Studying the Effect of Adding Sodium Silicate and Rock Wool to Concrete Mix on the Properties of Concrete

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Abstract

This research is studying effect of adding sodium silicate to water of concrete mix with ratios (2.5%, 3.75%, 5% and 6.25%) by the weight of water concrete mix. Also study effect adding rock wool to concrete mix with ratios (2.5%, 3.75%, 5% and 6.25%) by the weight of cement. After demolding the samples and curing in water 28 days and then dried in air to be ready to test. The samples tested compressive strength and tensile strength and density, the results show increase in compressive strength and tensile strength in ratios (2.5% rock wool and 3.75% of sodium silicate) compared to reference sample, and the density of samples decrease by increase the ratios of additives rock wool and sodium silicate to concrete mix.

Keywords: Concrete, Rock wool, Sodium silicate, Compressive strength, Tensile strength.

تأثير أضافة سيليكات الصوديوم والصوف الصخري للخلطة الخرسانية على خواص الخرسانة

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الخلاصة

تم في هذا البحث دراسة تأثير إضافة سيليكات الصوديوم الى ماء الخلطة الخرسانية بنسب وزنية مختلفة من وزن الماء (2.5%، 3.75%، 5% و 6.25%). كذلك تم دراسة تأثير أضافة الصوف الصخري الى الخلطة الخرسانية بنسب وزنية من وزن الإسمنت (2.5%، 3.75%، 5% و 6.25%). بعد استخراج العينات من القوالب عولجت بالماء لمدة 28 يوم، بعدها جففت بالهواء لتكون جاهزة للفحص. فحصت قوة الإنضغاط والشد والكثافة للعينات، وأظهرت النتائج زيادة في قوة الأنضغاط والشد عند النسبة (2.5% للصوف الصخري و 3.75 لسيليكات الصوديوم) مقارنة مع العينة الإعتيادية. إنخفضت الكثافة بزيادة نسبة إضافة الصوف الصخري وسيليكات الصوديوم للخلطة الخرسانية.

الكلمات المفتاحية: خرسانة، صوف صخري، سيليكات الصوديوم، قوة إنضغاط، قوة شد.

Introduction

Cement is a binder hardens by itself and binds other materials together and most its applications in construction and consider the basic material for any building whatever high, low, small and big from foundation to high point of these buildings. Cements are characterized hydraulic and non-hydraulic which are used for production mortars and concrete. Hydraulic cement is harden after combined with water and consists of Calcium Silicates (at least 2/3 by weight) and most cements of construction are hydraulic and based on Portland cement. Non-hydraulic cements like lime and gypsum plaster and there is special cement for special application. Actually, it is compound consist of polymer matrix with dispersed phase particles such as bioactive cement [1]. Concrete is engineering material made of cement paste with inert aggregates like sand, gravel and cement recycles used for civil infrastructures such as buildings, highways, underground mass systems,…etc. Fiber reinforced concrete is compound with random oriented direction of fibers in a concrete mix. The size of fibers are varied with ideal length less than 50 mm and diameter less than 1 mm and there is many types of fibers are used as reinforcement like steel fibers, glass fibers, …etc [2]. Rock wool is fibrous material of mineral inorganic with recognized characteristics and properties and used for thermo-acoustic insulation field and in many industries and buildings. Rock wool is consist of melting mix of basalt, limestone and coke in blast furnace with high temperature reach about $1500^{O}C$ and the result molten is draw and made to the thin fibers with high speed by using centrifugal machine. A binder is spray on these thin fibers with equal amount and dustproof oil, silicon oil and mechanical operations are

made then these thin fibers are processed to be desired product with unique physical and chemical properties[6]. The research is aimed from that to improve some mechanical properties for concrete that prepared it through interface the particles of Sodium Silicates with Concrete. Thus, in order to fully understand the mechanical strength of fiberglass, all these factors need to be thoroughly explored.

