Journal of Engineering Sciences
Assiut University
Faculty of Engineering
Vol. 46
No. 3
May 2018
PP. 282 – 298

CHARACTERISTICS AND DURABILITY OF CONCRETE CONTAINING SUGAR INDUSTRY WASTES (VINASSE) EXPOSED TO AGGRESSIVE ENVIRONMENTAL CONDITIONS

A. Megahed Ahmed, Mohamed M. A., Omar A. F. and Shawky M. H.

Civil Eng. Department, Faculty of Engineering, Assiut, University. Assiut, Egypt.

Received 6 March 2018; Accepted 25 March 2018

ABSTRACT

The formation of Ettringite after the hardening of cement minerals is accompanied by extra gypsum, which may lower the intrinsic strength of calcium silicate hydrate due to the presence of sulfate ions in its structure. The important factors influencing the resistance of concrete against internal sulfate attack are the chemical reactions between sulfate ions contained in the mixing water or extra gypsum and the minerals of cement during its hydration and the concentration of the reactant concerned in the pore solution**.** The main purpose of this research is to study experimentally the possibility of producing effective and economic admixtures from sugar industry wastes (Vinasse) and mix it with sodium naphthalene formaldehyde to produce (VSW 2016) additive. Then study of its effect on the compressive, tensile strengths and durability parameters represented in permeability, chemical attack and different cycles of durability are illustrated. Test investigations, show that, a limited dose of the (VSW 2016) in the mixing water of concrete mixture regulates its micro structures formation and improves the durability parameters in aggressive environment compared to the control specimens.

1. Introduction

Most of R.C constructions, especially underground, are always subjected to an aggressive environmental condition during their exploitation. These conditions are represented by chemical attack from surrounding soil and underground water. According to that, the actual compressive strength of R.C elements decreases accompanied with large deformations of concrete. Consequently, a higher reduction of the construction durability occurs.

Micro porous structure formation of the hardened cement stone in different stages of its hydration represent the major factor, which reduces or may prevents the deterioration of the hardened concrete in sulfate environment. Mostafa A. El-Razek et al [1] studied the mechanism effect and performance of a local and economical additive on the compressive strength and durability of concrete. They concluded that, compressive strength at age of 128 days (C128) of concrete specimens modified with wastes of petroleum refinery industries, coke industries and silica fume (BM 2010) hardening in fresh water, increased by about 9% compared to the control specimens without admixtures. C_{128} of concrete specimens modified with (BM 2010) hardening in (3 % NaCI + 6 % Na_2So_4) increased by about 15 % if compared to the control specimens without admixtures.

Hegerovitch [2, 3] studied effect of wastes of cellulose paper industries on the sedimentation velocity of cement solution , the suggested admixtures has the ability of decreasing the sedimentation of cement solution by about two times compared with the solution without admixture . Also, the hydrophobizing elements has not effect on the solubility with water, but by using dissolving materials such as (CaO) plasticizers which dissolve with water and consist a homogenous solution.

Rashwan M.M et al [4, 5] studied the compressive strength and durability of cement concrete containing alkali wastes of oil and cellulose paper industries and exposed to aggressive environmental conditions, they concluded that, optimum dose of each admixture, at which occurs maximum values of compressive strength and minimum values of water absorption was determined and equals 0.25% from weight of cement. After 50 cycles of durability tests, control specimens without admixture and with the control plasticizing admixture (DM2) showed a large decrease of the compressive strength.

Yu-M.Doroshanka et al [6] studied the effect of complex chemical additives on the durability of hydraulic-engineering concrete; they concluded the following results, complex chemical additives of calcium chloride and ammonium nitrate, effectively influencing the rate of hardening density and impermeability. Furthermore, NH4No3 does not corrode reinforcement. The strength of concrete with the additive exceeds the standard by 5-8 %. Shrinkage of the concrete during natural hardening increased by only 6 % .

Ibrahim A.M et al [7] studied the shrinkage of concrete using local pozzolanic material. They concluded that, the dry shrinkage was decreased by using pozzolanic, however, the maximum decreasing was attained from using 10% approximately in all sites.

Abdias M. Gomes et al [8] studied concrete durability depends largely on the ease (or difficulty) with which fluids (water, carbon dioxide, oxygen) in the form of liquid or gas can migrate through the hardened concrete mass. Concrete is a porous material. Therefore, moisture movement can occur by flow, diffusion, or absorption. Generally the overall potential for moisture and ion ingress in concrete by these three modes is referred to as it permeability. The evaluation of the permeability of a concrete from a ″ in situ ″ test using the Germanns water permeability test (GWT) equipment showed to be trustable and possible of being used in laboratory .

Magdy A. Abd El-Aziz [9, 10] studied durability of pozzolanic filed cements in Caron’s lake water and he concluded that, limestone increases the water consistency and apparent porosity. The initial and final setting times decrease with limestone content. Aggressive water, total sulfate and total chloride contents increase with the amount of limestone in the cement and decrease with fly ash.

Yousry B.S et al [11] studied durability of high strength and high performance concrete. They concluded that, low concentration of sodium sulfate such as 2700 mg/l has not any significant effect on the high strength and high performance concrete properties at 300 days exposure, 10 % replacement of cement by silica fume improved sulfate attack resistance of high strength and high performance concrete even at high concentrations. Truyen T.T. et al [12] studied gas and water permeability of concrete under loading and temperature effects. The obtained experimental relationships between the permeability coefficient (K) and the applied stress level as well as the damage level at different temperatures and different water pressures will be the basis for numerical simulations of water and gas permeability of concrete in construction structures. They concluded that, the permeability becomes higher and depends on stress level of concrete during loading process. Finally, macro cracks are generated and increase the porosity of concrete matrix.

Moaze M. [13] mentioned that, chemical attack by aggressive water is one of the factors responsible for damage of concrete. The presence of sulfate and chloride ions in waters accounts for its aggressive behavior to concrete because certain constituents of the cement paste can inter into deleterious chemical reactions with sulfate. Sea water, ground water from soils containing soluble alkali sulfates and also many industrial waters contain enough sulfate are to be potentially damaging Portland cement concrete.

F. Dufour et al [14] mentioned that, the permeability evolution is initially limited since only micro-cracking occurs without clear connection. In a second stage, a large increase is observed during the formation of the micro crack which opens a preferential path for the gas flow and connects the two specimen faces. In the final stage, the permeability increases up to three orders of magnitude is only due to the opening of micro-crack.

Delta and S ehdev [15] mentioned that, procedure of exposed concrete specimens to rapidly repeated cycles of freezing and thawing does not provide any quantitative measure of the service life that can be expected of a particular mix design, but can be used to compare performance of different designs. Durability factor and loss in mass were determined. The normal strength concrete is more economical than the high strength concrete, but develops its design properties more slowly.

