ISSN 2663-1563 Vol. 5, Issue 5: 33-38, DOI: 10.25236/AJAGE.2023.050506

Influence of mudstone parameters on vertical bearing capacity of sand-mudstone interbed foundation

Lin Zhong

Department of Railway Engineering, Sichuan College of Architectural Technology, Chengdu, 610300, China

Abstract: *Based on the analysis of the load simulation test of sand-shale interbed foundation with different physical and mechanical parameters of mudstone, the influence degree of bearing capacity and physical and mechanical parameters of sand-shale interbed foundation is obtained. The influence of mechanical parameters on bearing capacity of sand-mudstone interbedded foundation is found through the simulation of foundation load test of sand-mudstone interbedded foundation with different mechanical parameters of mudstone.*

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

1. Introduction

Table 1: Statistical table of physical and mechanical parameters of mudstone

Author	Rock type	Natural uniaxial compressive strength/MPa	Cohesion/kPa	Angle of internal friction/°	Young's Modulus/GPa	Siméon Denis Poisson	Natural density/g/cm3
Zhang Yuhao[1]	Weathered mudstone	-	500	35	0.365	-	-
Kang Jin Tao[2]	Mudstone	-	2280	34.8	0.582	0.311	2.25879
Zhang Yong-an[3]	Mudstone	-	1920	39.17	-	-	2.63
Zhou Yinghua[4]	Mudstone	8.7	1740	30.32	0.66~1.143	-	2.54
Zhao ming-hua[5]	Mudstone	4.43	700	41.3	-	-	2.45
We Da-shi[6]	Medium weathered silty mudstone	1.3~7.6	-	-	2.21~4.37	0.07~0.38	2.29~2.52
Xu Ya Hui[7]	Strongly weathered mudstone	0.3	450	28	0.1	0.3	2.1
Lu Haifeng[8]	Silty mudstone	-	9100	45.2	5.19	0.26	-
Deng Tonghai[9]	Silty mudstone	17.3	5260	42.25	4.025	0.28	-
Peng Bo-xing[10]	Strongly weathered mudstone	0.8~1.2	250	35	0.2	0.25	2.1
	Weathered mudstone	3.5~5.2	800	45	0.6	0.2	2.25
Wang Qihu[11]	Mudstone	1.25~8.6	1000	30.75	3.9~27.7	0.31	2.39
Zeng xiangyong[12]	Weathered mudstone	9.59~10.64	380~1330	35~40	1.5~1.8	0.26~0.3	-
Huang Chao[13]	Strongly weathered mudstone	0.3	450	28	0.1	0.3	2.1
Tan Xin[14]	Mudstone	1.6~20.1			1.081~8.0		2.71
Cheng Qiang[15]	Mudstone	5.28~9.36	1740~1920	30.32~39.17	0.645~3.7	0.21~0.29	2.54~2.63
Wang Yanchao[16]	Mudstone	19.19	1870	52.3	3.46	0.22	2.54
Su Dan[17]	Weathered mudstone	26.576	1441	44.46	4.173	0.37	2.7
Yin yueping[18]	Mudstone	6.74~24.81	-	-	5~20	0.2~0.35	2.26~2.64
Li Weishu[19]	Mudstone	-	330.0	42.0	4.25	0.26	-

In practical engineering, the physical and mechanical parameters of mudstone in different sites are different. In order to better understand the vertical load transfer characteristics of sand-mudstone interbedded foundation, it is necessary to analyze and study which red mudstone and interbedded structural plane parameters have influence on the vertical bearing capacity of mudstone interbedded foundation, by changing the values of these factors in a reasonable range, the vertical bearing

ISSN 2663-1563 Vol. 5, Issue 5: 33-38, DOI: 10.25236/AJAGE.2023.050506

characteristics of sandy mudstone interbed foundation are analyzed systematically. In order to determine the research scope of each influencing factor, this paper mainly studies mudstone physical and mechanical parameters, and statistics 19 mudstone physical and mechanical parameters in mudstone research:

