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Analysis of bearing capacity of sand-mudstone interbedded foundation under geometrical factors

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Abstract: *Batholith load test is the best method to determine the bearing capacity of foundation at present, but because the bearing capacity of mudstone is relatively high, the rock foundation load test in engineering site is not only time-consuming and labor-intensive, but also can be used to determine the bearing capacity of foundation, the ultimate bearing capacity of the foundation can not be obtained precisely because of the range of the jack or other reasons.*

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

1. Introduction

In this paper, the vertical bearing capacity of sand-mudstone interbedded foundation with different dip angles is studied, and the results show that the vertical bearing capacity of sand-mudstone interbedded foundation with different dip angles is higher than that of sand-mudstone interbedded foundation with different dip angles.

2. Methodology

2.1 load simulation test scheme of sand-mudstone interbedded foundation

Due to the different physical and mechanical parameters of sandstone-mudstone interbedded rock mass in different areas, in order to select better simulation parameters, this paper investigates and studies many literatures, the physical and mechanical parameters of sandstone-mudstone and sandstone-mudstone interbed in 6 related researches are calculated. The concrete parameters are shown in table 1.

Table 1: Statistical table of mechanical parameters of sand-mudstone interbeds

Author	Rock type	Young's Modulus/MPa	Poisson's ratio	cohesion/kPa	Angle of internal friction/°	D/ kg/m3	Kn/ GPa	Ks/ GPa
Ma Furong[1]	Mudstone	11	0.38	32	11	1.85	-	-
	Sandstone	22	0.26	355	34	2.2	-	-
Zhou Yong[2]	Sandstone	233	0.26	41	38.8	2.3	-	-
	Mudstone	7.83	0.28	28	22.4	1.94	-	-
	Structural plane	5.61	0.31	24.5	11	20.5	-	-
Dong Jinyu[3]	Mudstone	4000	0.3	300	32	2.35	-	-
	Sandstone	-	-	-	-	2.5	-	-
	Structural plane	-	-	100	25	-	1	0.1
He chunmei[4]	Mudstone	19.1	0.42	200	41.8	2.22	-	-
	Sandstone	4200	0.3	4000	33	2490	-	-
	Structural plane	-	-	2	15	-	2	1
Kang Jin Tao[5]	Mudstone	582.184	0.311224	2280	34.8	2258.79	-	-
	Sandstone	9194	0.22588	10100	45.1	2596.06	-	-
	Structural plane	-	-	45	27	-	5.2	0.68
Cao Yungang[6]	Structural plane	-	-	6.5	24.62	-	-	-

By collecting and analyzing the structural plane parameters of sand-mudstone and sand-mudstone interbedded in literature, the most complete structural plane parameters of sand-mudstone and sand-mudstone interbedded in this paper are determined as shown in table 2.

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Table 2: The parameters of numerical simulation of rock and discontinuity

	c/MPa	φ/°	G/GPa	K/GPa	D/kg/m3
Mudstone	2.28	34.8	0.222	0.514	2258.79
Sandstone	10.1	45.1	3.75	5.59	2596.06
-	-	-	Kn/GPa	Ks/GPa	-
Structural plane	0.045	27	5.2	0.68	-

According to the relevant requirements of bearing plate method test in GB/T 50266-2013[7] standard for engineering rock mass test methods, the calculated width of the model is more than 5 times of the bearing width (square loading area for convenience of calculation and loading) , and the depth is more than 3 times of the bearing width, so as to cover all the affected areas, taking symmetry into account, the model is built by taking 1/2 of the rock foundation, the bearing area is 1m × 0.5 m, and the side length of the foundation model is 10m×5m×5m.

The relevant calculation steps of numerical simulation of sand-mudstone interbedded foundation load test are as follows:

(1) FLAC3D was used to establish the plate load test model of sand-mudstone interbedded foundation, and the samples were given the moore-Cullen constitutive model and mechanical parameters of sand-mudstone and interbedded structural planes.

(2) Define the analysis step. The uniaxial compression simulation test consists of two steps, namely, the analysis step of in-situ stress balance and the analysis step of applying vertical load. FLAC3D analysis step will judge the initial stress and the corresponding load, boundary conditions between the balance, so as to simulate the initial state.

