SVU-International Journal of Engineering Sciences and Applications (2022) 3(2): 137-143
Print ISSN 2785-9967| Online ISSN 2735-4571
DOI 10.21608/svusrc.2022.157426.1067

Density Control of Sandy Soil in Laboratory Model

Emad A. M. Osman[1], Amr A. Hemada [2,], Ahmed M. A. Mohamed[3]

Abstract: According to geology, sand is a granular substance made up of finely separated pieces of regional rock and mineral, hence variations in sand particles are caused by regional rock conditions and rock sources. This variation in grain size, shape and its composition cause a problem in laboratory experiments when calculating sand density which is essential parameter. Also, it is the more essential problem in all laboratory experiments applied on granular soil like sand is forming a uniform density (density control). The method of forming a uniform sand bed, the used system, the factors effect on density control, and the more suitable conditions achieving density control were explained in this paper. The result proved that; the most suitable method for sand forming was sand raining, the most suitable method for sand forming was sand raining and the raining height achieving uniform density, so, sand raining, and vibratory compaction recommended when maximum dry density is required.

Keywords: Density Control, Sand Beds, Compaction, Sandy Soil, Raining Height.

1 Introduction

Density control have a most importance in all laboratory models, because all theories applied on granular material like sandy soil take in consideration that ideal conditions like uniform sand density, so that the process of formation a homogeneous and uniform sand beds is usually been under investigation, in order to control sand density, sand raining through a wooden system explained in details in this paper, after that by making several trials ideal conditions achieving density control can be calibrated. Relative density and uniform sand are important state parameters effected in the soil behavior. During extensive laboratory geotechnical testing, uniformly prepared sand samples are essential. [1], [2], [3].

To acquire accurate findings from laboratory tests, homogeneous sandy soil preparation and repeatable reconstituted sand samples must be done [4]. Previous studies the preparation procedure of sand beds to required relative density using several methods. The famous two methods are pluviation and pneumatic vibration. The conclusion of these methods are; to create consistent sand beds in a large test chamber, a stationary air pluviation system was created, the relative density of sand increases with decrease in the opening size through which the sand particles were pluviated and increase in the height of fall, a pneumatic vibratory method used to control in the relative density of sand beds, The suggested vibratory approach can be utilised to create consistent beds of grade ii and grade iii sand with the least amount of particle breakage at pressures up to 100 kpa. The pneumatic vibrator approach is also proven to be speedier than the pluviation method, and it may be used for test chambers of any size. [5], [6] Porosity of sand soil was expressed as a function of thermal conductivity. [7] The volumetric deformation of frozen sandy soil depends on the confining pressure. [8] The change of strength properties of sandy soil–cement admixtures depend on type of sandy soil. [9] There are an often conflicting views on the effect of drop height on relative density of pluviated sand samples are presented,

Received: 20 August 2022/ Accepted: 8 September 2022
Corresponding Author E-mail: ael.mahdy@yahoo.com

1 Prof. of Geotechnical Engineering, Faculty of Engineering, Minia University, Egypt.
2 Assoc. Prof. of Geotechnical engineering, Housing and building national research center, Egypt.
3 PH. D. Research Student. Minia University, Egypt.

such as the dependence of the relative density achieved on the drop height.[10] The result of the studies about the effect of density on the drained deformation properties of sandy soil deposits had been clear the density-dependence of their deformation properties, so samples have a low compressibility and a high expansibility in the direction of sample-deposition compared with the direction along the bedding plane.[11]

