The relationship between friction angle and surface roughness, and the relationship between frictional resistance and surface roughness were analyzed to research the influence of material types of structure.

Friction angle The internal friction angle of natural soil is 31.1° and wet soil is 34.3°. The friction angle of soil-structure interface is shown in Table.2. The friction angle and surface roughness curve is shown in Fig. 10

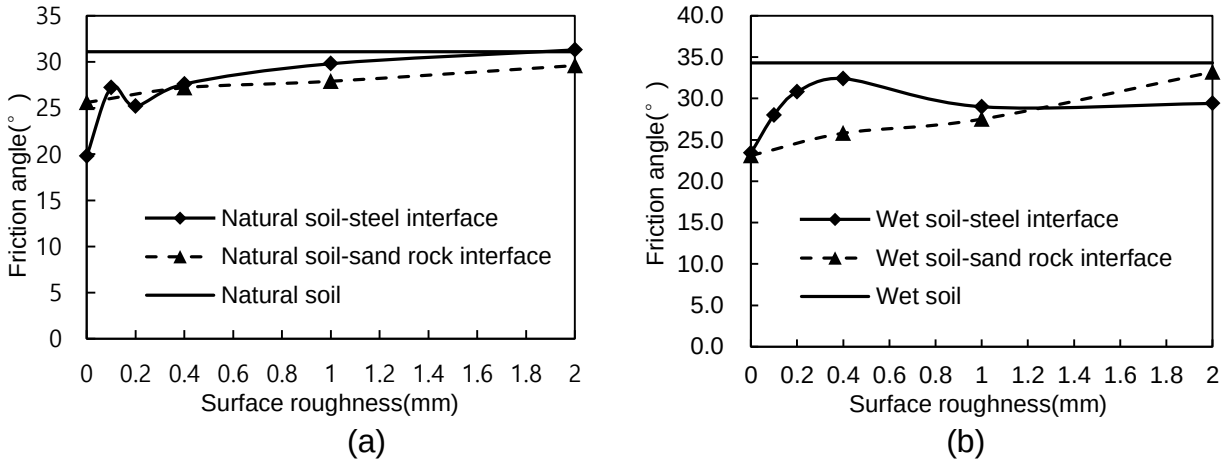


Fig. 10 Effects of material types of structure on friction angle. (a) Natural soil; (b) Wet soil

Fig. 10(a) (b) show that friction angle of interface is lower than internal friction angle of soil.

Fig. 10(a) shows that: (1) When surface roughness is less than 0.4mm, friction angle of natural soil-sand rock interface is larger than natural soil-steel interface. (2) When surface roughness is greater than or equal to 0.4mm and less than or equal to 2.0mm, friction angle of natural soil-steel interface is larger than natural soil-sand rock interface. (3) When surface roughness of steel is 0.1mm (relative roughness is about 0.05), friction angle of interface increases significantly.

Fig. 10(b) shows that: (1) When surface roughness is less than or equal to 1.0mm, friction angle of natural soil-steel interface is larger than natural soil-sand rock interface. (2) When surface roughness is equal to 2.0mm, friction angle of natural soil-sand rock interface is larger than natural soil-steel interface.

Frictional resistance The shear strength of soil is shown in Table. 7, and the interface frictional resistance is shown in Table. 3 to Table. 6, respectively.

Table. 7 Shear strength of soil

| Normal stress(kPa) | 100 | 200 | 300 | 400 |
|---|---|---|---|---|
| Natural soil(kPa) | 55.89 | 131.39 | 175.32 | 240.53 |
| Wet soil(kPa) | 81.85 | 171.73 | 203.8 | 298.51 |

The relationship between frictional resistance of shear surface and surface roughness is shown in Fig. 11 and Fig. 12

Fig. 11(a)-(d) show that: (1) Interface frictional resistance is lower than shear strength of soil, which means interface is weaker than soil. (2) As surface roughness increases, frictional resistance of natural soil-sand rock interface is larger than natural soil-steel interface at first, and then natural soil-steel interface is larger than natural soil-sand rock interface, which in accordance with the change trend of friction angle. (3) When surface roughness of steel is 0.1mm (relative roughness is about 0.05), interface frictional resistance increases significantly.