The elastic modulus of mudstone is 0.1 ~ 27.7 gpa, Siméon Denis Poisson ratio is 0.07 ~ 0.52, uniaxial compressive strength is 0.3 ~ 44.7 mpa, cohesion is 98.7 ~ 9100 kpa, the internal friction angle ranged from 15.9° to 52.3°, and the natural density ranged from 2.1 g/cm3 to 2.71 g/cm3. It can be concluded that mudstone elastic modulus, Poisson's ratio, uniaxial compressive strength, cohesion and internal friction angle have a larger range of values and a smaller range of natural density values, in the follow-up study of the influencing factors, the influence of the larger value interval on the vertical bearing capacity of sand-mudstone interbed should be emphasized. Considering the influence of the dip angle of sand-mudstone interbedded foundation, this paper simulates various parameters of sand-mudstone interbedded foundation with 0°, 28° and 45° dip angles respectively.

2. Methodology

2.1 Influence of mudstone volume and shear modulus on vertical bearing capacity of sand-mudstone interbedded foundation

It is known from Table 1 that the elastic modulus and Siméon Denis Poisson ratio of mudstone vary greatly. To study the effect of the variation of elastic modulus and Siméon Denis Poisson ratio on bearing capacity of sand-mudstone interbedded foundation, from equations 1 and 2, the elastic modulus and Siméon Denis Poisson ratio can be converted into bulk modulus and shear modulus.

$$K = \frac{E}{3(1-2v)} \tag{1}$$

$$G = \frac{E}{2(1+v)} \tag{2}$$

K: Bulk modulus

G: Shear modulus

E:Young's Modulus

v:Siméon Denis Poisson

Combining the elastic modulus and Siméon Denis Poisson ratio in Table 1, to better compare the simulation results, summarize the results of the regularity. In this paper, 0.257 GPA of the original cohesion is increased or decreased, and 0.257 GPA and 0.771 GPA of the mudstone bulk modulus are simulated by the sand-mudstone interbedded foundation load test, the simulation results are compared with the bearing capacity of mudstone cohesion of sand-mudstone interbed foundation as shown in Figure 1.

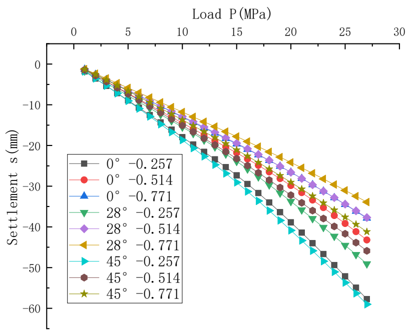

Figure 1: p-s curves of the bulk modulus of mudstone in different sand-mudstone interbedded foundation under three dip angles

As can be seen from Fig. 1, compared with the bulk modulus of 0.514 gpa, the bulk modulus of mudstone increases and decreases with the same dip angle, and the bearing capacity of sand-mudstone

ISSN 2663-1563 Vol. 5, Issue 5: 33-38, DOI: 10.25236/AJAGE.2023.050506

interbedded foundation also changes correspondingly, it shows that the bulk modulus has a great influence on the bearing capacity and settlement of sand-mudstone interbedded foundation. It is found that the bearing capacity of the sand-mudstone interbedded foundation with 28°dip angle is the highest under the same mudstone bulk modulus, and there is a big difference between the bearing capacity of the sand-mudstone interbedded foundation with 0°and 45°dip angle, the bearing capacity of 0°and 45°dip sand-mudstone interbedded foundation is close, but the bearing capacity of 45°dip sand-mudstone interbedded foundation is the lowest.

The same parameters are selected in Table 1. The load test simulation of sand-mudstone interbedded foundation is carried out for mudstone bulk modulus of 0.111 GPA and 0.333 GPA, respectively, the simulation test is carried out according to Section 3 -1, and the results of the simulation test are compared with the bearing capacity of cohesion of the original sand-mudstone interbedded foundation as shown in Fig. 2.

