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Effect of Using alkali Activator on Mortar Compressive strength

Magdy M. M. Genidi[1], Mohamed Helmy Agamy[2], Ahmed Mohamed Abd El − Khaliq[3], Eman Gomaa Abd − Elsalam[4]

, Associate Professor, Civil Engineering Department, Faculty of Engineering El − Mattaria, Helwan University[1],
, Associate Professor, Civil Engineering Department, Faculty of Engineering El − Mattaria, Helwan University,[2]
Lecturer, Civil Engineering Department, Faculty of Engineering El − Mattaria, Helwan University,[3]
Teaching Assistant, Construction and building Department, Faculty of Engineering [4] Egyptian Russian university,

الملخص العربى:

عادة ، يتم استخدام المنشطات القلوية في الخرسانة الجيولوجية لتنشيط الرماد المتطاير (FA) والخبث (AAS) والخرسانة الجيوبوليمرية القائمة على دخان السيليكا (SF) وهي خرسانة جديدة ممزوجة بالقلويات تمت دراستها تدريجيا على مدى العقود الماضية لما لها من فوائد بيئية خصائص هندسية فائقة. في هذا البحث تم دراسة تأثير استخدام المنشط القلوي بنسب مختلفة, لتنشيط نفايات مسحوق الزجاج ودخان السيليكا في وجود الأسمنت البورتلاندي على مقاومة ضغط الملاط. برنامج تجريبي متضمن ستة عشر ملاط تم تقسيمها إلى مجموعتين ، المجموعة الأولى تضمنت أربعة ملاط ، درست تأثير استخدام المنشط القلوي على قوة ضغط الملاط مع استبدال 30٪ من دخان السيليكا بمسحوق الزجاج وتأثير استخدام المنشط القلوي بنسبة 45٪ استبدال دخان السيليكا بمسحوق الزجاج ، بينما درست المجموعة الثانية تأثير استخدام القلويات على مقاومة ضغط الملاط بنسبة 10٪ ، 15٪ و 20٪ استبدال الاسمنت بمسحوق الزجاج. أظهرت النتائج أن استخدام المنشط القلوي له تأثير سيئ على ضغط الملاط بغض النظر عن النسبة والتركيز ، لا ينصح باستخدامه على الإطلاق.

Abstract:

Usually, alkalis activators are used in geopolymer concrete to activate the, fly ash (FA), Slag (AAS) and silica fume (SF) based geopolymer concrete a new blended alkali-activated concrete that has been progressively studied over the past decades because of its environmental benefits superior engineering properties. In this research, was studied the effect of using alkali activator by different proportions to activate the waste glass powder and the silica fume in presence of Portland cement on a mortar compressive strength. Experimental program including sixteen mortars mixture were divided into two groups, the first group included four mortars mix, studied the influence of using alkali activator on mortar compressive strength with 30% replacement Silica fume by Glass powder and The influence of using alkali

activator with 45% replacement Silica fume by Glass powder, while the second group studied the influence using alkali on mortar compressive strength with 10%,15% and 20% replacement Cement by Glass powder. The results show that, Usage the alkali activator has A bad effect on mortar compressive regardless of it is ratio and concentration, it is not recommended for use at all.
Key Words —Glass powder, Silica fume, Portland cement, mortar, alkali activator

I. INTRODUCTION

Recently, an urgent needed to use the new greener material instead of concrete requires two main characteristics; reduced environmental impact which is a main concern in the world and better structural performance. One of the efforts is to promote alternative binders by utilizing abundant of alumina-silicate (pozzolanic) wastes from industrial sector. The most common industrial byproducts used as binder materials are fly ash (FA)and ground granulated blast furnace slag (GGBS). GGBS has been used as a cement replacement material due to its latent hydraulic properties while fly ash has been used as a pozzolanic material. We can use GGBS and FA as prime materials to synthesize a cementitious binder by activating with alkaline solutions. Recent researches have shown that it is possible to use 100% fly ash or slag as the binder in concrete by activating them with an alkali component, such as; caustic alkalis, silicate salts, and non-silicate salts of weak acids [1],[2]. There are two models of alkali activation. Activation by low to mild alkali of a material containing primarily silicate and calcium will produce calcium silicate hydrate gel (C-S-H), similar to that formed in Portland cements, but with a lower Ca/Si ratio [3]. The second mechanism involves the activation of material containing primarily silicate and aluminates using a highly alkaline solution. This reaction will form an inorganic binder through a polymerization process [4],[5]. On another hand, the amount of waste glass gradually increased over recent years due to an ever-growing use of glass products. Most waste glasses have been dumped into landfill sites. The landfilling of waste glasses is undesirable because they are not biodegradable, which makes them environmentally less friendly [6],[7] . There is a potential for using waste glass in the concrete construction. The aim of this research study the effect of using alkali activator of molarity (M16) and different concentration on mortar compressive strength.

