Journal of New Approaches in Civil Engineering
(ISSN PRINT: 2588-6886) -(ISSN ONLINE: 2588-7122)-Vol.2, No.2, Pages: 39-48.

The Effect of Granular Trench's Depth on Bearing Capacity of Shallow Foundations on the Soft Ground

Aysan Ranjbar[1], Ali Akbar Golshani[2*]

[1] M.Sc. of Geotechnical Engineering, Department of Civil Engineering, Tarbiat Modares University, Tehran, Iran.

[*2] Assistant Professor, Department of Civil Engineering, Tarbiat Modares University Tehran, Iran. (golshani@modares.ac.ir)

ABSTRACT

The rapid growth of construction in urban areas has resulted in building structures on soft and weak soils. These soils possess the low bearing capacity and high settlements. One of the common ways to increase bearing capacity in weak soils is to use granular trench. Trenching can be built easier, faster and cheaper than deep foundations. The function of granular trench is similar to stone columns. However, the difference is that instead of a column of granular material, a large area of granular material is used. In this research, we compare the results of static bearing capacity for shallow foundation with and without trench obtained from numerical modeling using FLAC2D. Furthermore, the effect of depth of granular trench on bearing capacity has been studied and finally the optimum depth is presented.

Key words: *Shallow foundations, Static bearing capacity, Trench, Optimum depth, FLAC 2D.*

1. Introduction

There are many field situations where at least a moderate increase in the bearing capacity in their soils is desired. An effective solution for this situations, is stabilizing by granular trench beneath the shallow foundation. The granular trench functions similar to stone columns. The only difference is that instead of a column of granular material, a large area of granular material is used. Granular filling acts as a strong base and distributes the load over a wider area. In this method, post-construction settlements are reduced significantly.

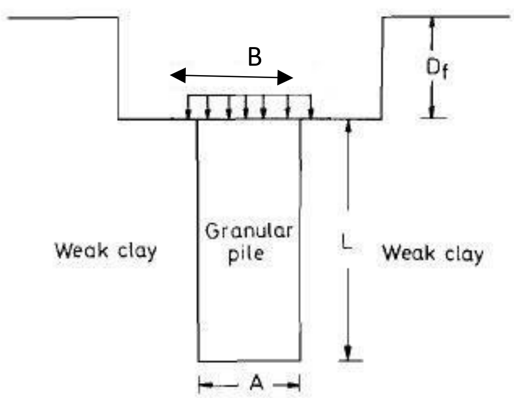

Fig 1. Granular trench in weak clay.

Despite theoretical, numerical and experimental studies on the stone columns, to the best of our knowledge there are a few studies about granular trench. Madhav and Vitkar (1978) [1] proposed a theoretical solution for the bearing capacity of shallow strip foundation in clay supported by a granular trench. Hamed (1986) [2], Naser (1986) [3] and Das (1988) [4] reported laboratory model investigations on shallow strip footing built on the granular trench in soft clay. Serma et al (1993) [5] cited some practical applications of the granular trench for ground modifications in India. They concluded that the existence of granular trench at some level helps to transfer of load intensity; therefore the low strength subsoil is not overstressed. Rajan and Unnikrishnan (2012) [6] reported experimental and numerical research on using triangular and rectangular shaped granular trenches to improve fine loose sand medium. Moreover, Sharmer (2002), Rao and Dutta (2004) [7] and

Unnikrishnan et al (2011) performed some experimental research on the behavior of reinforced granular trenches.

The bearing capacity of a strip footing supported by a granular trench depends on the mode of failure in composite soil medium. There are three possible failure modes for a granular trench supported strip footing. The first mode is a general shear failure, one form of which can be the Prandtl mechanism shown in figure 2a. The second mode of failure is bulging as shown in figure 2b. This mode has been observed in stone columns in soft soils. Using pressure meter observations or the cavity expansion factors, the limit of lateral pressure can be estimated. The ultimate bearing capacity q_{ult} of a foundation of the same size as the stone column is determined to be:

$$q_{ult} = ((1+\sin\phi)/(1-\sin\phi)) \quad (1)$$

Where, σ_{pl} is the limit lateral pressure. The third mode of failure shown in figure 2c is similar to rigid pile action wherein negligibly small lateral displacements are expected to occur in the trench on the column material. This mode predicts higher load bearing capacity than the earlier two modes. The analytical solution for predicting the ultimate static bearing capacity of a granular trench based on the first mode and the general shear failure mode, were proposed by Madhav and Vitkar(1978). They used upper bound limit analysis method and proposed a relation similar to conventional bearing capacity formulation:

$$q_u=C_uN_c+qN_q+0.5\gamma BN_\gamma \quad (2)$$

Where c_u and γ are cohesion and unit weight of soil, and D_f is depth of foundation. Whereas, B is the width of foundation that is equal to width of trench. N_c, N_q and N_γ are the dimensionless factors of bearing capacity which are related to the angle of friction. In this research, a comparison between static bearing capacity of shallow foundation with and without trench is investigated, which is obtained from numerical modelling.

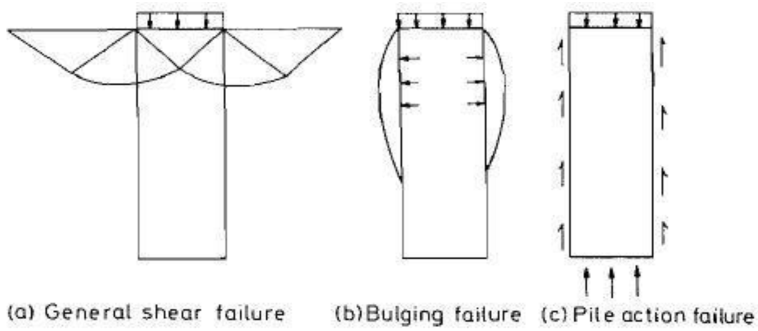

Fig 2. Modes of failure for strip footing supported by granular trench.

2. Numerical loading

In this paper, the FLAC2D has been used for numerical analysis of bearing capacity of shallow foundations with and without the granular trench. This method uses Lagrangian fast calculations to analyze and these calculations are the explicit finite difference. This approach has been used in the majority of geotechnical engineering models.

2.1. Example

A natural deposit has the following properties, in the absence of a trench in numerical analysis, the ultimate bearing capacity of soil obtained from FLAC2D is about:

C=20kPa, ϕ=0°, and unit weight= 14.71kN/m^3

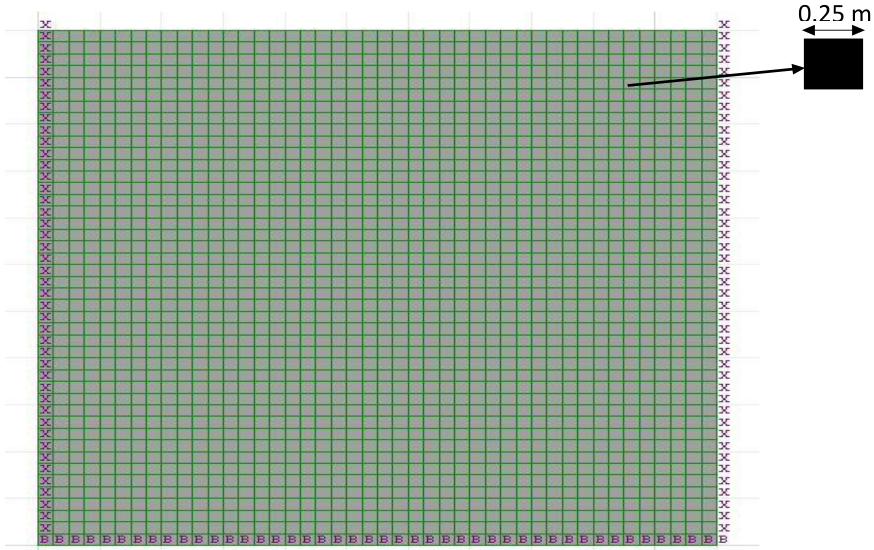

Fig 3. Meshing of the model without trench

In the diagram below, the vertical axis is the force that FLAC2D computes and bearing capacity is obtained from division of force over area of each mesh (0.25*0.25*1 m^3) the horizontal axis is the settlement of the strip footing while loading.