1- Experimental Work

2-1 MATERIALS:-

2.1.1 Cement

Ordinary Portland cement manufactured by (tasluga factory \ Bazian) cement factory was used throughout this investigation. Table (1) and (2) show the chemical and physical properties.

Table (1) chemical composition of the cement

Oxides composition	Content %	Limits of (Iraqi Standard) No.5/1984[6]
CaO	52.21	-
SiO_2	20.18	-
Al_2O_3	5.00	-
Fe_2O_3	3.60	-
MgO	2.31	<5.00
SO_3	1.44	<2.80
L.O.I.	3.29	<4.00
Insoluble residue	1.11	<1.5
Lime Saturation Factor,L.S.F.	0.94	0.66-1.02

Table (2) physical properties of the cement

Physical Properties	Test results	Limits of (Iraqi Standard) No.5/1984[6]
Specific surface area (Blaine method), m^2/kg	483	≥230
Setting time (Vicate apparatus), Initial setting, h:min Final setting, h:min	 2:50 4:30	 ≥00:45 ≤10:00
Soundness (Auto Clave) method, %	0.25	≤0.8

2.1.2 Fine aggregate:

AL-Ekadir in Karbala region sand was used as fine aggregate, Table (3) show the sieve analysis of fine aggregate, and table (4) show the physical and chemical properties of sand.

Table (3) sieve analysis of fine aggregate

Sieve Size (mm)	% Passing	% Passing according to limits of Iraqi Standard No. 45/1984 [7]
4.75	95	90-100
2.36	90	85-100
1.18	85	75-100
0.60	70	60-79
0.30	25	12-40
0.15	5	0-10
Fineness Modulus = 2.3		

Table (4) physical and chemical properties of sand aggregate

Property	Specification	Result	Iraqi Specification No.45/1984[7]
Specific gravity	ASTM C128-88	2.63	-
Absorption, %	ASTM C128-88	0.75	-
Dry loose- unit weight, kg/m3	ASTM C29-89	1592	-
Sulphate content as SO3 ,%	I.O.S No.45/1984	0.08	≤ 0.5
Material finer than 75μm sieve , %	I.O.S No.45/1984	3.8	≤ 5

2.1.3 Coarse Aggregate:

The coarse aggregate that crushed to12.5 mm maximum size was used. It was obtained from AL - Nebai source, Table (5) show the sieve analysis and table (6) show physical properties of coarse aggregate.

Table (5) sieve analysis of coarse aggregate

Sieve size (mm)	Selected % passing	% passing ASTM C330-87
12.5 9.5	95 70	90-100 40-80

Table (6) physical properties of coarse aggregate

Physical properties	Test results	Limits of Iraqi specification No.45/1984[7]
Specific gravity	2.630	-
Sulfate content	0.06%	≤ 0.1%
Absorption	0.63%	-

2.1.4 Tap Water: Tap water (drinking water) was used for concrete mixing and specimens curing.

2.1.5 Wool rock: It is used as reinforcement materials in concrete, table (7) show properties of fibers.

Table (7) properties of fiber

	Fiber length	Tensile strength	Density
Rockwool	6 mm : 12 mm	418N/mm^2	148 kg/m^3

2.1.6 Sodium Silicate:

The Sodium Silicate was used in this research is product 3 as shown in table (8) with typical properties for liquid Sodium Silicate.

Table (8) typical properties of sodium silicate

Product	Ratio SiO_2/Na_2O	% Na_2O	%SiO_2	Viscosity at 20^OC (Kg/m.s)	Density g/cm^3	Characteristics
1	3.22	8.90	28.7	0.18	96.83	Syrupy Liquid
2	3.22	9.15	29.5	0.40	98.50	Thick Liquid
3	3.25	9.22	30.0	0.83	98.50	Thick Liquid
4	2.88	11.00	31.7	0.96	102.67	Sticky, Heavy Liquid
5	2.40	13.85	33.2	2.10	108.51	Heavy Syrupy
6	2.00	14.70	29.4	0.40	106.85	Syrupy, Alkaline Liquid