II. EXPERMNTAL PROGARAM

A. Matarials

The materials used in this research included Portland cement CEM I (42,5) N cement was used manufactured locally and comply with the Egyptian and European standard specifications by El Suez Cement Company (El-Suez plant), waste glass powder locally available glass from market and dumped areas are collected and crushed into powder form. Glass powder was ground with an air classifier and jet mill. In order to determine Maximum particle-size diameter 120(μm) and Mean particle-size diameter 75 (μm) fineness, the GP with a mean particle diameter of 90 μm shown in "Fig. 1," siliceous sand its natural siliceous sand was used in this investigation after cleaning from impurities; silt, loam and clay, silica fume was used in this study produced by (Sika Egypt for Construction Chemicals) "Fig. 2," and the Sodium hydroxide (NaOH) it is available generally in solid state as pellets or flakes. The flakes form was utilized in this research, which was dissolved in the water to conform a solution has a certain required concentration shown in "Fig. 3," in addition to the Sodium silicate (Na_2SiO_3) is the second main alkaline solution used for activation process for pozzolanic martials. It is available in viscous translucent liquid form and it was purchased from the local suppliers as a commercial solution shown in "Fig. 4,". The chemical composition of used martials was shown in Table 1, and the physical properties was shown in Table 2 and Table 3.

TABLE1. CHEMICAL COMPOSITIONS (%) OF CEMENT, GLASS POWDER, AND SILICA FUME

Identification	cement	Sf	GP
(SiO_2) Silicon dioxide	21.0	96.00	76.00
(Fe_2O_3) Iron oxide	3.51	1.45	0.07
(Al_2O_3) Aluminum oxide	5.3	1.1	0.44
(CaO) Calcium oxide	63.29	1.2	9.94
(MgO) Magnesium oxide	1.02	0.18	3.70
(K_2O) Potassium oxide	0.12	1.20	0.03
(Na_2O) Sodium oxide	0.4	0.45	11.00
(SO_3) Sulfur trioxide	2.12	0.25	0.29
(ZrO_2)	-----	-----	0.01
Cl^-	0.01	-----	0.04

TABLE 2. PHYSICAL PROPERTIES OF CEMENT, GLASS POWDER AND SILICA FUME

Identification	S. F	GP	Cement
Blaine surface area (m^2/kg)	17800	80256	345
Unit weight(t/m^3)	2.15	2.6	3.15
Mean Particle size (um)	0.1	90	90
Color	Light gray	Waite	gray

TABLE 3. PHYSICAL PROPERTIES OF FINE AGGREGATE

Test	Siliceous sand
Specific gravity	2.50
Bulk density (t/m^3)	1.71
Fineness modulus	2.53
Materials finer than No 200 sieve	1.76

Figure1. The Silica Fume

Figure 2. The Glass powders

Figure 3. Alkali activator sodium hydroxide (NaOH)

Figure 4. Alkali activator sodium silicate (Na_2SiO_3)

B. Epermanital programe

Experimental program including sixteen mortars mixture were divided into two groups, the first group included four mortars mix, studied the influence of using alkali activator on mortar compressive strength with 30% replacement silica fume by glass powder and the influence of using alkali activator with 45% replacement Silica fume by glass powder by using alkali activator of molarity (M16) and different concentration ,while the second group studied the influence using alkali activator of molarity (M16) and different concentration on mortar compressive strength with 10% replacement cement by glass powder , the influence using alkali activator with different concentration on mortar compressive strength with 15% replacement cement by glass powder and the influence using alkali activator with different concentration on mortar compressive strength with 20% replacement cement by glass powder. mortars mix were designed with proportions (3:1:0.35) sand, cement and water respectively, water curing system was used in this research, the mixture proportioning of first group shown in Table 4, while mixture proportioning of second group shown in Table 5.