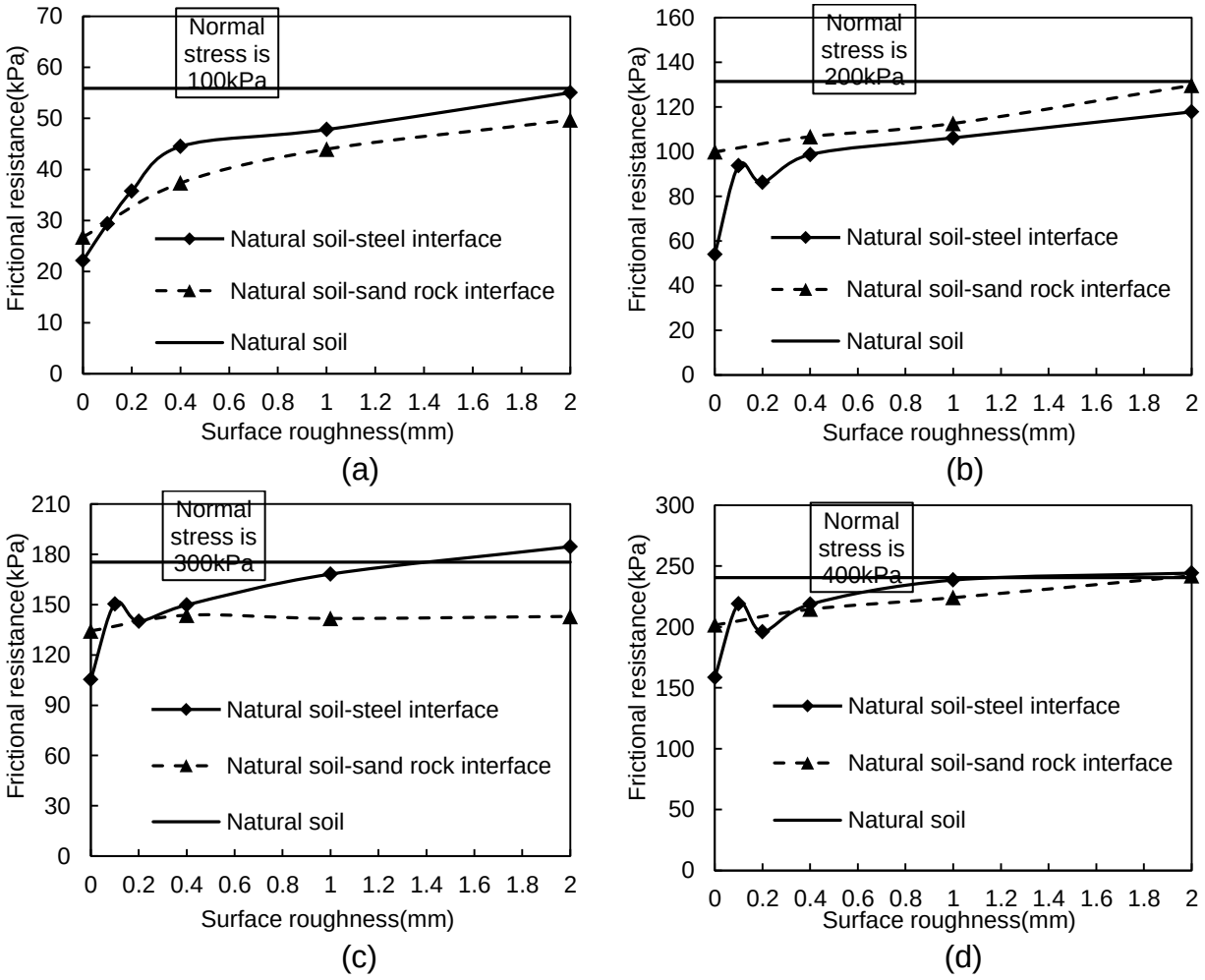


Fig. 11 Effects of material types of structure on frictional resistance of natural soil. (a)Normal stress is 100kPa; (b) Normal stress is 200kPa; (c) Normal stress is 300kPa; (d) Normal stress is 400kPa

Fig. 12(a)-(d) show that: (1) Interface frictional resistance is lower than shear

strength of soil, which means interface is weaker than soil. (2) When surface roughness is 0mm, frictional resistance of wet soil-sand rock interface is larger than wet soil-steel interface. The possible reason is that when surface roughness is 0mm, the micro roughness of sand rock is more rough than steel. (3) As surface roughness increases, frictional resistance of wet soil-steel interface is larger than wet soil-sand rock interface at first, and then wet soil-sand rock interface is larger than wet soil-steel interface, which in accordance with the change trend of friction angle.