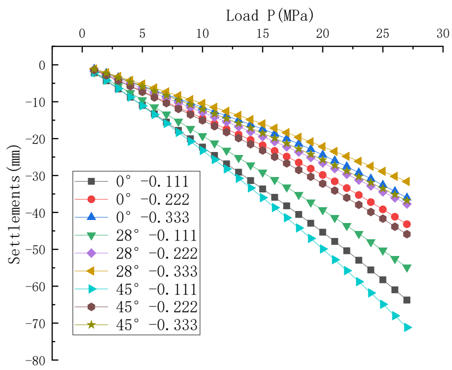

Figure 2: p-s curves of shear modulus of mudstone in different sand-mudstone interbedded foundation under three dip angles

It can also be seen from Fig. 2 that the change rule is consistent with Fig. 1, which shows that the influence of bulk modulus and shear modulus on sand-mudstone interbedded foundation is interrelated, it also shows the inner relation between Eq. 1 and Eq. 2.

2.2 Effect of internal friction angle of mudstone on vertical bearing capacity of sand-mudstone interbedded foundation

The internal friction angle of rock is a basic parameter of mechanical strength of rock, and it is also a very important parameter.

The internal friction angle of mudstone is between 15.9°and 52.3°according to Table 1. In order to better compare the difference of simulation results, the original internal friction angle of mudstone is increased or decreased by 34.8°with the gradient of 5°, the internal friction angles of 24.8°, 29.8°, 39.8°and 44.8°of mudstone are simulated by load test of sand-mudstone interbedded foundation. The simulation test scheme is simulated according to section 3.1, the simulation results are compared with the original cohesion strength as shown in Figure 3.

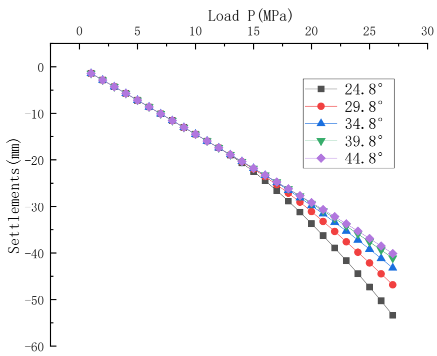

Figure 3: 0° p-s curve of different internal friction angle of sandstone-mudstone interbedded foundation

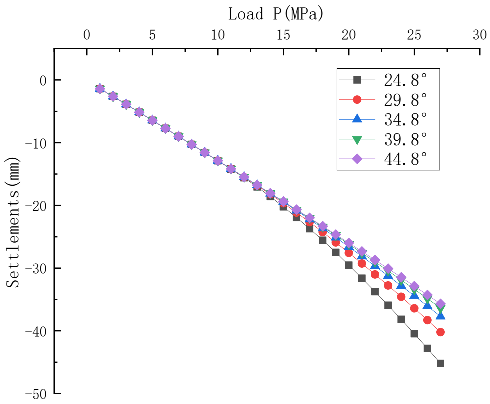

Figure 4: 28° P-S curve of different internal friction angle of sandstone-mudstone interbedded foundation

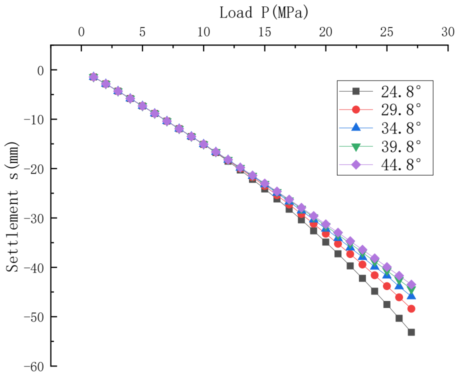

Figure 5: 45° dip angle of sand-mudstone interbedded foundation different mudstone friction angle P-S curve

From Fig. 3 to 5, it can be seen that the bearing capacity of sand-mudstone interbedded foundation under different dip angles coincides with the increase or decrease of the internal friction angle of mudstone, and the front section of p-s curve has no obvious change, the p-s curve bifurcates, and the subsidence of the sand-mudstone interbedded foundation is different, but the subsidence of the sand-mudstone interbedded foundation decreases faster with the decrease of the friction angle of the mudstone. It shows that the bearing capacity of sand-mudstone interbedded foundation can be effectively increased with the increase of internal friction angle of mudstone. The bearing capacity of sand-mudstone interbedded foundation is 28 ° > 0 ° > 45 °.

