Technical Research Report of HAZAMA ANDO CORPORATION Vol.1 2013

Dissertations

Studies on Design and Performance of Tunnel in Shirasu Ground

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The main purpose of this thesis is to establish a rational tunneling method in Shirasu ground.

Shirasu, which is defined as the non-welded part of pyroclastic flow deposits, is widely distributed in the southern part of Kyushu Island. Shirasu is regarded as soft ground when the mountain tunneling method is applied because its unconfined compression strength is 20-100 kN/m^2. Nevertheless, it is well known that Shirasu tunnels are comparatively stable. However, the stability mechanism has not been clarified, and rational tunneling methods in Shirasu ground are therefore not clear, either. In order to clarify this problem, these studies were executed.

The following are summaries of each chapter.

Chapter 1 as the introduction to these studies provides the background and briefly explains the purpose in order to clarify the significance of these studies.

Chapter 2 reconfirms definition of Shirasu, which has had various meanings, and gives it a new definition.

Chapter 3 describes the results of research of literature on past cases of constructing Shirasu tunnels.

In Chapter 4, the behavior under the excavated Shin-Takeoka Tunnel, which was constructed in Shirasu plateau, is analyzed.

Chapter 5 shows the deformation characteristics of Shirasu ground for tunneling. Primitive stress in deep Shirasu ground is much larger than its unconfined compression strength, so when examination of the physical properties of Shirasu is performed, the influence of stress liberation has to be carefully considered. The modulus of deformation of Shirasu in elastic domain of stress-strain curve has remarkable stress dependency. Specifically, the modulus of deformation of Shirasu decreases as its confining pressure decreases.

Chapter 6 shows the construction process of the original nonlinear constitutive model by using FDM taking account of the geotechnical properties of Shirasu ground. The result of a numerical experiment shows the basic dynamic structure of the cutting faces of Shirasu ground tunnels, which has not been explained by former theories.

As the cutting face of the tunnel approaches an arbitrary point in deep ground, the confining pressure at this point gradually decreases. When the cutting face reaches it, its confining pressure decreases much more. Following decrease in the confining pressure, the modulus of deformation of Shirasu decreases, too. And the ground where the modulus deformation has decreased can no longer take large loads, and so major principal stress also decreases. This is why the cutting faces in Shirasu ground are relatively stable. But, in the case where the overburden of the tunnel is higher than 50 m, the decrease in major principal stress is not enough to keep the cutting face stable, and the ground ahead of the cutting face is loosened. On the other hand, the ground at the back of the tunnel supports being under a triaxial compression state by the internal pressure effect is comparatively stable, and the tunnel supports are also comparatively stable.

In Chapter 7, the original nonlinear constitutive model is applied to Shin-Takeoka Tunnel and the dynamic structure of Shirasu tunnels is clarified, by comparing the numerical results with the field measurement data.

In Chapter 8, the original nonlinear constitutive model is applied to an extremely large cross section of 378 m^2 in an excavation area and clarifies the dynamic structure of the extremely large section.

Chapter 9 proposes a rational design and performance method for tunnels in Shirasu ground based on the above studies, and also describes several attention points in constructing tunnels under special ground conditions.

Chapter 10 describes the research results on a rational tunneling method for Shirasu ground. In addition, future prospects are given.

［出典］多宝 徹：しらす地山における山岳トンネルの設計・施工法に関する研究，鹿児島大学大学院学位論文，2013.3