

MECHANISM EFFECT OF A SUGGESTED LOCAL AND ECONOMICAL ADDITIVE ON THE COMPRESSIVE STRENGTH AND DURABILITY OF CONCRETE

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(Received September 2, 2012 Accepted October 18, 2012)

Abstract

Modern production of high quality concrete is closely connected with wide use of different types of admixtures, by which using of small doses allowed to obtain the required physical, technical, exploitation and economical properties of concrete. The use of concrete in water or wastewater tanks has many benefits such as strength, long service life and cost effectiveness. It has emerged as the dominant construction material for the infrastructure needs of the twenty-one century. In addition to being durable, concrete is easily prepared and fabricated from readily available constituents and is therefore widely used in all types of structural systems.

The challenge for the civil engineering community in the near future is to realize projects in harmony with the concept of sustainable development and this involves the use of high performance materials and products manufactured at reasonable cost with the lowest possible environmental impact

Physical, chemical absorption and chemical reactions may occur between the admixtures and the hydrating components of cements. Physical and chemical changes occur when admixtures such as accelerators, retarders, water reducers, and super plasticizers are added to the cement - water system.

Mechanisms of the action of admixtures, changes in water demand, viscosity, setting, slump loss, shrinkage, kinetics of hydration, micro structure, strength and durability of fresh and hardened cement pastes can be explained by the interaction effects.

Therefore, the main purpose of this research is to study experimentally the mechanism effect of a proposed local and economical additive on both the compressive strength and durability of concrete.

The experimental results showed that, the optimum composition of all components of the suggested admixtures (BM 2010) containing wastes from petroleum industries and silica fume and naphthalene sulfonate was successfully and experimentally achieved.

This paper focuses on the experimental studies about the possibility of producing new chemical organic admixtures containing in their compositions industries wastes by testing 180 cubic concrete specimens to propose the best-suggested admixture effect on their compressive strength and durability under these aggressive environmental conditions.

1. INTRODUCTION

In general, concrete has a low resistance to chemical attack. There are several chemical agents which react with concrete, but two forms of attack are most common, namely, leaching and sulfate attack. Sulfate attack on concrete leads to the conversion of hydrated products of cement to ettringite, gypsum and other phases, and also to the destabilization of the primary strength provided calcium silicate hydrate (C-S-H) gel. The formation of ettringite and gypsum is common in cementitious materials exposed to most types of sulfate solutions. The expansion resulting from sulfate attack is generally attributed to the formation of these two compounds, although there is some controversy surrounding the exact mechanisms causing expansion [1]. When attacking solution contains magnesium ions, such as magnesium sulfate (MgSO_4), the formation of magnesium hydroxide (brucite) and conversion of C-S-H into magnesium silicate hydrate M-S-H were observed [2, 3]. In general, concrete has a low resistance to chemical attack. Chemical agents essentially react with certain compounds of the hardened cement paste and the resistance of concrete to chemical attack therefore depends largely on the type of cement used. The resistance of concrete to chemical attack has improved with increase of its impermeability [4]. The general reactions involved in external sulfate attack have been described previously by Cohen and Bentur [5].

When cement-based materials are exposed to sodium sulfate attack, gypsum and ettringite are produced by chemical reactions of sulfate and $\text{Ca}(\text{OH})_2$, C_3A . Formation of gypsum plays an important role in the damage of materials [5, 6, 7]. There is a close relationship between $\text{Ca}(\text{OH})_2$ content and gypsum formation. Ettringite formation results in cracking and expansion of the material. Expansion is related to the water absorption of crystalline ettringite. So, it is necessary to increase the resistance of concrete against sulfate attack. Some researchers used pozzolanic, dolomite, fly ash, and silica fume materials in the technology of concrete for the increase its resistance to sodium sulfate attack. These materials react with $\text{Ca}(\text{OH})_2$ and the result is additional CSH gel. This transformation leads to the increase of cement materials resistance to sodium sulfate attack [5, 8, 9, and 10].

Over the past several years, there has been a concerned research effort to explore the mechanism effect of chemical plasticizing admixtures on the mechanical properties of R.C. structures. Increasing the concrete alkali content from 0.6% to 1.25% of Na_2O_e of the cement mass by adding alkali addition to the mixture water has harmful effects on most mechanical properties (compressive, splitting, direct tensile, and flexure strengths) of concrete [11, 12]. Admixtures, which contain in their compositions organic materials with limited doses, represent practical interest especially for our local country conditions. This practical interest attractive more investigators because of their availability and outstanding advantages such as: high compressive and tensile strength of concrete, durable concrete in aggressive environmental conditions, suitable

resistance to corrosion, very low cost and not causing epidemic for organism of man [13, 14].

The solubility mechanism of organic elements with water and mechanism of water adsorption on an organic or inorganic surface of a material are shown in **Figures 1 & 2**. Mechanism effect of organic elements on cement particles and on formation space of coagulate structure of cement material are shown in **Figures 3 & 4**. The action of organic elements on cement paste and concrete mixture is determined by the structure of their molecules and correlation between organic and non-organic particles of their molecules. It is known that, organic elements have the ability of adsorption on the surfaces of cement particles and solid phase. They also take part in formation space, coagulate structure and orientation molecules. The initial development of producing concrete with organic admixtures technique took place in the USSR laboratories for materials testing and research, which have highlighted the effect of organic materials on concrete properties since 1981. Many research works have been focused on the application of organic admixtures in the technology of concrete and reinforced concrete structures. Because of their positive influence on the physical and mechanical properties of R.C. elements not only on their early period of hardening, but also for the period of their exploitation in the building site[13–18].

