THE EFFECT OF ADDING MICROSILICAON THE MODULUS OF ELASTICITY AND ABSORBED ENERGY OF FINE SAND STABILIZED WITH CEMENT AT DIFFERENT PROCESSING TIMES.

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Abstract

To improve some physical characteristics of soils, a series of additives such as cement and microsilica are added to the soil. In this research, the uniaxial compressive strength test was performed on the samples prepared from fine sand with different proportions of cement and microsilica, and then the effect of additives on the modulus of elasticity and absorbed energy of the samples was discussed. According to the obtained results, it was observed that in two processing times of 1 and 7 days, with the increase in the amount of additives, the absorbed energy increases. In 1-day curing, although the modulus of elasticity increases with the increase of cement, but at a fixed ratio of cement, with the increase of microsilica, the modulus of elasticity first increases and then decreases. In the 7-day process, the modulus of elasticity increases with the addition of additives (cement and microsilica).

Keywords: Cement, microsilica, fine sand, modulus of elasticity, absorbed energy, processing time

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1. Introduction

In a large number of existing soil engineering projects, it does not have the necessary resistance against the load caused by the structure. Since replacing the soil with the right type in many cases due to the high volume of excavation or the lack of access to soil with the required characteristics requires a lot of money, so by using some methods such as adding cement and lime, the required properties can be obtained in the soil. They create an existing. The type and amount of additive for the desired effect is different in different types of soil. Due to the importance of this issue, many studies are being done on this issue. In recent years, efforts have been made to replace part of the main additive, such as cement, with some minerals such as microsilica, fly ash, and other materials. In this article, a type of fine sand is stabilized with cement and microsilica, and after two treatments of 1 and 7 days, it has been tested for uniaxial compressive strength. From the results of the tests, the modulus of elasticity and absorbed energy were calculated, then the effect of the amount of these additives on the parameters of the modulus of elasticity and absorbed energy were compared.

Some of the important goals of stabilization include the effective use of lateral loans, modification of soft and low-strength soils, increasing soil durability, increasing soil bearing capacity and reducing soil swelling [1], determining the type and amount of stabilizing substances in achieving the goals. Stabilization is very important. Cement is one of the widely used stabilizing materials, which has the best effect on fine-grained sandy soils [1]. Some of the materials used with cement include microsilica. Microsilica is a mineral substance that is produced by condensing the gases released from the working furnaces of silica mines and alloys in the form of small and round particles [2]. The effect of microsilica is due to the pozzolanic and filling properties of this material.

The filling property of microsilica is due to the very small particles of this material. The meaning of pozzolanic property is to react with calcium hydroxide produced in the hydration of cement and produce stable calcium silicate. It can be claimed that the addition of microsilica to the amount of 20% of the cement weight will convert almost all the calcium hydroxide in the cement paste into stable calcium silicate [3]. A lot of research has been done on the effects of cement on all types of soils, but there are limited studies on the effects of microsilica on the physical properties of soil. Some of these researches are mentioned below.

Clough et al. [4] conducted a series of triaxial, uniaxial and Brazilian experiments to investigate the effect of cementation degree and density of artificial and natural cemented sands. The results of their experiments showed that hardness and maximum strength increase with increasing density and degree of cementation. They concluded that in addition to density and cementation, particle size distribution and their arrangement (texture and structure) play a significant role in the behavior of cemented sands.

Mehdi Ezni Eshri et al [5] studied the effect of silt content on the resistance characteristics of cement-stabilized soil. Based on the results of triaxial static tests, adding cement to layered sandy soil increases the resistance, but the presence of non-paste fine grains and its amount in the soil can affect the amount and process of increasing the strength and hardness.

Haeri et al. [6] investigated the behavior of artificially hardened sandy sand. During this research, he conducted a series of triaxial and uniaxial tests on non-cemented and artificially cemented samples. In the undrained triaxial test, non-cemented samples and weakly cemented samples showed contraction behavior along with expansion of positive pore pressure at high all-round pressures. Also, the cemented samples and non-cemented samples showed expansion behavior along with negative pore pressure expansion at low all-round pressures. The results of the uniaxial tests also showed that the strength of the cemented samples increases with the increase in the degree of cementation and density.

