ISSN 2663-1563 Vol. 5, Issue 6: 9-15, DOI: 10.25236/AJAGE.2023.050603

Determination of bearing capacity of a sand-mudstone interbedded foundation in Chengdu

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Abstract: *In-situ test is the most accurate and authoritative method to study the modification of bearing capacity of rock foundation. The use of simulation software can quickly and efficiently explore the law and modify. In this paper, FLAC3D software is used to carry out static load test simulation calculation under different side load conditions and load plates with different widths.*

Keywords: *FLAC3D; simulation; surface; sand-mudstone*

1. Introduction

From top to bottom, the stratum distribution of the site is as follows: SU 23 backfill, silt quality backfill, silty clay, clay, fully weathered mudstone, strongly weathered sandstone, strongly weathered mudstone, moderately weathered mudstone, moderately weathered mudstone, slightly weathered mudstone and slightly weathered sandstone. The medium weathered mudstone layer is intercalated with several medium weathered sandstone layers. The medium weathered sandstone layers are mainly distributed in the west side of the foundation pit, and the dip angle from west to east is about 10 degrees. The geological expansion diagram of the foundation pit boundary is shown in Figure 1.

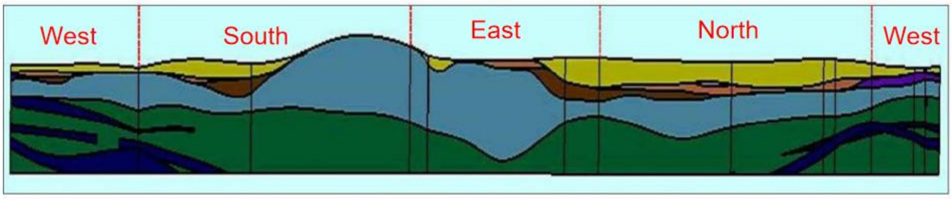

Figure 1: Geological expansion map of foundation pit edge

According to the geological expansion map and the horizontal section map of the foundation pit, the main building of the project is composed of sand-mudstone interbed and medium weathered mudstone as the bearing stratum of the foundation, in other areas, medium weathered mudstone is the bearing stratum of foundation. This shows that the foundation of the project can be divided into two types of analysis, the following FLAC3D software on the sand-mudstone interbedded foundation and medium weathering mudstone foundation of the bearing capacity of the specific analysis.

2. Methodology

2.1 Determination of bearing capacity of mudstone foundation

For the determination of bearing capacity of building foundation, the commonly used“Code for design of Building Foundation Foundation”(Gb50007-2011)[1] is determined, however, the method of determining the bearing capacity of rock foundation is only to calculate the bearing capacity by multiplying the saturated uniaxial compressive strength by the reduction coefficient, which is questioned by many scholars [2,3] , it is difficult to make full use of the bearing capacity of soft rock mass by using only the saturated uniaxial compressive strength of indoor rock to determine its bearing capacity, cause waste. Therefore, this paper combined“Building Foundation Foundation design code”(GB50007-2011). The bearing capacity of sand-mudstone interbed foundation is determined by studying the width and depth of the characteristic value of bearing capacity of foundation in Formula 1.

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$$f_a = f_{ak} + \eta_b \gamma (b - 3) + \eta_d \gamma_m (d - 0.5) \tag{1}$$

In formula: f_a——The modified eigenvalue of the bearing capacity of the foundation

f_{ak}——Characteristic value of bearing capacity of foundation

η_b、η_d——The modified coefficient of bearing capacity for foundation width and embedded depth

γ——the weight of the soil below the base of the foundation

b——Base width (m)

γ_m——The weighted average weight of the soil above the base of the foundation

d——Depth of foundation (m)

The characteristic value of bearing capacity of f_{ak} is 0m depth, the width correction is not considered when the plate width is less than 3m, and the buried depth is less than 0.5 m.

In-situ test is the most accurate and authoritative method to study the modification of bearing capacity of rock foundation. The use of simulation software can quickly and efficiently explore the law and modify. In this paper, FLAC3D software is used to carry out static load test simulation calculation under different side load conditions and load plates with different widths. The parameters required for sandstone-mudstone simulation are obtained through the study report, as shown in Table 1.

