Research of Acoustic Detection In Reinforcing Highway Slope With Frame Beam And Grouting Bolt

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Abstract. Grouting bolts are planted partly at the grid of frame beam in reinforcing highway slope. The dimension of frame beam and the length of bolts are the key parameters in design. Based engineering example by acoustic detection, the effect is appraised with the increasing rate of wave velocity along depth direction in detection hole, then the rationality is evaluated for the dimension and of frame beam, and the rationality of anchor length is appraised with the variation trend of wave velocity. In the following, the two reasonable parameters are gained, and the use for reference to similar projects is offered in the future expectably.

Introduction

There are many reinforcing classes for rock cutting slope in mountainous terrain, and the structure of frame beam and grouting bolt is one of those. This is the primary and progressing gradually form in recent years [1,2]. By placing frame beam on the surface and planting grouting bolt at the grid of it, composite structure is formed(refer with: Fig. 1). The construction of bolt and grouting is the hidden process, at the same time, is the key process. Certainly, the dimension of frame beam and the length of bolts are the key parameters in the reinforcing slope. The method of acoustic detection is available for detecting the integrity of rock mass and the effect of grouting, so it is applied widely. The increasing rate of wave velocity along depth in detection hole is generally appraising index in practical application [3,4].

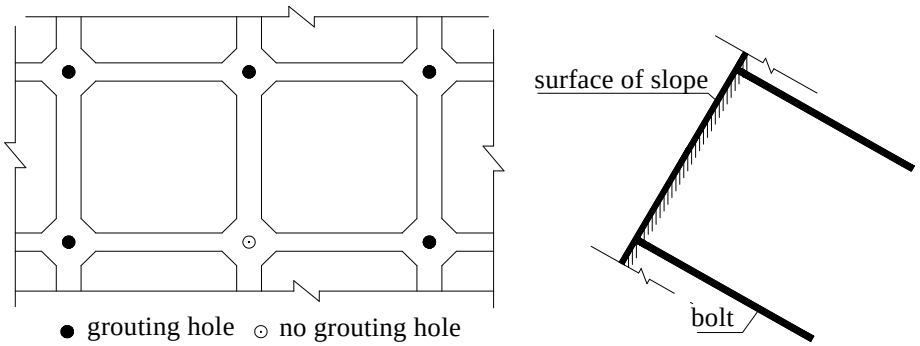

Fig. 1 The structure of frame beam and grouting bolt

Reinforcing Mechanism by Frame Beam and Grouting Bolt for Slope.

For the structure of frame beam and grouting bolt, when the displacement of rock mass comes into being, the bolt withstands external pressure, but it is the passive shoring on the force condition. There are three actions: stitching, internal pressure, pulling and bolting [5]. The frame beam links the outer end into the whole, counterpoises the all bolts, and supports the slope on surface. In general, the grouting bolt of it has changed the rock mass properties, and has improved the rock mass strength and

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stiffness, then has actively reinforced the rock mass of slope. It is important that how to furthest make use of the rock mass strength in bolt design for reinforcing slope [6].

Actually, the force of frame beam and grouting bolt is very complexity, because it is influenced not only by rock mass structure and properties, but also by displacement of slope, so the force is impossible to be calculated [7].

Principle and Method of Acoustic Detection

The principle of acoustic detection for grouting reinforcing rock mass is that the internality of it, such as crash, cranny, flabbiness layer, is evaluated by detecting the acoustics properties of it which is transmitting velocity, swing of wave, as so on, then the rock mass geologic properties is found out.

Before grouting, if it is one of the crashes, cranny, flabbiness layer, as so on, the wave is refracting or diffracting, then a period of transiting time is longer and the transmitting velocity is lower. But the rock mass has been grouted, the incomplete rock mass is changed into integrated one, then a period of transiting time is shorter and the transmitting velocity is faster. The effect of grouting reinforcing rock mass is valuated by the improvement from no grouting to grouting.

One transmitting sensor (F) and two receiving sensors(S1, S2) are placed into the hole that is full of water which is coupling dose, then acoustic wave monitor transmits, and the wave is received by rock mass(refer with: Fig. 2). The wave velocity is gained, using the distance between the two receiving sensors divided by the transmitting time.