Masoud Makarchian et al. [7] investigated the effect of microsilica on clay stabilized with lime in the vicinity of sulfate and the effect of humidity on the swelling of said soil. The results of his experiments showed that the addition of microsilica in the vicinity of suitable humidity reduces the destructive effects of sulfate and swelling.

Janalizadeh Choub Basti [8] studied the stabilization of fine-grained soils by adding microsilica along with lime and cement and the effect of adding microsilica on the geotechnical properties of soil, lime and cement soil mixtures by conducting experiments uniaxial and direct cutting. The obtained results show the great effect of microsils in increasing compressive and shear strength.

[9] investigated the behavior of soil stabilized with lime and microsilica by performing uniaxial compressive strength and consolidation tests. They showed that by adding microsilica, the resistance of samples against freezing and melting increases.

Malik Alizadeh [10] investigated the characteristics of marl soil stabilized with lime and microsilica by performing uniaxial compressive strength and CBR and swelling tests. The results of his research show that adding microsilica to lime-stabilized soil reduces swelling, increases compressive strength, and increases CBR.

2- Research method

In the present research, the soil used to prepare the samples is fine sand with specifications according to table (1), the soil grading chart is presented in figure (1). Additives include type 2 cement produced by Sufian Cement Factory along with microsilica produced by Iran's Ferrosilis Factory, which is used to stabilize fine sand. Also, in percentages of cement and microsilica (relative to the dry weight of sand) for the preparation of samples according to table (2). By performing the standard Proctor compaction test (ASTM D 698-78), the optimal moisture content of samples containing fine sand mixture with different proportions of cement and microsilica has been determined (Table (2)).

Also, the samples tested for uniaxial compressive strength are in the form of cylinders with dimensions of 3.5 x 8 cm, which were prepared by tubular molds with a density of 98%. After curing for 1 and 7 days, these samples were subjected to uniaxial compressive strength test (ASTM D 2166-87).

Figure (1): Soil granulation curve used in the experiments

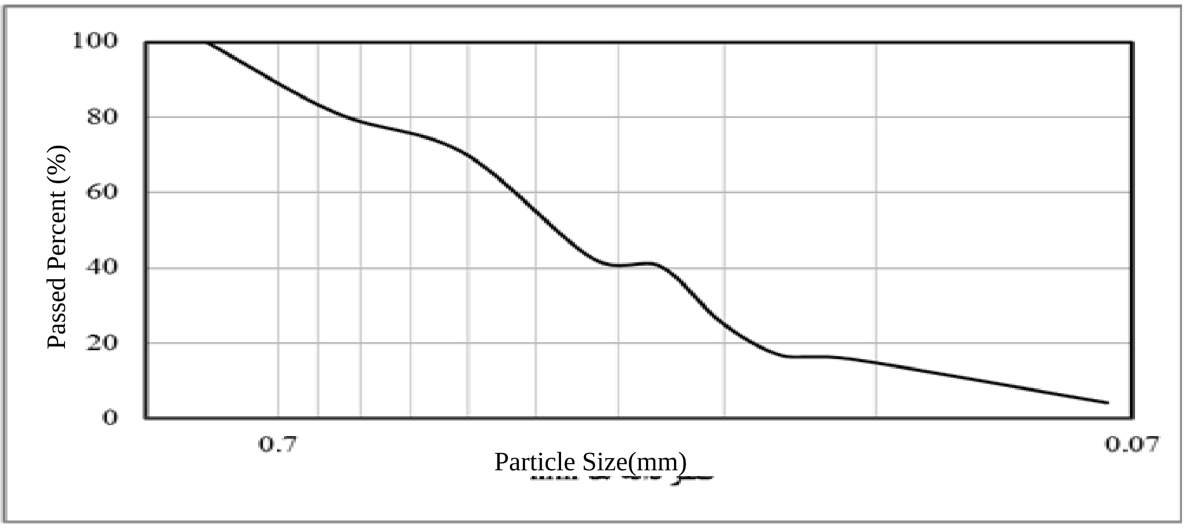


Table (1) characteristics of fine sand used in the experiments

soil name	Cc	Cu	Dmax (mm)	Gs (gr/cm3)	Optimum humidity (%)	γdmax (gr/cm3)
SP	1.4	3.89	0.8	2.66	11.9	1.89

