Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 54(9) (2022) 663-666
DOI: 10.22060/ceej.2022.20439.7433

Under-compaction method for sample preparation of Boushehr carbonated silty sand

E. Ghanbari Alamouti, R. Ziaie Moayed*, S. A. Naeini

Department of Geotechnical Engineering, Faculty of Engineering, Imam Khomeini International University, Qazvin, Iran

ABSTRACT: Because of the impact of the void ratio parameter on liquefaction and static strength of sandy soils, the preparation of samples which are homogenous in their heights in monotonic and cyclic triaxial tests is an important issue. The under-compaction method is an extended preparation method of wet tamping that is a suitable procedure to make homogenous sandy soil with fines. In this research, the under-compaction method is used in order to prepare samples of carbonated silty sand from Boushehr port and a method called injection of gelatin solution is used to control the homogeneity of samples. In order to investigate the effect of silt content on the homogeneity of prepared samples, Boushehr carbonated sand is mixed with silt percent of 0 to 40%, and gelatin solution is injected into the samples. Results show that samples prepared with the under-compaction method are homogenous, also the variation of silt content, changes the parameter of reduced compaction percent of the first layer (Un). In silt percents 0 to 20%, the Un parameter is limited to 4 and 6%, and in silt percent of 30 to 40%, the Un parameter is obtained 6 and 8%. It can be concluded that in silt percent of 0, 10 and 20%, inter-granular voids of sandy soil are filled with silt particles, thus the first layer is compacted close to the desired density, and the final compacted sample is more homogenous than the samples with higher percent of silt.

Review History:

Received: Aug. 24,2021
Revised: Jan. 04, 2022
Accepted: Feb. 08, 2022
Available Online: Feb. 21, 2022

Keywords:

Carbonated silty sand
Gelatin injection method
Under-compaction method
Silt content
Homogenous sample

1- Introduction

There are many different sample preparation methods that are used in loose sandy soils with or without fines. Some of the popular methods are wet tamping, dry deposition, dry air pluviation, water pluviation, water sedimentation and under-compaction. Under-compaction method is an extended method of the wet tamping method by Ladd [1] which is said that produce homogenous samples3 ,2]]. In this method, underneath layers are compacted in density less than desired density, and compaction of upper layers causes underneath layers to be compacted and reach the desired density. It can be said that water pluviation and water sedimentation cannot provide a homogenous sample because of their specific way of sample preparation[1, 2]. Furthermore, the dry air pluviation method produces less homogenous sample than the under-compaction method from stiffness and strong point of view4 ,2]].

The behavior of carbonated sandy soils has been investigated in many types of research [5-11], in which sample preparation method of dry air pluviation and wet tamping were used. Among previous researches, the behavior of carbonated sand with the presence of fines has not been investigated, also studying of homogeneity of these soils in different sample preparation method is not observed among previous researches. In this research, using the gelatin injection method in Boushehr carbonated silty sand, the homogeneity of prepared samples is investigated with different reduced compaction parameter Un and silt content. The optimal Un parameter is obtained in samples with similar silt content in order to provide homogenous samples.

2- Materials and method

In this research, Boushehr carbonated silty sand, which contains 72.5% calcium carbonate in the test based on BS1377 [12], is used. Silty sand is taken from the field which has 10 to 40% silt content, so the silt is separated from sand with wet sieving method and then silt content is added to the sand with weight percent of 0, 10, 20, 30 and 40%.

In the under-compaction method, when preparing the sample, the density of each compacted layer is reduced and the parameter of reduced compaction is shown with Un_i in each layer which has been defined in [1] and is given in eq. 1. In this equation, Un_1 is the reduced compaction parameter of the first layer at the bottom, Un_t is the reduced compaction Parameter for the last layer at the top.