TABLE 4. MIXTURE PROPORTIONING OF FIRST GROUP

Mix Code	Cement	SF	GP	Activator (gm)	
				NAOH	Na2SiO3
M (1)	519.37	66..2	11.69	---	
M (2)	519.37	54.53	23.37	---	---
M (4)	519.37	66.21	11.69	22.29	8.90
M (5)	519.37	54.53	23.37	22.26	8.90

TABLE 5. MIXTURE PROPORTIONING OF FIRST GROUP

Mix Code	Cement	SF	GP	Activator (gm)	
				NAOH	NA2SIO3
M (9)	467.43	77.9	51.94	---	---
M (10)	441.47	77.9	77.90	---	---
M (11)	415.50	77.9	103.87	---	---
M (12)	467.43	77.9	51.94	37.1	14.84
M (13)	441.47	77.9	77.90	44.51	17.81
M (14)	415.50	77.9	103.87	51.94	20.77
M (15)	467.43	77.9	51.94	11.13	4.45
M (16)	441.47	77.9	77.90	16.69	6.67
M (17)	415.50	77.9	103.87	22.26	8.90
M (18)	467.43	77.9	51.94	15.58	0.0
M (19)	441.47	77.9	77.90	23.37	0.0
M (20)	415.50	77.9	103.87	31.16	0.0

C. Specimen preparation and test methods

Metal mortar molds were used in this research shown in "Fig. 5," For each mix was casted nine mortar coups (50*50*50) mm, the compressive strength of a material is the uniaxial compressive stress reached when the material fails completely. A set of three cubes were tasted in each case and the average value of these three was reported. Compressive strength test of mortar ASTM C109 (ASTM, 2016C). Experimental set up for compression test for mortar are shown in "Fig. 5," ultimate load is noted for each specimen. Compressive loading for mortar was maintained as 900–1800 N/s and 20–50 psi/s. Mortar samples were tested for compressive strength at 7, 28 and 90 days.

Figure 6. Compressive strength set up

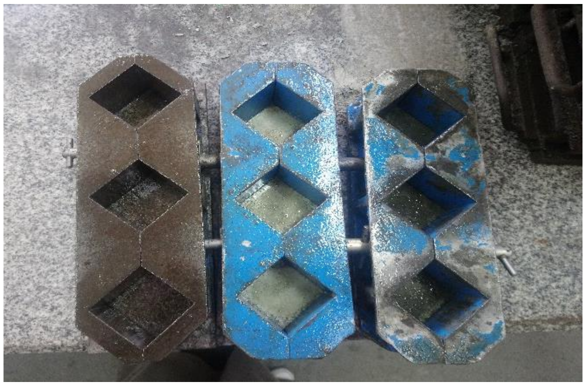

Figure 5. Metal mortar molds

D. Results and Discussion

Table 5, shows the compressive strength test resultes of first group of mortar mixesthat studied the influence of using alkali activator on mortar compressive strength with 30% replacement Silica fume by Glass powder and The influence of using alkali activator with 45% replacement Silica fume by Glass powder by using alkali activator of molarity (M16) and different concentration , while the Table 6 shows the compressive strength test resultes of second group compressive strength test resultes of mortar mixes that studied influence using alkali activator of molarity (M16) and different concentration , 10% replacement Cement by Glass powder , 15% replacement Cement by Glass powder and 20% replacement Cement by Glass powder.

"Fig. 7," shows the effect of using alkali activator with molarity (M16) and concentration 0.4 (Sf + GP) weight on mortars compressive results. The results indicate to the negative effect of using activator on mortar compressive strength. The mortar Mix (3) exhibited lower strength than the same mix without alkali activator (M1) about 10%,8 % and 20 % at age 7, 28 and 90 days, respectively. "Fig. 8," shows the effect of using alkali activator with molarity (M16) and concentration 0.3 (Sf + GP) weight on mortars compressive results, the mortar M (4) exhibited compressive strength lower than the same mix without activator (M2) about 18% ,19% and 7% with values were 26.00, 33.46 and 43.20 MPa at age 7, 28 and 90 days, respectively.

"Fig. 9," shows the influence of using alkali activator with different concentrations on mortar mixture that has 10% replacement cement by Glass powder on mortar compressive strength, the results show that alkali activator has a negative effect on mortar compressive strength, regardless of the alkali activator concentration ratio by comparation the same mortar mixture (10% replacement cement by GP) without using alkali activator. The mortar mix (M12) that has alkali activator with concentration 0.4(SF+GP) by ratio (NAOH/NA2SIO) = (2.5/1), this mix exhibited compressive strength lower than mortar mix (M5) about t 30%, 26%, and 25% at age 7, 28 and 90 days respectively, and the mortar mix (M11) that has alkali activator with concentration 0.3(SF+GP) by ratio (NAOH/NA2SIO) = (2.5/1), this mix exhibited compressive strength lower than mortar mix (M5) about 23%, 23%, and 30% at age 7, 28 and 90 days respectively, in addition to the mortar mix (M13) that has alkali activator with concentration 0.3(SF+GP) by ratio (NAOH/NA2SIO) = (3.5/1), this mix achieved worst compressive strength compared to the previous mixes (M8) ,(M11) and lower than the mortar mix (M4) about 44% , 50% and 50% at age 7, 28 and 90 days ,respectively.