Table 1: Parameters of rock numerical simulation

	Cohesion/MPa	Angle of internal friction/°	Young's Modulus/GPa	Siméon Denis Poisson	Density /kg/m3
Mudstone	0.36353	32.3	7.13	0.16	2480
Sandstone	1.41	42.3	9.35	0.1	2440

According to the suggestion of the C and φ values of the contact surface mentioned in the manual [4], taking into consideration the value of mudstone 0.7 times, the normal stiffness KN and the shear stiffness KS can be taken as 10 times the equivalent stiffness of the“Hardest” adjacent area. See also formula 2:

$$k_n = k_s = 10max\left[\frac{(K + \frac{4G}{3}}{\Delta z_{min}}\right] \tag{2}$$

In the formula, K is the bulk modulus, G is the shear modulus, and $\Delta Z_{\min}$ is the minimum size of the connection area in the normal direction of the contact surface.

2.2 Study on width modification law of Mudstone Foundation

In order to further explore the law of width modification, the static load simulation test is carried out with load widths of 1 m, 2 m, 4 m, 6 m, 8 m, 12 m in the rock foundation load test, in order to eliminate the influence of depth, the burial depth is 0m. By extracting the simulated test results and drawing p-s curve figure 2.

As can be seen from Fig. 2, the ultimate bearing capacity of mudstone foundation increases with the increase of the bearing area of the foundation, and the corresponding settlement value also increases. However, according to the settlement results, it is not reasonable to determine the ultimate bearing capacity according to the allowable value of average settlement of 200mm for the simple high-rise building foundation in the code for design of Building Foundation, it also shows that it is very important to correct the characteristic value of foundation bearing capacity in practical engineering.

Because the P-S curve in figure 2 changes more smoothly, and there is no obvious inflection point, referring to the research report, for the results of load simulation test of rock foundation, take one third of the ultimate load value as the characteristic value of bearing capacity, with the increase of width, the characteristic value of bearing capacity increases linearly, and the characteristic value of bearing

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capacity of each width is fitted linearly, the result is f_a = 0.16257B + 2.63417, R^2 = 0.98052.

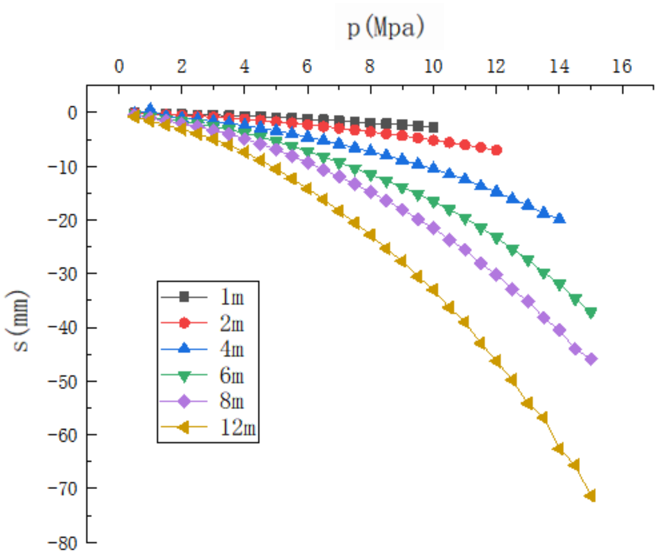
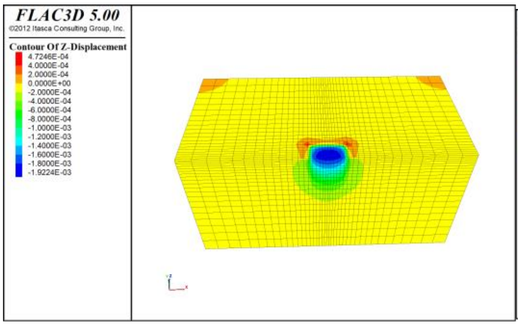
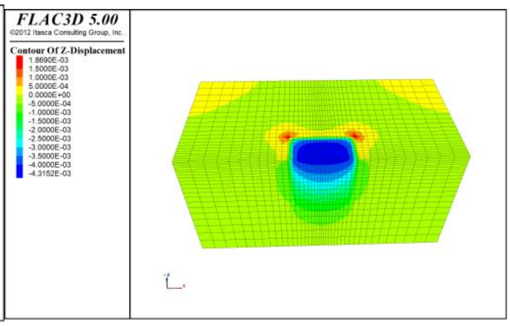


