A study on developing sealing packer for rock bolt grouts considering mixing ratio of admixture and strength

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ABSTRACT

Mixing ratio of admixture which acts the cement-grouted material in a rock bolt hole in the field works secures structure stability. The strength and curing time after mixing the materials like admixture for fully-grouted rock bolt holes should be assessed. Considering mixing ratio of admixture for cement-grouted holes in rock bolt, the laboratory and field works were tested. It shows the foaming phenomena to develop sealing packer through several tests according to faster foaming time in tunnel and slope, etc. When sealing the rockbolt hole by the packer developed in this study after filling the hole with packer including admixture, it was found to be able to prevent the grouting material (admixture) from flowing down (cement leakage).

Keywords: Admixture; Packer; Rockbolt

1 INTRODUCTION

Supports installed immediately after the first lining excavation or slope boring includes rockbolts and anchors. The gap between rockbolt and boring hole is filled with grouting material. The gap remains unfilled is exposed to groundwater, causing it to be corroded. Cement mortar used as grouting material for rockbolt hole may be used for soft rock or soil ground. Appropriately mixed mortar shall be used to prevent rockbolt grouting material in the tunnel from flowing down in Fig.1. Particularly for the rockbolt on tunnel crown side, the measures to prevent grouting material from flowing down onto rockbolt surface are needed.

Fig. 1. Overflowing mortar out of a rock bolt hole on tunnel crown.

To prevent grouting material from flowing down, using a piece of cloth or non-shrinkage mortar to close a hole is currently the common way domestically or globally. Flowing-down grouting material which is exposed to the workers would possibly threaten the safety at the site. It's difficult to fill the hole with grouting material completely which results in increase of material cost. Also, to deal with the dust generated from rockbolt drilling or other activities in the tunnel or smoking booth, the study on modular smoke control and dust collector has been currently underway in Korea.

In this study, sealing packer designed to prevent rockbolt grouting filler from flowing down in tunnel is developed. In a bid to produce the admixture to fill the drilling hole, grouting filler mold comprising of cement, water and urethane was mixed considering the mixing ratio and curing time and the strength was checked. As the packer containing the admixture shall plug up a hole, it shall be foamed and expanded in a short time as far as possible so as to avoid corrosion to rebar or settlement of surrounding ground which may threaten the structural safety. As a result of compressive strength test of grouting filler depending on curing time, adhesive strength between hole and additive could be identified. This study is intended to develop the sealing packer which is produced by integrating fully-grouted filler and plastic packer, in which admixture is foamed and expanded so as to close the hole completely.

2 TESTS FOR SEALING PACKER

Detailed tests for developing sealing packer and admixture are described as follows.

2.1 Foaming test

The admixture used as grouting material in packer is highly efficient in cut-off, expansion and quick-setting. Once the admixture is hardened quickly and seal the hole, grouting work is accelerated. And no backward-flow of grouting filler (admixture) occurs, cement milk with high liquidity may be used as grouting material. In this study, mixing test was conducted after selecting appropriate admixture for foaming, expansion and compressive strength test.

Foaming test was conducted over 3 times. The first test was conducted using low viscosity epoxy and urethane material, but couldn't be applied to the study because foaming and expansion test were excluded. The second test was conducted with urethane material alone referring to the first test result. According to the second test result, the optimal ratio of admixture, main material : hardener : auxiliary, was found to be 20 : 10 : 40.

In order to properly function as sealing packer to prevent grouting material from flowing down, strength and curing time of admixture mold comprising of admixture and water shall be identified in a short time as far as possible.

The third test was conducted after replacing the hardener (water) with accelerant in a bid to reduce the foaming time and curing time with foaming test at the site and the result is as Fig 2. Foam time was reduced to 2 seconds and completion time to 15 seconds on average.

