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Techniques for Obtaining High Quality Boring Core of Rock Mass

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ABSTRACT:
After examination on factors affecting quality of boring core of rock mass, it is revealed that following four techniques are useful to obtain high quality boring core of troublesome zone in dam foundation such as fault zone, joint zone, hydrothermal alteration zone, weathered zone for example. (1) It is basically important to employ an expert on boring core sampling who has thorough knowledge of geotechnical condition of rock mass at the damsite. (2) It is strongly recommended to use rotary double-tube sampler with sleeve for especially fissured zone or fault zone in hard rock. (3) It is very effective to use large diameter sampler compared to ordinary diameter sampler for almost all types of rock mass. (4) High quality boring core sampling technique by use of air bubble or water-soluble polymer solution as circulating fluid greatly improve quality of boring core of troublesome zone that is difficult to obtain high quality boring core by traditional sampling technique.

Keywords: High quality boring core

1. INTRODUCTION

Boring investigation is the most important technique to clear directly underground geotechnical condition and is almost always executed in the field of geotechnical investigation of dam engineering. It is possible to observe directly in-situ underground geotechnical condition and also to execute various laboratory core tests on obtained boring core. And using borehole television system, we can get information on strike and dip of discontinuities such as fault, joint for example, and can confirm the geotechnical condition of points that is impossible to obtain boring core owing to poor in-situ geotechnical condition. Furthermore, we can execute various in-situ rock mass tests such as logging, borehole load test, Lugeon test, groundwater level measuring, groundwater flow measuring in borehole.

Because of recent remarkable progress of techniques for boring core sampling, borehole observation, logging, boring investigation become more important than exploratory adit investigation which cause loosening and change of groundwater condition in surround rock mass by excavation. It is important to obtain high quality boring core of rock mass without disturbing intact structure to clear accurately overall in-situ underground geotechnical condition at the damsite. Therefore a great deal of efforts on obtaining high quality boring core has been made constantly. However in spite of these efforts, low quality boring core are often obtained at present for many reasons. In these circumstances, techniques for obtaining high quality boring core of rock mass are discussed and details are given as follows.

2. EXPERT ON BORING CORE SAMPLING

Although drilling and sampling techniques for rock mass are greatly improved, quality of obtained boring core depends severely on the technical level of a drilling engineer. Therefore it is basically important to employ an expert on boring core sampling who has thorough knowledge of geotechnical condition of rock mass at the damsite. Usually it is impossible to employ always the same expert on boring core sampling throughout geotechnical investigation phase of dam construction. As a natural consequence, boring core of various quality obtained by a drilling engineer of different technical level

exist at each damsite. So in case of observation of overall boring core obtained by a different drilling engineer at the damsite, special regard should be paid to the technical level of an individual drilling engineer, and correctly evaluate in-situ geotechnical condition of rock mass.

Figure 1 shows boring core of Cretaceous cracky shale obtained by the highly skilled drilling engineer under appropriate drilling condition with traditional sampling technique of 86 mm diameter sampler. Because the shale of this damsite is very hard and numerous hair cracks developed, obtained boring core of early geotechnical investigation phase was broken into many pieces along cracks during drilling. So it was impossible to evaluate accurate in-situ underground geotechnical condition of rock mass by such low quality boring core in early geotechnical investigation phase. But with the progress of geotechnical investigation phase, quality of boring core was gradually improved by understanding the geotechnical condition of the rock mass at this damsite. Finally very high quality continuous columnar boring core as shown in Fig. 1 was obtained. Namely it is possible to obtain high quality boring core by the expert on boring core sampling who has thorough knowledge of geotechnical condition of rock mass at the damsite. Quality of boring core as shown in Fig. 1 is equal to one obtained by later mentioned high quality boring core sampling technique.

Figures 2 and 3 show boring core of Pleistocene hyaloclastite at almost the same point of damsite. Boring core as shown in Fig. 2 was obtained by the unskilled drilling engineer under inappropriate drilling condition. Almost all soft volcanic ash matrix was washed out by circulating water, only hard andesite lava breccia was obtained. It is impossible to evaluate accurate in-situ underground geotechnical condition of rock mass by such low quality boring core. Boring core as shown in Fig. 3 was obtained by the highly skilled drilling engineer under appropriate drilling condition. Both soft matrix and hard lava were entirely obtained as continuous columnar core without any disturbance. It is only possible to evaluate accurate in-situ underground geotechnical condition of rock mass by such high quality boring core.

Figure 1. Boring core of Cretaceous cracky shale obtained by the highly skilled drilling engineer with traditional sampling technique of 86 mm diameter sampler

Figure 2. Boring core of Pleistocene hyaloclastite obtained by the unskilled drilling engineer

Figure 3. Boring core of Pleistocene hyaloclastite obtained by the higly skilled drilling engineer

3. ROTARY DOUBLE-TUBE SAMPLER WITH SLEEVE

Rotary double-tube sampler with sleeve was developed in the early 1980's. This is the technique that obtains boring core wrapping continuously by plastic film sleeve setting at inner tube of sampler. By this technique, continuous columnar high quality boring core of rock mass especially in fault or fissured zone was firstly obtained. Sleeve is made from transparent cylindrical shaped plastic film and is 0.04~0.06mm thick (Fig. 4). It reduces friction between

Figure 4. Boring core of Cretaceous deteriorated granite obtained by rotary double-tube sampler (86mm diameter) with sleeve

Figure 5. Boring core of Cretaceous highly weathered granite obtained by traditional sampling technique of the pre 1980's

inner tube and boring core as well as protects boring core from circulating water. Quality of boring core and core recovery rate were greatly improved by these function.

