test were conducted by the S. C. Geological Survey and Mining.

Table 9. Chemical requirements of SF according to ASTM C1240-03.

Chemical Composition	Test Result	Limit of ASTM C 1240-03
Silica (SiO_2), min	92.03	85.00
Loss on ignition (L.O.I) , max	3.78	6.00

Table 10. Technical description of GLENIUM51*.

Form	Viscous liquid
Color	Light brown
Relative density	1.1

PH	6.6
Viscosity	128 +/- 30 CPS
Transport	Not classified as dangerous
Labelling	No hazard label required

*Data sheet of the Manuscript.

Table 11. Details of the adopted mix.

Mix Ratio (by weight)	w/c	Mix Proportion (kg/m^3)				SP*	SF**
		Water	cement	Sand	Gravel		
1:2.35:2.59	0.37	169	400.5	607	1147	0.85	10%

*lt /100 kg of cement (Max limit is 2.7).
** Replacement by weight of cement.

Table 12. Percentage progress in concrete compressive strength.

Time Period , day	Progress in Comp Strength %			
	Tap	Well	River	Drainage
7-14	36	13	-1.5	22
14-28	3.0	7	-8.4	11
28-60	3.6	-14.8	- 3	0
60-60	2.5	20.7	31	-2.3
90-120	4	3	8	-0.1

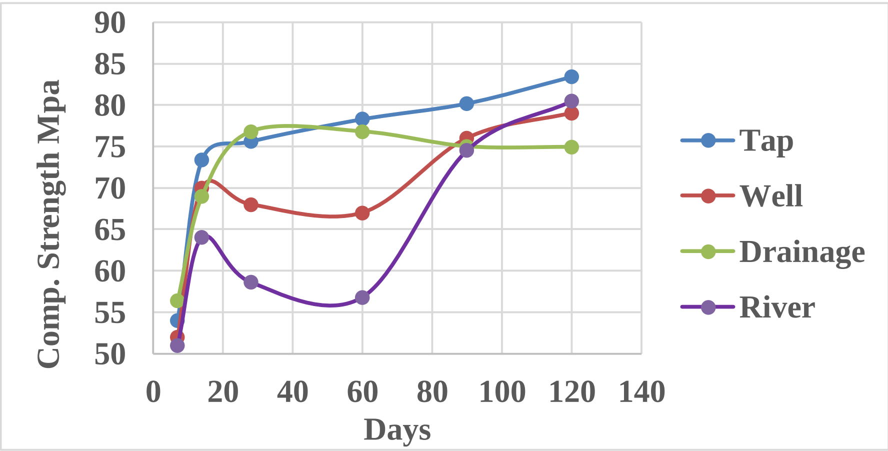

Figure 1. Effect of water's source type on the compressive strength of concrete.

تاثير نوعية الماء على خواص الكونكريت عالي المقاومة

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كلية الهندسة – جامعة بغداد

الخلاصة

يدرس هذا البحث تاثير مصدر الماء على مقاومة الكونكريت عالي المقاومة. استخدام اربع انواع من مصادر الماء في عملية صب الكونكريت وانضاجه هي ماء النهر, ماء الشرب, ماء البئر و ماء البزل (جميعها اخذت من محافظة ديالى في العراق). تم اجراء التحليل الكيميائي لكل نوع من انواع مصادر الماء المعتمدة في الدراسة واشتمل التحليل اجراء فحوصات (الحامضية, المواد الصلبة المذابة, العكرة, الكلوريد , نسبة المواد الصلبة العالقة و الكبريتات) وبالاعتماد على نتائج هذه الفحوصات الكيميائية وجد بان كافة مصادر الماء المعتمدة في البحث مطابقة لمتطلبات المدونة الامريكية الخاصة بخواص الماء المستخدم في انتاج الكونكريت (ASTM C 1602/C 1602M–04).

صممت ودققت الخلطة الخاصة بانتاج كونكريت عالي المقاومة (60 MPa) باعتماد نسبة سمنت/ماء مقدارها (0.37) وبتسب خلط مقدارها 400.5 كغم سمنت وبنسبة استبدال من السليكا فيوم 10%, 607 كغم من الرمل , 1147 كغم من الحصى و 0.85 لتر من الملدن لكل 100 كغم من السمت. تم اعتماد خمسة اعمار لفحص مقاومة الانضغاط هي(120,90,60,28,14,7) يوم.

أظهرت النتائج تاثر مقاومة الكونكريت في اعمار مختلفة بنوعية الماء المستخدم في عمليتي الصب والانضاج خاصة للفترة بين (28–90) يوم. اذ انخفضت مقاومة الانضغاط بنسبة تتراوح بين (3–8.5) % و (3–1.5) % لكل من ماء النهر والبئر بسبب تاثير الكلورايد

الكلمات المفتاحية: الكونكريت عالي المقاومة , ماء الخلط, الامتصاص, المقاومة.