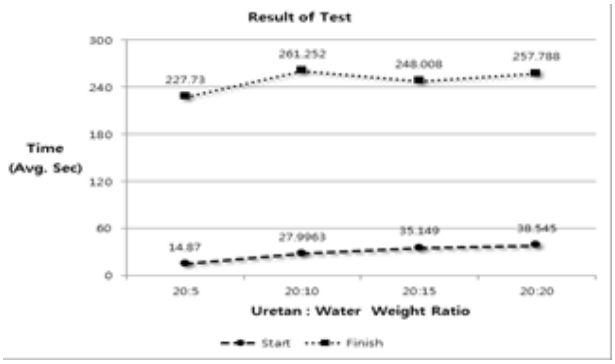

Fig. 2. Foaming time with urethane and water weight ratio.

Epoxy was found to have had no foaming and expandability while urethane foamed within a curing time required. But urethane was hardened in sponge form after foaming which is unfavorable in terms of the strength. Cement was added to secure the sufficient strength. Instead of water used as hardener currently, accelerant was used. As a result, more dense and appropriate cement mixing could be obtained.

2.2 Evaluation of admixture strength and development of packer

This test is designed for the admixture inside the sealing packer. For compressive strength test, adhesive strength between drilling hole and urethane admixture was measured in the form of unconfined compressive strength. The test was based on KS L 5105 and the specimen sized in 5×5×5cm was fabricated in a cubic mold with mixing ratio of admixture as seen in Table 1 & Fig. 3.

Table 1. Mixing ratio of urethane admixture for strength test.

Mixing stage	Main material	Hardener	Auxiliary
Optimal ratio	2	1	4
1st weight	20g	10g	40g
2nd weight	40g	20g	80g

Fig. 3. Laboratory uniaxial strength test of admixture.

The difference of test result from the first test and the second test is attributable to dense material by increased mixing ratio and effective confining to prevent the material from leaking from cubic mold during foaming, and also to high strength cement use for the 2nd test instead of ordinary portland cement used in the 1st test to increase the strength as well as reduce the hardening time. According to the first unconfined compressive strength test, the minimum value 144.56kg/cm^2 and maximum value 157.31kg/cm^2 respectively which corresponds to 153.1kg/cm^2 on average were obtained. According to the second test,

minimum 383.17kg/cm^2 and maximum 666.39kg/cm^2 which corresponds to 478.47kg/cm^2 on average were obtained.

The packer developed in this study is designed to seal off the hole after boring for the rock bolt, thereby preventing the grouting material (admixture) from flowing down (backward-flow). With regard to the study on admixture and packer, admixture with mixing ratio which can be foamed within 30 seconds and compressive strength 15.0 MPa at least so as to have high adhesive strength to the ground and frictional resistance. Moreover admixture shall have 300% or more expansion rate. The packer contains admixture without injection device. At such status, admixture is mixed when cutting the package to foam and expand to fill the packer with the admixture. Packer was designed using 3D design technique and the test product was produced and using this prototype sample, laboratory mock up test and field test were conducted.

2.3 Laboratory mockup test and field tension test

This laboratory test was intended to identify the behaviors of the packer such as actual operation of the packer and admixture mixing after injecting admixture into the sealed packer and boring hole condition of the original soil. Furthermore, cut-off performance was checked after pouring water on acrylic tube. The test procedure was as follows in Fig. 4 to 6.

(a) Put the admixture such as urethane, accelerant and cement into the packer according to the mixing ratio after packing them individually. (b) Put the packer into the bottom of acrylic tube and add the admixture for foaming. (c) When foaming begins, check the foaming process with the naked eye and when foaming is finished, add the paints and pour the water to check if it leaks.

Fig. 4. Putting packer with admixture into acrylic tube and foaming scheme.

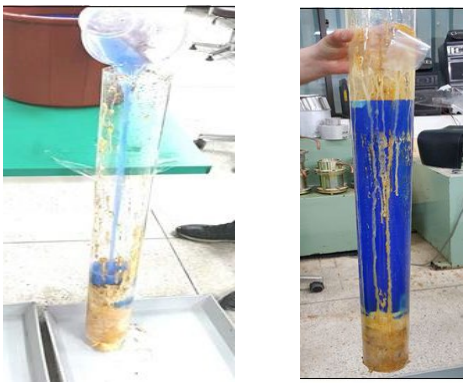

Fig. 5. Leaking tests of packer (12 hours after foaming).