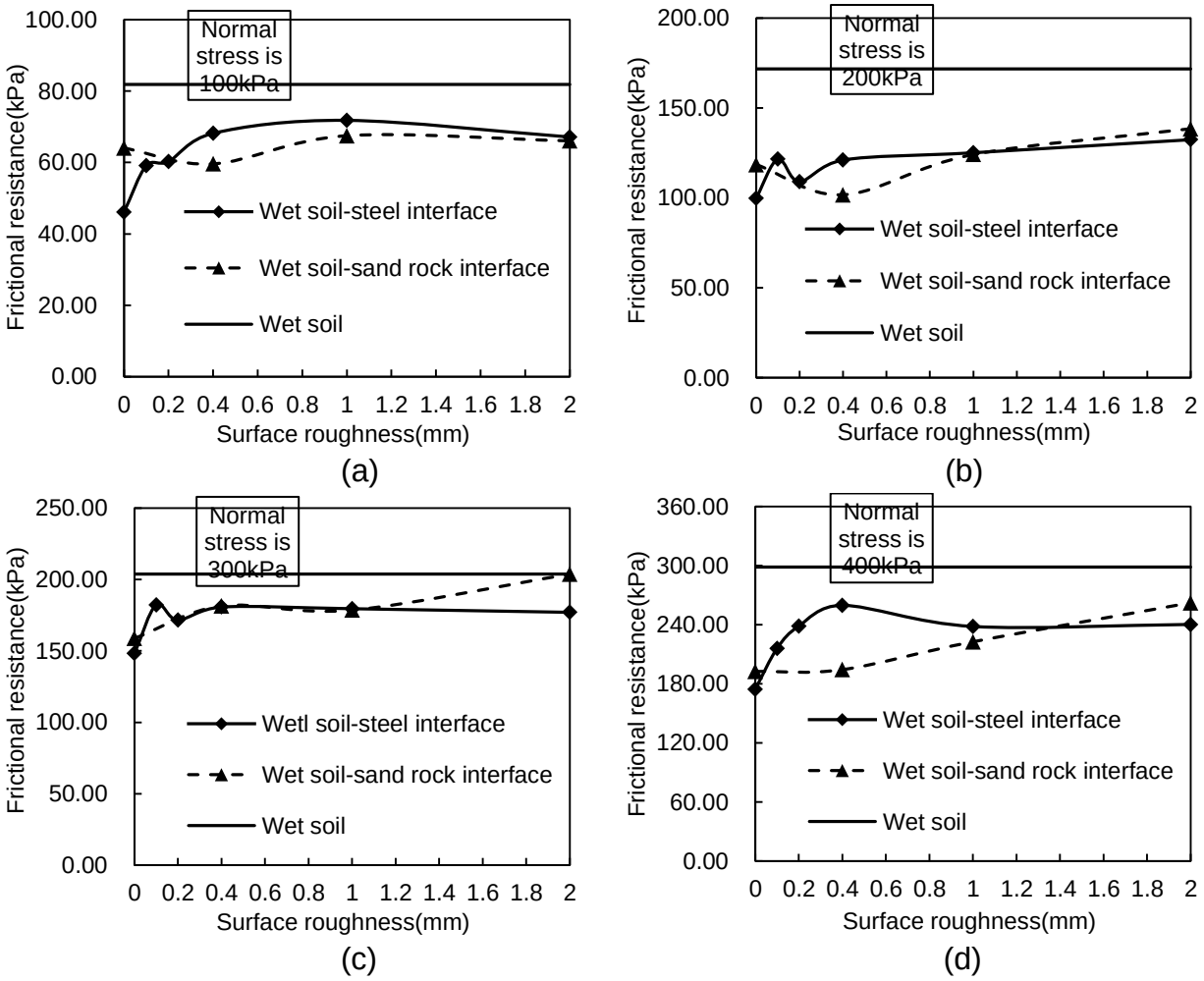


Fig. 12 Effects of material types of structure on frictional resistance of wet soil. (a)Normal stress is 100kPa; (b) Normal stress is 200kPa; (c) Normal stress is 300kPa; (d) Normal stress is 400kPa

*4.2 Soil water content*

Friction angle and frictional resistance of interface was analyzed to research the influence of soil water content.