Iggy Ip et al [16] said that sulfuric acid reacts with the concrete, decreasing the structural strength, durability and increasing the permeability. Sulfur attacks are a major issue in parts of Ontario which contain a high content of sulfur in water. To prevent premature failure of concrete structures in septic systems, it is important for regulators and concrete tank manufacturers to take responsibility and be aware of locations with sulfur-rich waters or contain sulfate-rich soils. Alternatives to concrete can be used as well, such as polyethylene tanks that are chemically resistant to sulfur attacks.

Ezz Elregal et al [17] concluded that, compressive strength, flexural strength and splitting strength were enhanced due to the effect of admixtures in increasing the interaction of cement which densities concrete mixtures. This increase in strength and density led to enhance permeability.

2. Experimental work

1- The comprehensive experimental technique was performed on standard concrete samples (cubes – prisms – cylinders) to which either (VSW 2016) or (Addcrete BVS) additions are added for comparison purpose. Four concrete mixes were made, where three mixes have an addition doses (1.5, 2.0, 2.5%) from cement weight and the fourth mix has no additions (control mix) and each mix contains 18 cubes, 12 prisms and 12 cylinders, considering keeping of workability for all mixes so as to study the influence on compressive, splitting and flexural strengths for concrete samples at 3 and 6 months (starting at 28days).

2- The durability features were measured in the hardened stage for all concrete mixes represented in:

- The permeability test (at age of 28 days) to determine the permeability coefficient or Darcy coefficient. Four Specimens were tested with cement content 350 kg/m^3 at doses (1.5, 2.5, and 2.5 %) and the fourth mix has no addition (control mix) through adding (VSW 2016) and (Adderete BVS) additions. Then, put the samples in the permeability cells in the testing system were water flow is controlled to pass through one of the two horizontal and parallel surfaces to the other surface. Then, the influence of 30 bar pressure continues at least 24 hours, followed by water collection where the following equation is used to calculate the coefficient of permeability (K): K = (CC*h) / (A*t*p)

Where: (CC) is quantity of water in cm^3, (h) is the sample height in cm, (A) sample surface area in cm^2, (t) test time in (seconds), (p) hydrostatic pressure (cm/sec).

- Resistance to deterioration caused by sulfur salts at 10 % concentration which starts at 28 days and lasts for (6) months and includes:
  - The loss in compressive strength resulting of adding (VSW 2016) addition or (Addcrete BVS) addition
  - The surface peeling and changing in weight.

The loss in strength, following up the change in weight and peeling of the surface were evaluated through testing six concrete cubes from each mix. After curing in water for 28 days, half the samples were immersed in 10% sulfur sodium solution for six months where remaining samples were kept in the water curing basin. The sulfur solution was changed every month to keep PH less than 9.75 according to specification requirements. The weight is recorded periodically and monitor the cubes surface to notice any peeling or cracks which may occurs on cubes surface.

- The expansion: This property was studied through testing the samples expansibility which is exposed to sulfur solution where testing was performed on (3) concrete prisms from each mix. Sample lengths were measured using comparison equipment where the samples were immersed in 5% sulfur sodium keeping, (HP) between (6-8) and performance efficiency standard doesn't exceed (0.1%) after exposed to sulfur solution for 180 days for mixes in ordinary media of sulfur and expansion doesn't exceed (0.5%) in very aggressive media. Double required sulfur concentration i.e. (10%) was used to accelerate the occurrence of any volume changes.
- Cycles of durability: When concrete samples were exposed to cycles of durability with time (at 28 days) for four cycles this was achieved after extracting the samples from curing water and left to dry in the air for one day, then kept in oven exposited to (+ 150 o) for one day, then left in the air for one day and finally immersed in water for one day. This process are repeated (4) times once every week and the compressive test is performed at age of (56) days.
- Studying the influence of temperature: on the samples when exposed to temperatures (60, 80,100 oc).

3- Chemical characteristics: After crushing specimens of cubes which expose to (10 %NO2SO4) at 6 months age, the different chemical tests will made as**:**

4- Diffraction, X-ray test [XRD]: On some mixtures to study the mineral composition and make sure that Ethringite which already formed.

5- Determine chloride and sulfate content.

3. Test results and discussion

3. 1. Results of compressive strength test at (28 days), 3 and 6 months

Table 1 shows results of compressive strength test at (28, 90,180) days using (VSW 2016) addition. Table 2 shows results of compressive strength test at (28, 90,180) days using (Addcrete BVS) addition in mix with cement content 350 kg/m^3. Figures (1, 2) show the relationship between (VSW 2016) addition and the change in compressive strength at 3&6 months. Figures (3, 4) show the comparison between (Addcrete BVS) addition, (VSW 2016) and the change in compressive strength at 3&6 months in mixtures with 350 kg/m^3 cement content. From results, it's clear that, the increase in mixes with (VSW 2016) addition compared with control mixes for cement content of 300,350,400 kg/m^3 respectively reaching 4 % and at age 90 days and reacting average 6 % at age 180 days. But by using (Addcrete BVS) addition reacting 6% at both ages of 3 and 6 months.

The little difference between results of compressive strength test at (28 days), 3 and 6 months for cement content of 300,350,400 kg/m^3 respectively resulting of increase drying shrinkage with time (3and months) and cement content, this lead to occur of internal cracks causes decreasing in increase average of compressive strength.

Table 1.
Results of compressive strength test at (28, 90,180) days using (VSW 2016)

Type & percentage of admixture	Cement content (C.C)kg/m^3	Compressive strength F_c kg/cm^2				
		F_{c28}	F_{c90}	$F_{c90(VSW)}/F_{c28(c)}$ %	F_{c180}	$F_{c180(VSW)}/F_{c28(c)}$ %
Control mix	300	257.4	276.0	107.2	297.3	113. 69
1.5% (VSW 2016)		312.0	336.4	107.821	337.6	107.90
2.0% (VSW 2016)		321.3	329.9	102.583	343.8	107.115
2.5% (VSW 2016)		340.7	341.5	101	351.7	103.104
Control mix	350	317.5	342.7	107.937	367.4	115.717
1.5% (VSW 2016)		327.7	354.3	108.117	375.2	114.495
2.0% (VSW 2016)		343.7	362.3	105.412	381.6	111.027
2.5% (VSW 2016)		390.8	389.8	101	393.2	100.614
Control mix	400	353.4	381.0	107.223	404.7	114.516
1.5% (VSW 2016)		393.0	423.6	107.678	426.4	108.499
2.0% (VSW 2016)		414.0	424.4	103.787	430.1	103.889
2.5% (VSW 2016)		416.5	425.7	102.209	432.7	103.89

Table 2.
Results of compressive strength test at (28, 90,180) days using (Addcrete BVS) at (C.C) 350kg/m^3

