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EFFECT OF SOAKING ON THE COMPACTION CHARACTERISTICS OF AL-NAJAF SAND SOIL

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ABSTRACT

The process of salt dissolution is a reason of structure severe deformation by effective settlement. This paper investigates the effect of soaking process on the soil samples from site near the Faculty of Engineering at University of Kufa. Four samples (S1, S2, S3 and S4) were taken from different locations near the selected site. These samples were soaked for two weeks' duration then tested with standard Proctor to estimate the change in the maximum dry density with reference one (natural samples). All samples experience an increase in the maximum dry density and this increase varies from sample to another (1.02, 18.73, 0.1613 and 5.61%) corresponding to the initial conditions of the samples such as water content (2.78, 8.33, 3.733 and 18.4%). The soil is expected, according to this increase in density, to experience an additional settlement upon the soaking, and this settlement increases with increasing the duration of soaking process.

KEYWORDS: Soaking, Al-Najaf, Compaction, Max. dry density, Groundwater.

1. INTRODUCTION

The sulphate and carbonate have main role and interact the stability of the soil structure. There are many geologic activities of groundwater, such as dissolution, chemical cementation and replacement, caves and caverns, sinkholes, and karst topography. Water is the main agent of chemical weathering. Groundwater is an active weathering agent and can leach ions from rock, and, in the case of saltstone and carbonate rocks like limestone, can completely dissolve the rock. If large areas of limestone underground are dissolved by the action of groundwater these cavities can become caves or caverns (caves with many interconnected chambers) once the water table is lowered (Canadian Building Digest).

Jawad and Jabbar, (2006), selected a natural gypseous soil samples with percentages of gypsum of 37% and 56% from Kirkuk city in the north of Iraq. They concluded that the compacted soil specimens at dry side of optimum tend to collapse after soaking with water while soil specimens compacted at wet side of optimum tend to swell for both compactive efforts. The percent of swell of soil with gypsum content of 37% is more than that with gypsum content of 56%.

Al-Sharrad, (2007), experimented samples from Al-Ramadi city soil in west of Iraq and he found a reduction in soil samples weight is continuous as salt leaching continuous and it may be predicted depending on the amount of total leached solids.

Abbas and Muarik, (2012), worked on a free of gypsum sand soil from Baquba city in east of Iraq, then they added four different gypsum percentages (10%, 20%, 30% and 40%). They concluded that the maximum dry density of the soil decreases 13% with increasing gypsum content from 0% to 40%. The increase of gypsum content of the soil increases 10% the optimum moisture content. As expected, increasing in the gypsum content lead to increase the recorded settlement during soaking and leaching process. The settlement obtained from soaking sandy gypsiferous soil is more than from leaching process. The total settlement/width of footing ratios are 0.1–0.18 which are relatively high and means that is a problematic soil.

In Al Najaf, with existence of the soluble contents of different salts in the soil such as sulphate and carbonate (Al-Saoudi and Al-Shakerchy, 2010a). The soil of Najaf is distinguished by the presence of high percentage of gypsum formations due primarily to its location in the arid to semi-arid zones where the high seasonal variation in temperature (Al-Saoudi and Al-Shakerchy, 2010b). There is a decreasing in the shear strength parameters (Φ) of the Al-Najaf city soil when the soil was subjected to the soaking period (Mahmood, 2017).

The soil properties may change with life of the structures. For the soil of Al Najaf city, these properties are changing with existence of the water movement which leaches the dissolved salts and forms voids and caves. Subsurface flow is slower than overland flow but faster than groundwater flow. Water table rises and/or subsurface flow rise to the surface, where along with direct precipitation, it forms overland flow (Al Abidi and Al Shakerchy, 2008).

From the above review, there is a fact that water is an important agent in process of dissolution of soil salts and makes alterations in soil properties. In this paper, the effect of the soil soaking on the characteristics of the laboratory soil compaction was investigated. Soil samples from Al-Najaf sand soil near the faculty of engineering at the University of Kufa.