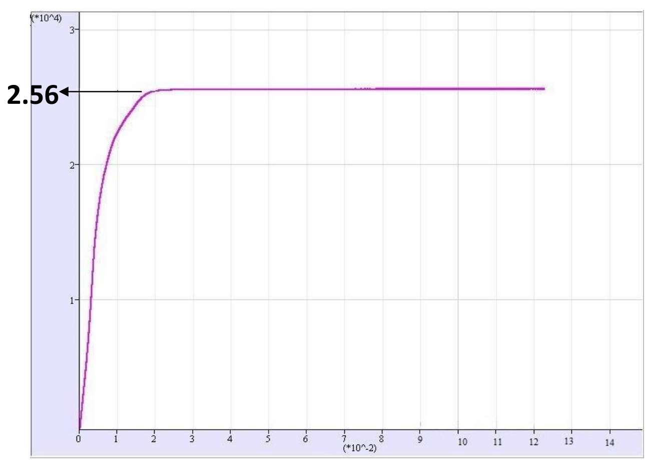

Fig 4. Bearing capacity of foundation without trench.

2.2. Effect of Trench's Depth (D)

The soil is stabilized with a granular trench with the properties, width of trench A=1m , width of strip load=1m. In the presence of granular trench in numerical analysis in FLAC2D effect of Trench's Depth (D) is presented as below:

C=0 kPa, ϕ=40°, Dilation=20, unit weight=19.60kN/m^3.

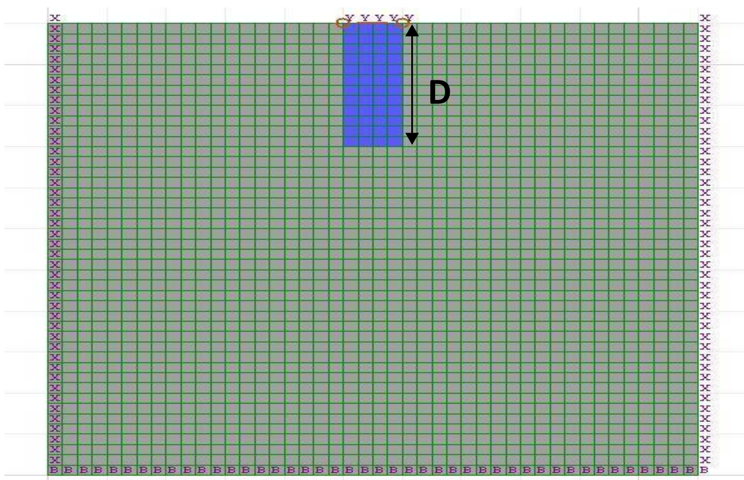

Fig 4. Meshing of the model with trench.

D=1m,

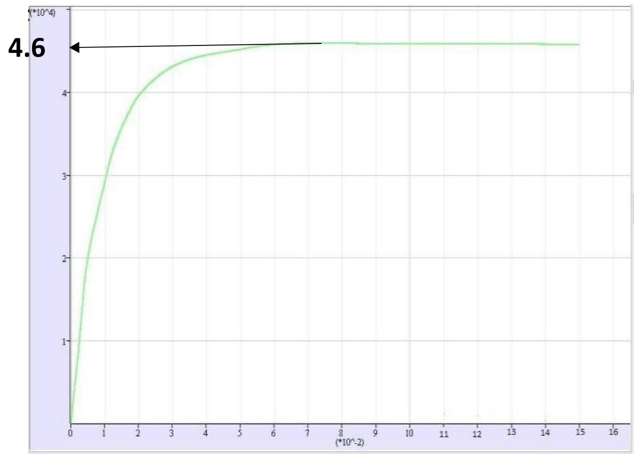

Fig 5. Bearing capacity of foundation with trench (D=1).