Interface friction angle The interface friction angle and surface roughness curve is shown in Fig. 13

Fig. 13(a) shows that: (1) When surface roughness is less than 1.0mm, friction angle of wet soil-steel interface is larger than natural soil-steel interface. (2) When surface roughness is greater than or equal to 1.0mm and less than or equal to 2.0mm, friction angle of natural soil-steel interface is larger than wet soil-steel interface.

Fig. 13(b) shows that: (1) When surface roughness is less than or equal to 1.0mm, friction angle of natural soil-sand rock interface is larger than wet soil-sand rock interface. (2) When surface roughness is equal to 2.0mm, friction angle of wet soil-sand rock interface is larger than natural soil-steel interface.

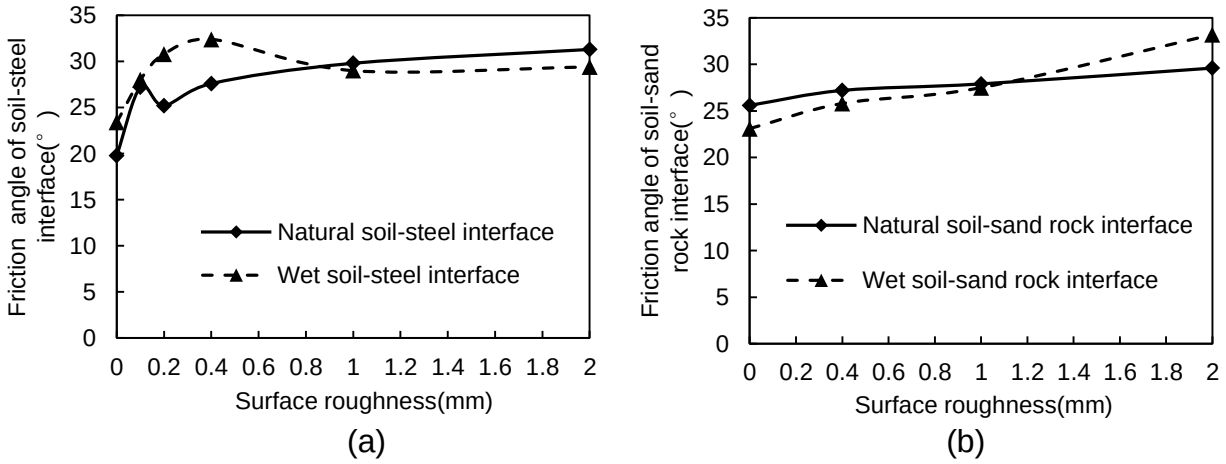


Fig. 13 Effects of soil water content on interface friction angle. (a) Steel; (b) Sand rock

Interface frictional resistance The relationship between interface frictional resistance and surface roughness is shown in Fig. 14 and Fig. 15

Fig. 14(a)-(d) show that: (1) When normal stress is less than or equal to 200kPa, the frictional resistance of wet soil-steel interface is larger than natural soil-steel interface; (2) When normal stress is greater than or equal to 300kPa, the frictional resistance of wet soil-steel interface is larger than natural soil-steel interface when surface roughness is less than or equal to 1.0mm, and the frictional resistance of wet soil-steel interface is less than natural soil-steel interface when surface roughness is equal to 2.0m, which means the interface is weakened by water.

Fig. 15a)-(d) show that: (1) When normal stress is less than or equal to 300Pa, the frictional resistance of wet soil-sand rock interface is larger than natural soil- sand rock interface; (2) When normal stress is equal to 400kPa, the frictional resistance of wet soil- sand rock interface is less than natural soil- sand rock interface when surface roughness is less than or equal to 1.0m, which means the interface is weakened by water, the frictional resistance of wet soil-sand rock interface is larger than natural soil-sand rock interface when surface roughness is equal to 2.0mm.

Natural soil is nearly drying and wet soil is unsaturated soil, so that matric suction exists in wet soil, which results the increase in interface frictional resistance.

