Orthogonal tests research on the influential Factors of the Shear Characteristics of interface between Coarse Sand and Concrete

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Abstract. The direct shear tester is refitted from RMT-150B testing system, which is utilized to carry out direct shear test for coarse sand with 0%, 8%, 16%, 24% water content and contact surface with four different kinds of roughness, strength concrete basement under different normal stresses, the variance analysis method is used to analyze the test data, the results show that the influence height of normal stress on the sand and structure contact surface is significant, and the roughness of contact surface has impact on it, and there are no significant effects of water content and concrete roughness.

1.   Introduction

The research of mechanical properties of soil and structure contact surface is the key to solve the interaction problem between soil and structure. Since the 1960s, Potyondy JG and so on sand have studied shear mechanical properties of the different contact surface of sand, clay, sticky granular soil and steel, concrete, wood through hundreds of direct shear test [1], many domestic and foreign scholars has done a lot of research on this question, and many valuable results have been achieved [2-7]. However, the above test researches are carried out under low stress or very low stress conditions, with the emergence of deep underground engineering, the applicability of the shear test results of soil and structure contact surfaces for shallow soils has been challenged, it is urgent to implement influencing factors research for shear characteristics between soil and structure contact surface under high stress condition. Thus, the direct shear test are carried out in 16 sets of coarse sands with different water content and concrete contact surface with different basement hardness and different roughness, variance analysis method is used to analyze degree that the shear characteristics of the contact surface are affected by the structural hardness, soil water content and interface roughness.

2.   Test Systems and Method

The existing RMT-150B rock mechanics system is transformed into a high-stress shear system which adapts to the shear test of sand and structure contact surfaces. C20, C30, C40, C50 four kinds of strength concrete basement are poured, which are set the same prism height and width, the angles are united at 45 °, prism height were 1mm, 2mm, 3mm, 4mm prism, respectively, carry out shear and sand with 0%, 8%, 16%, 24% water content, this contact surface direct shear test select the influencing factors of shear properties of the normal stress, the contact surface roughness, the basement hardness and the soil water content, every influencing factors are arranged 4 horizontal orthogonal array L16 (45) to plan. For the sake of recording, each group is tests is unified number, taking number A2-B3-C1-D4 for an example, normal stress is 4 MPa, the roughness of contact surface is 1 mm, the hardness of basement is 28.1, the water content is 0% and tested, the testing significances of other numbers are the same.

3. Analysis of Influencing Factors of Relative Ultimate Shearing Strength of Particles in Contact Surface

The Duncan formula is used:

$$\tau = w_s/(aw_s + b) \tag{1}$$

τu is: $\tau_\mu = \lim_{w_s \to \infty} \dfrac{w_s}{aw_s + b} = \dfrac{1}{a}$ (2)

The numerical analysis software is used to fit the shear stress of contact surface- test data of shear displacement and the Duncan hyperbola. The fitting results are shown in Table 1. According to Table 6, the shear stress under high stress- test data of shear displacement, when the Duncan hyperbola is used to fitting, the correlation coefficient is above 0.97, and it indicates that the shear of contact surface-shear displacement relationship can use the Duncan hyperbolic model under high stress to describe.

Table.1 Regression results of experimental data

condition	a/MPa^{-1}	b/(mm/MPa)	relevant parameter R
A2-B1-C2-D0	0.68917	0.5547	0.98846
A4-B2-C2-D24	1.16781	0.21739	0.97105
A6-B3-C2-D8	0.52026	0.1809	0.9928
A8-B4-C2-D16	0.39263	0.15594	0.98746
A2-B2-C3-D8	0.97873	0.50834	0.99759
A4-B1-C3-D16	0.89665	0.28069	0.97425
A6-B4-C3-D0	0.43934	0.21583	0.9951
A8-B3-C3-D24	0.36065	0.1378	0.99707
A2-B3-C4-D16	1.65606	0.45886	0.99354
A4-B4-C4-D8	0.64011	0.29172	0.99661
A6-B1-C4-D24	0.35361	0.18624	0.99352
A8-B2-C4-D0	0.28475	0.15206	0.99707
A2-B4-C5-D24	0.56072	0.70084	0.98907
A4-B3-C5-D8	0.39437	0.31606	0.99152
A6-B2-C5-D16	0.40263	0.19519	0.99456
A8-B1-C5-D8	0.53071	0.11682	0.99323

The equation (2) is used to calculate two regression parameters in Table 1, and obtain the ultimate shear strength of coarse sand and structure contact surface under high stress.

Table.2 Ultimate shear strength and initial shear stiffness

test number	ultimate shearing strength(MPa)	test number	ultimate shearing strength(MPa)
1	1.60353	9	4.49203
2	1.68672	10	4.27610
3	1.64336	11	4.49911
4	1.31415	12	3.90796
5	2.73716	13	6.00088
6	3.03982	14	5.56106
7	2.90442	15	5.86371
8	2.90265	16	5.27345

The variance analysis method is used to analyze the test data of shearing strength of the contact surface, the variance analysis table is shown in Table 3.

Table. 3 Variance analysis results of shear strength of contact surface

source of variance	sum of square of deviations	variance	mean sum of square of deviations	F value	significance
A	16.4513	3	5.4837	30.7781	specially significant
B	1.51238	3	0.5041	2.82947	have impact
C	0.40353	3	0.1345	0.75496	
D	1.15929	3	0.3864	2.16887	
error e	0.53451	3	0.1781		
total(T)	20.0610	15	1.3374		

It can be found from the analysis results of Table 3 that the effect of normal stress on the ultimate shearing strength of sand-structure contact surface is particularly significant, but the contact surface of concrete structure has impact on shearing but no significant, and the effect of water content is greater than concrete strength, the impacts of two are particularly insignificant.

4. Summary

(1)The shear stress of the contact surface under high stress- test data of shear displacement use Duncan hyperbola curve to fit well.

(2)The effect of normal stress on the ultimate shear strength of sand-structure contact surface is particularly significant; the concrete contact surface has impact on shearing strength but no significant, the effect of water content is greater than concrete strength, the impacts of two are particularly insignificant.

Acknowledgements

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