The proposal of the improvement of shear strength and pore-water pressure characteristics of sandy soil by mixed with plastic fine had given a good result in the un drained behavior of compaction specimens, the pore pressure generation response of sands, the shear behavior of specimens and the dependency on the characteristics of base sand and fine particles. [12] The concluded of the experimental study on the behavior of bounded square footing on sandy soil, clear that: the bearing capacity increases with the depth of the wall on sand of different densities, in loose and medium sand, the maximum effect of the wall on the value of bearing capacity and the existence of the wall is at a large distance from footing the bearing capacity effect approximately fades due to the decrease in soil confinement. [13] Increasing nano silica content causes cemented samples to have a faster hydration process due to the higher activity of nanoparticles. [14] Also, according to the previous study of bearing capacity of rectangular footing on sandy soil bounded by a wall investigated the behavior of model footings bounded by a wall of different depths and located at different distances from the footing resting on sandy soil. Different parameters are considered, such as relative density of sand, distance from the wall to the edge of footing (d), width of footing (b) and depth of wall (h), The results showed that in loose and medium sand, the wall's impact on bearing capacity is greatest when there is a 0.5-inch gap between it and the footing edge h/b, whereas in dense sand, the wall's impact is greatest when it is directly in contact with the footing edge h/b. [15] Due to a challenge for geotechnical engineers via determination of the in situ engineering properties of foundation materials. [16] The proposed constitutive model are a description to the characteristics of the mechanical behavior of improved sandy soil under monotonic loading summarized as; a failure criterion is easily incorporated in stress-strain relationships, a non-associative flow rule was used in the incremental constitutive equation, a generalized form of the modified clay model is applied to plastic potential and the isotropic hardening involves plastic work related not only to deviatoric but also to deformation volumetric change.[17]

The behavior of bounded foundations depends on the density of sandy soils. [18] The micro piles within any soil use to improve ground technique [19] Geosynthetic reinforcement on the bearing capacity of strip footing on sandy soil by fibers of coir improved both the friction angle and the cohesion of sand. [20] In experimental investigations of seepage in non-uniform sand bed channel, parameters such as, Reynolds shear stresses, shear velocities, thickness of roughness sub layer and velocity were found increasing with seepage. [21]

The use of stone columns as one of the effective methods in improving soil behavior can increase soil bearing capacity. One of the common methods in improving poor soil is the use of stone columns. Stone columns are considered one of the suitable options to improve the bearing capacity of loose cohesive and granular soils, which, in addition to reducing soil subsidence, is also considered an effective, economical, and environmentally friendly method in structures built on soil. Considering the financial and human losses caused by the construction of various buildings on poor soils, the importance of developing improvement methods in weak and unsuitable soils is essential.

A general review about the density control is done in this manuscript and some factors related to the density control are also indicated. Although the purpose of this study is explained. An experimental system is designed to obtain the suitable sand density using the sand raining. The method of forming a uniform sand bed, the used system, the factors effect on density control, and the more suitable conditions achieving density control were explained.

2. Factors affecting the density control

The following list of factors that have been mentioned in numerous research studies and have an impact on density control.

1- Sand raining intensity (the sand weight per unit area per unit time).
2- The raining height of sand particles from the wooden system. [22]
3- During deposition some dust is created which has some effect on deposition and the equipment used. [23]
4- Particle elasticity in case of comparing between different sands. [24]
5- The used pots in calibration with a solid bottom. [25]

3 Description of the used system

The experimental wooden system used for controlling of soil density, is shown in Figure 1. This system consists of two main parts (part A, and part B).

Fig. 1 wooden system used in density control.

The part A consists of four wooden columns to control of the level of the system with steps each step 25 mm, and a wooden box with clear dimension (560 mm length, 530 weight, and 150 mm height), this box has a circular holes 10 mm diameter, and the spacing between each hole from center to center 30 mm, finally a sliding wooden sheet based on rollers its job opening and closing the process of raining. Figure 2 shows the part (A) of the wooden system. Also, the more details of the part (A) with the actual dimensions is drawn in Figure 3.

Fig. 2 part (A) of the wooden system.