D=2m,

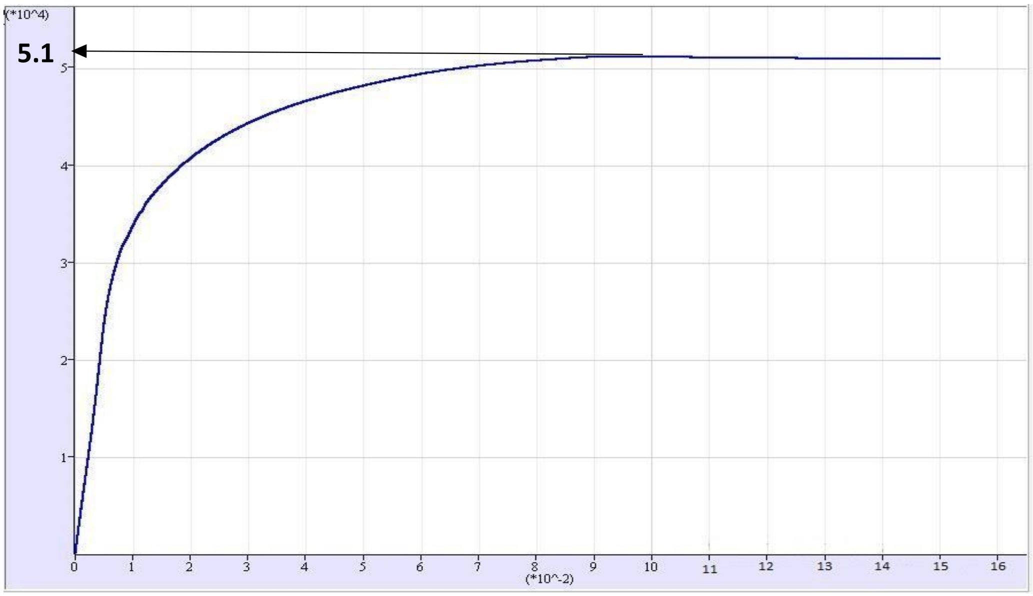

Fig 6. Bearing capacity of foundation with trench (D=2).

D=3m,

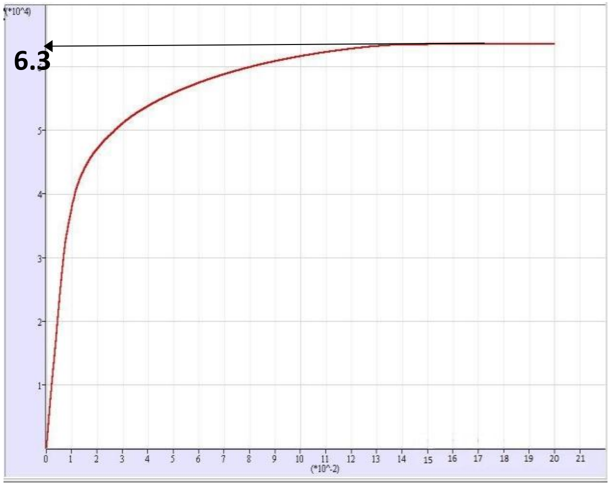

Fig 7. Bearing capacity of foundation with trench (D=3).