2.3 Effect of mudstone cohesion on vertical bearing capacity of sand-mudstone interbedded foundation

The cohesion of mudstone is a very important parameter to affect the strength of rock, which is also the focus of this paper. Combining with Table 1, we can know that the cohesion of mudstone is between 98.7 KPA and 9100KPA, in this paper, 0.58 MPA increase or decrease of the original cohesive force is used to carry out the load test simulation of sand-mudstone interbedded foundation for mudstone cohesive force of 1.14 MPA, 1.71 MPA, 2.85 MPA and 3.42 MPA, respectively, the simulation test scenario was modeled as described in section 3.1, and the results of the simulation test were compared with the strength of the original cohesion as shown in figs. 6 to 8.

ISSN 2663-1563 Vol. 5, Issue 5: 33-38, DOI: 10.25236/AJAGE.2023.050506

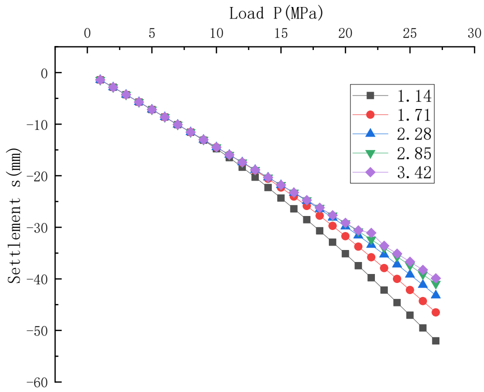

Figure 6: 0° dip angle of sand-mudstone interbedded foundation different mudstone cohesion p-s curve diagram

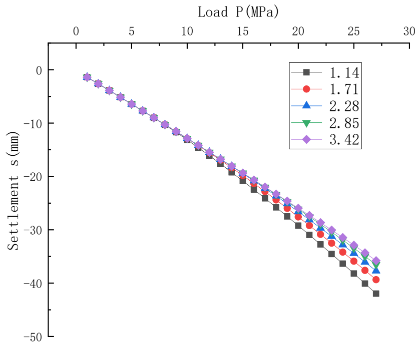

Figure 7: 28° P-S curve of different mudstone cohesion of sand-mudstone interbedded foundation

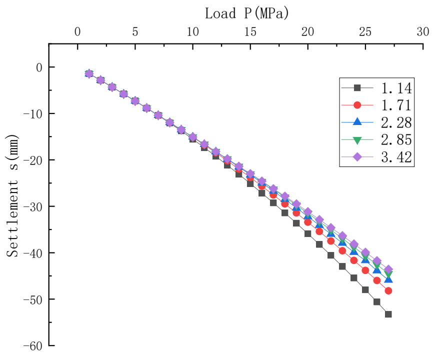

Figure 8: 45° dip angle of sand-mudstone interbedded foundation different mudstone cohesion P-S curve

From figs. 6 to 8, it can be found that the law of variation is the same as the law of the influence of the internal friction angle of mudstone, it is found that the effect of mudstone cohesion on the bearing capacity of sand-mudstone interbed foundation with 0°and 45°dip angle is greater than that of sand-mudstone interbed foundation with 28°dip angle.

3. Conclusion

Based on the load test of sand-mudstone interbed foundation with different physical and mechanical parameters of mudstone, the correlation between bearing capacity of sand-mudstone interbed foundation and physical parameters of mudstone is obtained. The influence of the variation of internal friction angle and cohesion of mudstone on bearing capacity of sand-mudstone interbedded foundation is divided into two sections, the increasing magnitude of settlement of different parameters is not the same, and the bearing capacity is higher when the parameters are increased. The p-s of sand-mudstone interbedded foundation is different from the beginning because of the variation of the volumetric modulus and shear modulus of mudstone, but the bearing capacity of the sand-mudstone interbedded

ISSN 2663-1563 Vol. 5, Issue 5: 33-38, DOI: 10.25236/AJAGE.2023.050506

foundation with the same parameter is higher.