*Corresponding author’s email: ziaie@eng.ikiu.ac.ir

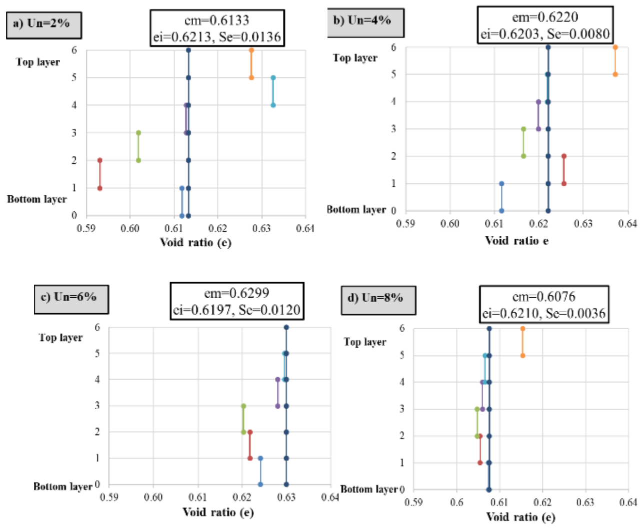

Fig. 1. Variations of void ratio through sample layers of sandy soil and reduced compaction percent of a) 2%, b) 4%, c) 6%, d) 8%

$$U_{ni} = U_{n1} - \left[\frac{U_{n1} - U_{nt}}{n_t - 1} \times (n_i - 1) \right] \quad (1)$$

In this research Un parameter for the first layer (which is shown instead of Un_1 hereafter) is selected 2, 4, 6 and 8% with some trial and errors. Layer thickness should not be more than 25 mm, which is taken 1.667 cm with 6 layers. Compaction height from the top and the wet weight needed for every layer is selected based on the equation given in [13]. The samples are prepared in a split-mold with 5 cm diameter and 10cm height and they are compacted with a hammer with diameter of 3.3 cm through under-compaction method. Then gelatin solution of 2% is injected through sample with injection pressure of 10 to 15 kPa, the sample is preserved in the refrigerator for 24 hours. Afterward, the sample is cut into 6 equal layers, diameter and height of which is measured and then is taken into the oven for 24 hours. After that dry weight of soil in each layer and volume of that is estimated in order to obtain the void ratio of each layer named ej. The average void ratio of layers through a sample can be obtained (em). The initial void ratio of each sample before injection is estimated through the volume of mold and the dry weight of soil is poured into the mold. In order to compare the void ratio of layers with the average void ratio, the standard deviation as given in equation 2 is determined for each sample.

$$S_e = \left[\frac{\sum (e_m - e_j)^2}{n_t} \right]^{0.5} \quad (2)$$

Table 1. Summary of initial and average void ratio and standard deviation of void ratios from average amounts in optimal Un

Soil type	Soil properties OptimalUn%	e_i	e_m	S_e
Pure sand	4	0/6200	0/6220	0/0080
Sand with 10% silt	6	0/6410	0/6350	0/0091
Sand with 20% silt	4	0/6720	0/6730	0/0109
Sand with 30% silt	6	0/7120	0/6810	0/0129
Sand with 40% silt	8	0/7650	0/7650	0/0120

3- Results and Discussion

Results of void ratio in each layer of a sample ej via layer numbers (0 to 1 is for the first layer at the bottom and 5 to 6 is for the last layer at the top) with Un=2, 4, 6 and 8%, in sandy soil are shown in Figure 1. Also, e_m is shown with a vertical line on each graph. S_e and e_i is written in a box above each graph. With lesser amounts of s_e it can be seen that the amounts of e_i are closer to e_m so the lines of void ratio of each layer are getting closer to the vertical line in each graph. Hence the least amount of s_e obtained among different U_n, shows the most homogeneous sample in that specific U_n which is called optimal Un. It can be seen from Figure 1 that s_e is decreasing with increase of U_n and then increasing with increasing of U_n. This result is in accordance with the results of [13].

The summary of results of other samples (silty sand samples) with e_m and e_i and s_e in optimal U_n is shown in Table 1. It can be seen that optimal U_n is variable with silt content. With silt content of 10 and 20% s_e has a little amount but with increasing in silt content s_e increases. This is due to substituting silt particles between sand voids up to 20% silt which contributes to better compaction of layers and more homogeneous sample. Also with increasing silt content, U_n increases from 4% in sandy soil up to 8% in sand with 40% silt. This is because of silt particles which dominate the sample with 30% and 40% silt and prevents them from getting compacted easily compared to sand with lesser amounts of silt (0 to 20%).