(3) Define boundary conditions. At the bottom of the model, Z = -5 defines the displacement in the direction of XYZ, the top surface is a free boundary, and at the boundaries of Model X = -5,5 defines the displacement in the direction of X, the displacement in the y direction at the boundaries of model Y = 0 and 5 is shown in Fig. 4-1. The load is divided into force load and displacement load. In this paper, we choose to apply graded external force load, and complete the graded load through the cyclic statement of FISH language in FLAC3D, after the calculation, the displacement value of the bearing surface under each stage load is extracted, and the P-S curve is drawn.

(4) Set the convergence number, to FLAC3D default convergence number 1.000e-05 to stop the simulation.

(5) Export the recorded data and curves for careful analysis.

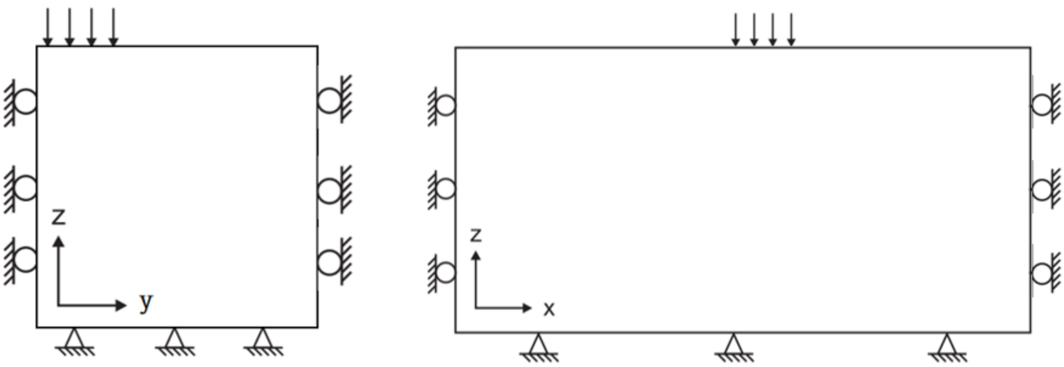

Figure 1: Sketch of Rock Foundation Load Simulation Test

2.2 Influence of dip angle of interbedded discontinuity on bearing capacity of sand-mudstone interbedded foundation

Nin (n=1,2,3...) is mudstone in numerical simulation model of foundation load of mudstone interbedded ground, sham (m=1,2,3...) sandstone, the interfaceH (h=1,2,3...) spacing of sand-mudstone interbedded discontinuities is 1 m, in this paper, FLAC3D built-in Extrusion function is used to divide the mesh of the model. The partial inclination model and the distribution characteristics of the structural plane are given below as shown in Fig. 2.

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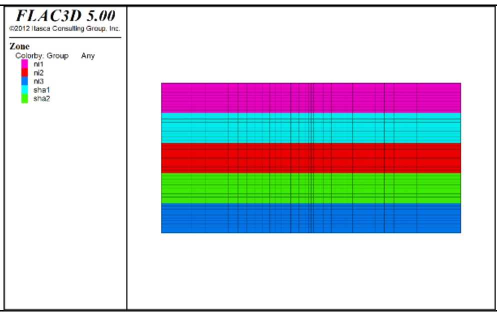
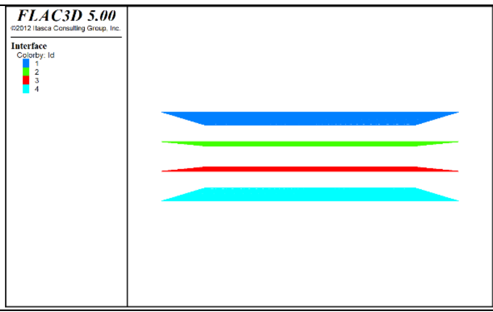
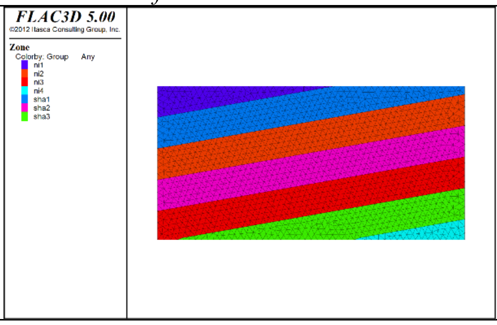