Figure 4 shows boring core of Cretaceous granite deteriorated by tectonic movement and heavy hydrothermal alteration obtained by rotary double-tube sampler(86 mm diameter) with sleeve. Fig. 4 shows the state of boring core immediately after extracted from the core barrel. The boring core is entirely wrapped by plastic film sleeve and protected from washing out by circulating water.

At present, rotary double-tube sampler with sleeve is inevitably used in boring core sampling at damsite in Japan. But usually, boring core obtained by this technique and by traditional sampling technique of the pre 1980's are stored together because geotechnical investigation term of dam construction is very long. Therefore in case of evaluation of boring core of the dam which boring investigation started from the pre 1980's, special attention should be paid for use or nonuse of rotary double-tube sampler with sleeve.

Figures 5 and 6 show boring core of Cretaceous highly weathered granite, and Figs. 7 and 8 show boring core of Miocene cracky rhyolite at almost the same point of each damsite. Figures 5 and 7 show boring core obtained by traditional sampling technique of the pre 1980's (nonuse of rotary double-tube sampler with sleeve). Almost all soft weathered part was washed out by circulating water, only hard core stone was obtained as shown in Fig. 5, or obtained boring core was broken into many pieces along cracks during drilling as shown in Fig. 7. It is impossible to evaluate accurate in-situ underground geotechnical condition of rock mass by such low quality boring core as shown in Figs. 5 and 7.

Figure 6. Boring core of Cretaceous highly weathered granite obtained by rotary double-tube sampler with sleeve

Figure 7. Boring core of Miocene cracky rhyolite obtained by traditional sampling technique of the pre 1980's

Figures 6 and 8 show boring core obtained by rotary double-tube sampler with sleeve. Both soft weathered part and hard core stone were entirely obtained as shown in Fig. 6, or obtained as continuous columnar core without any

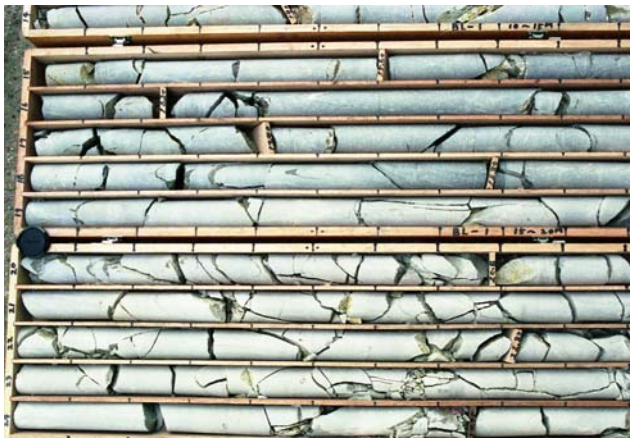

Figure 8. Boring core of Miocene cracky rhyolite obtained by rotary double-tube sampler with sleeve

Figure 9. Boring core of Mesozoic altered chlorite schist obtained by 66 mm diameter sampler

disturbance as shown in Fig. 8. It is only possible to evaluate in-situ accurate degree of weathering or condition of joint by such high quality boring core as shown in Figs. 6 and 8.

4. LARGE DIAMETER SAMPLER

Outer diameter of core bit for use as geotechnical investigation in dam construction is ordinary 66 mm, although large diameter core bit such as 86 mm or 116 mm is occasionally used also to improve quality of boring core. Quality of boring core depends on diameter of sampler, if the technical level of a drilling engineer is equivalent. It is very effective to use large diameter sampler compared to ordinary diameter sampler for almost all types of rock mass. But special attention should be paid for transportation or storage of boring core, because large diameter boring core is heavy and bulky compared to ordinary diameter one.

Figures 9, 10 and 11 show boring core of Mesozoic altered chlorite schist at almost the same point of damsite. Numerous soft talc veins were produced as a result of hydrothermal alteration in chlorite schist of this damsite. Figure 9 shows boring core obtained by ordinary 66 mm diameter sampler. The core was broken into pieces along numerous talc veins during drilling. Therefore large diameter sampler was used to improve quality of boring core, as shown in Figs. 10 and 11. Diameter of core bit as shown in Fig. 10 is 86 mm, while Fig. 11 is 116mm.