D=4m,

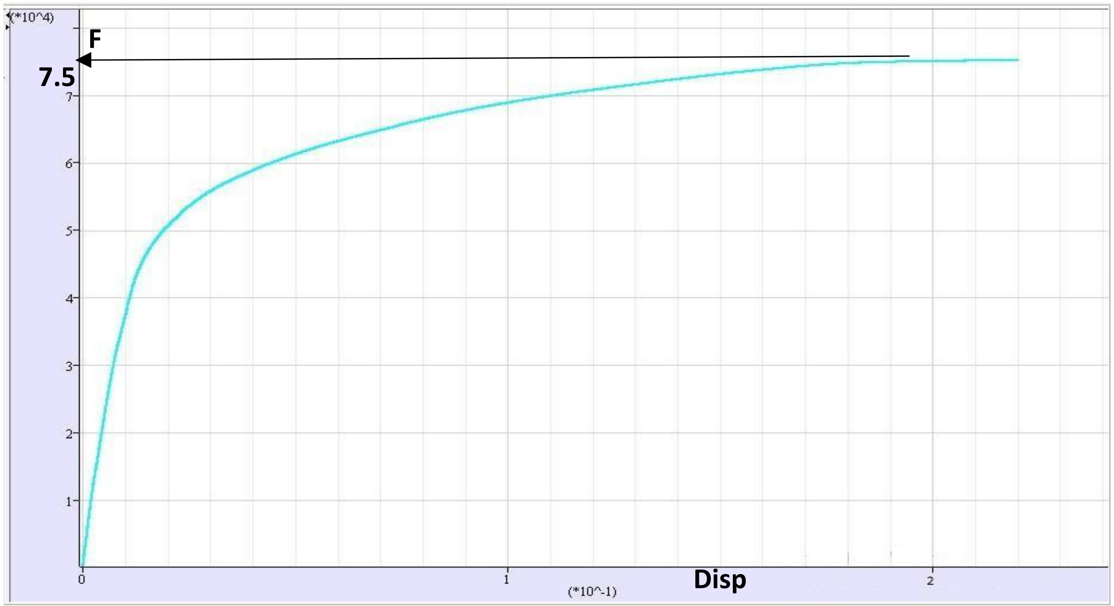

Fig 7. Bearing capacity of foundation with trench (D=4).

D=5m,

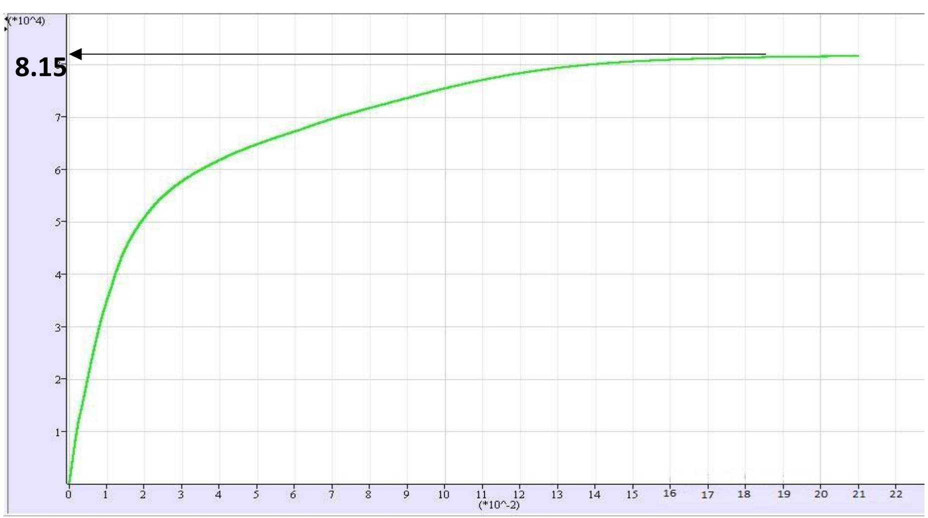

Fig 8. Bearing capacity of foundation with trench (D=5).

D=6m,

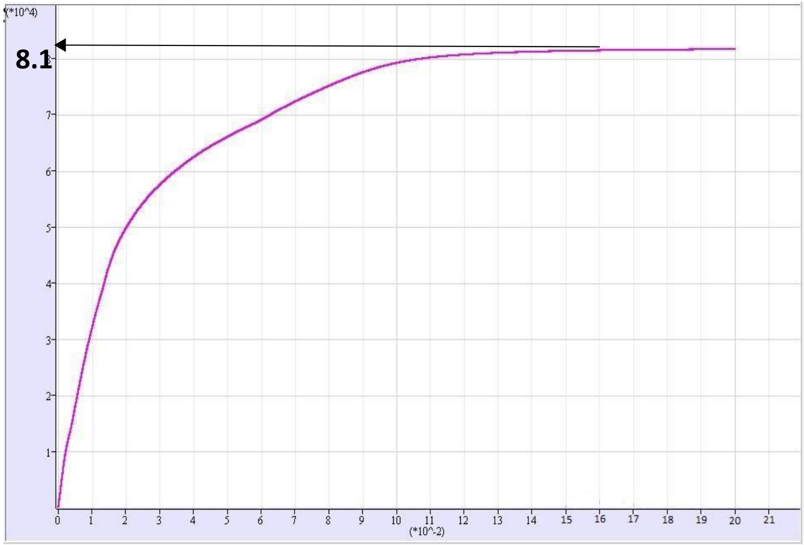

Fig 9. Bearing capacity of foundation with trench (D=6).