Table (2): ratio of cement, microsilica and optimal moisture percentage of the samples

Optimum humidity (%)	Microsilica ratio (%)	Cement ratio (%)
12.53	0	2
12.74	0.5	2
12.90	1	2
14.13	1.5	2
12.78	0	4
12.98	0.5	4
13.22	1	4
13.47	1.5	4
13.36	0	6
13.56	0.5	6
14.14	1	6
14.48	1.5	6

The cement used in the experiments is type 2, which is a product of Sofian Cement Factory, and also microsilica produced by Iran's Ferrosilis Factory was used.

In order to perform the standard proctor compaction test (ASTM D698-78), mixtures of sand with cement and microsilica additives were prepared and tested in the proportions indicated in table (2). To prepare uniaxial compressive strength test samples (UCS) to create sufficient access of microsilica to cement, first, cement and microsilica were mixed in the proportions according to table (2), then together with soil and optimal humidity inside a mold with a diameter of 3.3 cm meters and height of 8 cm, with a density of 98%, and after two treatments of 1 and 7 days, they were subjected to uniaxial compressive strength test.

3. ***Results and Discussion***

The results related to the current research, which were obtained through the stress-strain diagram of the uniaxial test on the samples, are presented below (Table (3)). In this table, the modulus of elasticity for the rupture stress of 0.4, the modulus of elasticity, E, and the area under the stress-strain diagram up to the rupture stress, has been calculated as absorbed energy.

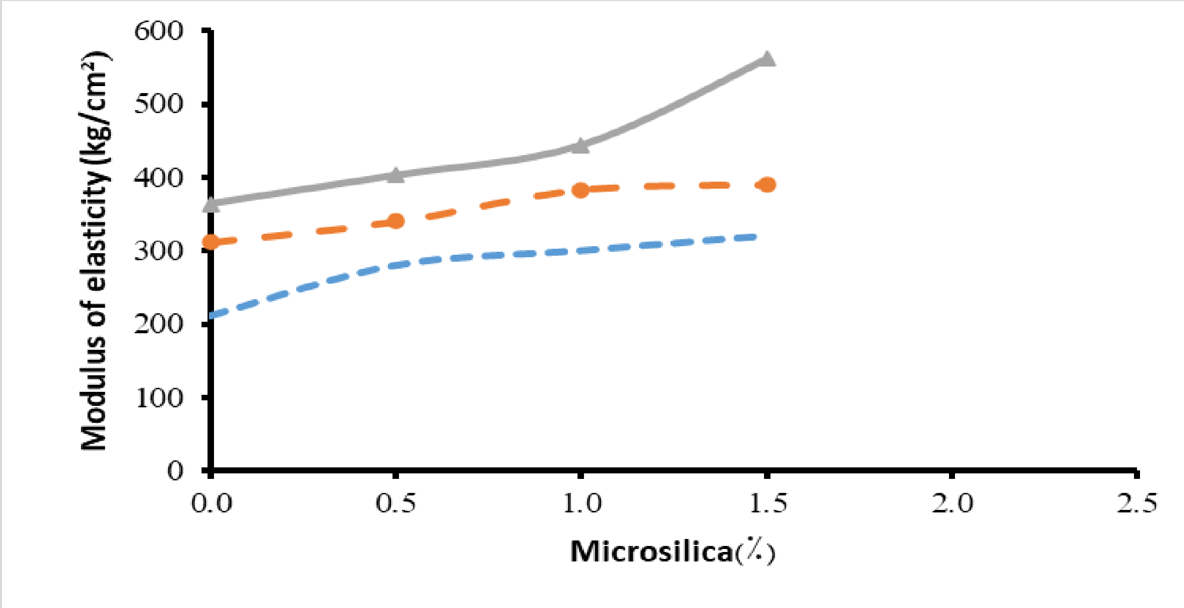
Table (3) modulus of elasticity and absorbed energy of the samples

