

Characteristic of loosen rock mass had in the dam site based on the hard sandstone layer in the Cretaceous

Kazumi YASUMOTO⁽¹⁾, Yoshiya HITOMI⁽¹⁾, Jun YAMAZAKI⁽¹⁾

(1) Docon Co., Ltd.
E-mail:ky1448@docon.jp

Abstract

In the dam site based on hard bedrock, loosen rock mass by the development of the matter such as sheeting joints, and it may be with a problem in the construction of the dam. The investigated dam site in investigation site, a hard sedimentary bedrock of the Cretaceous is distributed, and characteristic joints develops in the loosen rock mass. As an example of the evaluation method of the loosening introduced to evaluate index by measuring quantity of opening of the joint, but was not able to find an effective evaluation technique without having correspondence with the borehole findings in information in the investigation site. Therefore the authors performed a detailed description about the above-mentioned characteristic joints. Moreover, the evaluation technique of the loosen rock mass adopted analytical technique to connect borehole camera analysis with the detailed observation of the drilled core and summarized about a property of distribution, structure and features of the joints in the dam site. As a result, a characteristic of the joints for the advance of loosening and the distribution range of the joints is understood, and the loosen rock mass range of the dam site is distinguished. And moreover, new evaluation technique of loosen rock mass is also supported to geomorphic history viewpoint.

Keywords: loosen rock mass, topography-related joint

1. Introduction

Sheeting joints with stress release inter the rock may develop in the site distribute to hard bedrock. In case of the development of the matter such as sheeting joints in the dam site, and it may be with a problem for the strength and deformability of the bedrock in the construction of the dam. This is because a property of the bedrock changes by joints formed by a progress process of the loosening, and it is necessary to investigate the loosening for an appropriate evaluation of the bedrock.

In general, a loosening is explained that “The state that, as a whole, it is easy to transform it while producing outbreak, an opening and a gap of the crack by transformation, volume increase and density decrease, and so on that due to stress release, gravitation, weathering, and keeping a state of the bedrock and being both easy to deform and an inelastic property grew high (e.g., Sasaki et al., 2005)”. However, it is necessary to evaluate the loosen rock mass in each site because a progress style of the loosening varies according to the condition of

topography, geological features and influence of the external force.

To understand of the loosening generally used for the evaluation technique that paid attention to quantity of opening of the joints. However, in the investigation site, it became clear not to support the evaluation of loosening that the above-mentioned technique to the borehole findings. Therefore, it is necessary investigate new evaluation technique for understanding of the loosening. The authors evaluated the loosening by the evaluation technique of loosen rock mass that combined borehole-camera analysis with detailed drilled core observation.

The investigation site, local topography feature have the V-shaped valley, and both sides slope forms the same slope of dips around 35 degrees together (Fig.1). Gentle slope is confirmed both sides slope, and terrace sediments are distributed over the position that situated 10 meters high from the riverbed. Brecciated rocks less than 50 centimeters distributed over the surface of the earth, and the rolling stone of around 2 meters is rarely confirmed.

The lithological units in the site are consist mainly of hard sandstone layers, and mudstone and sandy mudstone layer are interbedded 10 meters thickness of the sandstone unit. The conglomerates accompanying the base of sandstone are usually less than 2 meters thickness. The geological structure forms the monoclinical structure that trends north and dips around 70 degrees west. In the site, the condition of the dam foundation rock is investigated 10 adits and 119 drilled core by boreholes for the purpose of confirming it.

2. Characteristic of the loosen rock mass in investigation site

2.1 Characteristic of the loosen rock mass

The parallel joint (topography-related joint) develops in the bedrock formed by the stress release of the slope, and, in the investigation site, the loosen rock mass that formed by deformation of gravity to the slope lower part. The loosen rock mass is characterized by the development of the joints of the reverse dip to topography, a large opening of the joint and a turn of the bedrock which transformed blocking (Fig.2). In the investigation site neighborhood, small collapse often occurs that affected by a heavy rain and the earthquake.

A characteristic of the loosen rock mass have a deep connection with joints represented by topography-related joint. It was necessary to confirm distribution and a condition of the joints for understanding of loosening. Therefore, for the

purpose of understanding the change of the joint condition to the depth direction, it is investigated that the wall surface observation in the adit and observation drilled core by borings.