2-2 Mixing Procedure:

By using manual mixing we used mixing ratio of concrete mixture as 1:1:2 (Cement: Sand: Aggregate). The amount of water addition was (300g) to pure concrete mixture as shown below in table (9):

Table (9) ingredients of concrete mixture

No.	Ingredients	Amount by weight (g)
1	Aggregate	1400
2	Sand	700
3	Cement	700
4	Water	300

2.2.1 Addition of Sodium Silicate for Concrete Mixture:

The research was made one pure Bitch from Concrete and four bitches from different additives of rock wool and Sodium Silicates as shown later. We used Sodium Silicate (Na_2SiO_3) with SiO_2/Na_2O ratio is 3.25 as additive material. The percentage of additions was varying to study the influence of additive Na_2SiO_3 on the Concrete properties as show below in table (10):

Table (10) the addition percentages of Na_2SiO_3 from additive water to conrete bitch

No. of Bitches	Na_2SiO_3%	Weight of Na_2SiO_3 (g)
1	2.5	7.5
2	3.75	11.25
3	5	15
4	6.25	18.75

2.2.2 Addition of rock wool for Concrete Mixture:

The rock wool is thermal insulator that used in heat saving and thermal barrier. The long tiny fiber of rock wool could use as reinforced fiber to other materials like cement and concrete…etc. The table (7) is showing the characteristics of rock wool that used in this research and with different percentage of additions to the Concrete Bitches as shown in table (12):

Table (11) the addition percentages of rock wool from weight of cement

No. of Bitches	Rock wool%	Weight of Wool Stone (g)
1	2.5	17.5
2	3.75	26.25
3	5	35
4	6.25	43.75

The table (12) shows the all mixtures pure and the additives to concrete mixture:

Table (12) the mixtures of concrete with and without additives

No. of Bitches	Na_2SiO_3% from the weight of water	Wt. of Na_2SiO_3 (g)	Rock wool % from the weight of cement	Wt. of Wool Stone (g)	Wt. of Cement (g)	Wt. of Aggregate (g)	Wt. of Sand (g)	Wt. of Water (g)
Pure	0	0	0	0	700	1400	700	300
1	2.5	7.5	2.5	17.5	700	1400	700	300
2	3.75	11.25	3.75	26.25	700	1400	700	300
3	5	15	5	35	700	1400	700	300
4	6.25	18.75	6.25	43.75	700	1400	700	300

The figure (1) indicated the mixing process with addition of Sodium Silicates and rock wool.

Figure (1): Mixing process of Concrete mixture and Additives.

2-3 Preparation of Samples:

Our research made cylindrical samples with diameter 70.54mm and height 140.97mm as shown in figure (2). The samples are curing with water for 28 days by immersed the samples in bath of water and after that the dimensions and weights of samples are taken as in table (13):

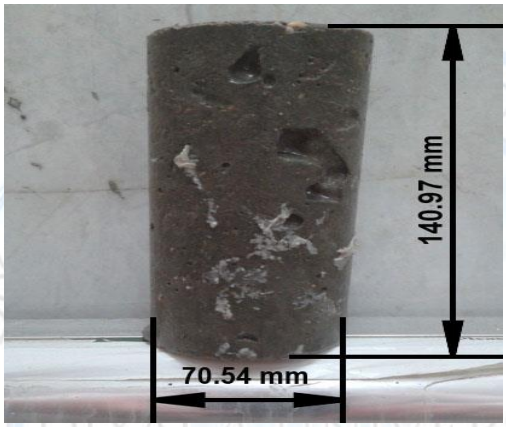

Figure (2): Shape and Dimensions of Sample.