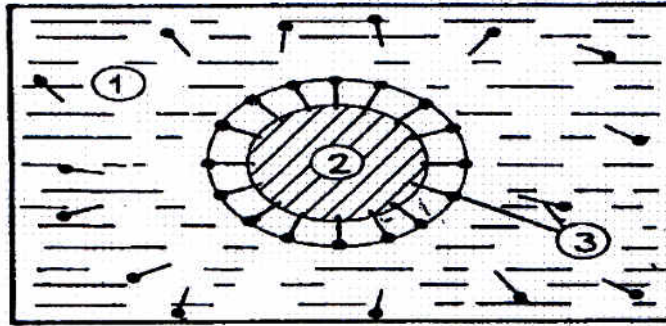
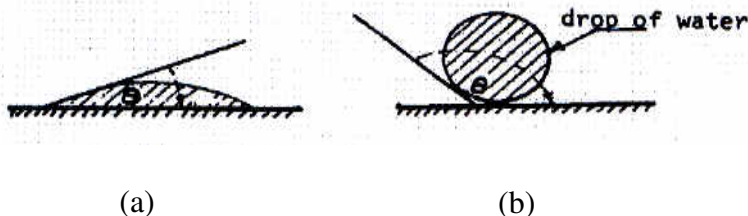


Figure 1 Solubility mechanism of organic elements with water
 1- water solution of dissolving material, 2- organic element (alkali wastes)
 3-elements of dissolving material such as CaO or super plasticizers



(a) (b)
 Figure 2 Mechanism of water adsorption on an organic or inorganic surface of a material
 a) Inorganic surface of a material , b) Organic surface of a material

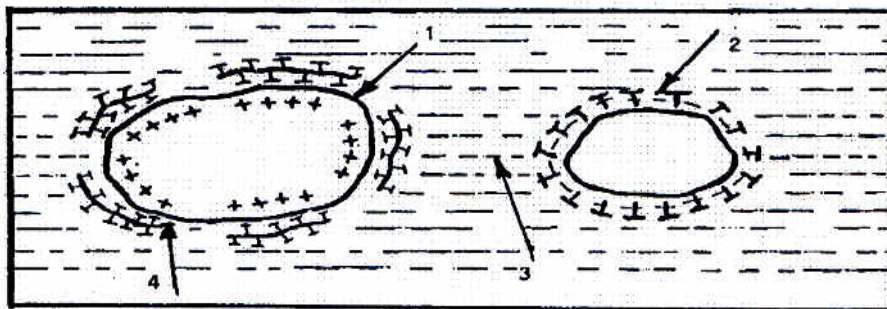


Figure 3 Mechanism effect of organic elements on the cement particles

- 1-Cement particle, 2- Bubble of drawing air, 3-Water,
4- Admixture molecule with negative charge on the surface

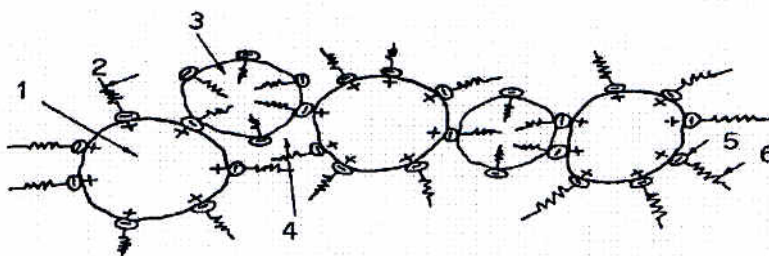


Figure 4 Effect of organic admixture on formation space and coagulate structure of cement material

- 1-Cement particle, 2- Admixture molecule, 3- Bubble of drawing air,
4-Zone of reducing effect of double layer of non polar chain of admixture molecule,
5-Anode group, 6- Non polar radical

Investigations of using chemical admixtures for the improvement of concrete properties in Egypt show that, they are not sufficient and the elements of these admixtures are foreign by the origin and not produced here. Therefore, the system of our constructions completely depends on the foreign firms. So, these elements become deficient and expensive. These are the actual problems for business and system of Egyptian industries. It is known that, the organic materials have not the solubility with water. So, in this research the solubility of these elements with water was achieved by using calcium oxide and superplasticizers such as "BVF" and "PVS". Investigations about using complex organic admixtures, which contain in their composition alkali wastes from oil industries, such as (LSM, CLSM, SM-B, SM-R) for the improvement of cement materials properties were carried out [16–18]. But, the mechanism effect of organic admixtures, containing wastes from petroleum industries, on the resistance of concrete elements against sulfate and chloride attack has not been enough studied.

2. EXPERIMENTAL PROGRAM

The major idea of this program is to investigate experimentally the compressive strength and durability of different groups of normal strength concrete specimens modified with by using new type of organic admixtures and exposed to different concentrations of sulfate and chloride solutions and 25 cycles of durability test.

2.1 Technique Of Preparing And Producing The Suggested Admixtures

The experimental technique for preparing and producing the suggested organic admixtures (BM 2010) were carried out by adding the naphthalene sulfonate to hot pure water in 50 °C and mix them with mechanical mixer and adding the wastes from petroleum industries and silica fume to the mixer until obtaining a homogeneous solution.

The composition and correlation of components of the proposed admixtures by weight from their solid particles are shown in Table 1.