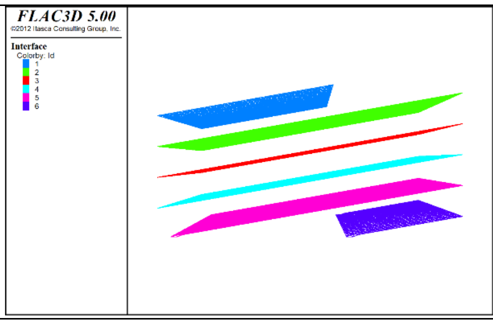
0 ° angle of sand-mudstone interbedded foundation model



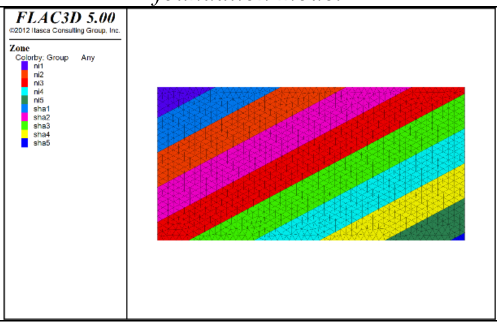
0 ° inclined plane distribution



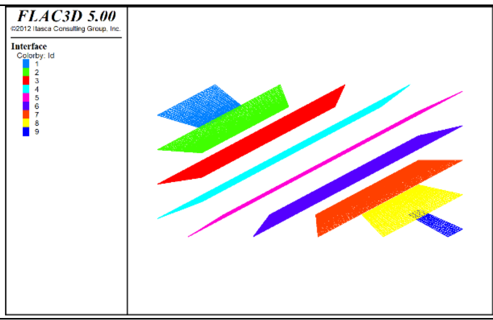
10° angle of sand-mudstone interbedded foundation model



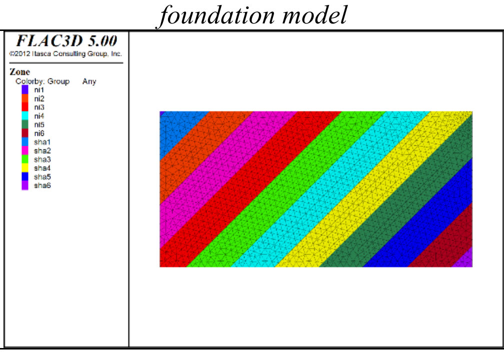
10 ° inclined plane distribution



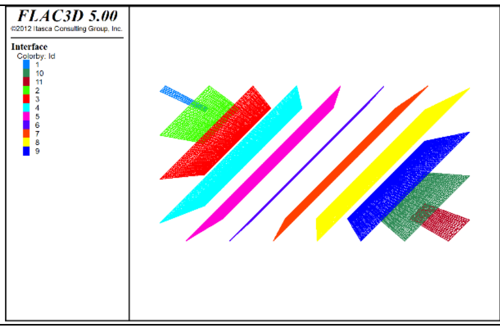
28° angle of sand-mudstone interbedded foundation model



28 ° inclined plane distribution



45°angle of sand-mudstone interbedded foundation model



45°inclined plane distribution

Figure 2: Sand-mudstone interbedded foundation model with different dip angle and distribution map of structural plane

Through the 2.1 section of Rock Foundation Load Simulation Program, the sand-mudstone interbed foundation with the dip angle of the above-mentioned interbedded structural plane is simulated, and the P-S curves extracted from the simulation results are compared as shown in Figure 3.

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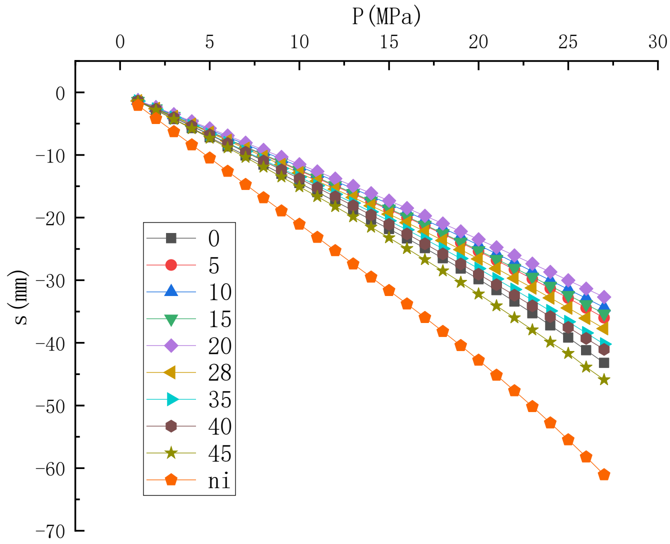
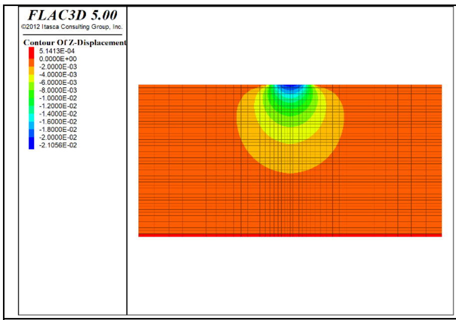
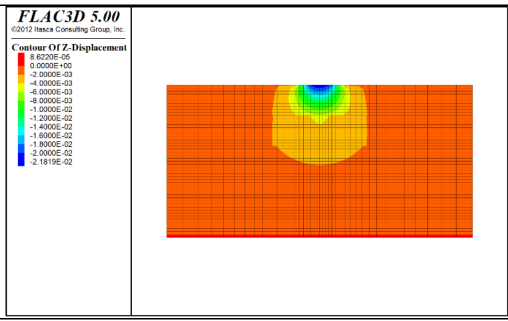