7days processing			1day processing			Micro silica ratio)%(	cement ratio)%(
Absorbed energy (kg/cm^2)	Modulus of elasticity (kg/cm^2)	Rupture stress (kg/cm^2)	Absorbed energy (kg/cm^2)	Modulus of elasticity (kg/cm^2)	Rupture stress (kg/cm^2)		
0.020	212	2.65	0.018	193	2.12	0	2
0.031	280	3.44	0.026	210	2.57	0.5	
0.044	300	4.90	0.039	191	3.16	1	
0.059	320	5.67	0.031	155	2.82	1.5	
0.056	312	5.88	0.033	207	3.70	0	4
0.103	340	8.22	0.043	2.35	3.95	0.5	
0.115	383	9.20	0.062	272	5.00	1	
0.158	390	11.28	0.062	297	4.93	1.5	
0.059	264	6.82	0.046	245	4.63	0	6
0.114	403	9.89	0.052	263	4.74	0.5	
0.130	444	11.34	0.067	298	5.39	1	
0.176	562	14.07	0.084	370	6.70	1.5	

1.3. *Investigating the effect of increasing the*
1.4. *amount of microsilica on the modulus of elasticity and absorbed energy in fixed sand-cement ratios*

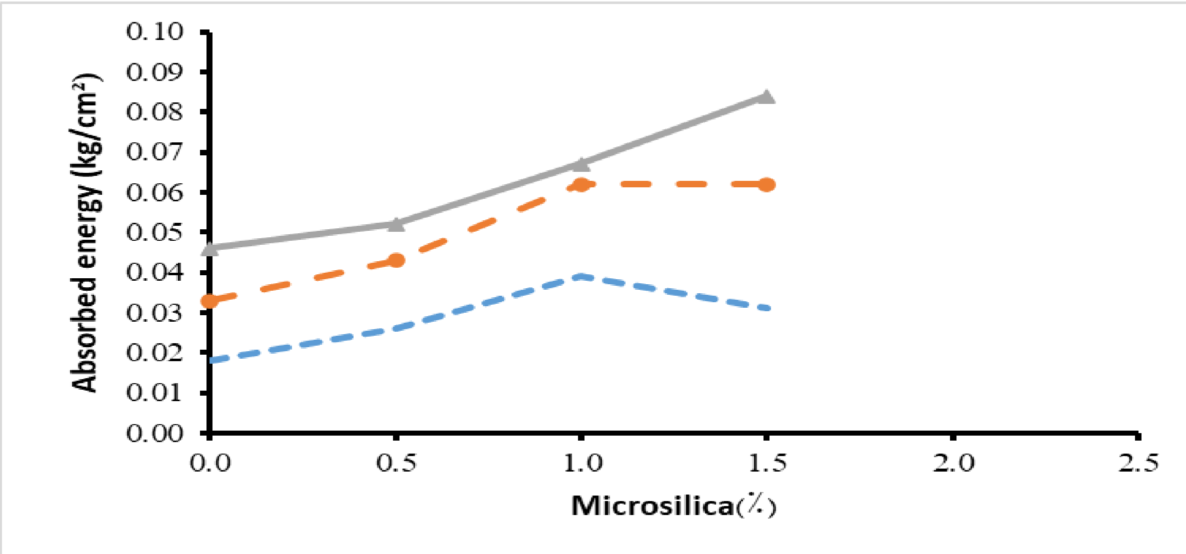
By adding microsilica up to 20% of the weight of cement, pozzolanic reactions occur and this increases the elasticity coefficient of the sand-cement mixture, but with a further increase of microsilica, the excess part of microsilica can only show its filling properties. As a result of the increase in fineness in the samples, this fineness in the vicinity of moisture causes a decrease in the elasticity coefficient. As it can be seen from Figure (2) that in 1-day processing, in the cement percentage of 2%, with the increase of microsilica amount from 0 to 0.5%, the elasticity coefficient increases, but with the further increase of the microsilica amount, the elasticity coefficient increases. decreases.