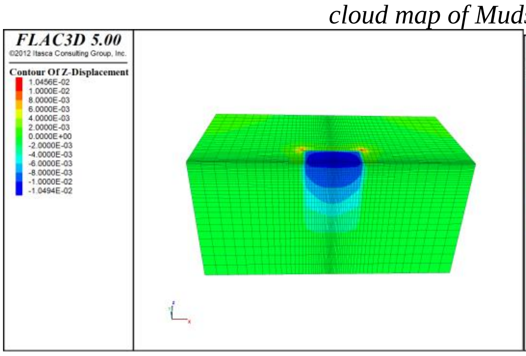
Figure 2: p-s curves of different foundation widths of Mudstone Foundation

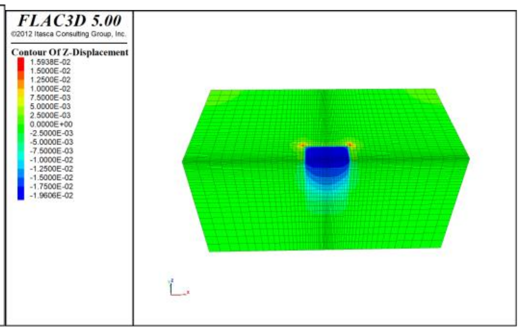
From Fig. 2, it can be found that when the width of load plate is more than 6 m, the characteristic value of bearing capacity still shows a linear increasing trend, it is not reasonable to take the value of 6m when the width of foundation base is more than 6m, which needs specific analysis. Compare the vertical displacement of each foundation width as shown in Figure 3.



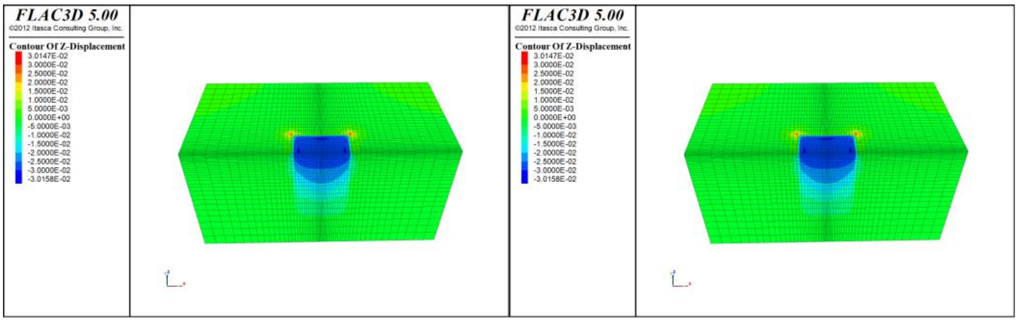


1 m wide vertical subsidence cloud map of Mudstone Foundation   2 m wide vertical subsidence cloud map of Mudstone Foundation





4 m wide vertical subsidence cloud map of Mudstone Foundation   6 m wide vertical subsidence cloud map of Mudstone Foundation



8 m wide vertical subsidence cloud map of Mudstone Foundation   12 m wide vertical subsidence cloud map of Mudstone Foundation

Figure 3: Vertical displacement nephogram under ultimate bearing capacity of each width

As can be seen from Fig. 3, the larger the width, the greater the depth of load influence, the larger the settlement, and the more concentrated the influence area, the same width of more than 6 m is increasing, which is consistent with the data collected by Wang enqi [5] . However, "Code for design of Building Foundation Foundation" is based on soil as the bearing stratum, in order to ensure the settlement of the foundation deformation, it will be greater than 6m by 6m calculation to control settlement.

2.3 Study on depth correction law of Mudstone Foundation

In order to carry out the load test simulation under different side load conditions, the compromise value of the rock mass is 2400kg/m3, and the side load conditions of 250KPA, 500kpa, 750kpa and 1000kpa are carried out respectively as shown in Fig. 4, the rock loads at the depths of 10.4 m, 20.8 m, 31.25 m and 41.67 m are calculated. The simulation results are shown in Fig. 5.