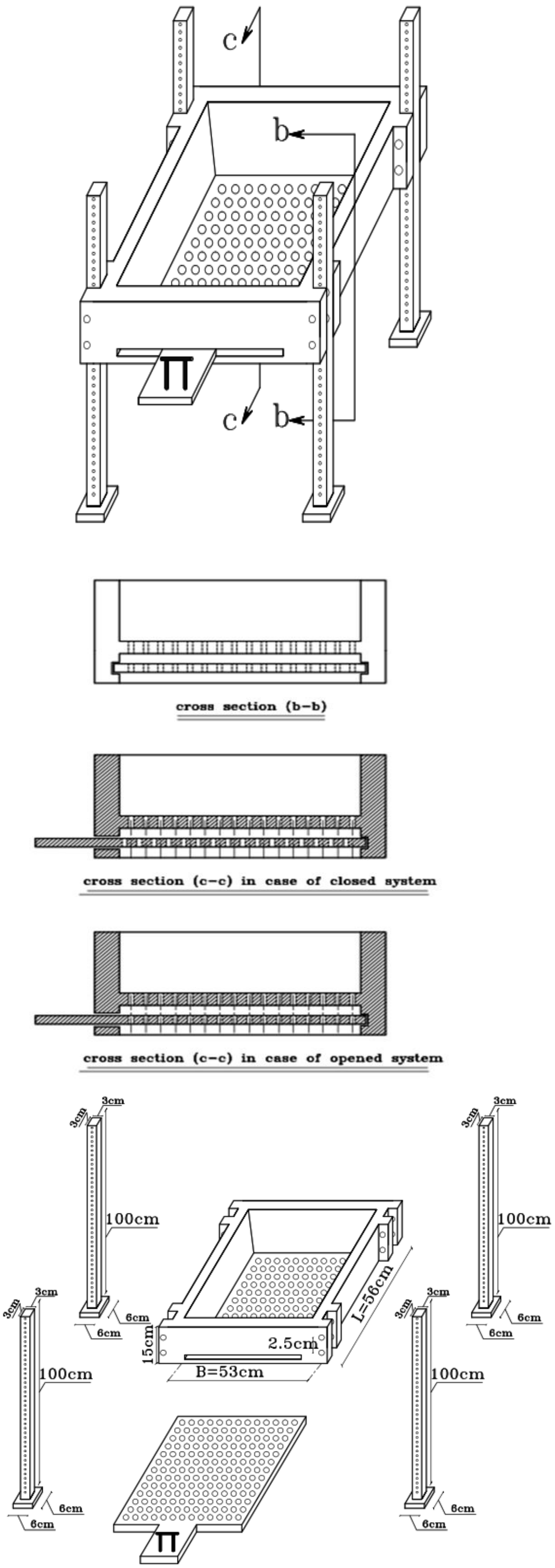

Fig. 3 shop drawing of part (A) of the wooden system.

The part B of the wooden system used in density control is called wooden box. It is conducted with dimension (460 mm width, 420 mm length, and 500 mm height) the box divided to 10 sections each section height 50 mm to control the process of soil raining. The height of the raining of sand maintained by making several trials (50mm, 100mm, 150, and 200mm), the density measured along each layer by using five metal Bots, and finally we can be comparing the results to fixing the raining height. Fig. 4 shows the part (B) of the wooden system. Also, Fig. 5 shows the drawing details of the part (B) of the wooden system.

Fig. 4 part B of the wooden system.

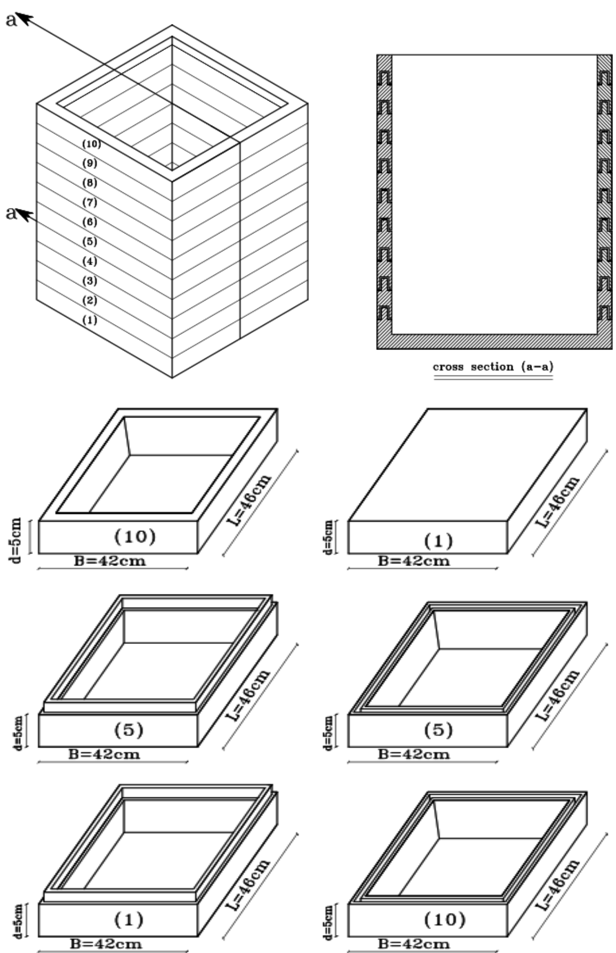

Fig. 5 shop drawing of part (B) of the wooden system.

