Evaluation of the 3-D Distribution of Fractures in a Rock Mass using Directional Borehole Radar Data from a Horizontal Borehole

*Kazuhiko Masumoto[1], Tomoaki Matsushita[2], Suguru Shirasagi[1], Takashi Ueki[3], Shinsuke Karasawa[3], Daiki Makino[3], Kazushige Wada[4]

1. Kajima Technical Research Institute, 2. Kajima Corporation, 3. Matsunaga Geo-Survey Co., Ltd., 4. Mitsui Mineral Development Engineering Co., Ltd.

Evaluation of the distribution of fractures in a rock mass ahead of a tunnel face is required for safe and reasonable tunnel excavation. To evaluate not only the position of fractures, but also their inclination before tunnel excavation, a directional borehole radar may be a suitable technique. A directional borehole radar can determine the inclination of fractures with a single pilot boring because it can estimate the arrival direction of the waves reflected by fractures, which are measured by a dipole array antenna with multiple elements. This study first examined the application of a directional borehole radar to investigate within a horizontal pilot boring. Next, field test using the directional borehole radar was conducted in a horizontal borehole drilled in the sidewall of a tunnel in order to confirm the applicability of the directional borehole radar for evaluating the three-dimensional distributions of fractures.

To apply the borehole radar for horizontal pilot boring in a tunnel, a casing is needed to prevent collapse of the borehole. Because the steel casing pipe which is typically used for pilot borings cannot be used for radar measurements, the applicability of a glass fiber reinforced plastic (GFRP) tube was verified as the borehole casing in this study. As the results of the experimental study, it could be concluded that GFRP tubes with steel joint couplers can be used as a borehole casing for measurements with radar.

Next, a directional borehole radar was applied to the survey of fractures in granite in a horizontal borehole drilled in the sidewall of a tunnel in order to confirm its applicability for evaluating the three-dimensional distribution of fractures. The results indicated that the strike and dip of each reflector estimated by the directional borehole radar measurements approximately corresponded to the fractures observed with a borehole scanner. Therefore, it was concluded that a survey with a directional borehole radar in a horizontal borehole could evaluate the three-dimensional distribution of fractures surrounding the borehole.

Keywords: borehole radar, horizontal borehole, distribution of fractures

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