Type & percentage of admixture	Compressive strength F_c kg/cm^2					
	F_{c28}	F_{c90}	$F_{c90(BVS)}/F_{c28(c)}$ %	F_{c180}	$F_{c180(BVS)}/F_{c28(c)}$ %	$F_{c180(VSW)}/F_{c180(BVS)}$
Control mix	317.5	342.7	107.937	367.4	115.717	100
(Addcrete BVS) 1.5%	322.1	349.2	108.414	370.1	114.902	101.4
(Addcrete BVS)2.0%	335.2	357.4	106.623	374.3	111.665	102
(Addcrete BVS)2.5%	355.5	371.7	104.557	392.8	110.492	100.1

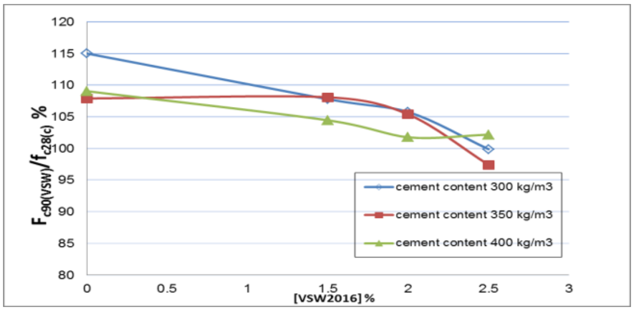

Fig. 1. Relationship between (VSW 2016) and change in compressive strength at 3 months.

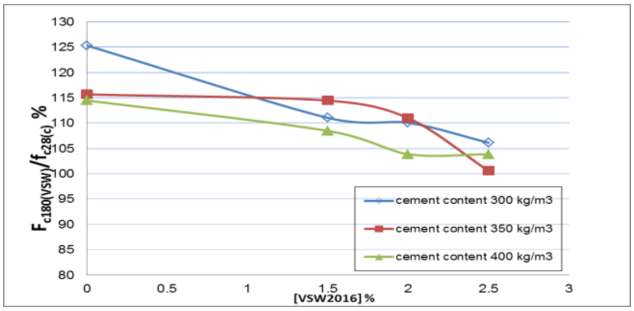

Fig. 2. Relationship between (VSW 2016) and change in compressive strength at 6 months.

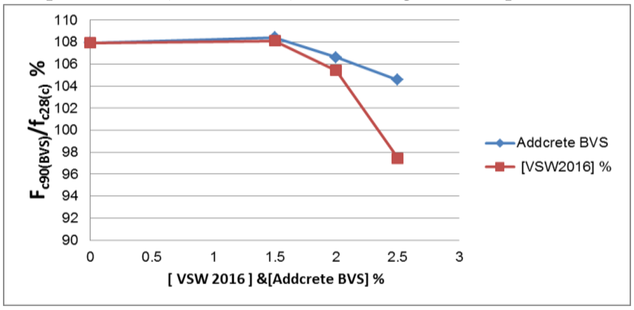

Fig. 3. Comparison between (VSW 2016), (Addcrete BVS) and change in compressive strength at 3 months.

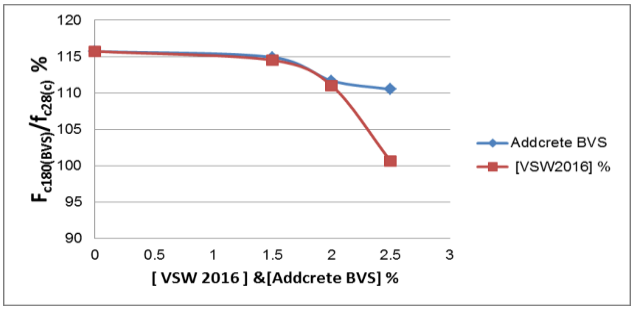

Fig. 4. Comparison between (VSW 2016), (Addcrete BVS) and change in compressive strength at 6 months.

From Figures 3, 4 it is clear that, the results of (Addcrete BVS) and change in compressive strength at 3 and 6 months are better than the results of (VSW 2016) and change in compressive strength at 3 and 6 months

3. 2. Results of splitting strength tests at 3 and 6 months

Table 3 shows results of splitting strength test at (28, 90,180) days using (VSW 2016) addition. Table 4 shows results of splitting strength test at (28, 90,180) days using

(Addcrete BVS) addition. Figures 5, 6 show the relationship between (VSW 2016), (Addcrete BVS) additions and the change in splitting strength at 3and 6 months. Figures 7, 8 show the comparison between (VSW 2016), (Addcrete BVS) and change in compressive strength at 3and 6 months. From results, it is clear that:

1- The optimal dose of (VSW 2016) addition for splitting strength equals 2% from cement weight. Also for (Addcrete BVS), it took the same direction as the increase of compressive strength.
2- From Fig .5. It is clear that, increase doses of (VSW 2016) lead to decrease the change in splitting strength at 3 months up to 2 % dose.
3- From Fig .6. It is clear that, increase doses of (VSW 2016) lead to decrease the change in splitting strength at 6 months up to 2 % dose.
4- From Fig .7. It is clear that, increase doses of (Addcrete BVS) lead to decrease the change in splitting strength at 3months up to 1.5 % dose
5- From Fig .8. It is clear that, increase doses of (Addcrete BVS) lead to decrease the change in splitting strength at 6 months up to 2 % dose

Table 3.
Results of splitting strength test at (28, 90,180) days using (VSW 2016)

Type & percentage of admixture	Cement content (c.c.)kg/m³	Splitting strength F_{spl}kg/cm²				
		F_{spl28}	F_{spl90}	$F_{spl90(VSW)}/F_{spl28(c)}$ %	F_{spl180}	$F_{spl180(VSW)}/F_{spl28(c)}$ %
Control mix	300	24.74	26.3	106.31	28.4	114.79
1.5% (VSW 2016)		28.9	30.1	104.15	31.1	107.61
2.0% (VSW 2016)		29.2	30.4	104.11	31.8	108.90
2.5% (VSW 2016)		29.9	31.0	103.68	32.3	108.03
Control mix	350	27.04	29.2	107.99	30.7	113.54
1.5% (VSW 2016)		28.9	30.1	104.15	31.1	107.61
2.0% (VSW 2016)		29.6	30.9	104.39	32.0	108.11
2.5% (VSW 2016)		31.4	32.6	103.82	33.7	107.32
Control mix	400	27.6	29.7	107.61	31.5	114.13
1.5% (VSW 2016)		29.3	30.5	104.10	31.8	108.53
2.0% (VSW 2016)		31.1	32.2	103.54	33.2	106.75
2.5% (VSW 2016)		31.9	32.7	103.06	33.8	106.04

Table 4.
Results of splitting strength test at (28, 90,180) days using (Addcete BVS) at (C.C) 350kg/m³