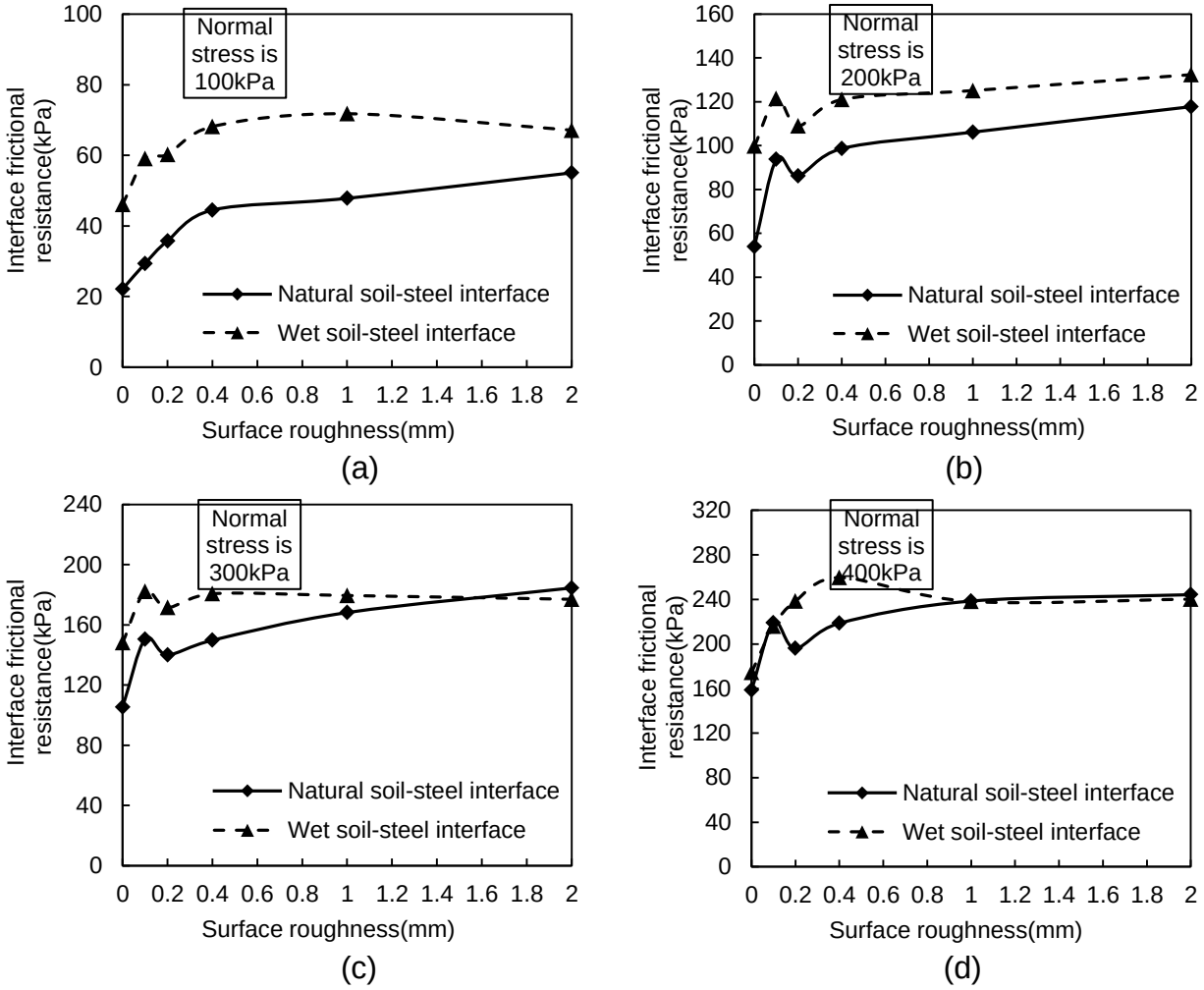


Fig. 14 Effects of soil water content on frictional resistance of soil-steel interface. (a)Normal stress is 100kPa; (b) Normal stress is 200kPa; (c) Normal stress is 300kPa; (d) Normal stress is 400kPa