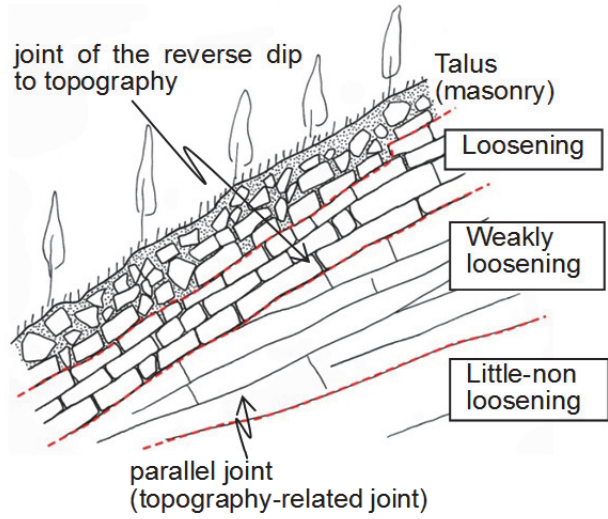


Fig. 2 Schematic model of loosen rock mass in the site

2.2 Characteristic of the topography-related joint

As for the topography-related joint that is one of the factors to cause the loosening, the continuity of joint is confirmed higher in sandstone than muddy rocks. The structure of joints is inclined parallel to a slope in the slope part and low-angle in the riverbed

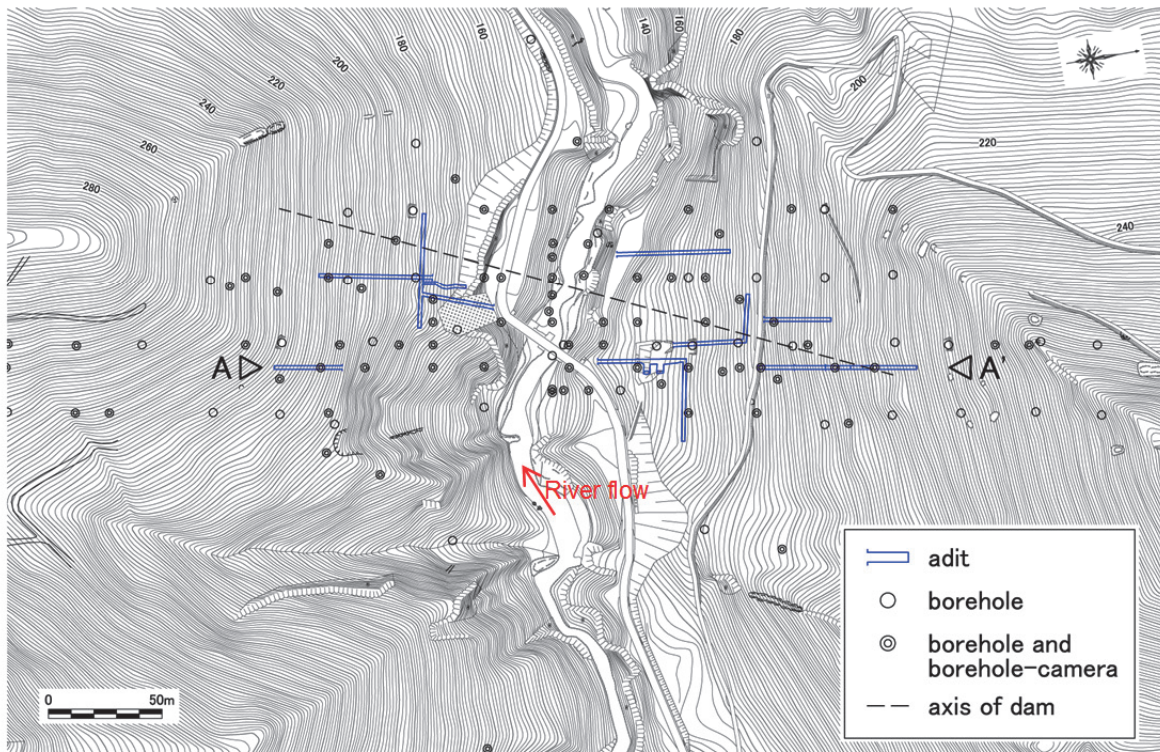


Fig. 1 Topographic map of the investigation site

Table 1 Change bedrock condition to the depth direction each factor of examination in the adit.