Figure (3): Modulus of elasticity of sand-cement-microsilica samples with 7-day processing



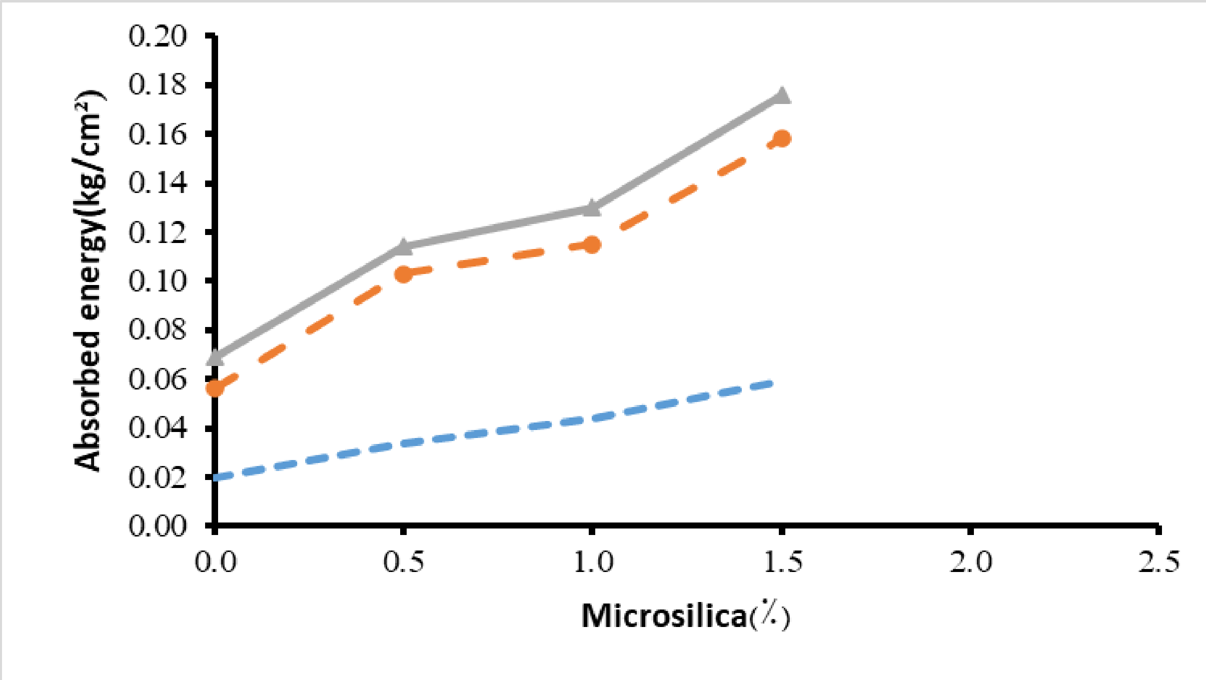
Also, by comparing the energy absorbed by the samples, it can be seen that in 1-day processing in a cement ratio of 2%, the amount of absorbed energy increases by increasing the amount of microsilica up to 1%, but when the amount of microsilica increases more than this amount, The absorbed energy decreases because increasing the amount of microsilica in this ratio of cement only increases the filling property compared to its pozzolanic property. In 4% and 6% cement ratios, unlike 2% cement ratio, with the increase in the amount of microsilica, the absorbed energy has an upward trend (Figure (4)).

Figure (4): Absorbed energy of sand-cement-microsilica samples in 1-day processing



In the 7-day processing, due to the increase in time compared to the 1-day processing, more pozzolanic reaction takes place between cement and microsilica, as well as the increase of microsilica to the amount necessary to perform the pozzolanic reaction with cement (20% of cement weight). also causes an increase in fineness, as a result, the absorbed energy increases (Figure (5)).

Figure (5): Absorbed energy of sand-cement-microsilica samples in 7 days processing



2.3. Investigating the combined effect of curing time and amount of microsilica on modulus of elasticity and absorbed energy in fixed sand-cement ratios.

According to figures (6) to (11) in all proportions of sand, cement and microsilica, with increasing processing time, more reactions between cement and sand and cement and microsilica are provided, which results in an increase in modulus of elasticity and absorbed energy. to be Figure (6) indicates that in samples with a cement ratio of 2% with 1 day curing, with an increase of microsilica more than 0.5%, the modulus of elasticity decreases, also with an increase of microsilica more than 1%, the absorption energy decreases because the increase of excess microsilica required for the pozzolanic reaction only increases fineness. Figures (7) to (11) indicate that in the rest of the cement ratios, the modulus of elasticity and absorbed energy increase with the increase in the amount of microsilica.