Table 1 Composition and correlation of components of the suggested admixture

Type of admixture	Components of the admixture	Correlation of components % by weight
(Suggested) “BM 2010“	1-Wastes from petroleum refining industries (brown liquid solution),	1.62%
	2- Wastes of coke factory (Naphthalene sulfonate)	32.25%
	3- silica fume is a by-product of melting process used to produce silicon metal and ferrosilicon alloys	1.62%
	4- pure water	64.51%

The experimental approaches in this study consist of testing standard cubic concrete specimens under static load. The main variables studied were:

A. Different types of admixtures:

- **Group 1** Suggested organic admixture (type: BM 2010).
- **Group 2** Control admixture (commercial admixture) (Sedrete Wp)
- **Group 3** Control sample (without admixture)

Suggested admixture (Type: BM 2010) Which were fabricated in the laboratory and contained in its composition wastes from petroleum industries and silica fume and Wastes of coke factory and pure water.

commercial admixture (Sedrete Wp) has a Dark brown colour. It has a great effect on producing concrete and mortar can resist salt and chemicals. It Increases

the durability of concrete and mortar, reduces mixing water, It gives workable and homogenous mixture, decreases the porosity of concrete (From Company Technical data sheet).

Admixtures optimum dose As shown in **Figure 5**

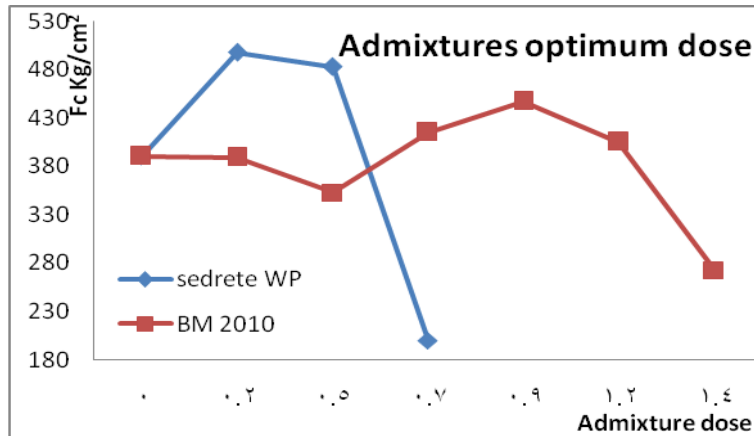


Figure 5 Admixtures optimum dose

B. Three different concentrations of surrounded sulfate & chloride solutions (Na₂SO₄+ NaCl):

Specimens of each group were cast and hardened in fresh water conditions until 28-days. After that, some of them (108 cubes) were immersed and hardened in different concentrations of sodium sulfate and sodium chloride solutions for a period of 100 days as shown in Table 2.

Table 2 Concentrations of salt solutions.

Salts	Concentrations		
NaCl	1%	2%	3%
Na ₂ SO ₄	2%	4%	6%

C. Durability test:

Each group consists of 60 concrete cubes subjected to 25 cycles of durability test after 28 days hardening in drink water. Each cycle take 4 days:

- 1 day** in Salt Solution have concentration NaCl 3% + Na₂SO₄ 6%
- 1 day** in 100 °c
- 1 day** in lab temp
- 1 day** in drink water

All groups of concrete specimens (180 cubes), with and without admixture were identical in size, 15x15x15cms. All groups of cubes were tested under axial static compression load.

2.2 Materials

2.2.1 Cement

Portland cement of specific gravity 3.15 was used (Assiut cement).

2.2.2 Aggregate

The used coarse aggregate was Local natural gravel & Local natural sand was used as fine aggregate in experimental work. The properties of the used aggregate are given in tables (3) & (4).

Table 3 Physical and mechanical and chemical Prop. of used Agg

Property	Gravel	Sand
Volume weight (t/m ³)	1.75	1.73
Specific gravity	2.6	2.63
F. M.	6.29	2.51
% Of clay & Fine	0.4	1.9
Crushing value %	13	---
Cl	0.01	0.04
So ₄	0.013	0.26
PH	7.1	7.4

Table 4 Results of sieve analysis of used aggregate

Sieve size	% Passing by weight.	
	Gravel	Sand
37.5mm	100	---
25mm	100	---
19mm	99.9	---
12.5mm	98.96	---
9.5mm	64.66	---
4.75mm	7.38	100
No. 4	---	99
No. 8	---	96
No. 16	---	77
No. 30	---	59
No. 50	---	15
No. 100	---	3
No. 200	---	1.9

2.2.3 Concrete mix

Concrete mixes were used to produce normal strength concrete having 28-days cubic compressive strength range from 250 to 350 kg/cm². Concrete mixes component shown in Table 5.

Table 5 Details and properties of concrete mixes at optimum dose

Mix No.	Cement (Kg/m ³)	Sand (Kg/m ³)	Coarse Agg. (Kg/m ³)	Additives		Water (Liter/m ³)	Slump cm	Fc kg/cm ²
				Dose Kg/m ³	Type			
1	400	650	1120	0	(Control)	220	7	255
2	400	653	1123	0.8	(Sedrete Wp)	217	7.5	258
3	400	665	1130	3.6	(BM 2010)	207	7	332

2.3 External Sulfate Solutions

Three different concentrations of sodium sulfate “Na₂SO₄“ and sodium chloride “NaCl” solutions were used as external sulfate & chloride attack as follows:

- 1%NaCl + 2%Na₂SO₄,
- 2%NaCl + 4%Na₂SO₄,
- 3%NaCl + 6%Na₂SO₄

2.4 Test Procedure

Some of the concrete cubes (36 cubes) were hardened in fresh water and others (108 cubes) in different concentrations of sulfate & chloride solutions for a period of 100 days. The retained cubes (36 cubes) were subjected to durability test of 25 cycles after 28 days hardening in fresh water. Each cycle consists of 4 days:

- **1 day** hardening in Salt Solution 3% NaCl + 6% Na₂SO₄
- **1 day** hardening in an oven of elevated temperature up to 100^oc
- **1 day** hardening in the laboratory conditions.
- **1 day** hardening in drink water

The testing machine (Control 2000 KN) was used. Each specimen was loaded axially and gradually keeping the rate of loading constant. The concrete specimens were tested under static axial compression loading after 28 & 128 days hardening in fresh water or in salt solutions. All tests were done in Arab Contractor Company Assiut branch laboratory.