"Fig. 10," shows the influence of using alkali activator with different concentrations on mortar mixture that has 15% replacement cement by Glass powder on mortar compressive strength, the results show that alkali activator has a negative effect on mortar compressive strength, regardless of the alkali activator concentration ratio by comparation the same mortar mixture

(15% replacement cement by GP) without using alkali activator. The mortar mix (M9) that has alkali activator with concentration 0.4(SF+GP) by ratio (NAOH/NA2SIO) = (2.5/1), this mix exhibited compressive strength lower than mortar mix (M6) about t 21%, 28%, and 33% at age 7, 28 and 90 days respectively, and the mortar mix (M12) that has alkali activator with concentration 0.3(SF+GP) by ratio (NAOH/NA2SIO) = (2.5/1), this mix exhibited compressive strength lower than mortar mix (M6) about 16%, 30%, and 36% at age 7, 28 and 90 days respectively, in addition to the mortar mix (M19) that has alkali activator with concentration 0.3(SF+GP) by ratio (NAOH/NA2SIO) = (3.5/1), this mix achieved worst compressive strength compared to the previous mixes (M8) ,(M11) and lower than the mortar mix (M6) about 23% , 47% and 56% at age 7, 28 and 90 days ,respectively.

“Fig. 11,” shows the influence of using alkali activator with different concentrations on mortar mixture that has 20% replacement cement by Glass powder on mortar compressive strength, the results show that alkali activator has a negative effect on mortar compressive strength, regardless of the alkali activator concentration ratio by comparation the same mortar mixture (20% replacement cement by GP) without using alkali activator. The mortar mix (M14) that has alkali activator with concentration 0.4(SF+GP) by ratio (NAOH/NA2SIO) = (2.5/1), this mix exhibited compressive strength lower than mortar mix (M6) about t 30%, 30%, and 35% at age 7, 28and 90 days respectively, and the mortar mix (M13) that has alkali activator with concentration 0.3(SF+GP) by ratio (NAOH/NA2SIO) = (2.5/1), this mix exhibited compressive strength lower than mortar mix (M6) about 27%, 34%, and 40% at age 7, 28 and 90days respectively, in addition to the mortar mix (M16) that has alkali activator with concentration 0.3(SF+GP) by ratio (NAOH/NA2SIO) = (3.5/1), this mix achieved worst compressive strength compared to the previous mixes (M8) ,(M11) and lower than the mortar mix (M6) about 43%,52% and 56% at age 7, 28 and 90 days ,respectively.

TABLE 5. TEST RESULTS OF FIRST GROUP

Mix code	Compressive strength (MPa)		
	7 days	28 days	90 days
M (1)	35.03	42.30	48.15
M (2)	31.80	41.20	46.52
M (3)	31.66	38.66	38.45
M (4)	26.00	33..46	43.2

TABLE 6. TEST RESULTS OF FIRST GROUP

Mix code	Compressive strength (MPa)		
	7 days	28 days	90 days
M (5)	40.00	46.40	51.05
M (6)	33.60	52.50	58.40
M (7)	35.50	46.20	52.01
M (8)	28.20	34.40	38.00
M (9)	26.60	38.00	39.00
M (10)	24.80	32.40	33.60
M (11)	30.80	35.80	36.00
M (12)	28.20	37.00	37.32
M (13)	26.00	30.40	31.22
M (14)	22.10	23.22	25.56
M (15)	26.00	27.85	28.23
M (16)	20.25	22.02	22.68

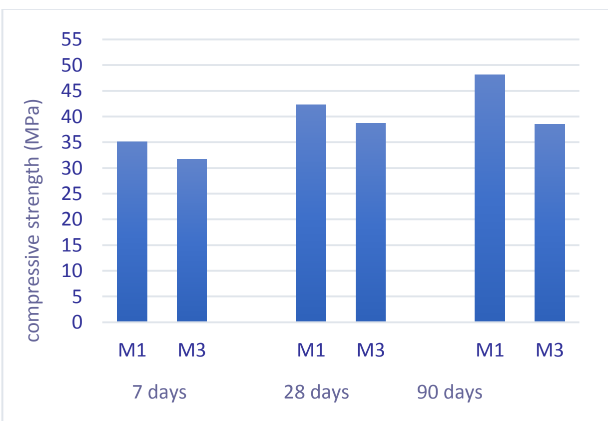

Figure 7. The influence of using alkali activator on mortar compressive strength with 30% replacement SF by GP