Type & percentage of admixture	Splitting strength F_{spl} kg/cm²					
	F_{spl28}	F_{spl90}	$F_{spl90(BVS)}/F_{spl28(c)}$ %	F_{spl180}	$F_{spl180(BVS)}/F_{spl28(c)}$	$F_{spl180(VSW)}/F_{spl180(BVS)}$
Control mix	27.04	28.3	104.66	30.7	110.9	100
1.5% (Addcrete BVS)	28.60	29.7	104.85	30.8	107.7	101
2.0% (Addcrete BVS)	29.20	30.2	103.42	31.5	107.9	101.6
2.5% (Addcrete BVS)	30.10	30.9	102.32	32.3	107.6	102.7

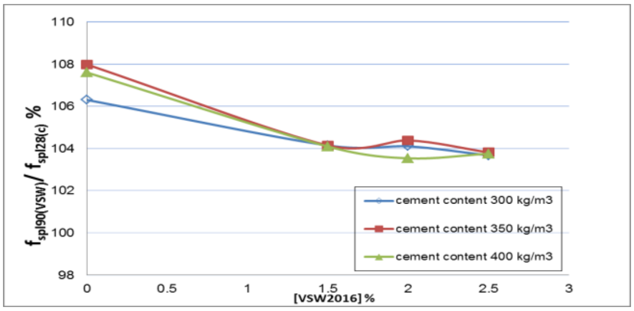

Fig. 5. Relationship between (VSW 2016) and change in splitting strength at 3 months.

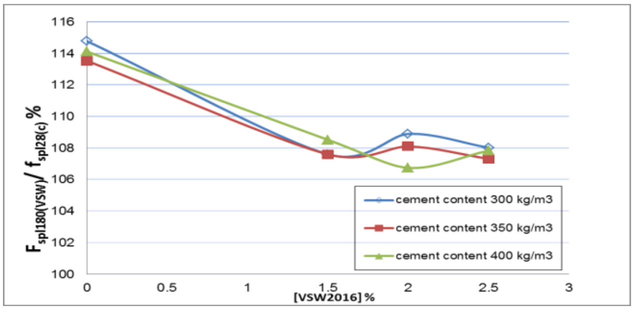

Fig. 6. Relationship between (VSW 2016) and change in splitting strength at 6 months.

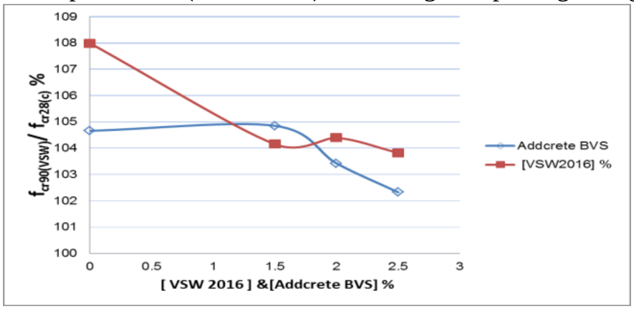

Fig. 7. Comparison between (VSW 2016), (Addcrete BVS) and change in F_{spl} at 3 months at (C.C) 350kg/m^3.

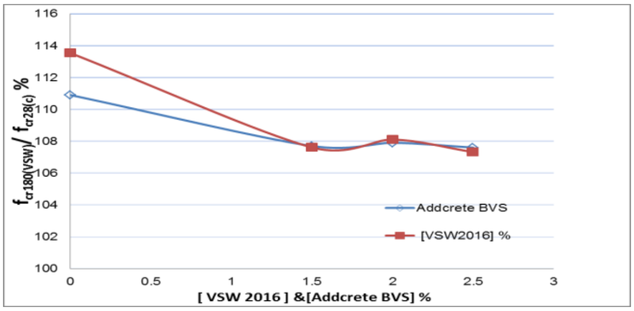

Fig. 8. Comparison between (VSW 2016), (Addcrete BVS) and change in F_{spl} at 6 months at (C.C) 350kg/m^3.

3.3. Results of flexural strength test at 3 and 6 months

Table 5 shows results of flexural strength test at 28 days and (3, 6) months using (VSW 2016) addition. Table 6 shows results of flexural strength test at 28 days and (3, 6) months using (Addcrete BVS) addition. Figures 9, 10 show the relationship between (VSW 2016), (Addcrete BVS) additions and the change in flexural strength at (3, 6) months. Figures 11, 12 show the comparison between (VSW 2016), (Addcrete BVS) additions and the change in flexural strength at 3 and 6 months. From results, it's clear that, the optimal dose of (VSW 2016) addition for flexural strength equals 2% from cement weight. Also for (Addcrete BVS), it took the same direction as the increase of compressive strength.

Table 5.

Results of flexural strength test at (28, 90,180) days using (VSW 2016)

Type & percentage of admixture	Cement content (c.c.)kg/m^3	Flexural strength F_{cr} kg/cm^2				
		F_{cr28}	F_{cr90}	$F_{cr(VSW)}$/ $F_{cr28(c)}$ %	F_{cr180}	$F_{cr180(VSW)}$/ $F_{cr28(c)}$ %
Control mix	300	39.6	42.4	107.07	45.3	114.39
1.5% (VSW 2016)		47.0	48.9	104.04	49.7	105.74
2.0% (VSW 2016)		51.0	52.8	103.53	54.5	106.86
2.5% (VSW 2016)		55.0	55.9	101.64	57.8	105.09
Control mix	350	42.3	45.5	107.57	48.4	114.42
1.5% (VSW 2016)		49.4	51.4	104.05	52.7	106.68
2.0% (VSW 2016)		54.3	55.8	102.76	55.7	105.31
2.5% (VSW 2016)		57.0	58.3	102.28	59.7	104.74
Control mix	400	48.5	51.7	106.60	55.6	114.64
1.5% (VSW 2016)		50.4	52.6	104.37	56.1	111.31
2.0% (VSW 2016)		55.1	56.4	102.36	59.2	106.63
2.5% (VSW 2016)		57.4	58.3	101.57	60.9	106.10

Table 6.

Results of flexural strength test at (28, 90,180) days using (Addcete BVS) at (C.C) 350kg/m^3

Type & percentage of admixture	Flexural strength F_{cr} kg/cm^2					
	F_{cr28}	F_{cr90}	$F_{cr90(BVS)}$/ $F_{cr28(c)}$ %	F_{cr180}	$F_{cr180(BVS)}$/ $F_{cr28(c)}$	$F_{cr180(VSW)}$/ $F_{cr180(BVS)}$
Control mix	42.3	55.0	103.57	56.3	105.49	100
1.5%(Addcrete BVS)	52.2	51.4	104.05	52.7	106.68	99.9
2.0%(Addcrete BVS)	57.8	55.8	102.76	55.7	105.31	101.2
2.5%(Addcrete BVS)	61.7	58.3	102.28	59.7	104.74	101.4

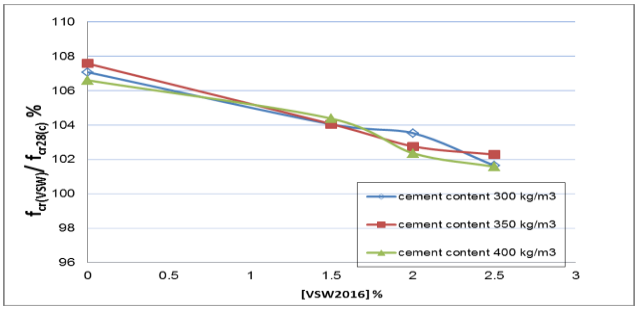

Fig. 9. Relationship between (VSW 2016) and change in flexural strength at 3 months.