2. METHODS AND MATERIALS

2.1. Methods

Four disturbed soil samples (S1, S2, S3 and S4) were taken from three locations near to the Civil Engineering Department at the Faculty of Engineering at Kufa University. Each sample weighs 50 kg divided into two parts, first for natural soil tests, and the second part being soaked in water for two weeks then tested with standard Proctor test. The purpose of this study is to study the effect of the soil on water exposure. The tests were performed at the Soil Mechanics Laboratory of the University of Kufa.

2.2. Location of the Site

The soil samples are at location near the Faculty of Engineering at University of Kufa. University of Kufa is on the border of Al-Najaf and Kufa cities and these cities are within Al-Najaf province. Al-Najaf is located in the middle part of Iraq.

2.3. Materials

Fig. 1 shows the results of sieve analysis tests of the four natural soil samples. The soil samples are classified according to USCS as SW-SM, SW-SM, SP and SW respectively. To investigate the correlation of the soil types of the samples, Table 3 correlates the soil particle sizes for the different soil samples. These correlation factors indicate that all samples are in similar soil size components with high values (minimum 0.991).

Table 3. Correlation Analysis for the Soil Particles Components.

	S1	S2	S3	S4
S1	1			
S2	0.995	1		
S3	0.989	0.997	1	
S4	0.991	0.997	0.996	1

Fig. 2 illustrates the results of the Standard Proctor tests for the samples. The maximum dry densities of the soil samples are 1.96, 1.505, 1.86 and 1.88 gm/cm^3 respectively and all values are within 5-10% air content with specific gravity (Gs) of 2.65. Table 1 summarizes the tests results of the samples. One can notice that there are different values of max. dry density and different O.M.C. from Proctor tests on the soil samples in spite of the semi similar gradation of the four soil samples. This may be caused by the initial water content and effect of salts content.

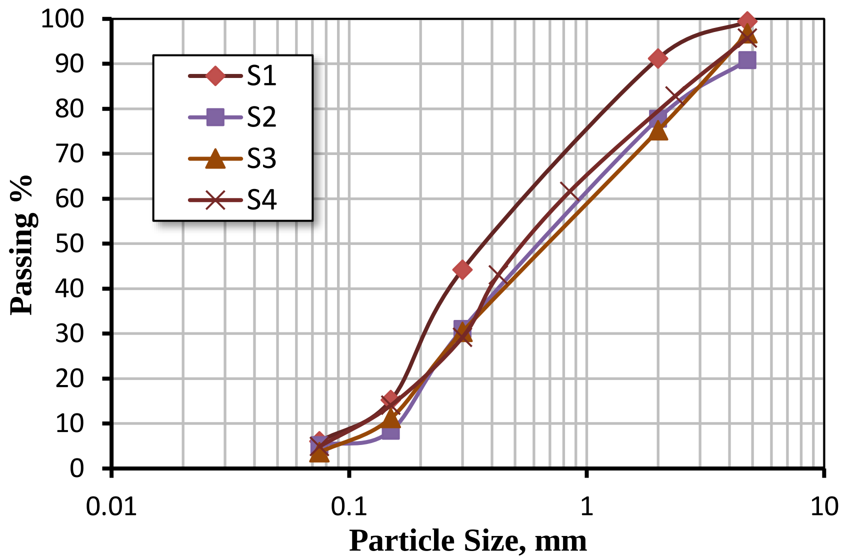


Fig. 1. The Sieve Analysis Results of the Four Soil Samples.