Table (13) the dimensions and weights of samples for different bitches

No. Sample or Bitch	Diameter (mm)	Height (mm)	Weight (g)
Pure	70.54	140.97	1219.94
1	70.54	140.97	1183.88
2	70.54	140.97	1094.32
3	70.54	140.97	1172
4	70.54	140.97	988

Result and Discussion

1. Density of concrete

From figure (3) show that all density of samples decreases by increase the Sodium Silicate and rock wool, but the decrease was slight decrease, density decreased because of the density of rock wool is less than the density of cement [8].

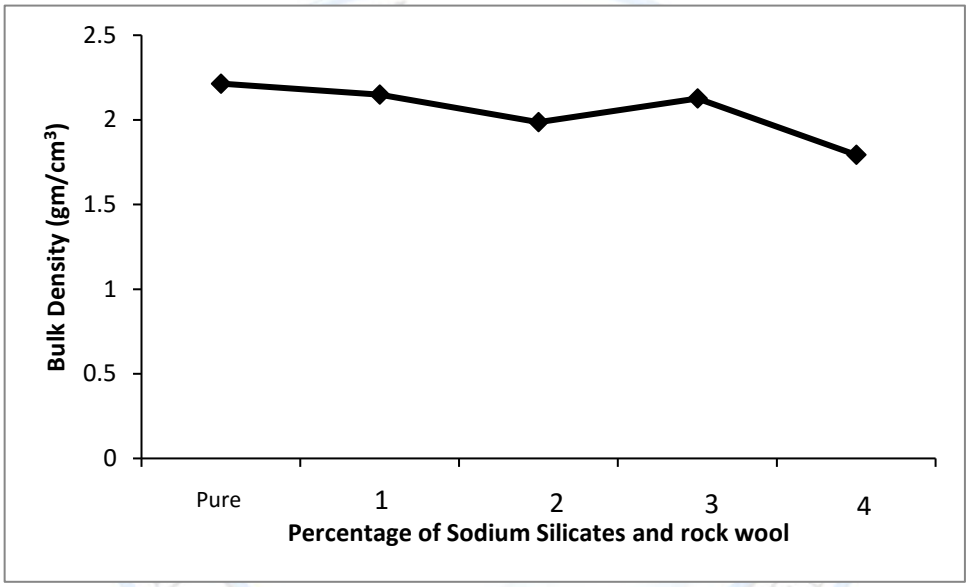

Figure (3): Show Bulk Density varying with different addition percentage of Sodium Silicate and rock wool.

2. Compressive Strength

From the figure (4) show the best ratio of all samples was 3.75% of rock wool from the weight of cement and 3.75% of sodium silicate from the weight water. compressive increase because the sodium silicate works by shrinking distances sodium silicate, which is their interaction with cement Gelatin fill the voids within the concrete, because the voids in the concrete mixture make up a small part of the total volume of concrete, which have the opposite effect in the resistance. Also noted by increase the ratio of rock wool and sodium silicate larger than 3.75% decrease the compressive strength [9].