Figure 3: P-S curve of sand-mudstone interbedded foundation with different interbedded dip angle

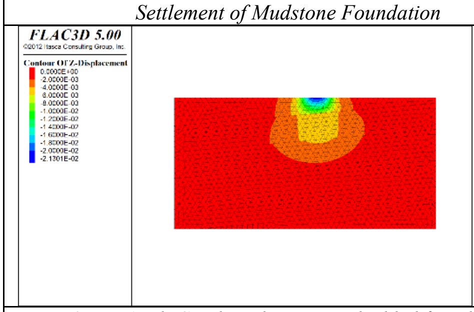
It can be seen from Fig. 3 that the P-S curves of sand-mudstone interbedded foundation with different dip angles tend to be the same, and the bearing capacity of the sand-mudstone interbedded foundation is obviously higher than that of the pure mudstone foundation, indicating that the sand-mudstone interbedded foundation can effectively improve the bearing capacity. However, with the increase of the dip angle, the settlement first decreases and then increases. The settlement of the 20 ° dip sand-mudstone interbedded foundation is the lowest, and the bearing capacity of the foundation is the highest, the bearing capacity of sand-mudstone interbedded foundation with 28 ° dip angle also has not found the phenomenon of steep drop, which shows that the low dip angle of sand-mudstone interbedded structural plane has little influence on the bearing capacity of sand-mudstone interbedded foundation under the constraint of surrounding rock mass. However, the bearing capacity of the sand-mudstone interbedded foundation with increased dip angle begins to decrease continuously from the angle of 28 ° , the bearing capacity of the sand-mudstone interbed foundation with 0 ° dip angle is between 40 ° dip angle and 45 ° dip angle, and the bearing capacity of the sand-mudstone interbed foundation with 45 ° dip angle is the lowest. This is the same as the third chapter, but the bearing capacity of the sand-mudstone interbedded foundation does not change with the increasing angle. It shows that the bearing capacity of sand-mudstone interbedded foundation is quite different from that of sand-mudstone interbedded rock mass. The load transfer at different inclination angles is shown in figure 4.