4. Experimental Results

The height of soil raining can be determined by making trials using the last system, the sand falling from heights 50, 100, 150, and 200mm, five metallic bots can be used in each layer for density control, as shown in Figure 6. After that the average density for each layer can be measured, and blotted related to the raining height as shown, finally determine the raining height which achieve the suitable density. Typical results for density with sand depth for different raining heights varying from falling from heights 50, 100, 150, and 200mm are plotted in Figures from 7 to 10.

Fig. 6 experimental work.

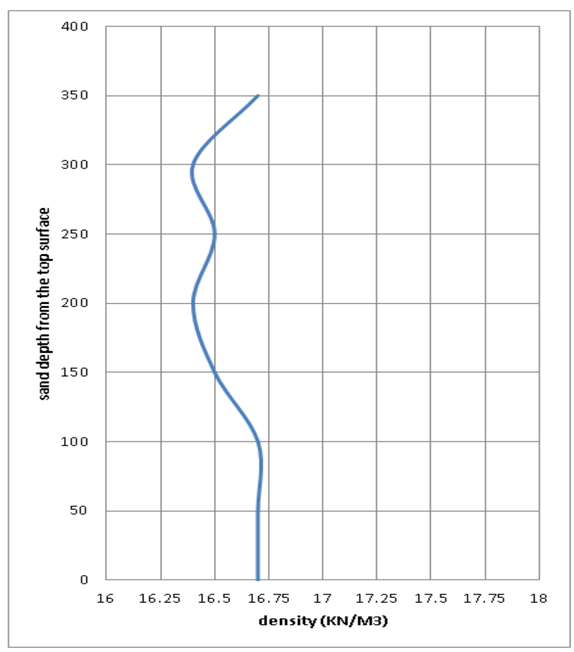

Fig. 7 Typical results for density with sand depth for raining height 50 mm.

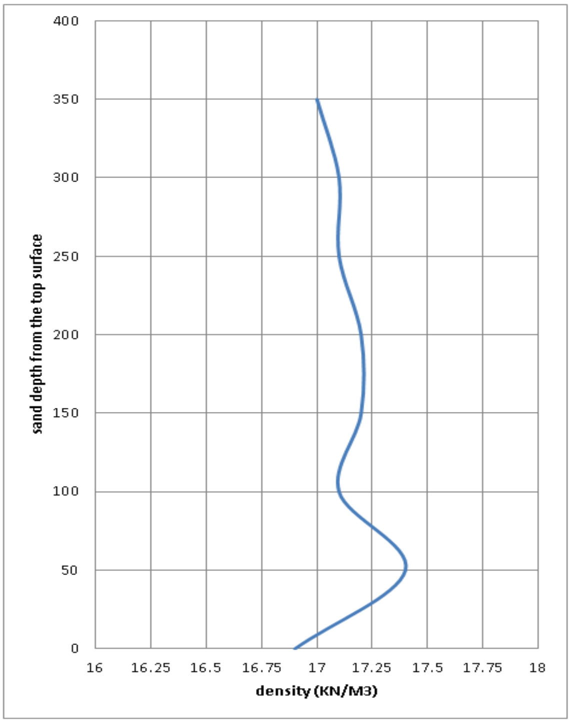

Fig. 8 Typical results for density with sand depth for raining height 100 mm.