Quality of boring core was improved proportionally to increase of diameter of sampler as shown in Figs. 9, 10 and 11. Namely, quality of boring core as shown in Fig. 10 is superior to Fig. 9 in several respects. Furthermore,

Figure 10. Boring core of Mesozoic altered chlorite schist obtained by 86 mm diameter sampler

Figure 11. Boring core of Mesozoic altered chlorite schist obtained by 116 mm diameter sampler

quality of boring core as shown in Fig. 11 is far superior to Figs. 9 or 10, and altered zone or fractured zone are obtained as continuous columnar core. It is only possible

to evaluate accurate degree of hydrothermal alteration or condition of fault by such high quality boring core.

5. HIGH QUALITY BORING CORE SAMPLING

Recently developed various high quality boring core sampling techniques are largely divided into two types. One is the technique that use water-soluble polymer solution, the other is the technique that use air bubble as circulating fluid. The former succeeded in obtaining high quality boring core by use of water-soluble polymer solution as circulating fluid to reduce pressure and volume of flowing circulating fluid. Because this technique needs no additional system, sampling cost is almost the same as traditional sampling technique. But it is inevitably necessary to use a pressure pump of low pulsation and control precisely rotational frequency or applied pressure of drilling machine depending on the in-situ condition of rock mass at the damsite.

The latter succeeded in obtaining high quality boring core by use of air bubbled surface-active agent as circulating fluid to remove cutting from borehole by adhering surface of air bubble. Because this technique needs additional system such as air bubble generating system and compressor, requires slightly high cost compared to traditional sampling system.

Figure 12 shows boring core of fault zone of Paleozoic alternation of sandstone and shale obtained by high quality boring core sampling technique by use of water-soluble polymer solution. Fault gouge and fault breccia was obtained as continuous columnar core without disturbing intact structure. Figure 13 shows boring core of Cretaceous granite obtained by high quality boring core sampling technique by use of air bubble. Very soft brownish clay infiltrated from another place into open crack is thoroughly obtained without disturbing intact condition.

It is impossible to obtain such high quality boring core as shown in Figs. 12 and 13 by traditional sampling technique. Soft fault gauge or infiltrated clay was washed out by circulating water and only hard breccia or jointed rock was obtained by traditional sampling technique. It is only possible to evaluate accurate in-situ condition of fault zone or open crack having severe influence on dam design by such high quality boring core.

Figures 14 and 15 show boring core of Cretaceous highly weathered granite at almost the same point of damsite. Figure 14 shows boring core obtained by traditional sampling technique of 66 mm diameter sampler. Almost all soft weathered part was collapsed into slime by

Figure 12. Boring core of fault zone of Paleozoic alternation of sandstone and shale obtained by high quality boring core sampling technique by use of water-soluble polymer solution

Figure 13. Boring core of Cretaceous granite obtained by high quality boring core sampling technique by use of air bubble

Figure 14. Boring core of Cretaceous highly weathered granite obtained by traditional sampling technique of 66 mm diameter

circulating water, only hard jointed rock was obtained. It is impossible to evaluate accurate in-situ underground weathering condition by such low quality boring core.

So, in order to evaluate accurate in-situ underground weathering condition of granite, high quality boring core sampling technique of 86 mm diameter sampler by use of air bubble was executed at almost the same point of damsite. Figure 15 shows boring core obtained by this technique. Both soft weathered part and hard jointed rock were entirely obtained as continuous columnar core without any disturbance. It is only possible to evaluate accurate degree of in-situ condition of weathering or joint by such high quality boring core.

Figure 15. Boring core of Cretaceous highly weathered granite obtained by high quality boring core sampling technique of 86 mm diameter sampler by use of air bubble

6. CONCLUSON

After examination on factors affecting quality of boring core of rock mass, it is revealed that above mentioned four techniques are useful to obtain high quality boring core of troublesome zone in dam foundation such as fault zone, joint zone, hydrothermal alteration zone, weathered zone for example. But high quality boring core is not always obtained by these four techniques as shown in Figs. 16 and 17.

Figure 16 shows boring core of Cretaceous cracky granite. Although this boring core was obtained by large diameter sampler (86mm), quality of this boring core is very low compared to the same diameter (86mm) boring core as shown in Fig. 10. Figure 17 shows boring core of fault zone of Paleozoic alternation of sandstone and shale. Although this boring core was obtained by high quality boring core sampling technique by use of air bubble, quality of this boring core is very low compared to the core obtained by the same technique as shown in Figs. 12, 13 and 15. The reason of obtaining low quality boring core is that these were drilled by the unskilled drilling engineer under inappropriate drilling condition for rock mass.

In order to obtain high quality boring core corresponding to these four techniques, it is very important that the same attention for traditional sampling technique should be paid for high quality boring core sampling technique. Namely the drilling engineer who has thorough knowledge of geotechnical condition of rock mass at the damsite should drill under the best drilling condition for rock mass. In case of inappropriate drilling condition for rock mass, high quality boring core was not obtained as shown in Figs. 16 and 17 even if use above mentioned four techniques.

Figure 16. Boring core of Cretaceous cracky granite obtained by 86 mm diameter

Figure 17. Boring core of fault zone of Paleozoic alternation of sandstone and shale obtained by high quality boring core sampling technique by use of air bubble