Factor of examination	Change bedrock condition to the depth direction (Result of the wall surface observation in the adit)
Quantity of opening and continuity of the joint	The opening joint increase in number and quantity of opening in superficial part. The opening joint is rarely confirmed in a deep part. The joint continues in superficial part, and it becomes discontinuous as deepen, and the opening joint is not distributed at around 10-20 meters depth in a deep part.
Structure of the joint dip	The topography-related joint and the joint of the reverse dip to topography are distributed in superficial part. The reverse dip to topography is not distributed at 10-20 meters depth in a deep part.
Frequency of the joint	Frequency of joint is distributed more than five per one meter in superficial part. Frequency of the joint is decrease as deepen.
Degree of weathering brown	The bedrock has weathering brown generally in superficial part. A ratio of weathering brown is decrease as deepen.
Seismic wave velocity in ground	In superficial part, it is less than 1 km/sec and fast as deepen. However, it is difficult to let the velocity support the bedrock condition.
Water permeability into bedrock	High water permeability into bedrock is confirmed to the deep part.

part. The bedding plane dips down stream side, and structure is different from topography-related joint. The frequency of joints is distributed on the superficial part and becomes infrequent as deepen.

The joint is formed of multiple joints with a brown oxidation zone (weathering brown). The joint performs divergence and convergence (transfer) having undulation.

3. Investigation for the loosen rock mass

3.1 Investigation for the evaluation technique of the loosen rock mass

In the site, at much borehole points, the borehole wall is observed by using "bored hole television camera (borehole-camera)". As for the understanding of the loosening, it was expected that can evaluate based on opening quantity of the joint to conform by borehole-camera analysis. However, an opening of the joint was reported in the deep part more than 100 meters depth in the site, and it became clear not to

correspond with the loosening that confirmed in the adit findings. Thus, the understanding of the loosening came to need rearranging by new evaluation technique not to assume only quantity of opening of the joint an evaluation standard.

Therefore the factor that related to loosen rock mass was extracted by the wall surface observation in the adit (Table 1). These factors were examined whether an evaluation of the loosening was possible as dam foundation rock by a method to compare each factor.

Of these factors, the depth direction was able to understand the joint condition other than seismic wave velocity and water permeability. In addition, the loosening condition and correspondence may not take frequency and weathering brown of the joint as factor of becoming it because different factors such as the dislocation participate. As a result of the aforementioned reasons, it shows that classification of the loosen rock mass in the site (Table 2).

Table 2 Characteristic of classification of loosen rock mass

Classification of loosen rock mass	Condition of bedrock (Result of the wall surface observation in the adit)
Loosening part	The topography-related joint and the joint of the reverse dip to topography distribute at random, and often opened and continued. Some of them have quantity of opening more than 10mm. Weathering brown of bedrock is generally confirmed.
Weakly loosening part	Topography-related joint almost develops two-five per one meter. The joint of the reverse dip to topography is not mostly confirmed. Although the joint is rarely opened, the joint has not continuity. Weathering brown part and fresh part are mixed.
Little-non loosening part	Topography-related joint almost develops non-three per one meter. The joint is closely contact. A fresh part is distributed widely.

Table 3 Technique for judging of degree of the contact of the joint based on comparison of the two observation

Degree of contact of the joint		Borehole-camera analysis		
		Closely contact	Sandwiched rock fragment	Opened
Detailed drilled core observation	Engaged	Closed	Closed	Closed
	Not engaged	Closed	Possibility of opened	Opened

3.2 Application to the dam site for evaluation technique of loosening

The understanding of the joint condition of the whole dam site had to make effective use of result by boreholes that investigated regionally. Therefore the factors of quantity of opening and continuity and structure of the joint that investigated effective understand of the loosening in the adits.

Then, it is reported that degree of quantity of the joint in observation of borehole-camera is not correspond with findings in the adit due to the joint considered to a opening with a borehole camera is confirmed as the closely contact joint in the adit (Hitomi and Yamazaki, 2006). As a reason for that the closely contact joint is evaluated by mistake as the opening joint, because of the rock fragment is sandwiched between the joints in a adit is exfoliated from borehole wall by mistaking water supply pressure and contact the core sampler during borehole investigation. That is to say, in case of remaining the rock fragment to the joint by borehole camera analysis and confirming the rock fragment sandwiched between the joints by observation of drilled core, the joint is evaluated as possible to closely contact.

Note the occurrence mentioned above, it is tried

to classify the loosening by distribution and the condition of these joints that the joint to relate loosening is extracted from various joints distributing in dam site except for closely contact joints.

The evaluation of degree of the contact of the joint is compared condition of the joint is based on the borehole camera analysis with degree of engagement of the joint is based on the detail core observation. Therefore, the evaluation of degree of the contact of the joint is judged from comparison of the two observation techniques (Table 3).