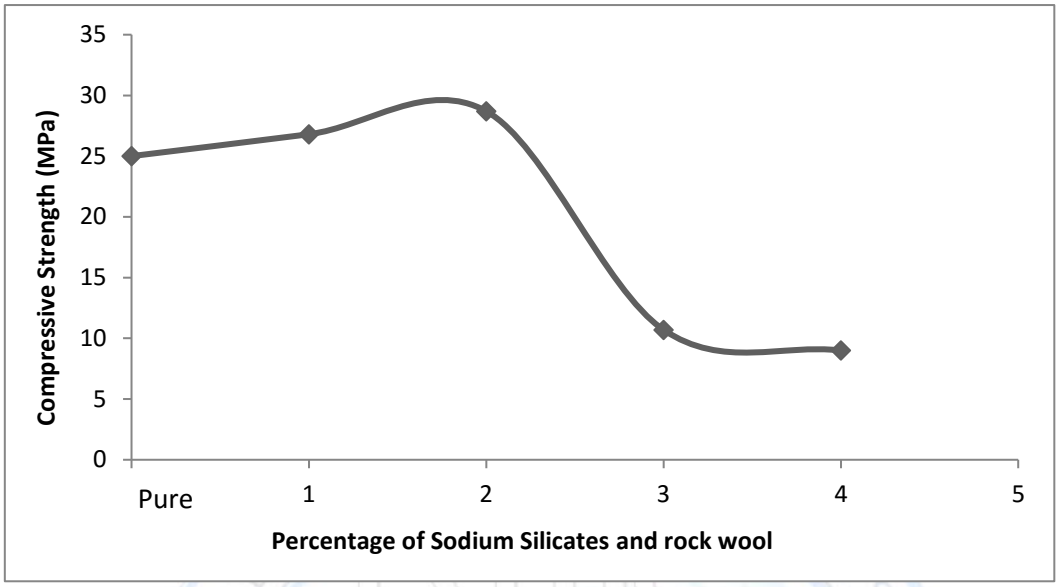

Figure (4): the compressive strength with different percentage of sodium silicates and rock wool additives

3. Tensile Strength:

Noted from figure (5), the best ratio from all samples was 2.5% of rock wool from the weight of cement and 2.5% of sodium silicate from the weight water. Increase the tensile due to the presence of rock wool in the concrete mix that resist tensile strength and presence of sodium silicate not affect in tensile strength. Noted from other samples by increase the ratio of rock wool and sodium silicate decrease the tensile strength [10].

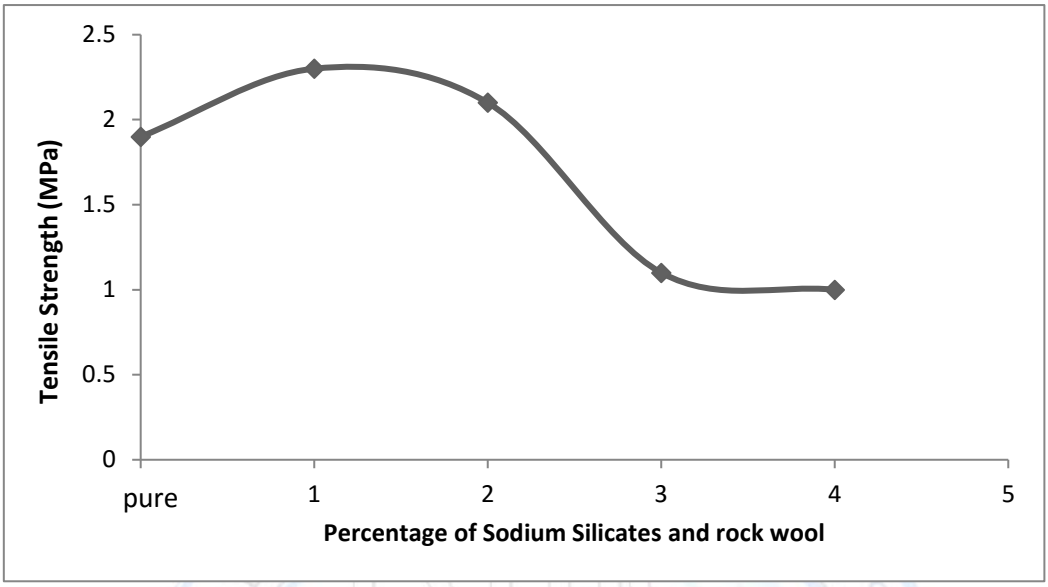

Figure (5): the Tensile Strength with different percentage of Sodium Silicates and rock wool additives

Conclusion

Concluded from this research the best ratio of sodium silicate (3.75%) that effect on compressive strength and by increase over this ratio the compressive strength will be decrease this causes weakness cement particle correlation together. The best ratio of rock wool (2.5%) that effect on tensile strength, where an increase of this ratio causes a decrease in tensile strength, thus should make sample contain this best ratios. Also conclusion the density of samples decrease by increase the ratio of rock wool basically and sodium silicate secondary.

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