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Adding Portland cement as a Stabilizer to Wadan Soil to improve its Properties

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Abstract: The structural properties of soil are of great importance in knowing its behavior when exposed to various loads after construction on it and the degrees of subsidence or shearing. This behavior may change when the soil is exposed to multiple factors that can help reduce its bearing strength. These factors are the chemical compounds the soil contains that can interact with water or dissolve in it and thus cause the soil to weaken between its grains, which causes it leads to its weakness and danger to the structures built on it. Therefore, it is necessary to conduct multiple studies of this soil in order to read the variables that may occur in it.

This study aims to test the extent of soil improvement when adding cement as a stabilizing material, and to determine the economic ratio that gives good soil stabilization results. It is an attempt to shed light, find successful solutions, and achieve a broader understanding of the use of cement as a material to improve soil properties.

The research was based on conducting laboratory experiments (liquidity limit experiment (using the Casagrande device), liquidity limit experiment (cone penetration device), plasticity limit experiment, compaction test, and California loading ratio experiment). This is to study the effect of adding cement on soil properties.

Laboratory experiments were conducted on a soil sample in order to examine it and test its durability and in an attempt to improve its properties by adding cement in different percentages (3%, 5% and 8%), taking into account the economic aspect. In general, the use of cement has improved some of its properties in the soil used. In addition, this material is available and cheap compared to some materials that may be used and may be expensive.

Keywords: Soil, Cement, Wadan, Testing, Construction.

I. INTRODUCTION

Soil is involved in all construction projects, because it is the foundation upon which any construction project is built. Therefore, it has been the subject of interest to researchers and designers, as the science that studies it has witnessed tremendous development. It includes cases of making improvements to the soil, when it is not suitable for the facility that is intended to be built on it. An example of this is in the issue of soil stabilization, where it was observed that soil placed on roads, over time, collapses in the face of the enormous increase in the weight of the machinery that passes over it and with the harsh natural conditions. Therefore, materials were added that improve the performance of the soil when it is exposed to such conditions, provided that it is taking into account the economic factor and the amount of improvement in the soil when adding these materials.

There are many difficulties that hinder the implementation of construction projects, including, for example, the placement of foundation soil, and the implementer may be forced to implement it with soil that needs many improvements, and whose properties are not suitable for the project to be implemented. Suitable alternatives may not be available for the site, so it is necessary to implement the soil by introducing major modifications and improvements in its properties, including, but not limited to, increasing the load capacity in the most extreme site conditions, such as the inhabited condition, for example, as well as avoiding any excessive and unexpected subsidences by increasing compaction and obtaining the maximum density. Reducing the percentage of voids it also increases shear resistance and reduces soil compressibility.

In general, a careful and complete examination of work sites is an essential part of the implementation requirements. Therefore, the complete examination’s primary goal is an attempt to create compatibility between the project, its requirements, and the soil on which it will be implemented without neglecting the economic aspect.

Improving soil properties can be done in several ways, including compaction, drainage, injection, reducing the groundwater level, as well as using artificial fabrics.

Chemicals can be used as materials to improve soil properties, but at the same time they have drawbacks, including their high prices. They have a positive side, which is their low viscosity, as well as the ease of handling and controlling them. Installation with cement and synthetic materials has become more common, especially in the field of road construction.

II. STUDY AREA

The sampling site for the study is located in the city of Wadan in Al-Jufra Governorate, which is an ancient city located at latitude 29.1°, longitude 16.1°, and is about 650 km southeast of the Libyan capital, Tripoli. It is located in the Jufra Depression in the middle of Libya, and Boudan is surrounded by mountain ranges to the northeast and northwest.

The climate of the Jufra Oasis is generally considered a desert climate, where temperatures rise and drought prevails in the summer, and the temperature decreases in the winter, and the average annual temperature is about 30 degrees. On the other hand, the amounts of seasonal rain in that region are small, and in most cases the rain falls rarely, and if it does fall, it causes floods within the valleys in that region, and the quality of the soil in the Wadan region is predominantly dry desert in nature, but parts of it form irrigated agricultural areas of limited area. Its presence is due to the availability of surface well water and running springs. Dunes and sandy soil cover vast areas of the oasis. It is worth noting that the region’s soil is sandy, sometimes mixed with limestone formations, or covered by gravel formations, and often has a rocky layer underneath it, especially when it is located in gravel plains.