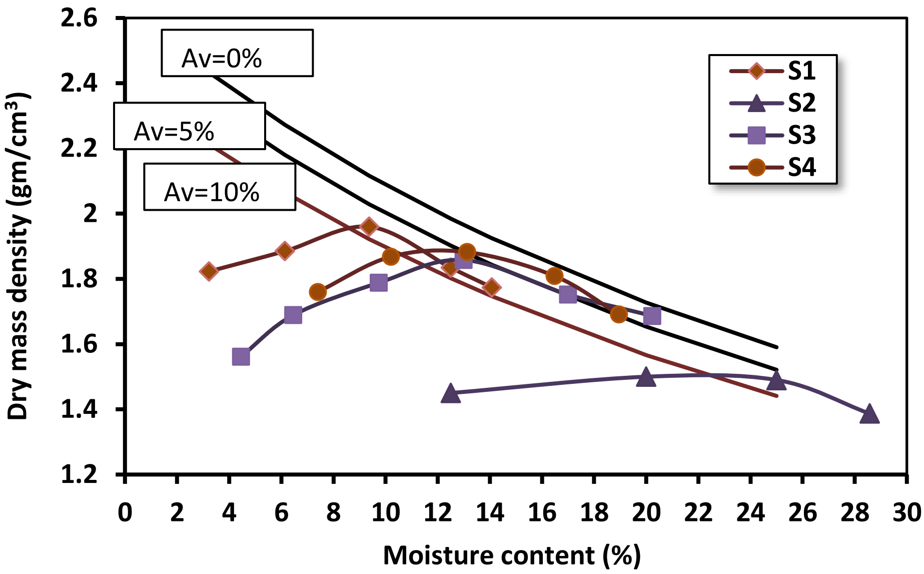


Fig. 2. The results of Standard Proctor Tests for the Four Soil Samples.

Table 1. Summarized Properties of the Four Soil Samples in Natural Situation.

Sample	Initial Water Content, %	Soil Classification	Coarse Grained, %	Fine Grained, %	ρd Max. gm/cm3	O.M.C., %
S1	2.78	SW-SM	94	6	1.96	9.375
S2	8.33	SW-SM	94.8	5.2	1.505	25
S3	3.733	SP	96.4	3.6	1.86	13
S4	18.40	SW	95.12	4.88	1.888	12.27

3. RESULTS AND DISCUSSION

3.1. For Sample #1

Fig. 3 shows the results of the standard Proctor test for the sample #1 before and after soaking for two weeks. After soaking, ρdmax slightly increased to 1.98 gm/cm3 and OMC increased slightly to 10.3%, and still the ρdmax within 5% -10% air content. Corresponding to the results of the reference sample (natural), there is an increase with 1.02% in ρdmax and increasing in OMC with 9.8%.

Low initial water content (2.78%) may be the reason of the small increase in max dry density and may needs more soaking duration (more than 2-weeks) to show significant increasing. Also, this statement can be extending to the OMC.

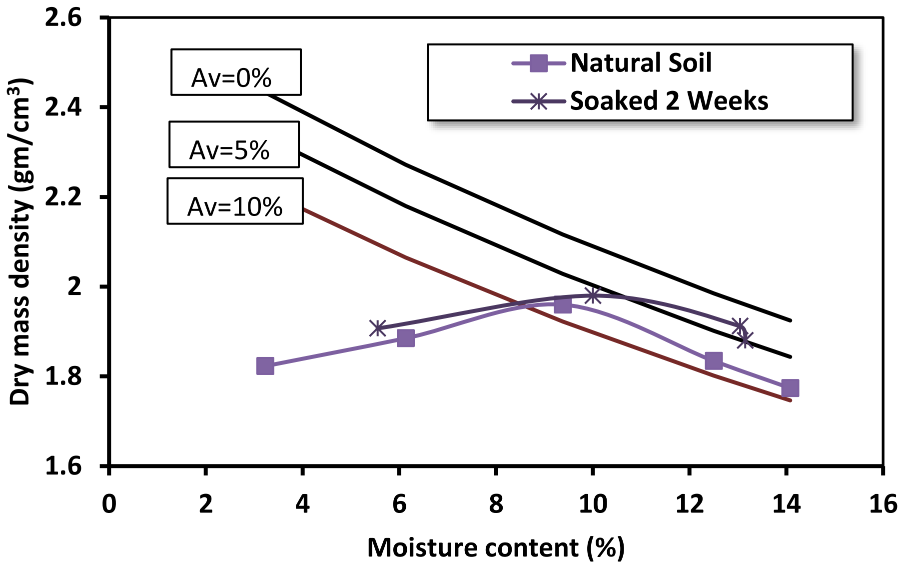


Fig. 3. Standard Proctor Tests of the Natural and Soaked Soil Sample #1.