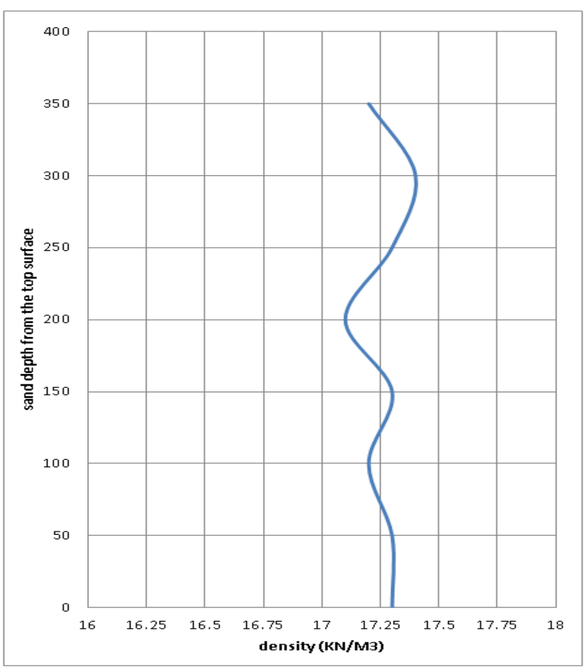

Fig. 9 Typical results for density with sand depth for raining height 150 mm.

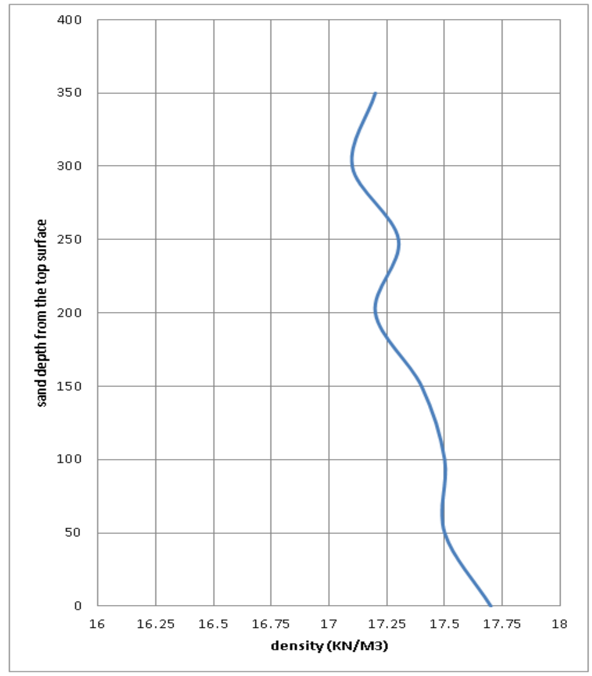

Fig. 10 Typical results for density with sand depth for raining height 2 mm

5. Conclusions

After using ive metallic bots can be used in each layer for density control, the heights of soil raining were determined by making trials; 50, 100, 150, and 200mm. The average density for each layer measured, and blotted related to the raining height, finally determine the raining height which achieve the suitable density. The most suitable method for sand forming was sand raining. The raining height achieving uniform density is 150 mm. Sand raining, and vibratory compaction recommended when maximum dry density is required.

References

[1] Hariprasad, C., Rajashekhar, M., & Umashankar, B. (2016). Preparation of uniform sand specimens using stationary pluviation and vibratory methods. Geotechnical and Geological engineering, 34(6), 1909-1922.

[2] Dave, T. N., & Dasaka, S. M. (2012). Assessment of portable traveling pluviator to prepare reconstituted sand specimens. Geomechanics and Engineering, 4(2), 79-90.

[3] Renuka, I. H. S., & Kuwano, R. (2011). Formation and evaluation of loosened ground above a cavity by laboratory model tests with uniform sand. In Proc. of

13th International Summer Symposium, Uji, Japan (pp. 211-214).

[4] Kapetas, L., Dror, I., & Berkowitz, B. (2014). Evidence of preferential path formation and path memory effect during successive infiltration and drainage cycles in uniform sand columns. Journal of contaminant hydrology, 165, 1-10.

[5] Gade, V. K., & Dasaka, S. M. (2016). Development of a mechanized traveling pluviator to prepare reconstituted uniform sand specimens. Journal of Materials in Civil Engineering, 28(2), 04015117.

[6] Torres, A., Brandt, J., Lear, K., & Liu, J. (2017). A looming tragedy of the sand commons. Science, 357(6355), 970-971.

[7] Alrtimi, A., Rouainia, M., & Haigh, S. (2016). Thermal conductivity of a sandy soil. Applied Thermal Engineering, 106, 551-560.

[8] Xu, X., Lai, Y., Dong, Y., & Qi, J. (2011). Laboratory investigation on strength and deformation characteristics of ice-saturated frozen sandy soil. Cold Regions Science and Technology, 69(1), 98-104.