References

[1] Zhang Yuhao. Study on shear behavior and load transfer mechanism of Red Mudstone Pile Foundation [D]. Southwest Petroleum University, 2017.

[2] Kang Jintao, Wu Qiong, Tang Huiming, etc. Mechanism of strength deterioration of Badong Formation soft-hard interbedded rock mass caused by rock/discontinuity deterioration [J]. Earth sciences, doi: 10.3799/dqkx. 2019.110.

[3] Zhang Yongan, Li Feng, Chen Jun. Study on water-rock interaction of red mudstone [J]. Engineering geology, 2008(01): 22-26.

[4] Zhou Yinghua, Zhou Depei, Feng Zhijun. Study on strength and deformation characteristics of three red beds under conventional triaxial compression [J]. Engineering geology, 2005(04): 477-480.

[5] Peng L I , Yanyu Z , Huijuan C ,et al.Effect of interwell mudstone interlayers' physical parameters on steam-assisted gravity drainage[J].Journal of Henan Polytechnic University(Natural Science), 2019.

[6] Malik B A, Shah M Y, Sawant V A. Influence of micropile parameters on bearing capacity of footings[J]. 2021. DOI: 10.1007/s11356-021-14062-7.

[7] Xu Yahui. Study on calculation method of bearing capacity of red mudstone pile foundation considering pile-rock interaction [D]. Southwest Petroleum University, 2016

[8] Lu Haifeng. Study on engineering characteristics and failure mechanism of soft rock slope in Padang Formation [D]. Chinese Academy of Sciences Graduate School (Wuhan Institute of Geotechnical Mechanics), 2010.

[9] Deng Tonghai. Water-rock interaction of red beds in central Yunnan and its influence on tunnel engineering [D]. Chengdu University of Technology, 2017.

[10] Lin H , Yang R , Li Y ,et al.Deformation Mechanism and Control Technology of Coal Roadway with Thin Sand-mudstone Interbed Roof[J].Mining, Metallurgy & Exploration, 2022:1-13. DOI:10.1007/s42461-022-00707-9.

[11] Wang Qihu. Study on engineering geological characteristics and slope stability of red beds in Gansu province [D]. Beijing University of Technology, 2016.

[12] Zeng Xiangyong, Huang Zhipeng, Deng Anfu, etc. Study on strength characteristics of red bed soft rock: the 8th National Congress of Rock Mechanics and engineering, Chengdu, China, 2004[C].

[13] Huang Chao. Study on calculation method of pile bearing capacity considering sediment effect in red mudstone [D]. Southwest Petroleum University, 2015.

[14] Tan Xin, Pu Yu, Peng Wei. Experimental study on correlation between mechanical parameters of red mudstone and sound velocity [J]. Journal of the Changjiang Academy of Sciences, 2014(11): 51 -55.

[15] Cheng Qiang. Study on disaster-causing mechanism and prevention technology of excavation slope in red bed soft rock [D]. Southwest Jiaotong University, 2008.

[16] Wang Yanchao. Creep mechanical properties of mudstone in Padang Formation and time-effect study of slope deformation and support [D]. China University of Geosciences, 2018.

[17] Su Dan. Study on bearing characteristics of pile foundation of frame wharf on inland soft rock foundation [D]. Chongqing Jiaotong University, 2015.

[18] Yin Yueping, Hu Ruilin. Study on engineering geological characteristics of purplish red mudstone in the Padang Formation (T) of the Three Gorges Reservoir area [J]. Engineering geology, 2004 (02):124-135.

[19] Li Weishu, Zhang Ruilin. Analysis of influence of friction coefficient of foundation rock mass on anti-slide stability of gravity dam [J]. Journal of Underground Space and engineering, 2015(s 2): 514-517.