TABLE I
SIEVE ANALYSES OF WADAN SOIL

Sieve number (mm)	Reserved weight (gm)	Cumulative reserved ratio (%)	Pass-through ratio (%)
4.57	491.26	9.44	90.56
2	428.65	14.45	85.51
0.85	385.36	20.31	79.69
0.425	341.39	25.28	74.72
0.3	324.38	28.01	71.99
0.15	300.59	36.99	63.01
0.075	301.2	82.55	17.45
pan	282.16	100	0

III. PREVIOUS STUDIES

In 2016, samples of gypsum soil were studied to study their density and properties by adding cement and aggregate. The results proved that it is possible to obtain the highest density by adding 20% of cement or by adding 46% of aggregate [1].

A set of tests such as X-ray fluorescence (XRF) and X-ray diffraction (XRD) were used to determine the chemical compound and morphological composition quantities on three soil samples. The strength of the samples under the influence of cement content in the soil was tested through the California soaked bearing ratio (CBR) test, the unconfined compressive strength test (qu), the third point loading test, and the plate loading test. The results after a period of 28 days showed that with the increase in the percentage of cement in the samples, the modulus of rupture (MR), CBR, and the coefficient of base reaction (K) also increased[2, 3].

On the other hand, tests showed that using different types of cement as soil stabilizers gave positive and satisfactory results, and the best of these results was using Portland cement [4].

A study was conducted in 2011 on soil from two different locations, and a set of experiments were conducted to determine its properties in order to study its behavior and classify it when used as road foundations. After adding a liter of improving material for every 300 liters of water and cement in proportions ranging between 2% and 7% of the weight of the soil used, the bearing capacity increased to approximately seven times compared to the original soil. When time was included in the treatment, it was noted that the endurance capacity increased to about 10-fold after 28 days [5, 6].

On the other hand, two different types of soil samples (clay and sand) were studied by performing a partial replacement process using locally available materials such as limestone powder and Aswan clay, as well as adding an amount of cement at a rate of 8% of the total weight of the mixture.

The results were satisfactory, and this added percentage of cement reduced thermal energy consumption by rates ranging from 5% to 25% compared to other types of mixtures [7, 8 and 6].

Wadan soil is considered a soil widely used in concrete mixes, and after conducting experiments on the mixtures manufactured by adding Wadan soil to them, it gave good and acceptable results, especially after a period of time of treatment [9, 10 and 11].

IV. PRACTICAL ASPECT

After the samples were brought from the specified location, various tests were conducted on them. These tests were the liquidity limit test (using the Casagrande device), the liquidity limit test (using the cone penetration device), the plasticity limit test, the compaction test, and the California loading ratio test this study was tested for the Atterberg limit values following the ASTM D 4318 (1994) test procedure. This was after cement was added in different proportions, which were 0%, 3%, 5%, and 8%, by weight of the soil.

V. DISCUSSION AND CONCLUSIONS

Laboratory experiments were conducted on a soil sample in order to examine it and test its durability, and in an attempt to improve its properties by adding cement in different proportions, taking into account the economic aspect.

TABLE II
THE EFFECT OF DIFFERENT CEMENT RATIOS ON WADAN SOIL SAMPLES

Propertis of soil with different ratio of cement	0%	3%	5%	8%
Ideal humidity %	10.30	14.50	16.20	17
Dry Density gm/cm3	1.94	1.72	1.68	1.62
WL %	21.93	28.15	32.13	34.25
WP%	17.91	NP	NP	NP
Dry CBR	105.57	41.88	83.18	68.38
Sub CBR	41	65	87.08	93.18
Swelling ratio %	0.56	0.15	0.077	0.065
Passing Sieve NO200	16.45	2.925	1.70	1.34

1) The increase in the liquidity limit after adding cement and the proportion between the increase in this limit and the proportions of cement are directly proportional. The increase in the ideal humidity in the curves of compaction experiments in fixed proportions is proportional to the increase in the proportions of cement. The reason for this increase is the voraciousness of cement for water and its need for large quantities of it to complete its hydration and give the required strength.
2) There was a decrease in dry density in constant proportions in both the compaction and California loading experiments. This is due to the increase in coarse materials and the addition of cement clearly, as the cement grains collect around the soil particles to form a rough grain and thus larger voids and a decrease in the density of the soil. Experiments with sieve analysis of samples after adding cement in different proportions confirm this, as a decrease in fine materials passing through inlet No. 200 was observed after adding cement.
3) A decrease in the value of soil-bearing CBR when adding cement in the dry state as a result of what was mentioned in the previous paragraph. However, in general, it can be said that soil loading experiments in the dry state need more experiments to form a conclusion in this aspect.
4) The value of the plastic limit is constant before adding cement, but after adding cement to the soil, there are no plasticity evidence results, that is, the soil after adding (NP), and the reason for this is the increase in coarse materials in the sample.
5) Increasing the value of (CBR) for submerged soil at high rates, and stabilizing the soil can be considered effective in the submerged state because it represents the worst condition of the soil. This is due to the cement grains completing their distinction and thus gaining strength over time. Table No. 3 shows the percentage increase in the submerged CBR values compared to the submerged case without cement.