3.2. For Sample #2

Similar to sample #1, Fig. 4 presents the results of the standard Proctor test for the sample #1 before and after soaking for two weeks. Frequently, after two weeks soaking, the density obviously increased to 1.787 gm/cm^3 and OMC noticeably decreased to 14%, and the max. density between 5% -10% air content. The percentage change of 18.73% in max. dry density while the OMC decreases with 44% related to the reference sample (natural).

The initial water content (8.33%) may have a share in the case of increasing the max dry density vice versa in sample #1. For the OMC, the trend of changing is radical and it is, also, correlated to the wc(i).

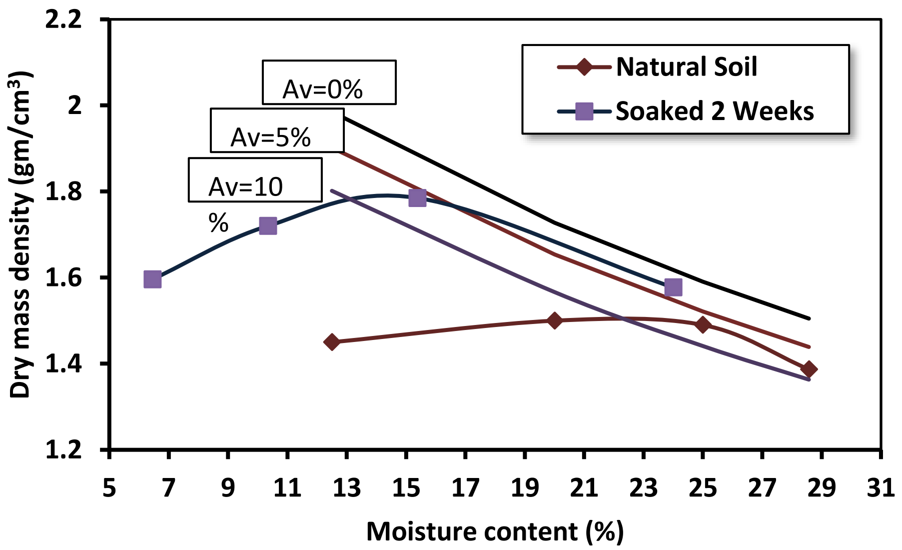


Fig. 4. Standard Proctor Tests of the Natural and Soaked Soil Sample #2.

3.3. For Sample #3

As for samples 1 and 2, Fig. 5 illustrates the results of the standard Proctor test for the sample 3 before and after soaking for two weeks. There is a little increase in max. dry density after soaking to 1.863 gm/cm^3 and the OMC decreased to 12.68% and the percentage change of 0.16% and -2.46% respectively related to the natural one (reference).

The initial water content is low (3.73%) relates to the OMC in both before and after soaking process. This case may cause a little increase in max dry density, as in sample #1, and may increase with increasing the soaking duration (more than 2-weeks) leads to more increasing in the density. As in sample #1, the OMC changed lightly and for same reason (low wc(i)).