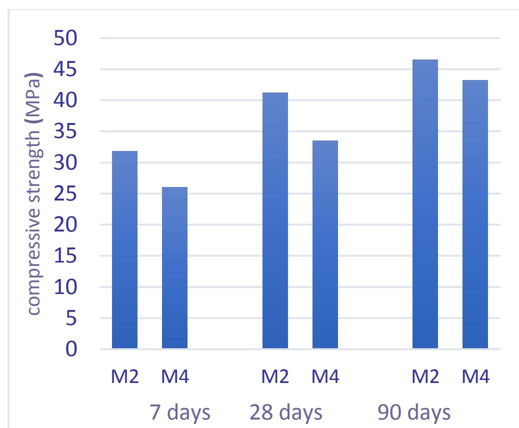

Figure 8. The influence of using alkali activator on mortar compressive strength with 45% replacement SF by GP

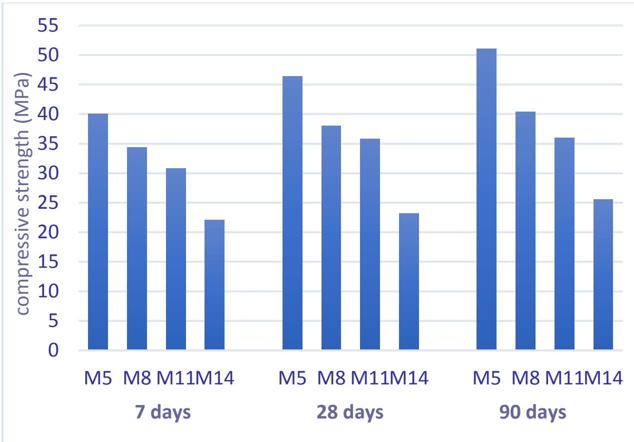

Figure 9. The influence using alkali activator with different concentration on mortar compressive strength with 10% replacement Cement by GP

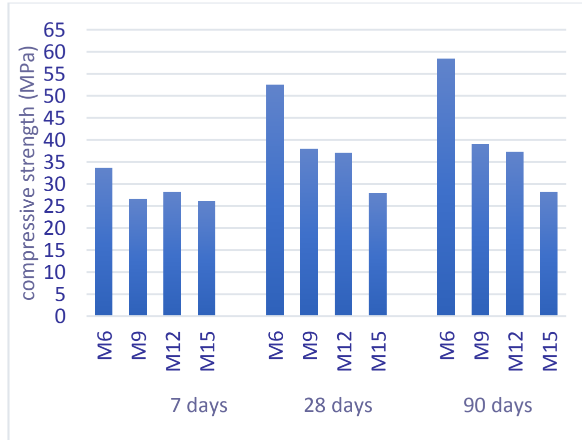

Figure 10. The Influence using alkali activator with different concentration on mortar compressive strength with 15% replacement Cement by GP

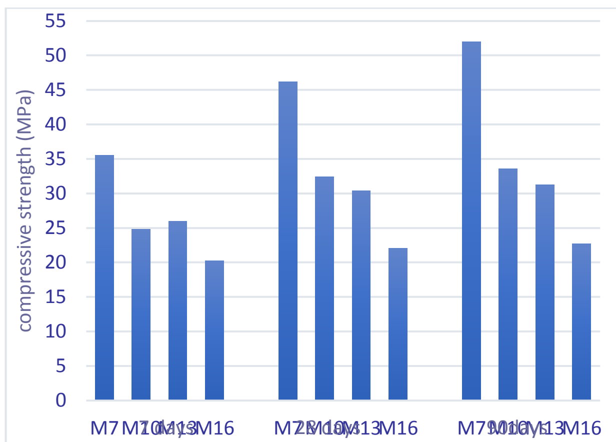

Figure 11. The Influence using alkali activator with different concentration on mortar compressive strength with 20% replacement Cement by GP

E. .conclusion

From the results you can conclusion that

- alkali activator has a negative effect on mortar compressive strength, regardless of the alkali activator concentration ratio by comparation the same mortar mixture without using alkali activator.
- The has alkali activator with concentration 0.3(SF+GP) by ratio (NAOH/NA2SIO) = (2.5/1), this mix exhibited compressive strength higher than concentration 0.3(SF+GP) by ratio (NAOH/NA2SIO) = (3.5/1).

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