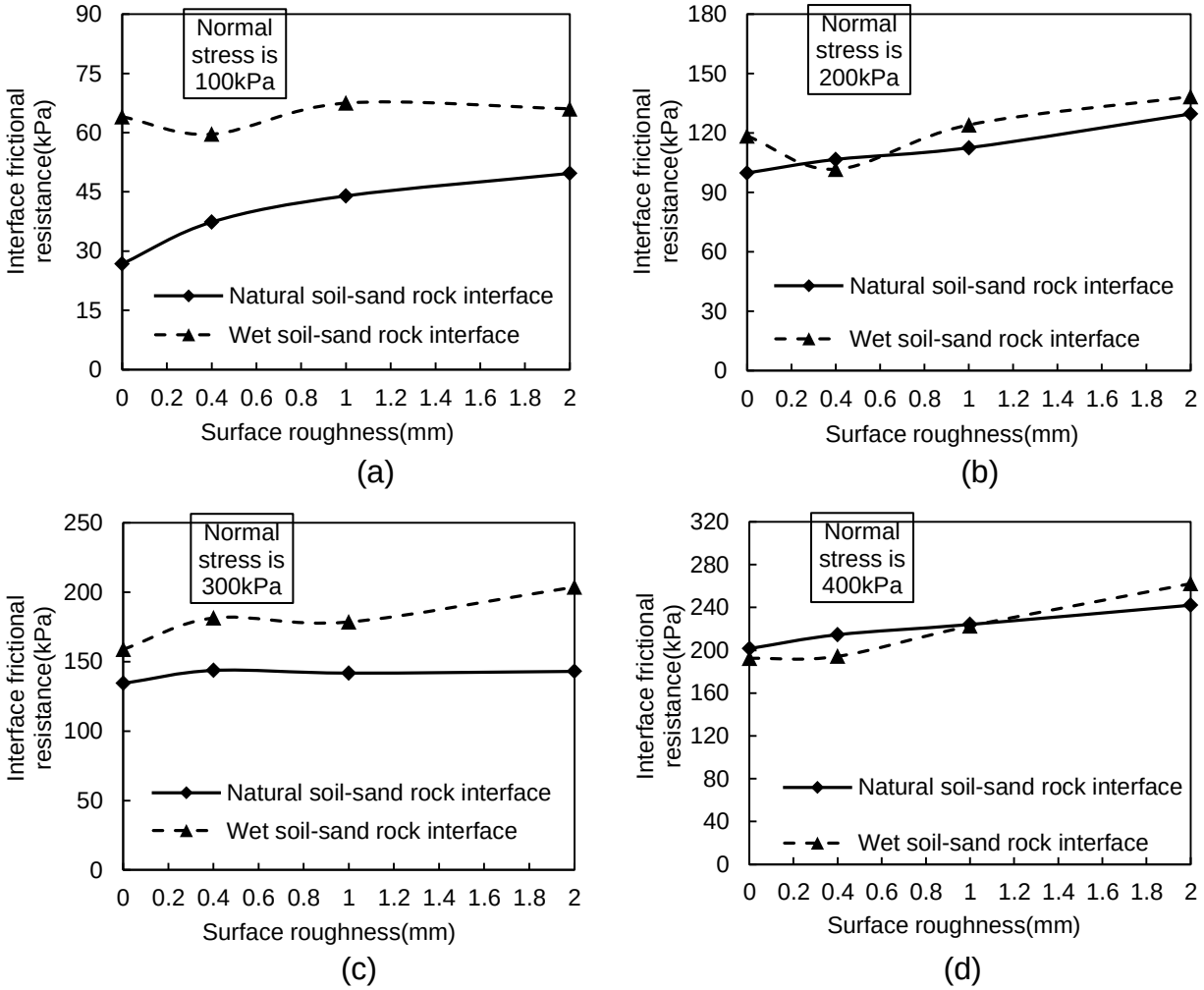


Fig. 15 Effects of soil water content on frictional resistance of soil-sand rock interface. (a)Normal stress is 100kPa; (b) Normal stress is 200kPa; (c) Normal stress is 300kPa; (d) Normal stress is 400kPa

## 5. CONCLUSION

The frictional properties of interface between filling soil and bedrock of Chongqing airport was investigated by directed shear test. The main conclusion of this study are as follows:

(1) The friction angle of interface and interface frictional resistance increase as the surface roughness of structure increases.

(2) The interface frictional resistance is lower than the shear strength of soil, which means the interface is weaker than soil.

(3) The material types of structure and soil water content have influence on interface frictional resistance, and the interface is weakened by water under specific condition.

(4) The relationship between interface frictional resistance and normal stress meet the Mohr-Coulomb criterion.

(5) The interface friction and shear displacement curve is without softening and close to the Clough-Duncan hyperbola.

(6) The relationship between normal displacement and shear displacement is mainly shear contraction.

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