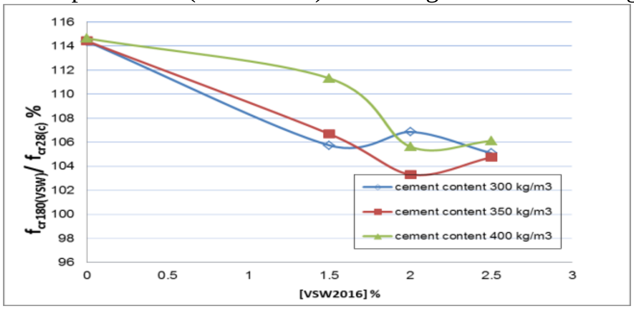

Fig. 10. Relationship between (VSW 2016) and change in flexural strength at 6 months.

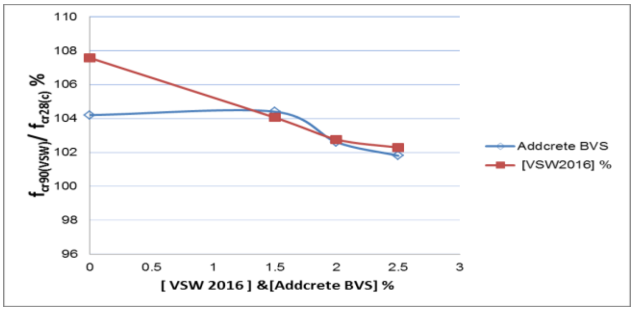

Fig. 11. Comparison between(VSW 2016), (Addcrete BVS) and change in F_{cr} at 3 months at (C.C) 350kg/m^3.

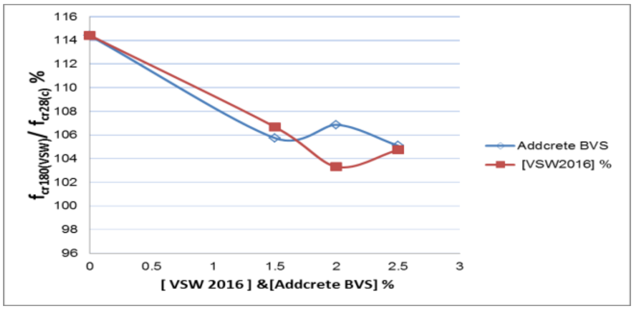

Fig. 12. Comparison between (VSW 2016), (Addcrete BVS) and change in F_{cr} at 6 months at (C.C) 350kg/m^3.

The little difference between Results of flexural strength at 3 and 6 months for cement content of 300,350,400 kg/m³ respectively resulting of increase drying shrinkage with time (3and months) and cement content , this lead to occur of internal cracks causes decreasing in increase average of flexural strength(took the same direction as compressive strength) .

3. 4. Results of durability characteristics

3. 4. 1. Compressive strength after 4 cycles of durability test

Table 7 shows the results of compressive strength after 4 cycles of durability test. It's clear from fig.(13, 14) that, the compressive strength of concrete specimens which modified with (VSW 2016) addition and subjected to 4 cycles of durability test ($F_{CD(56)}$) increases by about 4 % ranges 7 % up to 2 % compared with the control specimens subjected to the same durability test. But specimens which modified with (Addcrete BVS) addition with cement content 350 kg/m^3 are increased by about 3% up to 5% compared with control specimens subjected to the same durability test.

Table 7.

Results of compressive strength for concrete exposed to 4 cycles of durability test

Type & percentage of admixture	Cement content (c.c)kg/m³	Compressive strength kg/cm² using (VSW 2016)			Compressive strength kg/cm² using (Addcrete BVS)			$F_{cD(56)(VSW)}/F_{cD(56)(BVS)}$ %
		F_{c28}	$F_{cD(56)}$	$F_{cD(56)}/f_{c28}$%	F_{c28}	$F_{cD(56)}$	$F_{cD(56)}/f_{c28}$%	
Control mix	300	257.4	270.9	106				
1.5%		312.4	340.3	109				
2.0%		321.3	359.2	112				
2.5%		340.7	357.7	105				
Control mix	350	317.5	338.4	106	317.5	323.8	102	103.9
1.5%		327.7	359.2	110	322.1	344.6	107	102.8
2.0%		343.7	390.8	114	335.2	362.0	108	105.6
2.5%		390.8	418.2	107	355.5	359.1	101	105.9
Control mix	400	353.4	377.1	108				
1.5%		393.0	436.3	111				
2.0%		414.0	475.4	115				
2.5%		416.5	453.9	109				

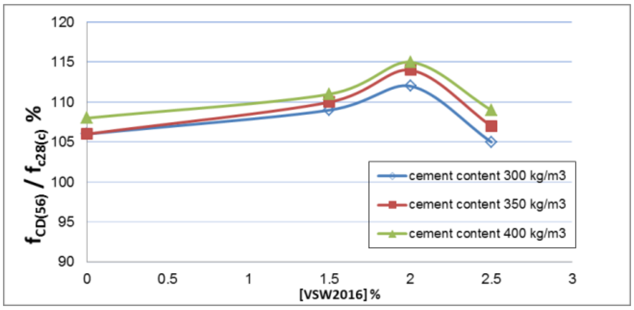

Fig. 13. Relationship between (VSW 2016) and change in compressive strength after 4 cycles of durability test.

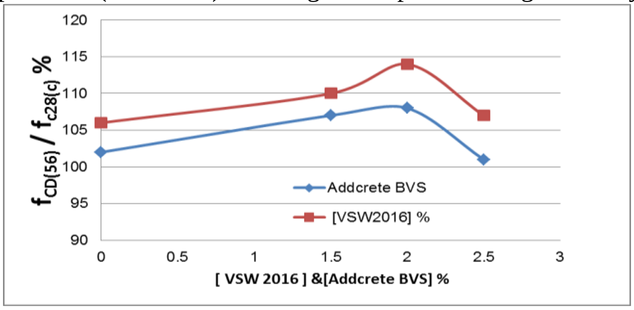

Fig. 14. Comparison between (VSW 2016), (Addcrete BVS) and change in Fc after 4 cycles of durability test.

