Tab.3 The internal stable reliability index of slope supporting structure under different working conditions

Failure mode		Safety factor	Reliability index	Failure probability
The invalidation of single anchor	no damaging	1.3241	3.6477	0.0132
	The first row	1.2744	3.1809	0.0734
	The second row	1.2561	3.0146	0.13
	The third row	1.2615	3.0646	0.11
	The fourth row	1.2640	3.0687	0.11
	The fifth row	1.2462	2.9680	0.15

The tab.2 shows that the reliability index of a single anchor tensile failure relates to the corresponding axial force. The axial force is greater, the reliability index is smaller. The tab.3 shows that the internal stability reliability index of slope supporting structure under different conditions has a certain relationship with the slope safety factor, and the safety factor is larger, the corresponding reliability index is greater.

3.1 The influence of the variation coefficient on reliability index

If the different variation coefficient is taken to internal friction angle, cohesion and the soil heavy, the internal stability reliability index of supporting structure is different, which is showed in Fig.4, Fig.5 and Fig.6. The general trend of these three figures shows that with the increase of the variable coefficient of corresponding parameters, the corresponding reliability index decreases.

3.2 The change of axial force

The axial forces of anchor 13, 23, 33, 43, and 53 are shown in Fig.7. According to the anchor length, if a measuring point for per meter is arranged, from the picture you can see the general trend of anchor axial force. The axial force of anchor declines from the anchorage segment, and the value goes greatly at first, but become smooth finally.

Fig.8 shows the axial force trend at different row of the anchor from top to bottom. In this example, the slope height is 13 meter and arranged with 5 rows of prestressed anchors. From this figure you can see that the axial force of anchor increases gradually from top to bottom, the axial force of the anchor in the fourth row is the largest, and then it decreased.

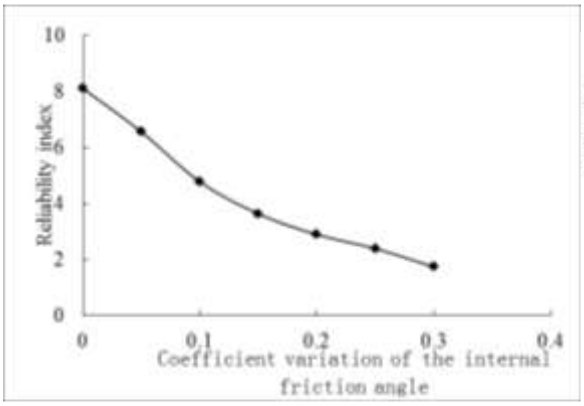


Fig.4 The reliability index of coefficient variation of the internal friction angle compatibility

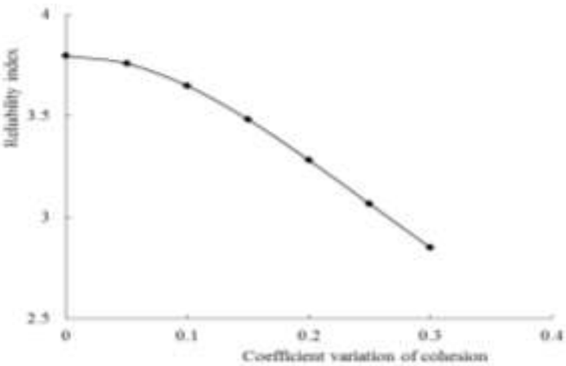
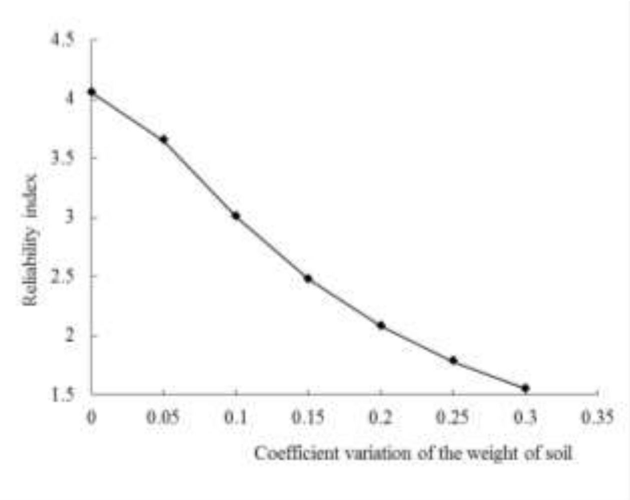