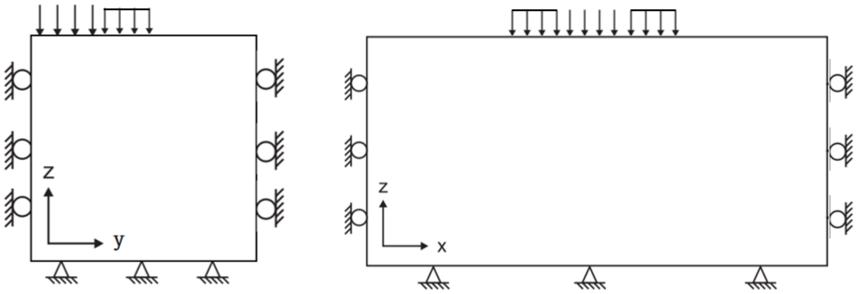


Figure 4: A side load calculation diagram

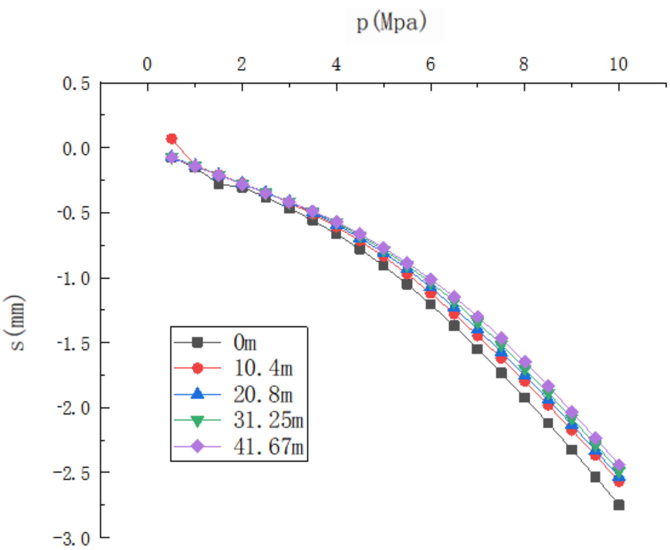


Figure 5: p-s curve of mudstone foundation in different depth

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As can be seen from Fig. 5, the P-S curve of mudstone foundation shows the same trend at different burial depths, and its variation is small, indicating that the burial depth of mudstone foundation has little influence on bearing capacity of mudstone foundation. The bearing capacity of mudstone foundation in different depth is basically the same, and its depth correction coefficient is 0.

To sum up, the characteristic value formula of bearing capacity of the weathered mudstone foundation is: .

$$f_a = 0.16257b + 2.63417 \tag{3}$$

f_a——Characteristic value of foundation bearing capacity(MPa)

b——Base bottom width(m)

The characteristic value of bearing capacity of mudstone calculated from Formula 3 is compared with the characteristic value of bearing capacity of rock foundation load test (taking the minimum value of test) in engineering research as follows Table 2.

Table 2: Characteristic values of bearing capacity of rock foundation with different widths

	300mm	500mm	800mm
Test values(MPa)	2.8	3	2.7
The calculated value(MPa)	2.682941	2.715455	2.764226
Compare values (%)	95.82	90.52	102.38

It can be clearly seen from table 2 that the ratio of the calculated value and the actual test value is above 90%, so the formula of characteristic value of bearing capacity of mudstone is reasonable.

2.4 Determination of bearing capacity of sand-mudstone interbedded foundation

In this paper, the simulation of sand-mudstone Foundation is established according to the research data. The 460m elevation, 455m elevation and 450m elevation correspond to the depth of 30m, 35m and 40m respectively. The scale of model sand-shale is 1:2, the thickness of sandstone is 1 m, the thickness of mudstone is 2 m, the size of model at 460 m elevation is 10m×5m×10m, the size of model at 455 m and 450 m elevation is 10m×5m×5m, as shown in Figure 6.