3. TEST RESULTS AND DISCUSSIONS

Test results of the all-cubic concrete specimens, without admixtures and modified with the suggested admixture, which hardened in different aggressive environmental conditions are presented in Tables 6, 7 & 8.

It is useful that, formation of structure, physical and mechanical properties of cement concrete depends mainly on the workability and sedimentation of the mixture.

3.1 Compressive Strength Of Concrete Specimens Exposed To Salt Solutions

Cubic compressive strength of all types of concrete containing optimum doses of the suggested admixture and hardened in different concentrations of salt solutions are shown in Tables 6 & Figure 6,7.

Table 6: Effect of optimum dose of each admixture on the compressive strength of concrete specimens hardened in salt solutions

Type of Admixture,	% O.D.	Compressive Strength, kg/cm ²					
		1%NaCl+2%Na ₂ So ₄		2%NaCl+4%Na ₂ So ₄		3%NaCl+6%Na ₂ So ₄	
		28 days	128 days	28 days	128 days	28 days	128 days
Control	0	278	339	282	314	250	294
Sedret wp, (Control)	0.2	223	307	247	244	266	232
BM 2010, (Suggested)	0.9	293	345	297	361	303	339

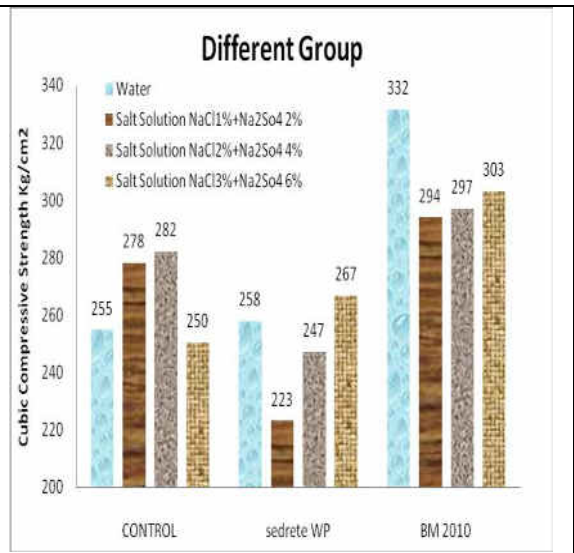
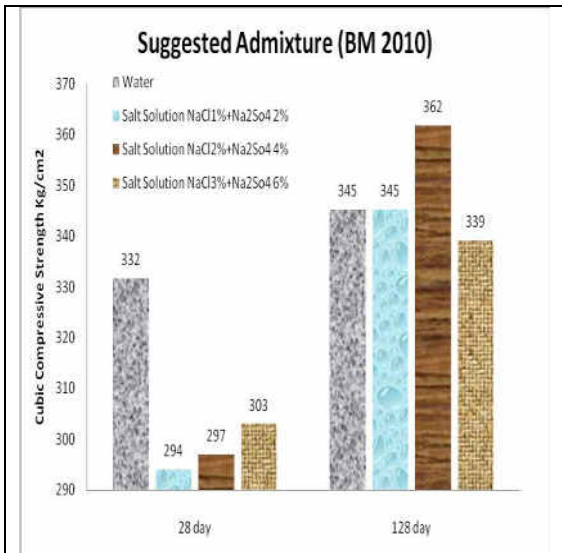


Figure 6 Cubic compressive strength of concrete specimens versus age of concrete as for different salt solutions.

Figure 7 Cubic compressive strength of concrete specimens different groups (age = 28 days).

Obviously, the organic admixture (type BM 2010), have a good effect on increasing compressive strength of concrete hardening in these aggressive conditions compared to the control specimens. Where,

- It increases the compressive strength by about 5% , 2% at 28 , 128 days for specimens immersed in (1%NaCl + 2%Na₂So₄),
- It increases the compressive strength by about 5% , 15% at 28 , 128 days for specimens immersed in (2%NaCl + 4%Na₂So₄),
- It increases the compressive strength by about 21%, 15% at 28, 128 days for specimens immersed in (3%NaCl+6%Na₂So₄) compared to the control specimens without admixtures.

It is necessary to notice that, these admixture also have a good effect on increasing compressive strength of concrete specimens compared to that modified with the known admixtures “Wp” and hardened in the same conditions shown in Tables 6.

- They increase it by about 31% for Fc₂₈ & increase it by about 12% for Fc₁₂₈ for specimens immersed in (1%NaCl + 2%Na₂So₄),
- They increase it by about 20% for Fc₂₈ & increase it by about 48% for Fc₁₂₈ for specimens immersed in (2%NaCl + 4%Na₂So₄),
- They increase it by about 14% for Fc₂₈ & increase it by about 46% for Fc₁₂₈ for specimens immersed in(3%NaCl+6%Na₂So₄) compared to the control specimens with known admixture “ Wp”.