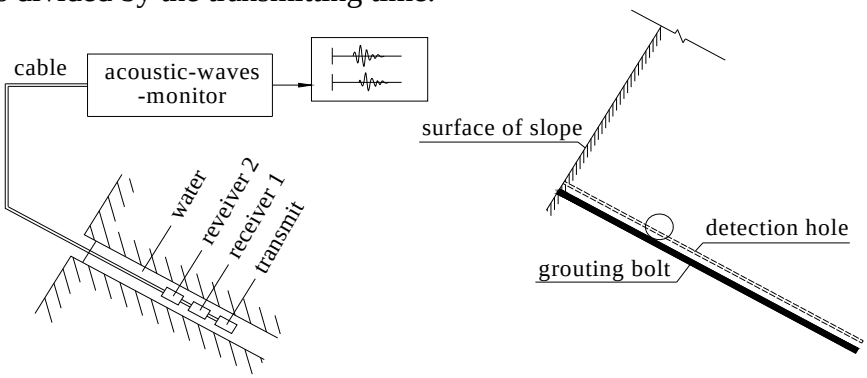

Fig. 2 The method of detection

The increasing rate of wave velocity (R) after grouting is calculated with the detected wave velocity (v_p) (refer with: Eq. 1). The effect of grouting reinforcing rock mass is valuated by R.

$$R = \frac{v_{p2} - v_{p1}}{v_{p1}} \times 100\% \quad (1)$$

In this equation: vp1 is wave velocity before grouting, vp2 is wave velocity after grouting.

Engineering Example

It is the one highway slope, whose gradient is from 45 to 60 degrees, and whose plants on the earth's surface is very exiguity, and whose rock mass is mainly weathering, denudating and crossing. The frame beam and grouting bolt reinforces this slope, whose parameter is seen (refer with: Fig. 3).

The detection holes are around the grouting and no grouting bolts. The coupling dose is water, the acoustic wave monitor is RSM-SY5, the detection mode is in one hole with one transmitting sensor and two receiving sensors, whose distance between two sensors is 20 centimeters, and upgrade distance is 20 centimeters which threes sensors is stepped up at one time during the course of detection, when the detection data is abnormal, the distance is lessened, every hole depth is about 5 meters. The four holes (1#, 2#, 5#, 6#, refer with: Fig. 3) on grouting area is taken for the detection holes after grouting and the two holes (3#, 4# refer with: Fig. 3) on no grouting area is taken for the detection holes before grouting. The variation trend of wave velocity is got (refer with: Fig. 4) and the increasing rate of wave velocity is got (refer with: Fig. 5).

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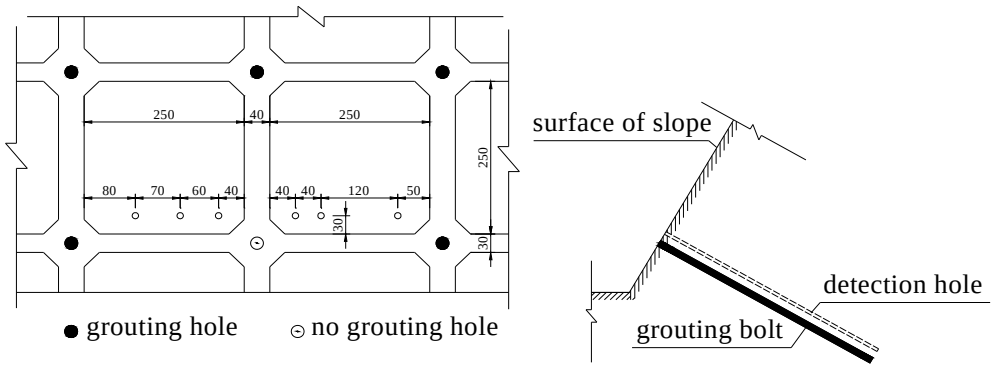