Figure (6): Comparison of modulus of elasticity of sand samples containing 2% cement with different amounts of micro-silica and different processing time

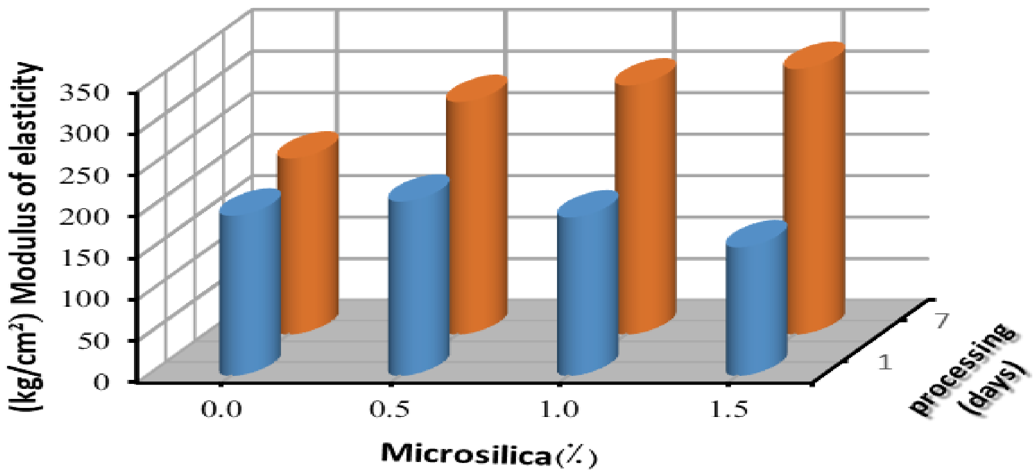


Figure (7): Comparison of modulus of elasticity of sand samples containing 4 percent of cement with different amounts of microsilica and different processing time

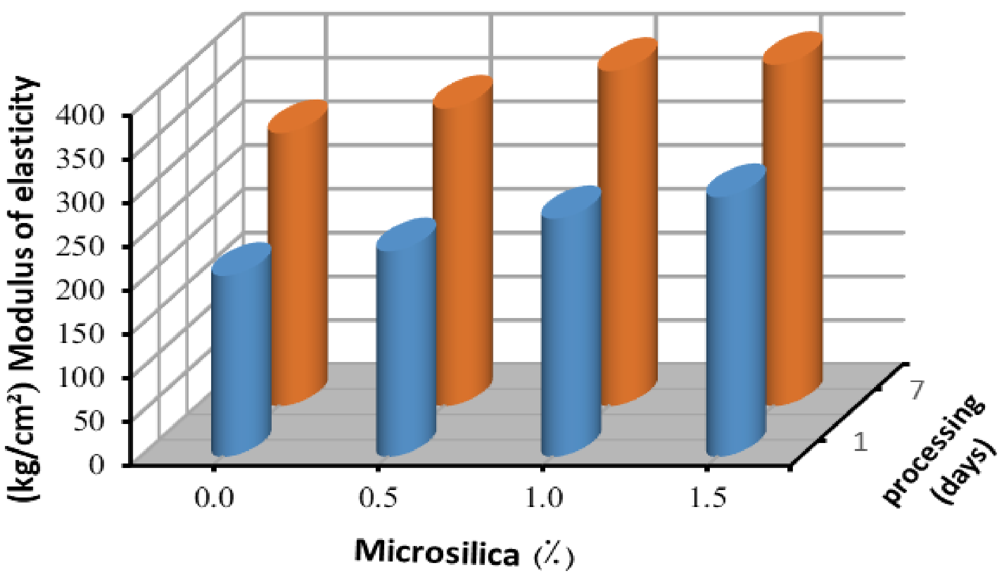


Figure (8): Comparison of modulus of elasticity of sand samples containing 6% cement with different amounts of microsilica and different processing time