Fig.5 The reliability index of coefficient variation of cohesion



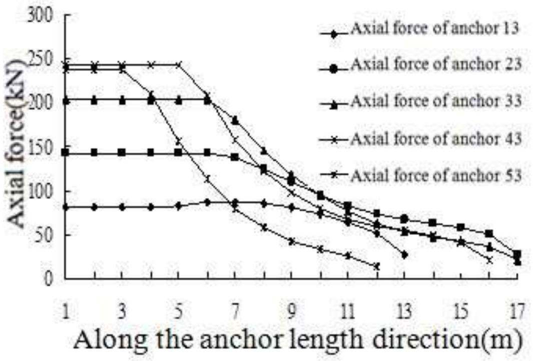


Fig.7 The axial force variation diagram of different row of anchor

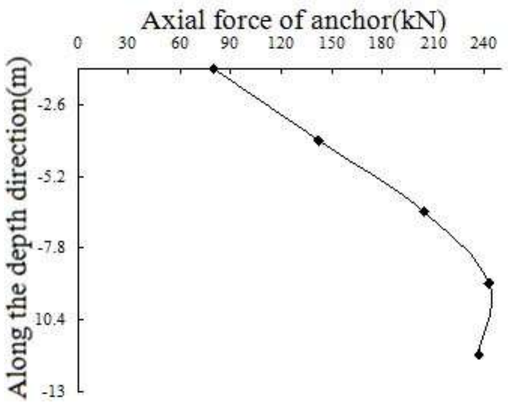


Fig.8 Axial force trend in different row of the anchor from top to bottom

3.3 The changes of displacement

The corresponding displacement of slope in the anchor position is shown in Fig.9. The maximum displacement of the slope occurred in the corresponding position of anchor 33 that can be seen in the figure. That to say, the largest displacement is in the middle of the slope, and the general trend of slope displacement shift is parabolic, the displacement waves in the position of last row anchor.

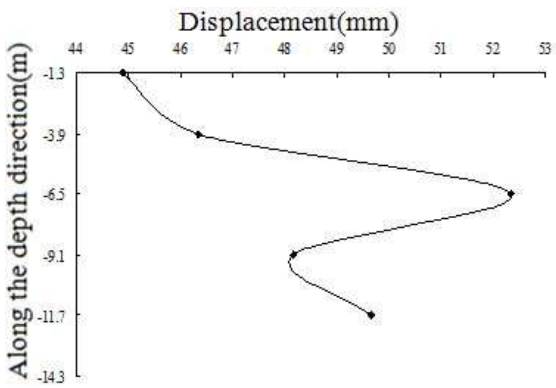


Fig.9 Slope displacement of different anchor positions

3.4 Parametric analysis

（1）The change of cohesion

For this example, there are two layers of soil, the cohesive force are 9.1kPa and 16kPa respectively. On the basis of it, by changing the value of cohesive force while keeping other parameters constant, the maximum slope displacement corresponding to different cohesive force and the axial force of anchor 33 is shown in Tab.4 and Tab.5(The numbers in brackets show the change of cohesive force for the soil in the second layer). Fig.10 and Fig.11 show the maximal displacement and the axial force of anchor 33 under the condition of different cohesion.

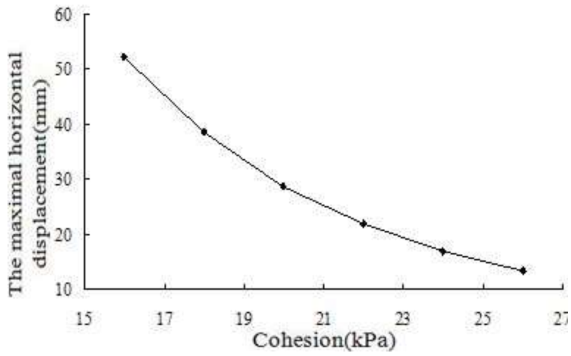


Fig.10 The maximum horizontal displacement of slope corresponding

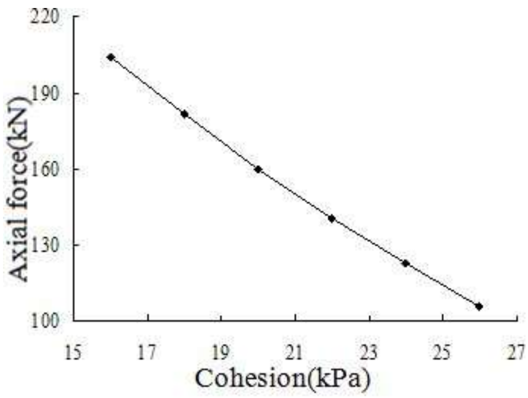


Fig.11 The axial force of anchor corresponding to different cohesion

Tab.4 The maximum horizontal displacement of slope corresponds to different cohesion