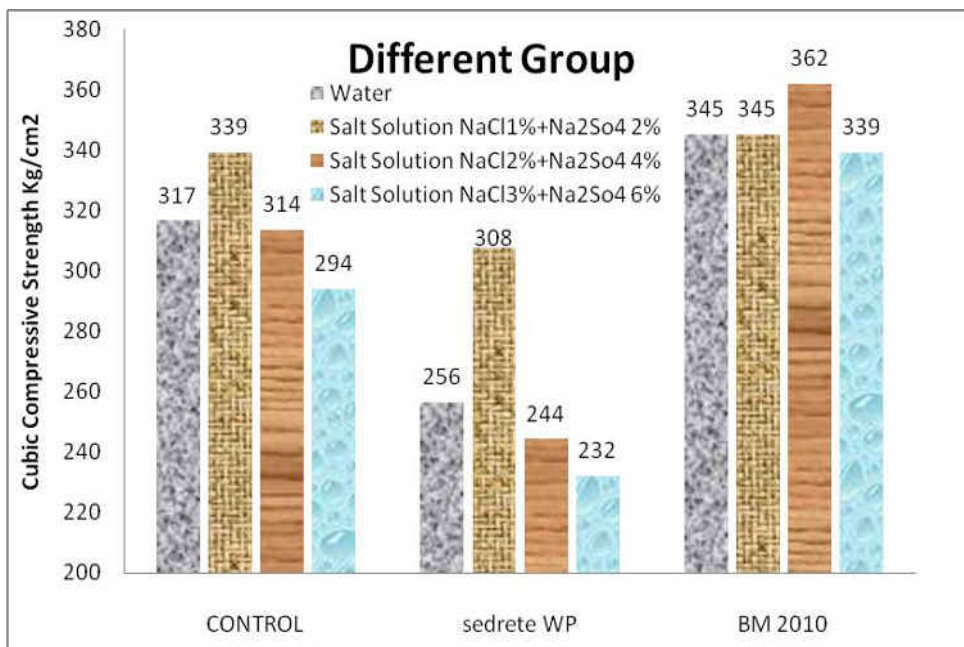


Figure 8 Cubic compressive strength of concrete specimens of different groups (Age = 128 days)

Obviously, the suggested admixture (type BM2010) increased compressive strength of concrete specimens hardened in these aggressive conditions after 128 days by about 2, 15, &15% respectively compared to the control specimens hardened in the same conditions. Also, this admixture has a good effect than the known admixture (sedret Wp).

Compressive strength values of concrete specimens containing the suggested admixture and hardened in aggressive environmental conditions were plotted versus age of concrete (as shown in Figure 7,8).

As the concentration of salt solutions increases from 3% to 6%, concrete compressive strength of control specimens after 28 days with control admixture (Sedret Wp), decreased by about 19%,12% and increased by about 6% at salt concentration 9%. But, concrete compressive strength of control specimens after 128 days with control admixture (Sedret Wp), decreased by about 9%, 22% and 21% at salt concentration 9%.

As the concentration of salt solutions increases from 3% to 6%, concrete compressive strength of control specimens after 28 days with control without admixture, increased by about 9%,10% and decreased by about 2% at salt concentration 9%. But, concrete compressive strength of control specimens after 128 days without admixture, increased by about 7% at salt concentration 3% and decreased by about 1% and 7% at salt concentration 6% and 9% respectively compared to the same specimens hardened in fresh water.

3.2 Compressive Strength of Concrete Specimens Hardened in drinking water

Cubic compressive strength of all types of concrete containing of the suggested admixture and hardened in drinking water is shown in Tables 7 & Figure 9, 10.

Table 7 Effect of each admixture on the compressive strength of concrete specimens hardened in drinking water

Type of Admixture	Compressive Strength after 28 days (kg/cm ²)	Compressive Strength after 128 days (kg/cm ²)
Control	255	316
Sedret wp,(Control)	258	256
BM 2010,(Suggested)	332	345

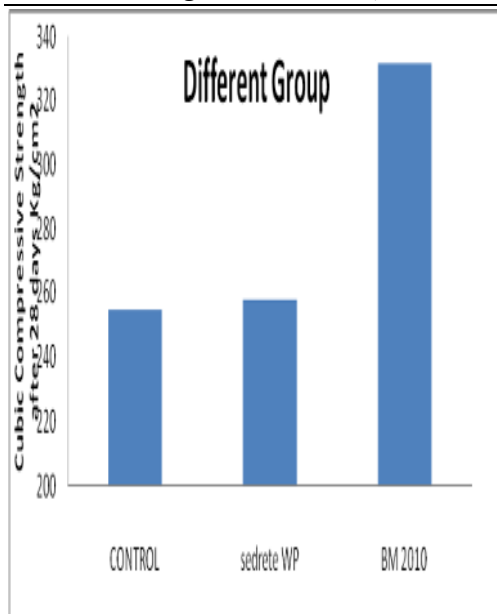


Figure 9 Cubic compressive strength of concrete specimens after 28 days age hardening in fresh water.

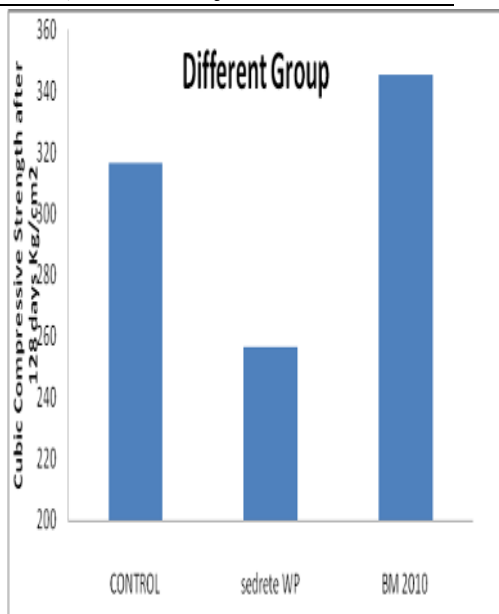


Figure 10 Cubic compressive strength of concrete specimens after 128 days age hardening in fresh water.

Concrete compressive strength after 28 days of suggested admixture (BM2010) increased by about 30% compared with control specimens. Concrete compressive strength after 128 days of suggested admixture (BM2010) increased by about 9% compared with control specimens.