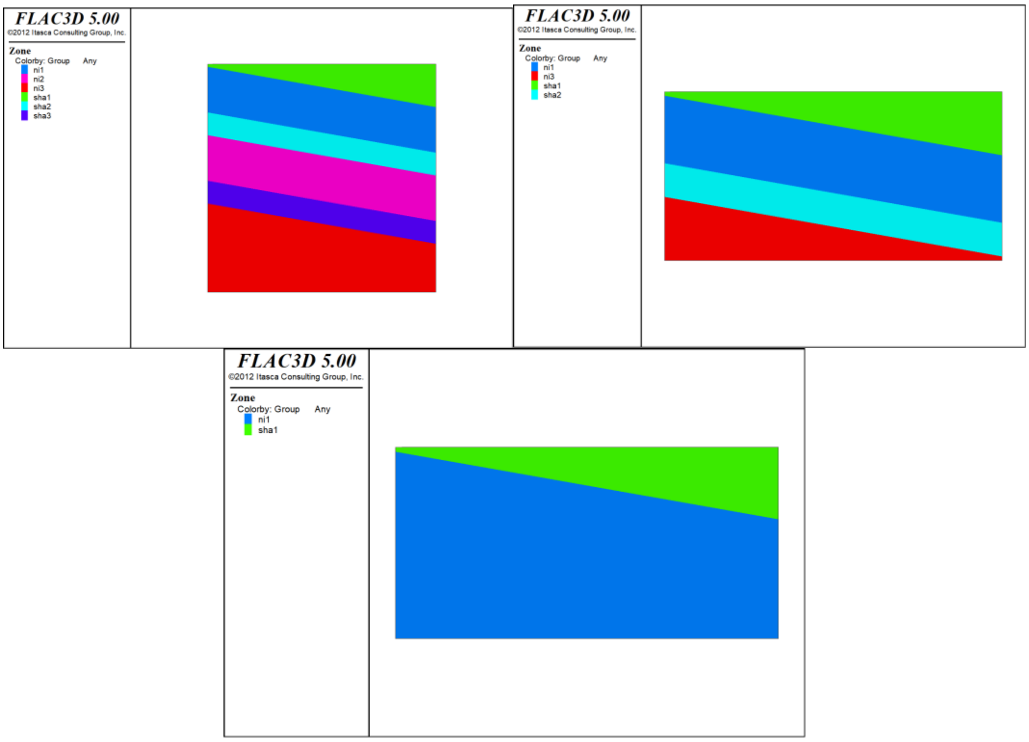

Figure 6: Model diagram of elevation from high to low (Left-right-bottom)

The deep load test of sand-mudstone interbed foundation is simulated by the scheme of side load condition. The difference is that mudstone is used as bearing surface before, but this time, sandstone is

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used as bearing surface. The simulation results are shown in Fig. 7.

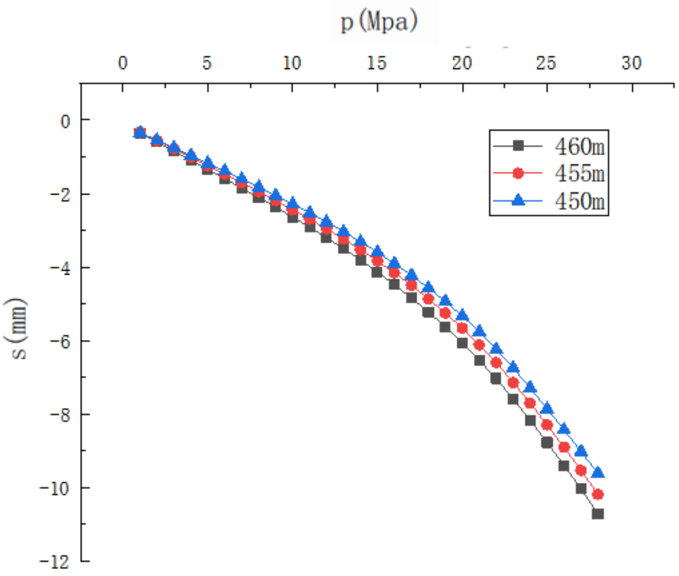

Figure 7: p-s curves of sand-mudstone interbedded foundation in different depths

From Fig. 7, we can see the same rule as Fig. 5-10, that is, the depth of burial has no great influence on the bearing capacity of sand-mudstone interbed foundation, and the bearing capacity of sand-mudstone interbed foundation with different burial depths is basically the same, however, its bearing capacity is obviously higher than that of Mudstone Foundation, and its settlement is also relatively lower. Considering that the proportion of sandstone with depth of 35m is the highest, it is reasonable to select the depth of 35m as the basement.

Based on the study of the different widths of the mudstone foundation at Section 5.2.1, it is found that the widths of the rock foundation should be corrected, foundation width should not be less than 3 m without correction. Therefore, the width of sand-mudstone interbed foundation is 0.5 m, 1 m, 2 m, and the edge load condition of 35 m depth is also given to eliminate the influence of depth. The simulation scheme is carried out according to the rock foundation load simulation scheme of 3.1, and the simulation test results are shown in Figure 8.