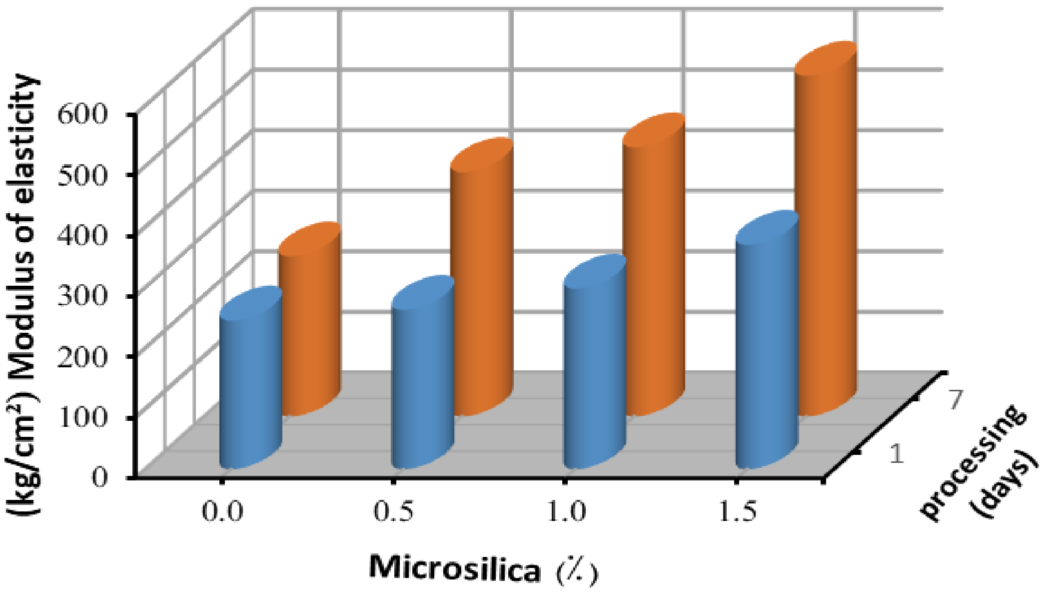


Figure (9): Comparison of absorbed energy of sand samples containing 2% cement with different amounts of microsilica and different processing time

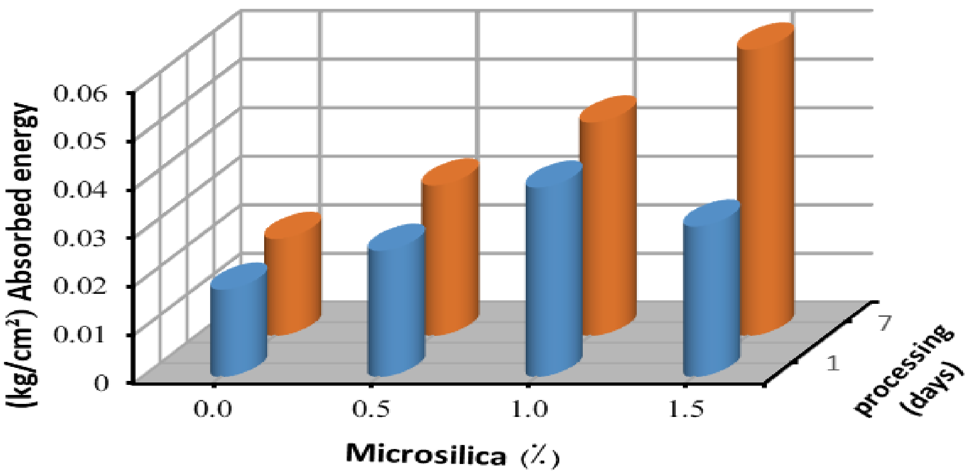


Figure (10): Comparison of absorbed energy of sand samples containing 4% cement with different amounts of microsilica and different processing time