Concrete compressive strength after 28 days of control admixture (Sedret Wp), increased by about 2% compared with control specimens. Concrete compressive strength after 128 days of control admixture (Sedret Wp), decreased by about 19% compared with control specimens.

3.3 Compressive Strength of Concrete Specimens Exposed To Durability Tests

The most important factors affecting durability of concrete elements hardened in aggressive environmental conditions represent compressive strength. So, the effect of each admixture on the compressive strength of concrete specimens before and after durability cycle of durability tests was investigated with the comparison of the control specimens. The results were determined and shown in Table 8 and Figures 11 and 12.

Table 8 Effect of each admixture on the compressive strength of concrete specimens exposed to durability tests

Type of Admixture,	Compressive Strength Before durability (kg/cm ²)	Compressive Strength After durability (kg/cm ²)
Control	255	226
Sedret wp,(Control)	258	186
BM 2010,(Suggested)	332	309

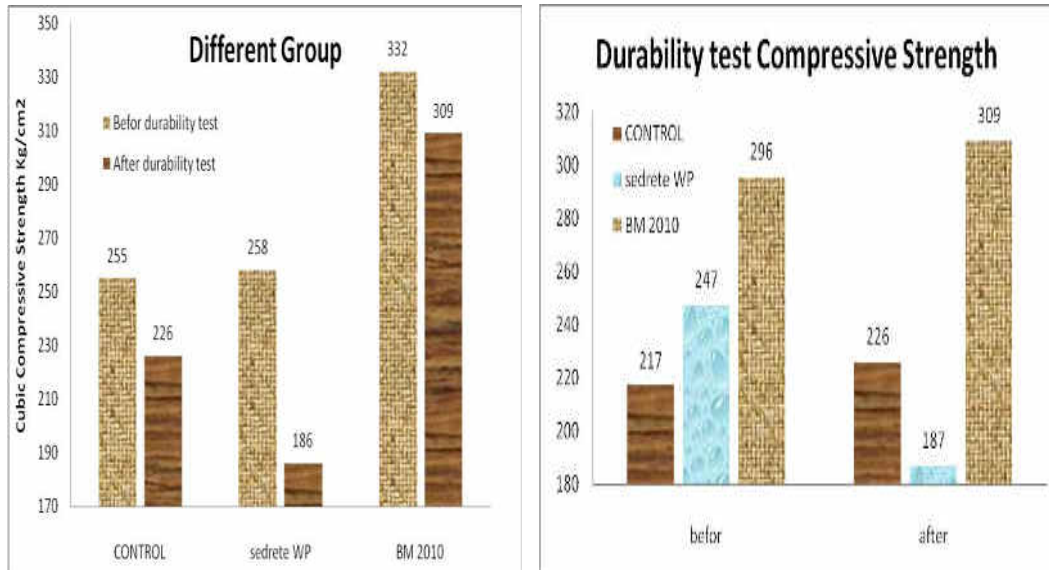


Figure 11 Cubic compressive strength of concrete specimens with control admixtures

Compressive strength of concrete specimens with and without admixtures, which exposed to 25 cycles of durability test was determined and the results are shown in Figure 11. Obviously, compressive strength of concrete specimens containing suggested admixture (BM 2010) decreased by respectively about 7 %, after these cycles of durability test if compared with the same type of specimens before durability test. But, Control specimens without admixtures decreased by respectively about 11 % after these cycles of durability test if compared with the same type of specimens before durability test.

Specimens with the control admixture (Sedrete Wp) showed a large decrease of their compressive strength by respectively about 28% compared with the same specimens before these cycles of durability test.

It is necessary to notice that, specimens modified with the suggested admixture (BM 2010) increased their compressive strength by about 30% compared with the control specimens without admixtures before durability test and increased their compressive strength by about 37% compared with the control specimens without admixtures after durability test.

Specimens modified with the control admixture (Sedrete Wp) increased their compressive strength by about 1.2% compared with the control specimens without admixtures before durability test and decreased their compressive strength by about 17% compared with the control specimens without admixtures after durability test.

It is also necessary to notice that specimens modified with the suggested admixture (BM 2010) increased their compressive strength by about 28% compared with the specimens have control admixture (Sedrete Wp) before durability test and increased their compressive strength by about 66% compared after durability test,

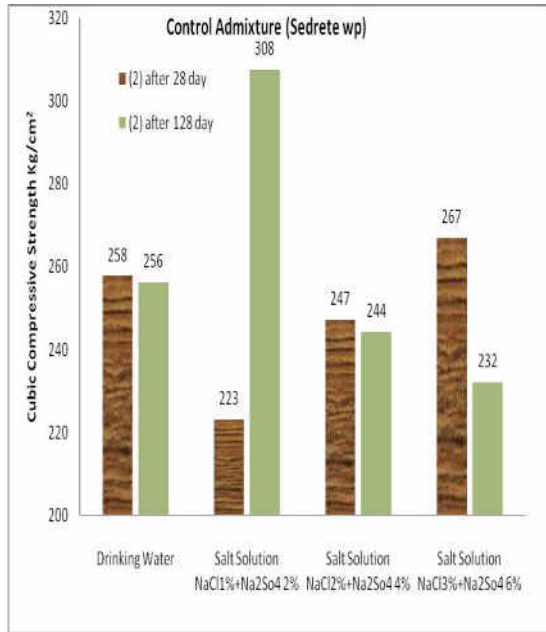


Figure 12 Cubic compressive strength of concrete specimens with control admixture