The bedrock in the site is divided into three zones based on evaluation technique of the loosen rock mass by Quantity of opening and continuity of the joint, distribution of the joint of the reverse dip to topography and frequency of the joint for the joint to relate loosening is extracted on Table 3(the joint belong to possibility of opened and opened) (Fig.3).

Cross section of division of loosening are used result of the evaluation of loosening in each borehole (Fig.4).

The physical property of each loosening division indicated distributed concentrating each division. That is to say, the weakly loosening part and little-non loosening part are judged adapted to the dam foundation rock.

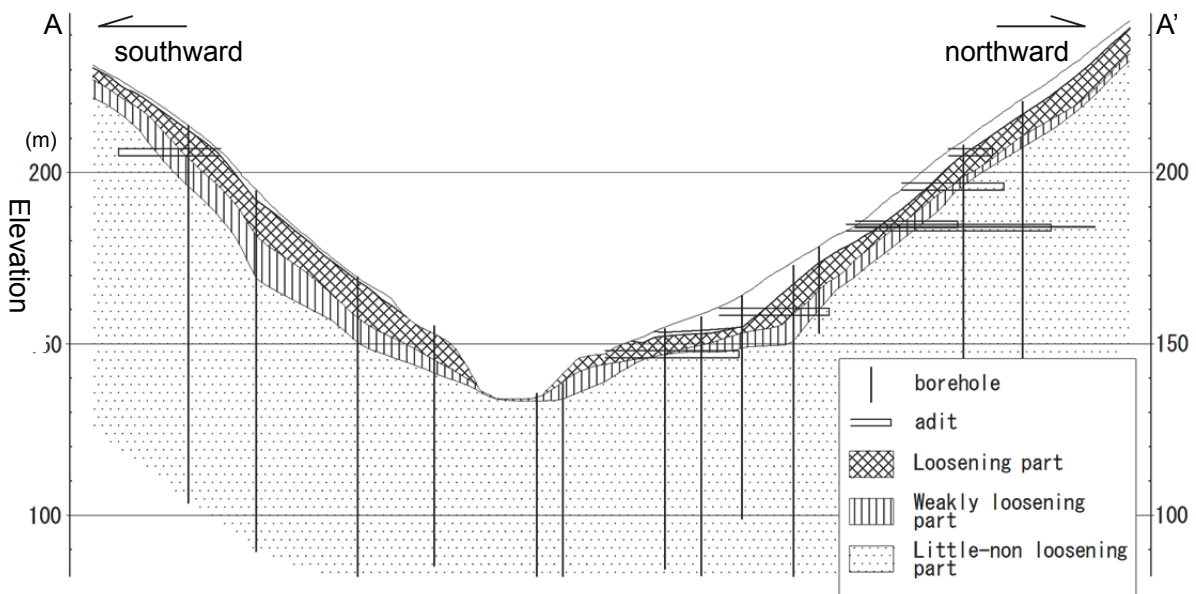


Fig. 4 Cross section of division of the loosening

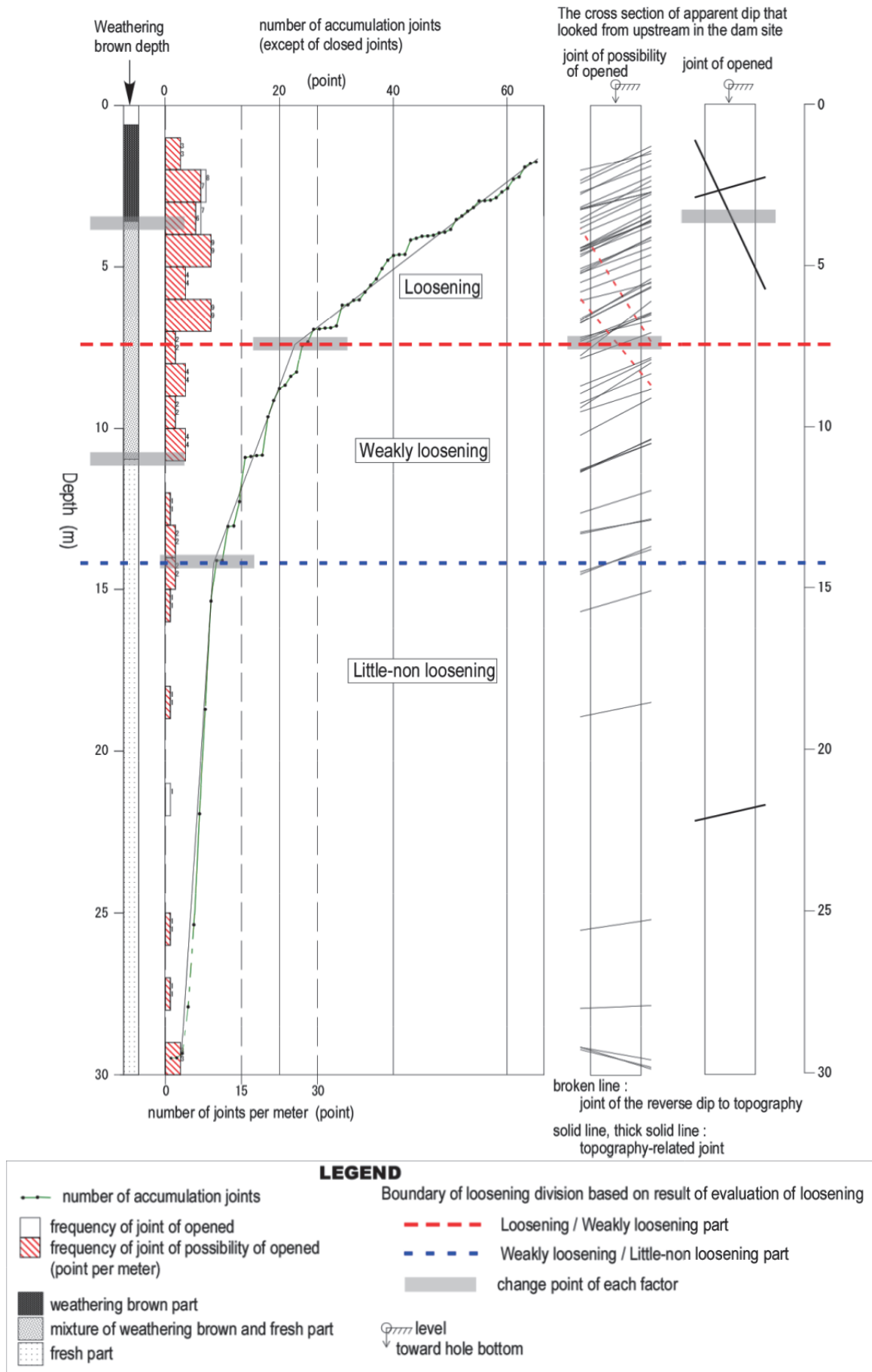


Fig. 3 Example of the evaluation of the loosening on borehole-camera analysis

4. Evaluation of the loosening indicates slope process of the site

In the site, the loosening that the topography-related joint formed by stress release in the slope, make progress by the creep to the slope lower part by the gravity. The talus is more progressive part of loosening relatively early. In particular, the talus is distributed thick in a south-facing slope affected by the sunlight. In the undeveloped part of the joints of the reverse dip to topography, loosening is little developed, it forms erosion surface by recent downward erosion. Distribution of loosen rock mass that divided into three zones in this paper greatly change at altitude of terrace surface, the loosening is undeveloped at the lower altitude. This characteristic of topography is indicated progress of downward erosion by river.

5. Conclusions

We understood a characteristic of the joint in the investigation site from a geologic and topographical standpoint and classified the joint, and understood a characteristic of the joint in conjunction with the development of the loosening in the foundation rock. And, the problems of the analytical technique using quantity of opening of the joint are indicated by comparison examination of the adit with observation of the core. The classification of loosen rock mass by new technique relate to degree of the contact of the joint is tried to divide. Note the classification mentioned above is also supported to slope process viewpoint. Therefore, evaluation of the loosen rock mass of the dam site is judged appropriately.

Acknowledgements

We express sincere gratitude to Y. Wakizaka and S. Anan (Public Works Research Institute) for helpful suggestion, and also to K. Tomioka and Y. Tago (Docon Co., Ltd.) for support during our field investigation.

References

- Hitomi, Y. and Yamazaki, J. (2006): An evaluation method of slack bedrock by comparison of a boring core. Japan society of engineering geology conference 2006 collected papers, pp.505-508.
- Sasaki, Y., Katayama, H. and Kurahashi, T. (2005): An actual condition report and suggestion of the classification tentative plan of loosen rock mass for dam foundation rock. Engineering for dams, No.228, pp.9-11.