4- Conclusions

Results of this research are given below:

Generally, in samples with similar silt content, with increasing in U_n, s_e decreases up to a specified U_n (optimal U_n) wherein s_e gets the minimum value after that s_e increases with increasing U_n.

In silt content of 0 to 20% Un is limited to 4 and 6% and with silt content of 30 and 40% this parameter increases to 6 and 8%. Also in silt content of 0 to 20%, s_e is less than 0.01, with increasing in silt content this parameter increases up to 0.013. This represents that silt particles are substituting with sand particles voids in silt content of 0 to 20% which contributes to better compaction and more efficiency of under-compaction method and also produces more homogeneous samples.

References

[1] R. Ladd, Preparing test specimens using undercompaction, Geotechnical testing journal, 1(1) (1978) 16-23.

[2] S.A. Naeini, M.H. Baziar, Effect of sample preparation on steady state, in: Geotechnical Measurements: Lab and Field, 2000, pp. 16-29.

[3] J. Shi, W. Haegeman, V. Cnudde, Anisotropic small-strain stiffness of calcareous sand affected by sample preparation, particle characteristic and gradation, Géotechnique, 71(4) (2021) 305-319.

[4] Y. Jafarian, I. Towhata, M. Baziar, A. Noorzad, A. Bahmanpour, Strain energy based evaluation of liquefaction and residual pore water pressure in sands using cyclic torsional shear experiments, Soil Dynamics and Earthquake Engineering, 35 (2012) 13-28.

[5] Y. Jafarian, H. Javdanian, A. Haddad, Strain-dependent dynamic properties of Bushehr siliceous-carbonate sand: experimental and comparative study, Soil Dynamics and Earthquake Engineering, 107 (2018) 339-349.

[6] J. Shi, W. Haegeman, J. Andries, Investigation on the mechanical properties of a calcareous sand: the role of initial fabric, Marine Georesources and Geotechnology, (2020) DOI:10.1080/1064119X.1062020.1775327.

[7] H. Shahnazari, R. Rezvani, M.A. Tutunchian, Post-cyclic volumetric strain of calcareous sand using hollow cylindrical torsional shear tests, Soil Dynamics and Earthquake Engineering, 124 (2019) 162-171.

[8] X.-Z. Wang, Y.-Y. Jiao, R. Wang, M.-J. Hu, Q.-S. Meng, F.-Y. Tan, Engineering characteristics of the calcareous sand in Nansha Islands, South China Sea, Engineering geology, 120(1-4) (2011) 40-47.

[9] Y. Xiao, Z. Yuan, C.S. Desai, M. Zaman, Q. Ma, Q. Chen, H. Liu, Effects of load duaration and stress level on deformation and particle breakage of carbonate sands, International Journal of Geomechanics, 20(7) (2020) 06020014-06020019.

[10] A. Sadrekarimi, Evaluating the liquefaction and reliquefaction behavior of a carbonate sand, (2017).

[11] S. Kargar, H. Shahnazari, H. Salehzadeh, Post-cyclic behavior of carbonate sand with anisotropic consolidation, International Journal of Civil Engineering, 12(4) (2014) 316-325.

[12] BS1377-3, BS 1377: part 3 Chemical and electro-chemical tests, BSI, London, 1990.

[13] S.A. Naeini, The influence of silt presence and sample preparation on liquefaction potential of silty sands, Iran University of Science and Technology, Tehran, Iran, 2001.

HOW TO CITE THIS ARTICLE

E. Ghanbari Alamouti, R. Ziaie Moayed, S. A. Naeini, Under-compaction method for sample preparation of Boushehr carbonated silty sand, Amirkabir J. Civil Eng., 54(9) (2022) 663-666.

DOI: 10.22060/ceej.2022.20439.7433