3. 4. 2. Results of permeability test

The concrete permeability is very important property and it is closely correlated to the concrete durability because it measures the ability of useless ions and salts to penetrate the concrete. Table 8 shows the results of concrete permeability coefficient (K) and depth of water penetration (Dp) for both (VSW 2016) and (Addcrete BVS) additions. Figures (15, 16) show the results of (K) and (Dp) for both (VSW 2016) and (Addcrete BVS) additions at cement content 350 kg/m^3. From the results, it is clear that, the values of (k) and (Dp) are lowered by using (VSW 2016) and (Addcrete BVS) to concrete mixes up to dose 2% and then goes up when increasing doses of (VSW 2016), (Addcrete BVS) additions. Therefore the ideal dose for both (VSW 2016) and (Addcrete BVS) additions for (K) and (Dp) is 2% by cement weight.

Table 8.

Results of concrete permeability coefficient (k) and depth of water penetration (Dp)

Type & Percentage of admixture / cement weight	Concrete permeability coefficient(k) m/sec×10^{-12}		(k)VSW2016/ (k)Addcrete BVS%	Depth of water penetration (Dp) mm		(Dp)VSW2016/ (Dp)Addcrete BVS%
	[VSW2016]	[Addcrete BVS]		[VSW2016]	[Addcrete BVS]	
Control mix	1.22	1.22	100	6.00	6.00	100
1.5 %	1.07	1.10	97.3	5.20	5.4	96.3
2.0 %	1.02	1.07	95.3	5.0	5.1	98.0
2.5 %	1.17	1.12	104.5	5.70	5.9	96.6

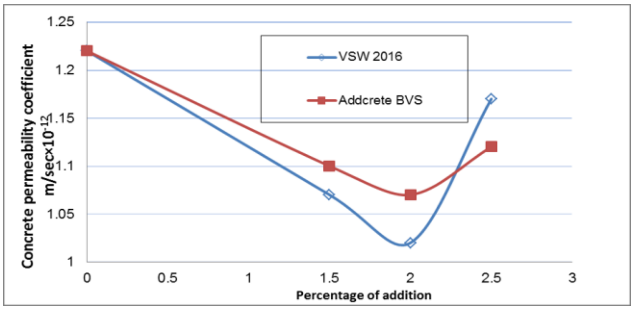

Fig. 15. Results of concrete permeability coefficient (K) for both (VSW 2016) and(Addcrete BVS) at cement content 350 kg/m^3

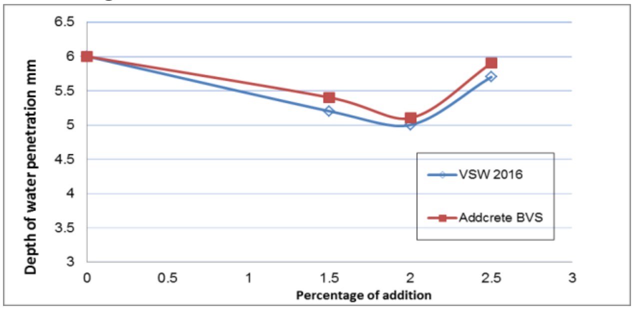

Fig. 16. Results of depth of water penetration for both (VSW 2016) and (Addcrete BVS) at cement content 350 kg/m^3

3. 4. 3. The deterioration strength caused by sulfur salts

3.4.3.1. The loss of strength

Table 9 shows results of compressive test at (6) months using (VSW 2016), (Addcrete BVS) additions exposed to SO_4. Figure17 shows a comparison between the compressive strength of the samples exposed to solution of 10 % sulfur sodium at (6) months with those which are cured with water until testing time for all cement contents. It's clear that, the reduction in the compressive strength resulting of exposing to 10% sodium sulfur for (6) months which ranges 6% to 7% for concrete mixes without (VSW 2016) addition (control mix) and from 4% to 5% from concrete mixes at dose 1.5% and from 3% to 4% for concrete mixes at doses 2%, 2.5%. when using (Addcrete BVS) addition at cement content 350 kg/m^3, the figure 18 shows that the reduction in the compressive strength resulting of exposing to 10% sodium sulfur at (6) months which ranges from 7% to 8% for concrete mixes either without or with using (Addcrete BVS) addition, the concrete strength to deterioration resulting of exposing to sulfur salts was improved by using (VSW 2016) addition due to a reduction in quantity of mix water. The compressive strength of all mixes with (VSW 2016) addition after exposing to 10% solution of sodium sulfur at (6) months, was significantly greater compared with its similar samples without of (VSW 2016) addition and curing with water at same age (6) months. This shows the effectiveness of admixtures which water reduces type such as (VSW 2016) addition in improving the concrete durability.

Table 9.
Results of $F_{c180\,(So4)}$ using (VSW 2016), (Addcrete BVS) additions

Type & Percentage of admixture / cement weight	Cement content (c.c.)kg/m³	Compressive strength at 180 days exposed to So_4 ($F_{c180(So_4)}$)kg/m²					
		(VSW 2016)			(Addcrete BVS)		
		F_{c180}	$F_{c180(So_4)}$	$F_{c180(So_4)}/F_{c180}$ %	F_{c180}	$F_{c180(So_4)}$	$F_{c180(So_4)}/F_{c180}$ %
Control mix	300	322.7	301.2	93.34			
1.5%		346.6	327.9	94.60			
2.0%		353.8	337.9	95.51			
2.5%		361.7	345.4	95.49			
Control mix	350	367.4	341.7	93.00	367.4	339.8	92.49
1.5%		375.2	396.1	95.57	375.2	347.1	92.51
2.0%		381.6	371.3	97.30	381.6	353.0	92.51
2.5%		393.2	374.5	95.24	393.2	363.4	92.42
Control mix	400	404.7	376.4	93.01			
1.5%		426.4	406.1	95.24			
2.0%		430.1	410.7	95.49			
2.5%		432.7	413.2	95.49			

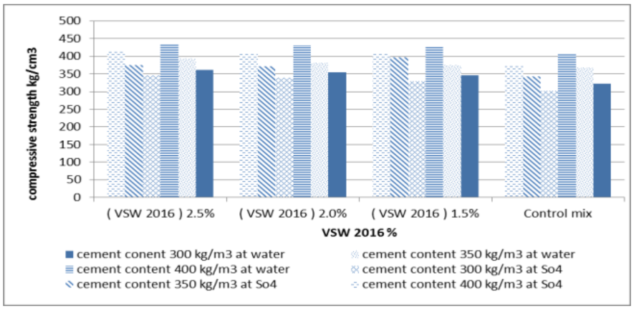

Fig. 17. Comparison between $F_{c180\,(So4)}$ with those cured with water until testing time using (VSW 2016)

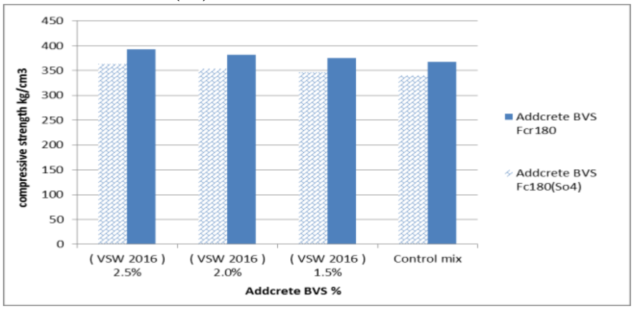

Fig. 18. Comparison between $F_{c180\,(So4)}$ and those cured with water until testing time using (Addcrete BVS) at cement content 350kg/m^3

3.4.3.2. The deterioration in the surface layers and the change in concrete weight

Weight all the concrete samples periodically during the test period (6 months) shows the presence of slight increase (less than 1%) in the weight of samples. There are no peels or cracks were observed in the surface of any tested samples. There are no differences between (VSW 2016) mixes and the control mixes in this subject.