The results of FLAC2D are represented in Figure 10:

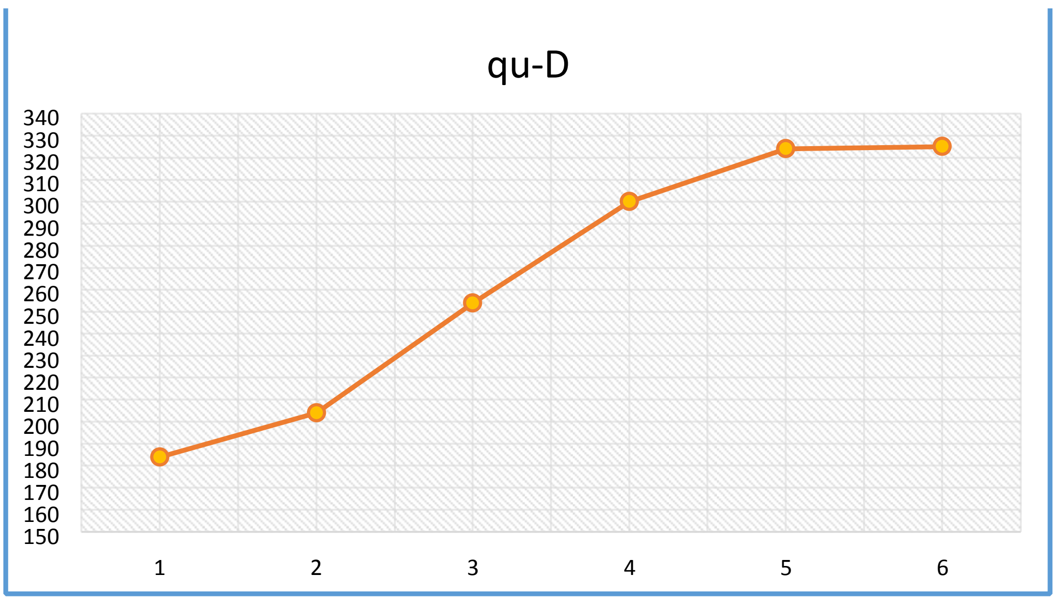

Fig 10. Results (The vertical axis is bearing capacity and the horizontal axis is the depth of trench).

3. Conclusion

The increase in the ultimate bearing capacity with the installation of a trench at least is about 80%. On the other hand if a trench is installed in an specific depth, the bearing capacity increases to a maximum value and after the highest value it remains constant. The bearing capacity of a foundation on a soil stabilized with a granular trench is determined using the upper bound theorem. If the trench material has a higher ϕ value, a larger increase in bearing capacity can be expected. In this study, the optimum depth of trench using FLAC2D is computed to be approximately 5m.

References

[1]-Madhav, M. R., and P. P. Vitkar. (1978). Strip footing on weak clay stabilized with a granular trench or pile, Canadian Geotechnical Journal 15(4), 605-609.

[2]-Hamed, J. T., B. M. Das, and W. F. Echelberger Jr. (1986). Bearing capacity of a strip foundation on granular trench in soft clay, Civil engineering for practicing and design engineers 5(5), 359-376.

[3]-Yousif, Naser A. (1986). The bearing capacity of a strip foundation on a granular trench.

[4]-Das, B. M. (1988). Bearing Capacity of Shallow Foundation on a Granular Trench in Clay, In Fifth Australia-New Zealand Conference on Geomechanics: Prediction versus Performance; Preprints of Papers, p. 278. Institution of Engineers, Australia.

[5]-Sarma, P. Kameswara, J. R. Somayazulu, and K. Rama Sastri. (1993). Granular Trenches and Stone Columns as Ground Improvement Techniques- Case Histories of Field Applications.

[6]-Unnikrishnan, N., Susha Rajan, and A. S. Johnson. (2011). Bearing capacity of strip footings on encapsulated granular Trenches, Diamond, 2.

[7]-Rao, G. Venkatappa, and R. K. Dutta. (1997). Ground improvement with waste Plastic, Indian Institute of Technology, New Delhi, India, Dutta, RK, National Institute of Technology, Hamirpur, India.