Cohesion	11.1(16)	13.1(18)	15.1(20)	17.1(22)	19.1(24)	21.1(26)
Displacement (mm)	52.334	38.545	28.697	21.877	16.895	13.46

It can be concluded from Tab.4 that if the cohesive force increases 2kPa, the corresponding displacement increment is 6.25%、25.55%、23.77%、22.77% and 20.33% respectively. We can see that with the increase of the cohesive force, the maximum horizontal displacement of slope gradually decreases, and basically in a linear gradient.

Tab.5 The axial force of anchor 33 corresponds to the different cohesion

Cohesion	11.1(16)	13.1(18)	15.1(20)	17.1(22)	19.1(24)	21.1(26)
Axial force	203.7	181.5	160	140.7	122.9	105.9

It can be concluded from Tab.5 that if the cohesive force increases 2kPa, the corresponding axial force reduction is 22.2 kN、21.5 kN、19.3 kN、17.8 kN and 17kN respectively. According to this changing trend, the axial force of anchor tends to a certain value when the cohesive force increases to a certain value.

Fig.10 and Fig.11 show the maximal displacement and the axial force of anchor 33 under the condition of different cohesion. The following conclusions can be obtained from the two figures: the axial force of anchor in the frame structure with prestressed anchor decreases with the increase of the cohesive force and basically decreases linearly; the overall trend for maximum horizontal displacement of slope is that it reduces with the increase of cohesive force. In terms of the maximum horizontal displacement, the change of displacement is more sharp when the cohesive force is within a certain range, then it goes gently when the cohesive force reaches a certain value, and basically changes linearly.

（2）The influence of internal friction angle

There are two layers of soil in this slope, the internal friction angles are 16.5° and 17° respectively. On the basis of it, by changing the value of internal friction angle while keeping other parameters constant, the maximum slope displacement corresponding to different cohesive force and the axial force of anchor 33 is shown in Tab.6 and Tab.7(The numbers in brackets show the change of internal friction angle for the soil in the second layer). Fig.12 and Fig.13 show the maximal displacement and the axial force of anchor 33 under the condition of different internal friction angle.

Tab.6 Maximum horizontal displacement of the slope corresponds to the different internal friction angle

Internal friction angle	16.5(17)	18.5(19)	20.5(21)	22.5(23)	24.5(25)
Displacement (mm)	133.91	88.045	62.329	44.228	31.335

It can be concluded from Tab.6 that if internal friction angle increases 2°, the corresponding reduction of displacement is 34.25%、29.21%、29.04% and 29.15% respectively. We can see that with the increase of internal friction angle, the maximum horizontal displacement of slope decreases gradually, and when the internal friction angle reaches a certain value, the maximum horizontal displacement of slope basically reduces with the increase of internal friction angle.

Tab.7 The axial force of anchor 33 corresponds to different internal friction angle

Internal friction angle	16.5(17)	18.5(19)	20.5(21)	22.5(23)	24.5(25)

Axial force (kN)	281.1	242	215.2	191.6	169.2

It can be concluded from Tab.7 that if internal friction angle increases 2°, the corresponding reduction of axial force is 39.1kN、26.8 kN、23.6 kN and 22.4 kN respectively, and basically changes linearly.

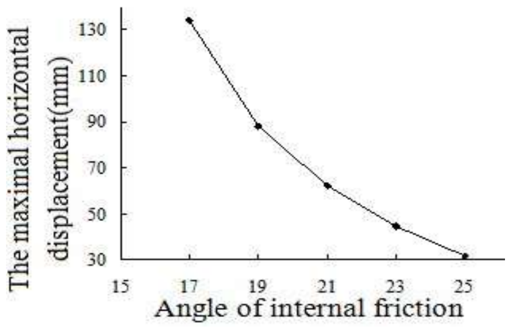


Fig.12 The maximum horizontal displacement of slope corresponds to different internal friction angle