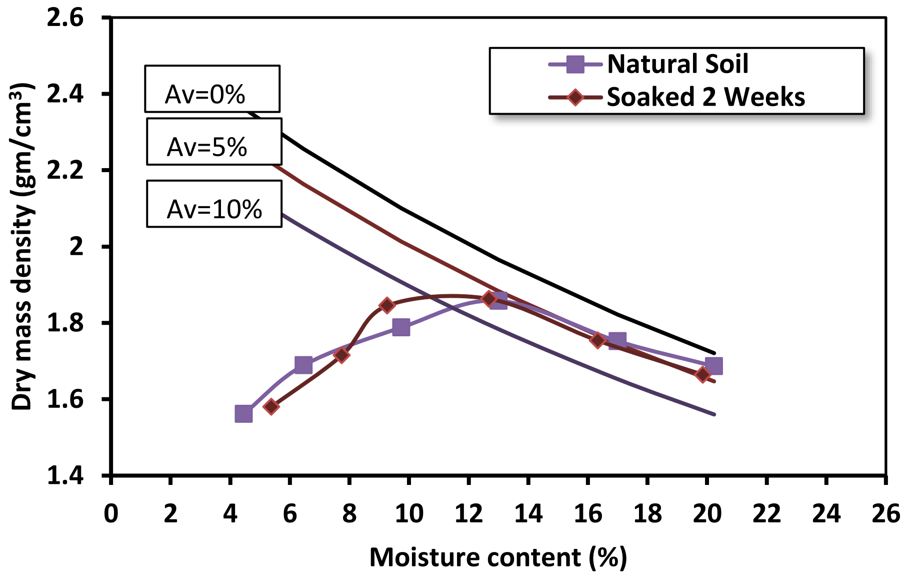


Fig. 5. Standard Proctor Tests of the Natural and Soaked Soil Sample #3.

3.4. For Sample #4

Fig. 6 shows the results of the standard Proctor test for the sample #4 before and after two weeks soaking. There is a clear increase in max. dry density after soaking to 1.994 gm/cm^3 and the OMC decreased to about 8%. The density, as in natural sample, within 5%-10% air void. The percentage change of 5.6% and -34.7% respectively associated to the reference one (natural).

Both OMCs (before and after soaking) are less than the initial water content (18.4%), i.e., the soil was under soaking process in natural situation. This situation may lead to the increase of max dry density in addition to the process of 2-weeks soaking. As in sample #2, the OMC changed but with a trend less than in sample #2.

3.5. Summary of the Results

Fig. 7 presents the results of the Proctor tests for the different soil samples after 2-weeks soaking process. One can notice that all curves under the curve of 0% air void and within 5-10% air void.

All samples demonstrate an increase in maximum dry density (MDD) after the process of 2-weeks soaking. This increasing is different from sample to another and this condition may be caused by effect of the initial condition of the sample, such as, natural water content (wc (i)) and salts content. Fig. 8a shows the change of max. dry density before and after soaking process. Fig. 8b reveals that the maximum change in the sample #2 (18.7%) then sample #4 with change percentage of 5.6%. Vice versa, the sample #3 indicates the smallest change in the max. dry density. Figs. 9a and 9b illustrate the change in the OMC for the different samples and percentage change in OMC respectively. The results in Fig. 9 meet the conclusions in Fig. 8, where the maximum OMC percentage change (-44% and -34.7%) corresponding to the highest MDD and these results correlate to the highest initial water content (8.33% and 18.4%).

The increasing in the density of the soil let us realize that the soil will experience additional settlement upon the soaking process of the soil.