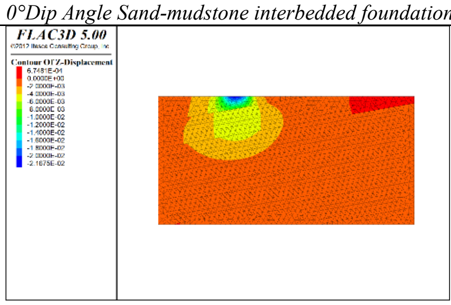
Settlement of Mudstone Foundation



0°Dip Angle Sand-mudstone interbedded foundation settlement



5° Dip Angle Sand-mudstone interbedded foundation



10°Dip Angle Sand-mudstone interbedded foundation

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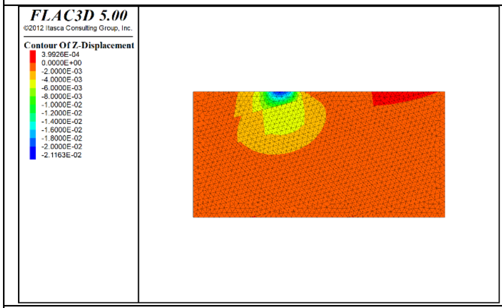
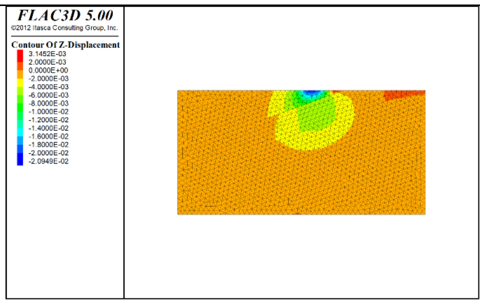
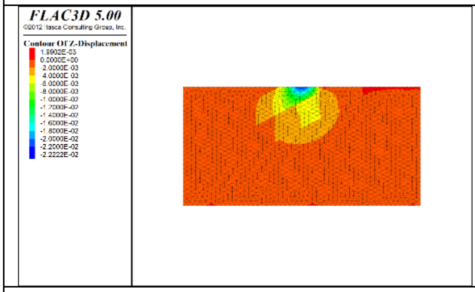
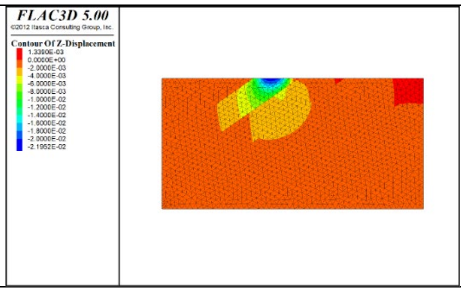
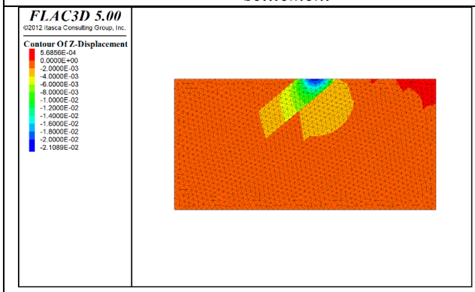
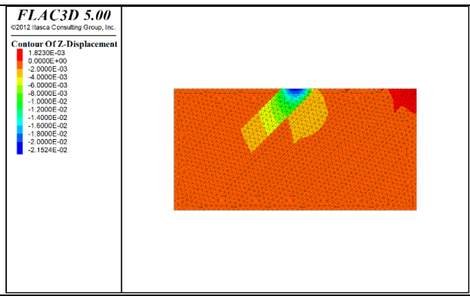
settlement	*settlement*
	
15°Dip Angle Sand-mudstone interbedded foundation settlement	*20° Dip Angle Sand-mudstone interbedded foundation settlement*
	
28°Dip Angle Sand-mudstone interbedded foundation settlement	*35° Dip Angle Sand-mudstone interbedded foundation settlement*
	
40° Dip Angle Sand-mudstone interbedded foundation settlement	*45° Dip Angle Sand-mudstone interbedded foundation settlement*

Figure 4: Cloud Map of foundation settlement of mudstone and sand-mudstone interbedded with different interbedded dip angle

It can be seen from Fig. 4 that the settlement of sand-mudstone interbedded foundation is obviously separated from that of mudstone foundation and varies with the dip angle of interbedded structural plane and increases with the dip angle, the more the vertical displacement deviates to the dip angle of the discontinuity, the closer the sandstone layer is to the foundation, and the uplift occurs on the nearest angle between the mudstone layer and the sandstone layer.

3. Conclusion

In this paper, a series of uniaxial compression simulation tests of sandstone-mudstone interbedded rock mass are carried out to study the influence of dip angle of interbedded structural plane on its strength. The results and conclusions are as follows:

The bearing capacity of sand-mudstone interbedded foundation and the dip angle of interbedded discontinuities are obtained by the load simulation test of sand-mudstone interbedded foundation with low dip angle of interbedded discontinuities. The Q-S curves of sand-mudstone interbedded foundation with different dip angles tend to be consistent, and the bearing capacity of sand-mudstone interbedded foundation increases greatly compared with that of mudstone foundation, showing the rule that the thickness of sand-mudstone interbedded foundation increases first and decreases first. Although the bearing capacity of the sand-mudstone interbedded foundation with 28°dip angle is not found to drop steeply, the 28°dip angle is still located at the inflection point of ascending variation and descending, this indicates that the dip angle of interbedded structural plane still has great influence on bearing capacity of sand-mudstone interbedded foundation.

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