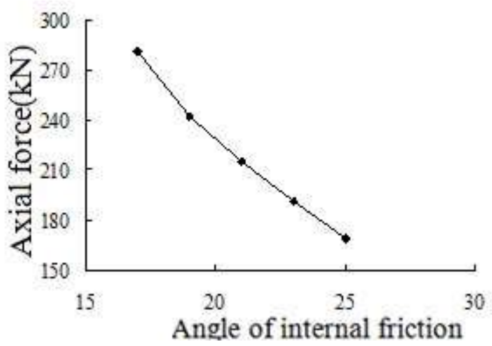


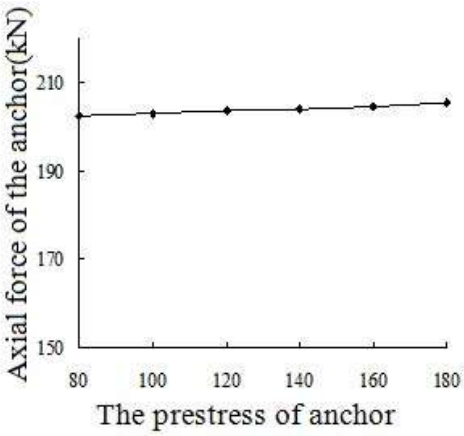
Fig.13 The axial force of anchor corresponds to different internal friction angle

Fig.12 and Fig.13 show the maximal displacement and the axial force of anchor 33 under the condition of different internal friction angle. And the following conclusions can be obtained from the two figures: the axial force of anchor in the frame structure with prestressed anchor decreases with the increase of the internal friction angle and basically decreases linearly; the overall trend for maximum horizontal displacement of slope is that it reduces with the increase of internal friction angle.

(3)The influence of prestress value

About the influence of prestress value to the axial force of anchor and slope, considering prestress value 80 kN、100 kN、120 kN、140 kN、160 kN and 180 kN to the anchor, the influence of different prestress values on the axial force of anchor and slope is shown in Fig.14 and Fig.15.

The Fig.14 shows that the prestress value on anchor basically has no influence on the axial force of anchor, that is to say the axial force of anchor only related to the parameters of soil. It can be concluded from Fig.15 that the prestress value on anchor has influence on the displacement of slope, and the maximum displacement decreases with the increase of prestress value. For this engineering example, when the prestress value increases from 80kN to 180kN, the maximum horizontal displacement of slope decreases from 53.731mm to 50.015mm. Therefore, we can say that the prestress value on anchors should be controlled in the range of 80 kN to 100 kN, the increase of prestress value over this range has no obvious influence on the slope displacement restriction.



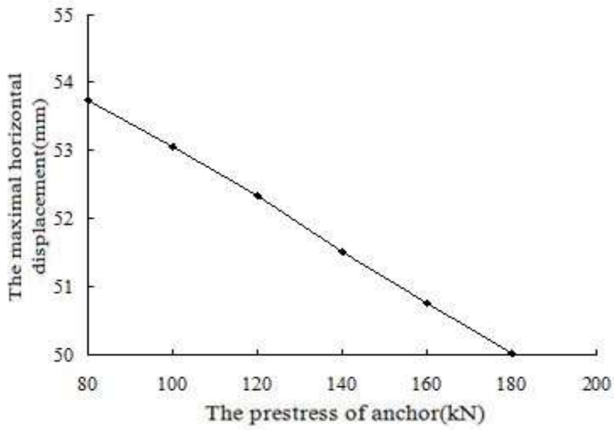


Fig.14 The axial force of anchor

Fig.15 The maximum horizontal

4. CONCLUSIONS

（1）The results of reliability index analysis of internal stability on the supporting structure shows that the safety factor is larger, the corresponding reliability index is larger, and the variability of the parameters is greater, the reliability index is smaller.

（2）The general trends of the axial force of freedom segment and anchorage segment are as follows: the axial force in the freedom segment is almost invariant, and it gradually decreases in the anchorage segment, and it reaches a certain value finally; the change trend of axial force of anchor is parabolic from top to bottom, it gradually increase at first, become biggest in the middle, and then decreases.

（3）The roughly change trend of slope displacement increases at first and then decreases after reaches a certain value. In this project example, the displacement in the position of anchor 53 has a tendency to increase.

（4）The change of the slope displacement and axial force in the condition of different cohesive force or internal friction angle decreases with the increase of the cohesive force or internal friction angle.

（5）Seen from the change of prestress value, with the increase of prestress value, the change of axial force of anchor is small. Although the corresponding displacement of slope reduces gradually, the decrease scope is small, so the prestress value of 100kN is relatively appropriate.

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