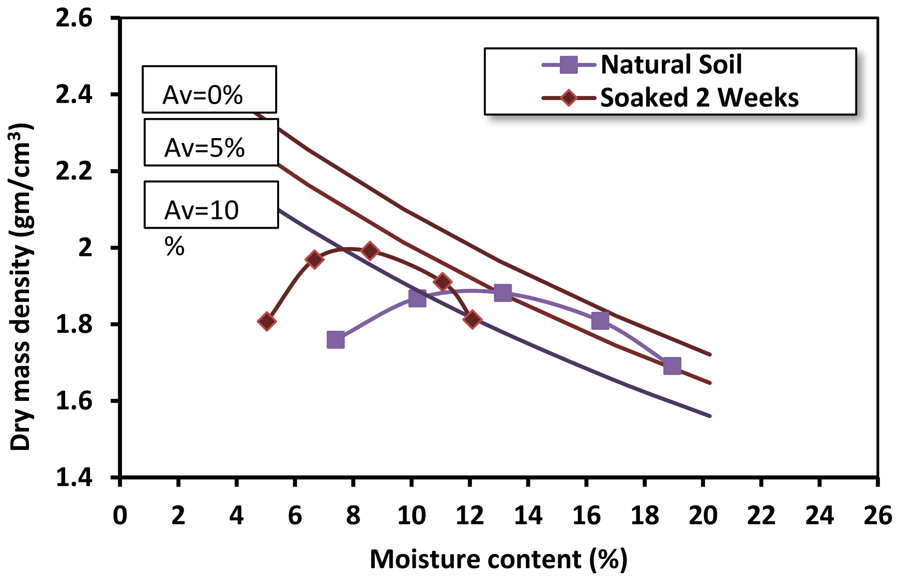


Fig. 6. Standard Proctor Tests of the Natural and Soaked Soil Sample #4.

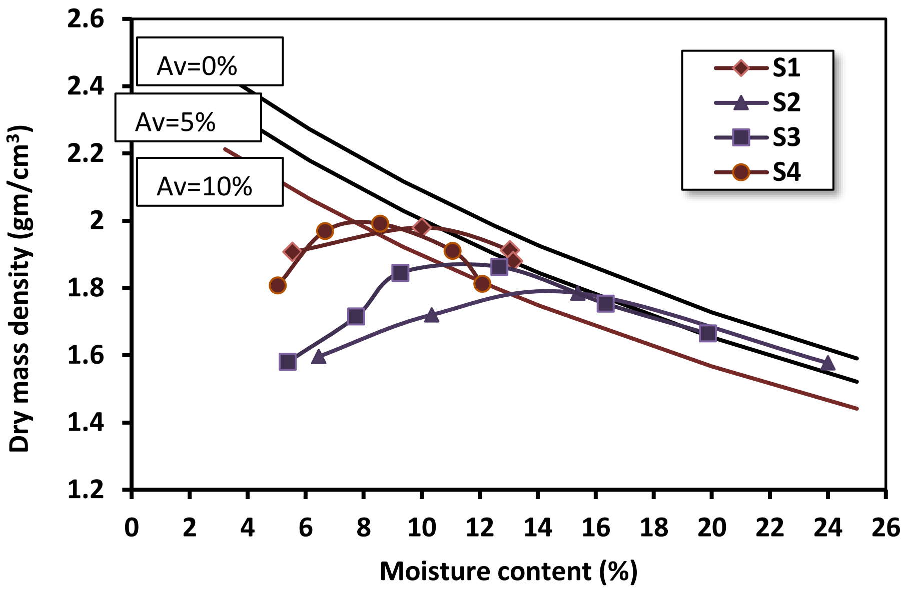


Fig. 7. Standard Proctor Tests of the Natural and Soaked Soil for All Sample.