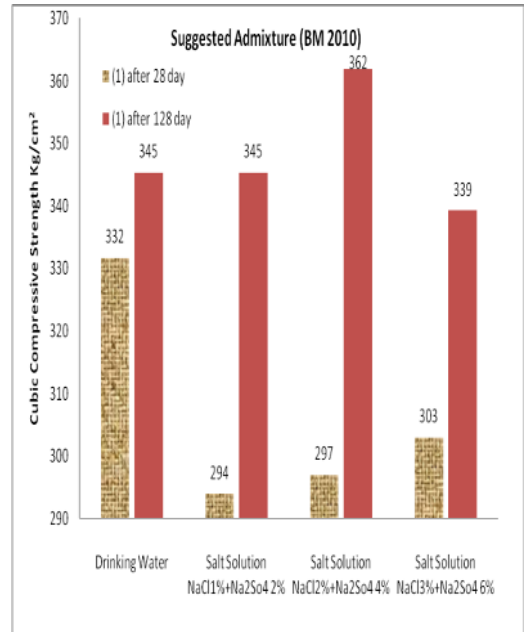


Figure 13 Cubic compressive strength of concrete specimens with suggested admixture

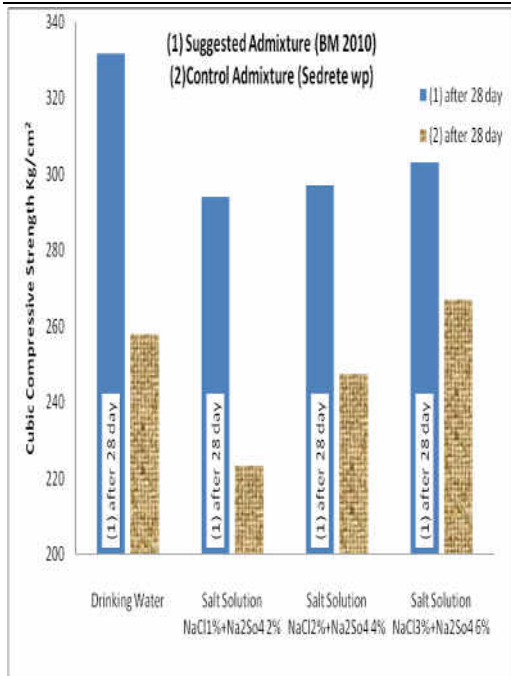


Figure 14 Cubic compressive strength after 28 days of concrete specimens with admixtures

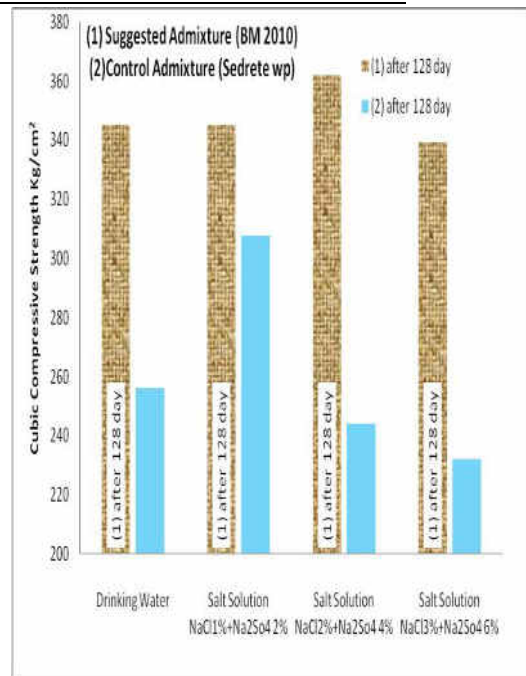


Figure 15 Cubic compressive strength after 128 days of concrete specimens with admixtures

4. CONCLUSIONS

Based on the results of the experiments carried out on the concrete mixes and specimens containing in their compositions wastes from petroleum industries and silica fume and naphthalene sulfonate and pure water and hardened in different concentrations of salt solutions for a period of 128 days and exposed to 25 cycles of durability tests, the following conclusions can be drawn out:

- 1- Optimum composition of all components of the suggested admixtures (BM2010) containing wastes from petroleum industries and silica fume and naphthalene sulfonate and pure water and production of them in a liquidity solution were successfully and experimentally achieved.
- 2- Optimum dose of the Control Admixture at which occur maximum values of compressive strength equals 0.2% from weight of cement. But for organic admixture (BM2010) equals 0.9%.
- 3- Compressive strength of concrete specimens modified with the organic admixtures (BM2010), at age of 128 days hardening in fresh water, increases by about 9% compared to the control specimens without admixtures. But, it decreases by about 19% for concrete specimens modified with the control admixture (Sedrete Wp) compared to the control specimens without admixtures.
- 4- The suggested admixture (type BM2010) increases cubic compressive strength of concrete specimens hardened in aggressive salt solutions (3%NaCl+6%Na₂So₄) after 128 days by about 15% if compared to the control specimens without

admixture hardened in the same conditions. Also, these admixtures have a good effect than the control admixture (type Sedrete Wp).

- 5- The increase of the concentration of the surrounded salt solutions from 3% to 9% has no influence on compressive strength of organic concrete specimens, after 128 days hardening in these conditions, modified with the suggested organic admixture. But it has a clear influence on the control specimens without admixture and with control admixture (Sedrete Wp) .
- 6- After 25 cycles of durability tests, control specimens with the control admixture (sedrete wp) and without admixture showed a large decrease of their compressive strength. But, specimens modified with the suggested admixture (BM 2010) showed respectively a small increase of their compressive strength by about 7% if compared with the same specimens before these cycles of durability test. The suggested admixtures showed a better influence compared to the control admixture sedrete wp.