Here, the acrylic tube stands for drilling hole of rock bolt.

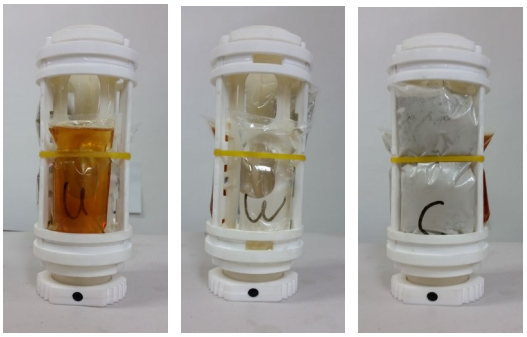

Fig. 6. Admixture adding into packer prototype.

According to mockup test 5 times, sealed packer operated well and admixture foamed properly. Cut-off after foaming and expanding was verified and at the fourth test (No.4) the water in acrylic tube was completely leaked which was attributable to admixture flowing out of packer causing insufficient foaming.

Table 2. Results of mock up tests.

No.	Cut-off time	Foaming direction	Remarks
1	12 hours	upper	O.K.
2	12hours	upper	O.K.
3	12 hours	upper	O.K.
4	2 hours	lateral	N.G.
5	12 hours	upper	O.K.

Fig. 7. Sealing packer prototype developed for this test.

Field test was conducted in anchor hole on slope, instead of the tunnel. The test was intended to check the tensile strength of the ground stiffener (anchor) after installing sealed packer, and prevent the grouting material from flowing down as well as to come up with the measures to improve the performance when applying at the site. This field test is the proof test method which is the part of soil nail tests according to FHWA. The test was conducted at 5 sites where the developed packer was applied (No 1~5) and another 5 sites where the soilnailing method was used instead of the packer (No 6~10). Through this test, load displacement relationship and anchor creep were measured and soil nailing stability was checked in in Fig. 8 to 9.

According to the test result, creep of soil nail No 1~5 using the sealed packer was lower than the result from No 6~10, which was attributable to adhesive strength between soil nails and original ground in hole which was secured by admixture in packer. Thus, the packer when used was able to prevent grouting material from leaking as well as to make commitment to securing the slope stability.

Fig. 8. Foaming photo of field test on slope.

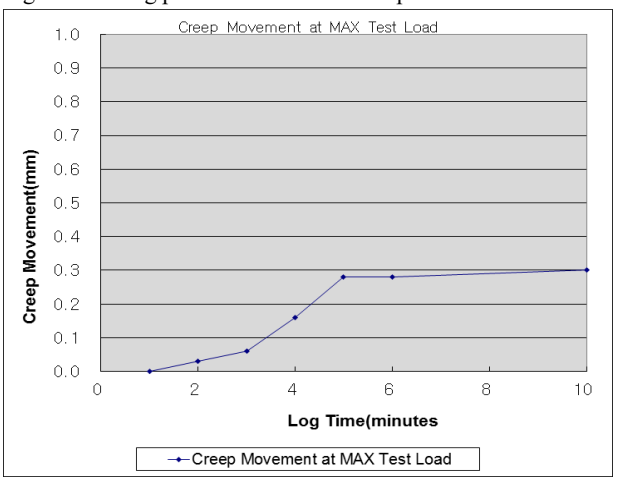

Fig. 9. Field creep test of anchor

3 CONCLUSION

In this study, laboratory compressive strength test was conducted to check the adhesive strength of urethane admixture with the hole while changing the mixing ratio and curing time in a bid to develop the rock bolt hole filler (admixture). The strength of the mold comprising of cement, water and urethane varied depending on mixing ratio and in addition, adhesive strength between the hole and urethane admixture was checked through lab compressive strength test and the effect at the site was also verified. When sealing the rock bolt hole by the packer developed in this paper after filling the hole with packer including admixture, it was found to be able to prevent the grouting material (admixture) from flowing down (cement leakage).

The results of this study should be applied to a practical tunnel and slope design through understanding the trends of supports effects.

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