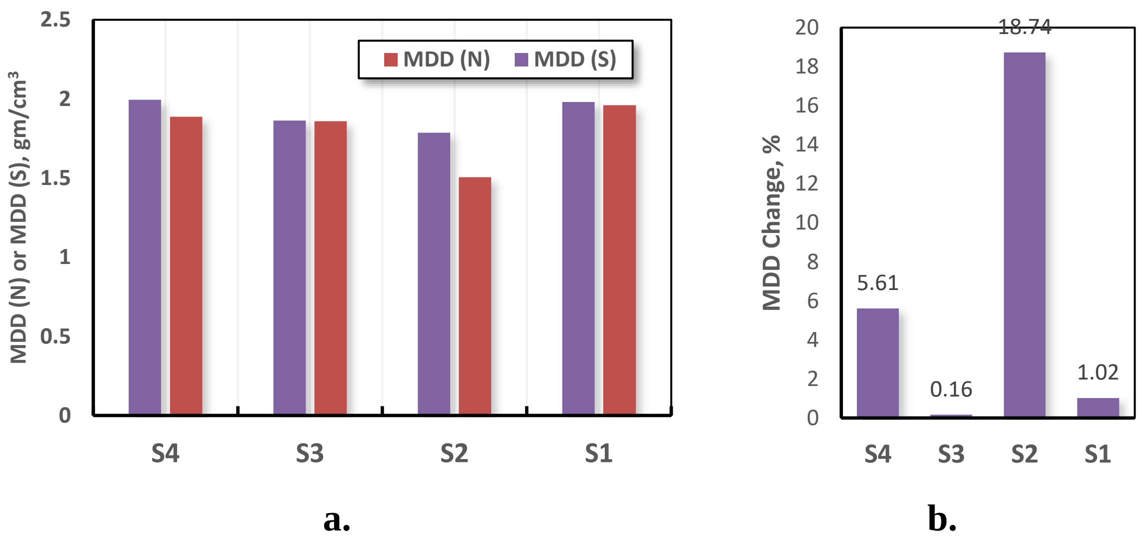
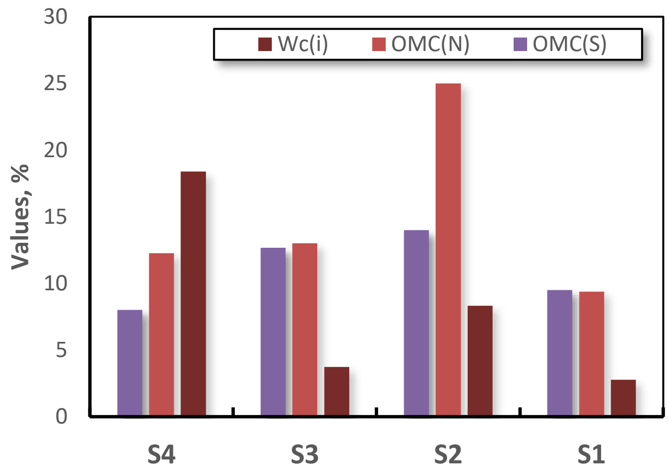


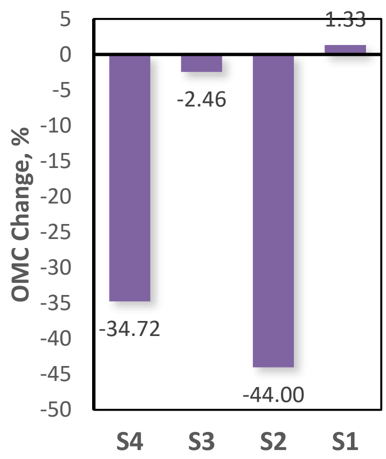
Fig. 8. The Change of Dry Density for the Different Samples, a. Comparison of MDD, b. Percentage Change of MDD.

3.6. Correlation-Based Analysis

To examine the correlation of the different compaction characteristics, Table 4 presents the correlation factors for the MDD and OMC before and after soaking process from different tests and soil samples (S1, S2, S3 and S4). One can notice that there is high correlation for the MDD(N) with MDD(S), %change(MDD) and OMC(N). there is good correlation for the MDD(N) with OMC(S) and %change(OMC). The MDD(S) can be correlated to the OMC(N) and OMC(S). So, the initial max. dry and optimum moisture content have great effect on the results of compactions tests after soaking process.



a.



b.

Fig. 9. The Change of Moisture Content for the Different Samples, a. Comparison OMC with Initial Water Content, b. Percentage Change in OMC.

Table 4. Correlation Analysis for the Different Tests and Soil Samples.

	MDD (N) gm/cm^3	**MDD (S) gm/cm^3**	**% Change (MDD)**	**OMC (N) %**	**OMC (S) %**	**% Change (OMC)**
MDD (N), gm/cm^3	1					
MDD (S), gm/cm^3	0.866	1				
% Change (MDD)	0.945	0.656	1			
OMC (N), %	0.999	0.861	0.947	1		
OMC (S), %	0.763	0.980	0.519	0.754	1	
% Change (OMC)	0.738	0.354	0.868	0.752	0.161	1

4. CONCLUSIONS

From the research work, it can be concluded that there is an increasing in the MDD(N) from standard Proctor compaction test after a soaking process for two weeks. This increase varies from sample to another corresponding to the initial condition, such as, water content (wc(i)). The low wc(i) (3.73% & 2.78%) shows a slight increase in MDD(S) (0.16% & 1.02%), while the high wc(i) (18.4% & 8.33%) illustrate obvious increase in the MDD(S) (5.61% & 18.74%) and this may be donated to the soaking process duration.