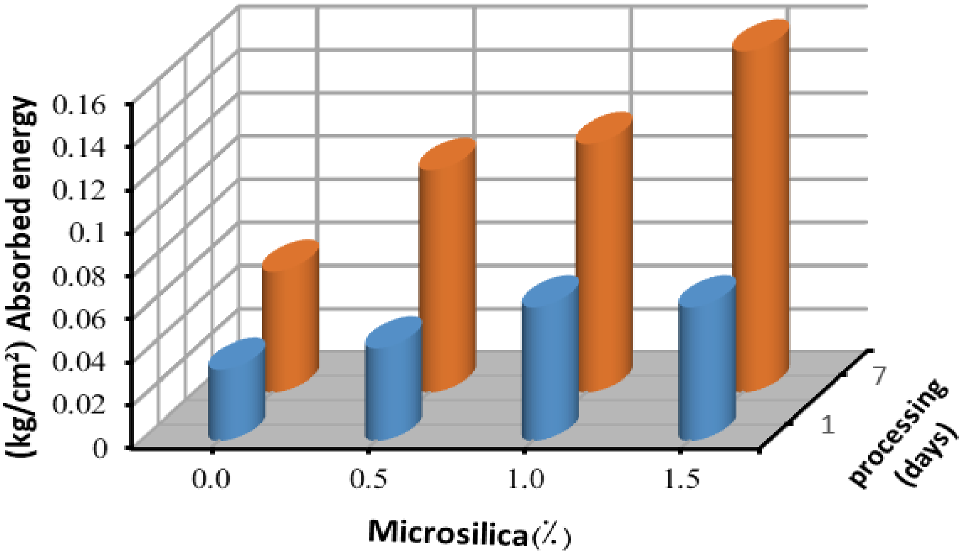
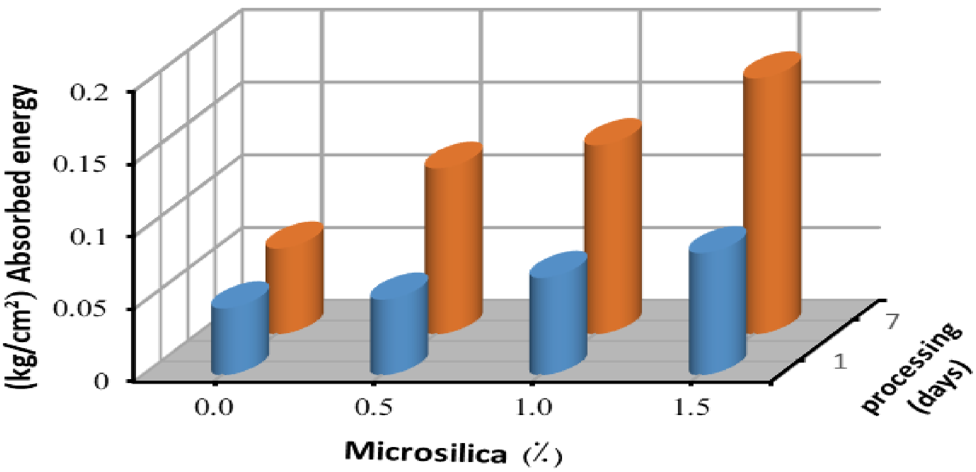


Figure (11): Comparison of absorbed energy of sand samples containing 6% cement with different amounts of microsilica and different processing time



Conclusion

1. In general, according to the conducted experiments, it can be concluded that:

2. In the 1-day processing, by increasing the amount of microsilica to the amount required to carry out the chemical reaction with cement (approximately 20% of cement weight), the modulus of elasticity of the sand-cement-microsilica samples increases, then with the further increase of microsilica, the modulus of elasticity decreases. Find

3. In the 7-day processing, the modulus of elasticity increases with the increase of

microsilica.

4. In 1-day processing for samples with 2 and 4% cement, with the increase of microsilica up to 1%, the absorbed energy increases, then with the further increase of microsilica, the absorbed energy decreases.

5. In the 7-day treatment, the absorbed energy increases with the increase in the amount of microsilica.

6. With increasing processing time, the modulus of elasticity of sand samples with cement and without microsilica increases, the rate of this increase is lower for 2% cement ratio than 4% and 6% cement ratios. The same rate of increase is observed for 4% and 6% cement ratios.

7. As the processing time increases, the modulus of elasticity of sand samples with cement and microsilica increases, the rate of this increase is almost the same for different proportions of cement.

8. As the processing time increases, the absorbed energy of all samples increases. The increase rate of absorbed energy for 2% cement ratio is lower than 4% and 6% cement ratios. For cement ratios of 4% and 6%, the rate of increase is almost the same.

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