TABLE III
THE CBR WAS AFFECTED BY INCREASING CEMENT PERCENTAGES.

Cement percentage **%**	Submerged CBR **%**	Percentage of increase **%**
%0	42.98	0
%3	63.84	48.53
%5	87.08	102.61
%8	93.18	102.61

6) Most of the swellings in the submerged sample after adding cement are much less than the swellings before adding cement, due to the lack of soft materials that cause benefit.
7) The economic rate is 5% because it gives great resistance, although the rate of 8% gives greater resistance, but this difference was in very small percentages. What reinforces this is that relevant sources and research confirm that 5% is the appropriate percentage for sandy soil.

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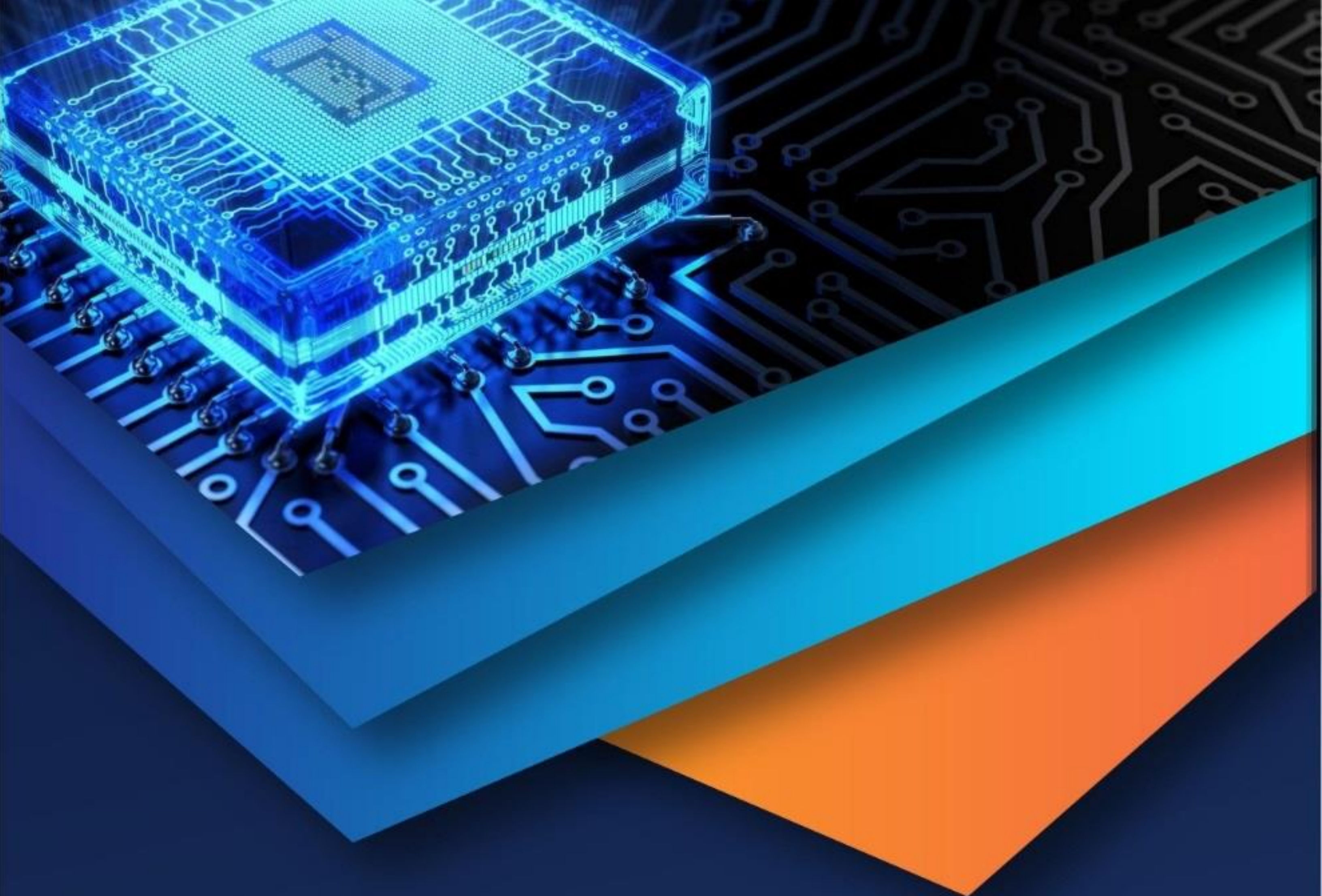

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