[9] da Fonseca, A. V., Cruz, R. C., & Consoli, N. C. (2009). Strength properties of sandy soil–cement admixtures. Geotechnical and geological engineering, 27(6), 681-686.

[10] Vaid, Y. P., & Negussey, D. (1984). Relative density of pluviated sand samples. Soils and Foundations, 24(2), 101-105.

[11] Haruyama, M. (1987). Effect of density on the drained deformation behavior of Shirasu (volcanic sandy soil) under three-dimensional stresses. Soils and foundations, 27(1), 1-13.

[12] Bayat, M., Bayat, E., Aminpour, H., & Salarpour, A. (2014). Shear strength and pore-water pressure characteristics of sandy soil mixed with plastic fine. Arabian journal of geosciences, 7(3), 1049-1057.

[13] Fattah, M. Y., Shlash, K. T., & Mohammed, H. A. (2014). Experimental study on the behavior of bounded square footing on sandy soil. Engineering and Technology Journal, 32(5 Part (A) Engineering), 1083-1105 .

[14] Choobbasti, A. J., & Kutanaei, S. S. (2017). Microstructure characteristics of cement-stabilized sandy soil using nanosilica. Journal of Rock Mechanics and Geotechnical Engineering, 9(5), 981-988.

[15] Fattah, M. Y., Shlash, K. T., & Mohammed, H. A. (2014). Bearing capacity of rectangular footing on sandy soil bounded by a wall. Arabian Journal for Science and Engineering, 39(11), 7621-7633.

[16] Mohammadi, S. D., Nikoudel, M. R., Rahimi, H., & Khamehchiyan, M. (2008). Application of the Dynamic Cone Penetrometer (DCP) for determination of the engineering parameters of sandy soils. Engineering Geology, 101(3-4), 195-203.

[17] Hirai, H., Takahashi, M., & Yamada, M. (1989). An elastic-plastic constitutive model for the behavior of improved sandy soils. Soils and foundations, 29(2), 69-84.

[18] Lai, Y. M., Zhang, Y., Zhang, S. J., Jin, L., & Chang, X. X. (2009). Experimental study of strength of frozen sandy soil under different water contents and temperatures. Rock and Soil Mechanics, 30(12), 3665-3670.

[19] Zhou, J. J., Gong, X. N., Wang, K. H., Zhang, R. H., & Yan, J. J. (2017). Testing and modeling the behavior of pre-bored grouting planted piles under compression and tension. Acta Geotechnica, 12(5), 1061-1075.

[20] Al-Subari, L., Hanafi, M., & Ekinci, A. (2020). Effect of geosynthetic reinforcement on the bearing capacity of strip footing on sandy soil. SN Applied Sciences, 2(9), 1-11.

[21] Sharma, A., & Kumar, B. (2017). Structure of turbulence over non uniform sand bed channel with downward seepage. European Journal of Mechanics-B/Fluids, 65, 530-551.

[22] Kolbuszewski, J. and Jones, R.H. (1961): " The Preparation of Sand Samples For Laboratory Testing " Proceeding of The Midland Soil Mechanics and Foundation Engineering Socity, Vol. 4, Paper A6.

[23] Macare, J.C. and Gray, W.A. (1961): " Significance of The Properties of Materials in The Packing of Real Spherical Particles " British Journal of Applied Physics, Vol. 12, pp. 164-172.

[24] X. J. Chai, K. Deng, C. F. He, Y. F. Xiong, "Laboratory Model Tests on Consolidation Performance of Soil Column with Drained-Timber Rod", Advances in Civil Engineering, vol. 2021, Article ID 6698894, 8 pages, 2021.

[25] Butterfield, R. and Andrawes, K.Z. (1970): "An Air Activated Sand Spreader for Forming Uniform Sand Beds" Geotechnique, London, Vol. 20, Technical Notes, PP. 26.

[26] Ali Yousefi Samangani, Reza Naderi, "Numerical and Larg-Scale Laboratory Study of Rock Column Groups in Sandy Soil Behavior Improvement", Advances in Civil Engineering, vol. 2022, Article ID 9259093, 11 pages, 2022.