3.4.3.3. The expansion resulting of exposing to sulfur salts

Table 10 shows the maximum strain expansion resulting of exposing to a solution of 10% sulfur sodium at (6) months on concrete mixes with cement contents 300, 350, 400 kg/m^3 using (VSW 2016) addition with doses (1.5%, 2%, 2.5%) and without (VSW 2016). Figure 19 shows the relationship between expansion resulting of exposing to a solution of 10% sulfur sodium at (6) months on concrete mixes with cement content 350 kg/m³ and time in sulfate solution. From table 10 and figure 19, it's clear that, the values of expansion was reduced by increasing the contents of cement or increasing the doses of (VSW 2016) addition

Table 10.
Results of maximum strain expansion resulting of exposing to a solution of 10% of sulfur sodium

Type & percentage of (VSW2016)of cement content	Cement content (c.c.) kg/m³		
	300	350	400
Control mix	0.1168	0.0975	0.093
VSW 2016 (1.5%)	0.092	0.0893	0.087
VSW 2016 (2.0%)	0.089	0.086	0.0725
VSW 2016 (2.5%)	0.087	0.081	0.061

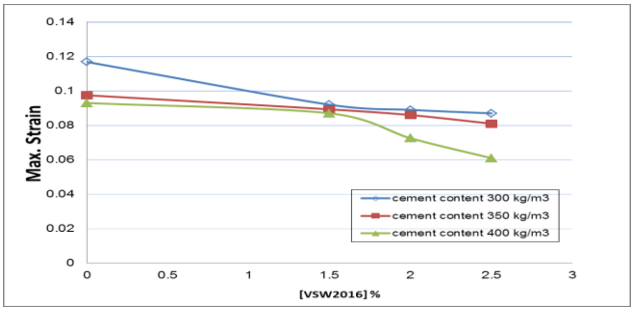

Fig. 19. Relationship between expansion strain and time in sulfate solution

3. 4. 4. Determine sulfate and chloride content

After crushing and grinding some of concrete specimens which exposed to solution (10 %NO2SO4) at 6 months age and containing cement content 300,350,400 kg/m ³ with doses (1.5% , 2% , 2.5 %) of (VSW 2016) addition and cement content 350 kg/m ³ with doses (1.5% , 2% , 2.5 %) of (Addcrete BVS) addition

3. 4. 4. 1. Determine sulfate content in concrete

The total content of sulfate in the concrete which evaluated with form So3 due to all of water, aggregate, cement and additives must not exceed than 4 % of cement content, the chemical analysis method was performed to evaluate sulfate content. Table 11 shows the results which not exceed than 4 % of all cement contents at all doses of both (VSW 2016) and (Addcrete BVS) additions

3.4.4.2. Determine chloride content in concrete

The maximum limit of content of ions chloride in concrete for protecting reinforced bars from rusting must not exceed than 0.3% of cement content, where the total contents of ions chloride due to solvable in water, aggregate, cement and additives. The laboratory analysis (Volhard method) was performed to determine chloride content. Table 11 shows the results which not exceed than 0.3% of cement contents at all doses of both (VSW 2016) and (Addcrete BVS) additions (compared with control mix).

Table 11.
Results of sulfate and chloride content for concrete mixtures with both (VSW 2016) and (Addcrete BVS) additions

Type & percentage of admixture	Cement content (c.c.)kg/m³	(VSW 2016)		(Addcrete BVS)	
		Sulfate Content %	Chloride Content %	Sulfate Content %	Chloride Content %
Control mix	300	3.66	0.27		
1.5%		3.71	0.28		
2.0%		3.82	0.289		
2.5%		3.95	0.298		
Control mix	350	3.53	0.266	3.53	0.266
1.5%		3.64	0.275	3.58	0.271
2.0%		3.75	0.283	3.74	0.280
2.5%		3.82	0.294	3.78	0.288
Control mix	400	3.42	0.257		
1.5%		3.54	0.268		
2.0%		3.68	0.279		
2.5%		3.77	0.288		

Conclusions

The current study is concerning with the influence of addition of (VSW 2016) on the concrete (consists of ordinary Portland cement and round graded aggregate) durability, the test results show the following points:-

1- The influence of (VSW 2016) addition on the strengths of compressive and tension at ages 3 and 6 months.
- Increase in compressive strength to mixes with (VSW 2016) addition compared with the control mixes at cement contents 300,350,400 kg/m³ respectively reaching 4 % and at age 90 days and reaching average 6 % at age 180 days. But by using (Addcrete BVS) addition reaching 6% at ages 3 and 6 months.
-Tension strengths (splitting and flexural) take the same direction of increasing compressive strength and the optimal dose for tension strengths equals 2%

2- The influence of (VSW 2016) addition on the durability characteristics:Using (VSW 2016) addition as water reducing has appositive influence on the concrete durability characteristics which is represented in improving the density of internal structure for concrete where
- Permeability and depth of water penetration were reduced and the optimal dose of (VSW 2016) for permeability and depth of water penetration equals 2%
-The concrete strength to deterioration improved resulting of exposing to 10% sodium sulfur at (6) months age, the reduction in concrete strength ranged from 4% to 5% for concrete mixes of (VSW 2016) with dose 1.5% and ranged from 3% to 4%for remaining (VSW 2016) doses . But the reduction in concrete strength reaching about 7%at control mixes
-The compressive strength for the mixes with (VSW 2016) addition exposed to sulfur solution was higher with a significant difference compared with mixes samples without (VSW 2016) addition and curing with water at same age. It was also higher significant compared to its similar samples using (Addcrete BVS) addition and exposed to sulfur solution.
-The potential to form expansion compounds which are expandable was reduced as a result of exposing to sulfur, where the expansion test results showed a better volume steady for (VSW 2016) mixes and the values of expansion was reduced by increasing the cement content or increasing the (VSW 2016) doses.