Fig. 3 The parameter of frame beam and grouting bolt

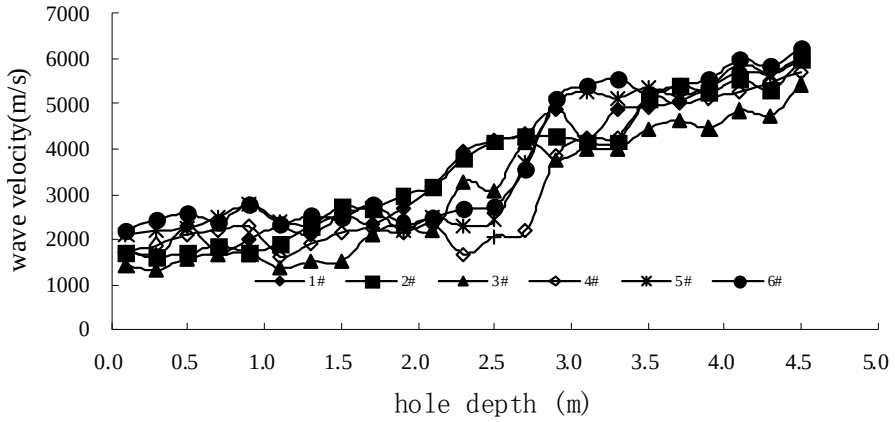

Fig. 4 The variation trend of wave velocity

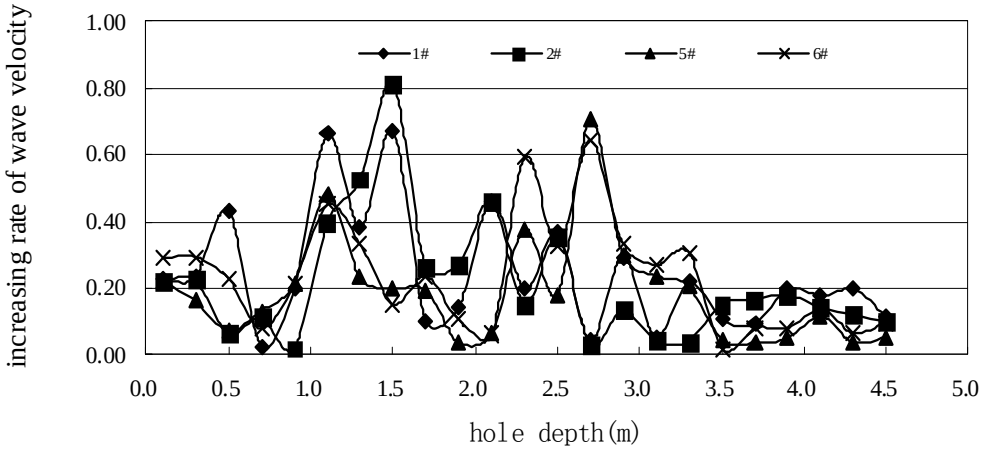

Fig. 5 The increasing rate of wave velocity

The result is got after comprehensive analysis.

(a) The distance from hole 3# and 4# to grouting hole is 2.29 meters. Because the slurry doesn't sink into 3# and 4#, the area at these two holes is no grouting. Seen figure 4, the wave velocity is increasing along the hole depth from jaws to bottom, but it mutated at 2.9 meters. So the rock mass from the depth 0 to 2.9 meters is very deeply weathered and denudated and the rock mass more than 2.9 meters is preferably integrally. On the conclusion, the length of bolt must be more than 2.9 meters in design for reinforcing slope by bolt.

(b) The distance from hole 5# and 6# to grouting hole each is 1.05 meters and 1.71 meters. The distance from 1# and 2# to grouting hole each is 0.79 meters and 1.90 meters. Seen figure 5, in the range from the depth 0 to 2.9 meters except very few, the increasing rate of wave velocity is greater than 20 percent, but in the range more than 2.9 meters, it is all less than 20 percent. So the rock mass more than 2.9 meters is preferably integrally, and the grouting effect is not significantly.

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(c) On the increasing rate of wave velocity, in the range from the depth 0 to 2.9 meters except very few, the increasing rate of wave velocity is less than 50 percent. It indicates that the slurry has diffused to 3# and 4#. So the size of frame beam that is 2.5m×2.5m is very reasonable.

Conclusion

The conclusion can be summarized.

(a) The size of frame beam and the length of bolt are the key parameter in design for grouting reinforcing highway slope.

(b) The grouting effect to highway slope is evaluated with increasing rate of wave velocity at the every detection point, and then the rationality of frame beam grid size is evaluated, when it is detected by acoustic wave.

(c) The rationality of grouting bolt length is evaluated by the variation trend of wave velocity in the hole, when it is detected by acoustic wave.

References

[1] Chen Liangkui. The Geotechnical Technolgy of Anchorage Engineering. Beijin: People's Transportation Press (1996)

[2] Zuo Deqin. The Application of Complex Shorting for Slope. Shanxi Aarchitecture, 7(20):87~88(2010)

[3] Hunag Xiaoguang. The Evaluation for Detection Method to grouting effect. Safety of Coal Mine. 2(10):38-39(2001)

[4] Guo Jianqiang. Manual of Geologic Calamity Perambulate by Physical Geography. Beijin: Geolgic Press(2003)

[5] Zhang Chenbin. The Mechanism and Destroy Analysis for Soil Nailing Wall. Beijin: People's Transportation Press(1998)

[6] Pi Yongpei. The Application of Frame Beam and Bolt to the Transformer Substation Slope in Changsha. Geotechnical Engineering, 2(10): 57~59(2007)

[7] Li Ning, Yao Xianchun, Zhang Chenke. Several Points in Dynamic Stability Analysis of Rock Slope, Rock Mechanics and Engineering Journal. 5:873~881(2012)