The soil is expected, according to increase in MDD, to experience an additional settlement upon the soaking, and this settlement increases with increasing the duration of soaking process.

5. AKNOWLEDMENT

I would like to thank the staff of the Soil Mechanics laboratory in the University of Kufa for their help to perform the required tests.

6. SYMBOLS

MDD(N)	: Maximum dry density for natural soil samples;
MDD(S)	: Maximum dry density for soaked soil samples;
OMC(N)	: Optimum moisture content for natural soil samples;
OMC(S)	: Optimum moisture content for soaked soil samples;
$W_C(i)$	: Initial water content
% Change(MDD)	: Percentage Change in Max. Dry Density.
% Change(OMC)	: Percentage Change in Optimum Moisture Content.

7. REFERENCES

Abbas, H. O. and Muarik, S. M., 2012, Behavior of compacted gypsiferous sandy Soil during soaking and leaching process, Journal of Wassit for Science & Medicine, ISSN: 58161992, Wassit University, Vol. 5, No. 1, pp. 165-176. URL: http://iasj.net/iasj?func=fulltext&aId=51982

Al Abidi, A. J. and Al Shakerchy, M. Sh., 2008, Groundwater in Al Najaf City and Its Engineering Problems, First Scientific Conference for Pure and Applied Sciences, University of Kufa, Al Najaf, Iraq. pp. 137-144.

Al-Jorany, A. N., Al-Shakarchi, Y. J. and Karkush, M. O., 2008, Leaching Behavior of Gypseous Soils, Journal of Engineering, ISSN: 17264073, Baghdad University, Vol. 14, No. 4, pp. 3077-3089. URL: http://iasj.net/iasj?func=fulltext&aId=24139

Al-Mufty, A. A., 1997, Effect of Gypsum Dissolution on The Mechanical Behaviour of Gypseous Soils, Ph. D. Thesis, Civil Engineering Department, College of Engineering, University of Baghdad.

Al-Sharrad, M. A. A., 2007, Leaching Effects On Some Properties of Sandy Gypseous Soils, Iraqi Journal of Civil Engineering, ISSN: 74281992, Al-Anbar University, Vol. 8, pp. 79-89. URL: http://iasj.net/iasj?func=fulltext&aId=14142

Al-Saoudi, N. K. S. and Al-Shakerchy, M. Sh. M., 2010a, Statistical Analysis of Some Geotechnical Properties of Najaf City, Proceedings of International Geotechnical Conference, 7-10 June 2010, Moscow, Russia, Vol. 3, pp. 1173-1180. URL: http://geo-bookstore.ru/files/2010-Msk_Volume-3.pdf

Al Saoudi, N. K. S. and Al Shakerchy, M. Sh. M., 2010b, Water Infiltration Characteristics of Al Najaf City Soil, Proceeding of the 4th International Conference on Geotechnical Engineering and Soil Mechanics, November 2-3, 2010, Tehran, Iran, Paper No. 524. URL:http://www.civilica.com/EnPaper-ICGESM04-ICGESM04_263.html

Al-Shakarchi, Y. J. and Jabbar, M. A. , 2006, Effect Of Compaction On The Behaviour Of Kirkuk Gypseous Soil, Journal of Engineering, ISSN: 17264073, Baghdad University, Vol. 12, No. 4, pp. 998-1018. URL: http://iasj.net/iasj?func=fulltext&aId=24187

Canadian Building Digest , http://irc.nrc-cnrc.gc.ca/pubs/cbd.

Mahdi, B. O., 2004, Some Aspects of Gypseous Soil of the Middle Part of Iraq, Ph. D. Thesis,

Mahmood, Mohammed Shaker, 2017, Effect of Time-Based Soaking on Shear Strength Parameters of Sand Soils, Applied Research Journal, 3(5), pp. 142-149, Islamic Azad University, Arak, Iran.