This in turn implied improving the concrete strength to sulfur salts by increasing the compressive strength and improving the internal structure compared to reducing of mixing water and increasing the cement content

3- In concrete specimens which exposed to solution (10 %NO2SO4) at age 6 months both sulfate and chloride contents (compared with control mix) accordance with specification requirements.

REFERENCES

[1] Mostafa A. EL-Razek.K. PH.D. Dissertation "Local economical additive for produce high durable concrete for water tanks "civil dept. faculty of Eng. Assiut University2014.

[2] Hegerovitch M.E., Soloviun, V.E., Tomoshplske A.D. "Complex admixture for the concrete mixes "A.C.No 769212, USSR .Rub. In B.E., N.2 1981.

[3] Hegerovitch M.E., Bajor, V.E., "Hydropholizing plasticizing admixtures for cement, solution and concrete" M.Stroyezdat 1975.

[4] Rashwan M.M, Mohamed H.A, Aly G.A. and Abu Elfadel M. Megahed "Behavior of R.C columns containing Alkali wastes of oil and cellulose paper industries and exposed to sulfate and chloride attack under axial static loads " Journal of engineering sciences, Assiut University, vol. 34.No 4 pp. 1111,July 2006 .

[5] Abo EL- Fadal M. PH.D. Dissertation "Protection of underground R.C elements from aggressive sulfate attack by using alkali wastes of oil and cellulose paper industry" Journal of engineering science, civil dept. faculty of engineering. Assiut University, 2009

[6] Yu-M. Doroshanks and L.D.Z arudnaya "Effect of complex chemical additives on the durability of hydraulic engineering concrete "Translated from gidreotekhnick nicheskoc stroitel st,o No.9pp.12-16,September 1978

[7] Ibrahim A. Mokhatar and Abdusalam M. Akasha "Shrinkage of concrete using local pozzalanic materials "the ninth Alex. Inter. Corf .On structural and geot. Eng. Alex. University, 2016

[8] Abdias M.G "Permeability of concrete: A study intended for the" in situ" valuation using portable instruments and traditional techniques " Federal Mina Gerais, Brazil. Juliaha oliverira costa, Non – Destructive testing in civil engineering 2003

[9] Magdy A.Abd EL-AZIZ "Durability of pozzolanic- filled cements in Caron's lake water " 1st Inter. Conf. of civil eng. Science, iccesi, vol .11 2010

[10] Magdy A.Abd EL-AZIZ and M. Heckal "Characteristics and durability of cements containing fly ash and lime stone subjected to Caron's lake water". Advances in cement research no.3 July 2009

[11] Yousry B.shoken , saad A.Alhamrwy and saeed A.M "Durability of high strength and high performance concrete "1st inter. Conf . of civil eng. Science . iccesi 2010

[12] Truyen.T. Tran, R.charlier and F. Collin "Gas and water permeability of concrete under loading and temperature effects "Argenco Dep . univ. of lieg (ULg) 2006

[13] Moaze M.review ortile on "Chemical attack on concrete "prepared for permanent scientific committee 56 for structural and construction eng. Zagazig univ. June 2002

[14] F.Duf lour ,M.E.EL Dandachy, M.Briff out and S.dal Pont "Coupling cracking and permeability to assess the leakage rate of concrete structures " Proceedings of the 15 st inter .conf .on civil . Structural and environmental eng. Computing civil – comp Press, Stirlingshire, Scotland 2015

[15] Delatte and A.Sehdev "Mechanical properties and durability of BCO (Bonded concrete overlays) and UTW (Ullralhim water tapping) concrete " Department of civil and evini. Eng. The univ. of Alabama at Birmingham. No v. 2002

[16] Iggy IP.B.A.SC. And EI.T " Sulphur attack on industry tanks :A problem in the on – site waste water (industry that needs to be addressed) water Bio filter system Inc 2004

[17] Ezz Elregal A.A., Diaa G. and Had hood H. "The effect of retempering with type F admixture on different FRC (Fiber reinforced concrete) types containing type D,G,F and silica fume admixtures "10 th Alex. Intes . conf. on structural and geot . Eng. Department of structural Eng. Faculty of Eng.Alex. Univ. Egypt 2016.

JES, Assiut University, Faculty of Engineering, Vol. 46, No. 3, May 2018, pp.282–298

خصائص وديمومة الخرسانة المحتوية
علي مخلفات صناعة السكر (الفيناس) والمعرضة لظروف بيئية قاسية

الملخص العربى

إن كثيرا من المنشآت الخرسانية المسلحة وخاصة المدفونة تحت سطح الأرض غالبا ما تتعرض إلي ظروف بيئية قاسية أثناء فترة تشغيلها التي تتمثل في الهجوم الحاد لكبريتات الصوديوم والماغنيسيوم من التربة أو المياه المحيطة بها أو أية ظروف بيئية أخري قاسية مثل التعرض لدرجات حرارة مرتفعة (حريق مثلاً) ثم التبريد بالإطفاء. عندما تتعرض المواد المصنعة من الاسمنت لهذا الهجوم فانه يتكون الجبس والاترنجيت نتيجة لتفاعل ايونات الكبريتات المخترقة للغطاء الخرساني مع هيدروكسيد الكالسيوم وثلاثي الومنيات الكالسيوم .إن تكوين الجبس والاترنجيت يلعب دور مهم في تلف هذه المواد وحدوث شروخ داخلية وتمدد لها. طبقا لذلك فان مقاومة الضغط الفعلية لهذه العناصر الخرسانية المسلحة تقل عن المقاومة التصميمية ويكون ذلك مصحوب بتشكلات كبيرة الفاعلية بالخرسانة وبالتالي يحدث نقص كبير في قوة تحمل هذه العناصر مع الزمن مما يقلل من العمر الافتراضي لها. إن استخدام مخلفات صناعة السكر (الفيناس) مع منتجات ثانوية لمصانع الكوك في تكنولوجيا إنتاج وتصنيع إضافة كيميائية فائقة اللدونة للخلطة الخرسانية (مكونة من اسمنت بورتلاندي عادي وركام مستدير ومتدرج) ومحسنة لخواص الخرسانة يمثل دراسة علمية وعملية شيقة خاصة من الناحية الاقتصادية والبيئية.

<u>ولهذا فان الغرض الرئيسى من هذا البحث</u> هو عمل دراسة معملية لإمكانية إنتاج وتصنيع إضافات عضوية اقتصادية وفعالة من مخلفات صناعة السكر (الفيناس) ومنتجات مصانع الكوك (صوديوم نفتالين فورمالدهيد) متمثلة في الإضافة المقترحة (VSW2016) ذلك بعد أن تم التأكد من التأثير الايجابي لهذه الإضافة علي تخفيض كمية ماء الخلط وبالتالي زيادة ملحوظة في اجهادات الشد والضغط وتأخير ملحوظ في زمني الشك الابتدائي والنهائي يفي بمتطلبات المواصفات المصرية.