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تأثير إضافة محلية إقتصادية مقترحة علي مقاومة الضغط وقوة التحمل مع الزمن للخرسانة

أصبحت الحاجة ماسة وضرورية إلى استخدام إضافات فعالة واقتصادية لحماية العناصر الخرسانية المختلفة وخصوصا المدفونة تحت سطح الأرض من الهجوم الكبريتي الحاد أو أية ظروف بيئية قاسية مثل التعرض لدرجات حرارة متفاوتة. إن استخدام مخلفات من المنتجات الثانوية لبعض المصانع في تكنولوجيا إنتاج وتصنيع إضافات كيميائية ملدنة للخلطة الخرسانية ومحسنة لخواص الخرسانة يمثل دراسة علمية وعملية شيقة خاصة من الناحية الاقتصادية والبيئية.

ولهذا فإن الغرض الرئيسي من هذا البحث هو عمل دراسة معمليّة لإمكانية إنتاج وتصنيع إضافات اقتصادية وفعالة وذلك من مخلفات مصانع تكرير البترول ومصانع فحم الكوك ومصانع السبائك الحديدية. ثم دراسة ميكانيكية تأثير الجرعة المثلي لهذه الإضافات علي مقاومة الضغط وقوة التحمل مع الزمن للمكعبات الخرسانية المصنعة من الخرسانة عادية المقاومة والمعرضة إلى هجوم خارجي حاد من محاليل كبريتات الصوديوم وكوريد الصوديوم وكذلك المعرضة إلي دورات عديدة (25 دورة) كاختبارات لقوة التحمل مع الزمن .

إن المتغيرات الرئيسية التي تمت دراستها في هذا البحث علي عدد 180 عينة من المكعبات الخرسانية القياسية هي:

1. ثلاثة حالات مختلفة من استخدام الإضافات :
 - بدون إضافات كعينة للتحكم والمقارنة.
 - باستخدام إضافة ملدنة معروفة بالسوق المصري (نوع Sedrete Wp) كعينة للتحكم والمقارنة.
 - باستخدام الإضافة المقترحة من مخلفات المصانع (نوع BM2010) .
2. ثلاثة تركيزات مختلفة من محاليل كبريتات الصوديوم وكوريد الصوديوم المحيطة بالعينات:
 - مجموعة (أ) عينات تم غمرها بعد 28 يوم من تاريخ الصب في محلول ملحي بتركيز 2% كبريتات الصوديوم + 1% كلوريد الصوديوم.
 - مجموعة (ب) عينات تم غمرها بعد 28 يوم من تاريخ الصب في محلول ملحي بتركيز 4 % كبريتات الصوديوم + 2% كلوريد الصوديوم.
 - مجموعة (ج) عينات تم غمرها بعد 28 يوم من تاريخ الصب في محلول ملحي بتركيز 6 % كبريتات الصوديوم + 3% كلوريد الصوديوم وذلك لمدة 100 يوم لكل مجموعة علي حدة.
3. دورات اختبار قوة التحمل مع الزمن (25 دورة) وذلك بعد 28 يوم من تاريخ الصب والتصلب في مياه الشرب.

لقد أوضحت نتائج الإختبارات العملية أنه قد تم بنجاح تحضير إضافة جديدة من مخلفات مصانع تكرير البترول ومصانع فحم الكوك ومصانع السبائك الحديدية وأن ميكانيكية تأثير هذه الإضافة بجرعتها المثلي علي عينات الخرسانة المتصلبة في ظروف بيئية قاسية ومختلفة لمدة 128 يوم بينت أن مقاومة الضغط وقوة التحمل مع الزمن للعينات الخرسانية المختبرة تتأثر بوضوح بالإضافة المقترحة و تركيز محاليل كبريتات الصوديوم وكلوريد الصوديوم المحيطة بها و وكذلك دورات قوة التحمل مع الزمن كما يلي :

- مقاومة الضغط لعينات الخرسانة المحتوية على الإضافة المقترحة (نوع BM2010) بعد عمر 128 يوم من التصلب بمياه الشرب زادت بنسبة 9% مقارنة بالعينات التي تم إعدادها بدون إضافات.
- مقاومة الضغط لعينات الخرسانة المحتوية على الإضافة المقترحة (نوع BM2010) التي تم غمرها بعد 28 يوم من تاريخ الصب في محلول ملحي مكون من (6 % كبريتات صوديوم + 3% كلوريد صوديوم) وذلك لمدة 100 يوم زادت بنسبة 15% مقارنة بالعينات التي تم إعدادها بدون إضافات وتم تعريضها لنفس الظروف وأيضاً حققت تأثير أفضل من العينات التي تم إعدادها باستخدام الإضافة من السوق المصري (نوع Sedrete Wp).
- زيادة تركيز المحلول الملحي من 3% الى 9% لم يكن له تأثير واضح على مقاومة الضغط للعينات التي تم إعدادها باستخدام الإضافة المقترحة (نوع BM2010) ولكن كان لها تأثير واضح على العينات التي تم إعدادها باستخدام الإضافة من السوق المصري (نوع Sedrete Wp) وأيضاً للعينات التي تم إعدادها بدون استخدام إضافات.
- بعد التعرض لعدد 25 دورة من إختبار مقاومة التحمل مع الزمن أظهرت العينات المصنعة باستخدام الإضافة من السوق المصري (نوع Sedrete Wp) وأيضاً العينات التي تم إعدادها بدون استخدام إضافات نقص كبير في مقاومة الضغط أما العينات التي تم إعدادها باستخدام الإضافة المقترحة (نوع BM2010) أظهرت زيادة في مقاومة الضغط بنسبة 7% مقارنة بمثيلاتها قبل التعرض لدورات إختبار مقاومة التحمل مع الزمن.