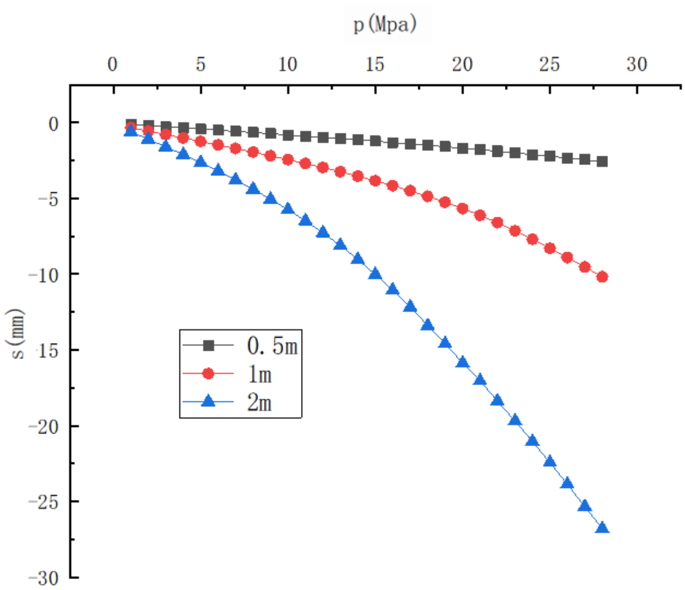

Figure 8: p-s curves of different foundation widths of sand-mudstone interbedded foundation

As can be seen from Fig. 8, the law is the same as that of mudstone foundation, but with the

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increase of foundation width, its bearing capacity and settlement increase even more. Because the curve changes more smoothly, and there is no obvious inflection point, for the plate load test, refer to the project research report, take one-third of the ultimate load value as the bearing capacity characteristic value, the characteristic value of bearing capacity increases linearly with the increase of the width, and the relationship between the characteristic value of bearing capacity and the width is f_a = 0.90286B + 6.5, R^2 = 0.98278.

The characteristic value formula of bearing capacity of sand-mudstone interbedded foundation is as follows:

$$f_a = 0.90286b + 6.5 \tag{4}$$

f_a——Characteristic value of foundation bearing capacity(MPa)

b——Base bottom width(m)

In conclusion, the characteristic values of bearing capacity of mudstone foundation and sand-mudstone interbedded foundation can both meet the design requirement of 2.4 mpa. Considering that the proportion of sandstone with the depth of 35m is the highest, and the bearing capacity of sand-mudstone interbedded foundation far exceeds the design requirements, for the sake of more safety, it is more reasonable to select the depth of 35m as the foundation.

3. Conclusion

In this chapter, the characteristic values of bearing capacity of sand-mudstone interbed foundation and medium weathered mudstone foundation are determined by load simulation test. The results and conclusions are as follows:

(1) The characteristic value formula of bearing capacity of medium weathered mudstone foundation is obtained by simulating test of mudstone foundation with different width and burial depth. With the increase of the width, the characteristic value of the bearing capacity increases linearly and linearly. The linear fitting formula is: = 0.16257B + 2.63417; Similarly, by applying side load to simulate different depths of rock foundation load test, with the increase of depth, the characteristic value of bearing capacity does not change significantly; Finally, the modified formula of bearing capacity characteristic value of weathered mudstone foundation is obtained as f_a = 0.16257B + 2.63417.

(2) The characteristic value of bearing capacity of 35m deep sand-mudstone interbedded foundation is obtained through the simulation test of foundation load under the depth of sand-mudstone interbedded foundation. The bearing capacity of sand-mudstone interbedded foundation with different depths has no obvious change, but its bearing capacity is obviously increased compared with mudstone foundation, and its settlement is also relatively increased, finally, the characteristic value formula of bearing capacity of sand-mudstone interbedded foundation is obtained as f_a = 0.90286B + 6.5.

References

[1] (2011) GB5007-2011 code for design of building foundation. China Construction Industry Press, Beijing.
[2] Khuzaie H M A .Verification of Scale Effect of Shallow Foundation in Determination of Bearing Capacity of Sandy Soil[J].University of Mosul, 2011(2).DOI:10.33899/RENGJ.2011.27328.
[3] Ullah S N, Hu Y. Peak Punch-Through Capacity of Spudcan in Sand with Interbedded Clay: Numerical and Analytical Modelling[J]. Canadian Geotechnical Journal, 2017:cgj-2016-0597. DOI:10.1139/cgj-2016-0597.
[4] Chen Yumin, Xu Dingping (2011) FLAC/FLAC3D Foundation and engineering example. China Water Conservancy and Hydropower Press, Beijing.
[5] Wang Enqi. Study on determination of bearing capacity of foundation by tangent modulus method [D]. South China University of Technology, 2013.