Republic of Indonesia, Ministry of Public Works
Directorate General of Water Resources

Indonesia
Expert Dispatch Scheme
Dam Design and Construction Advisory Services

Completion Report

Supporting Report 3

Establishment of Risks Management System in Dam Construction

Study on
"The necessity and Methods of Risk Management"
(presented in Workshop, INACOLD Seminar in 2023/2024)

February 2025

Japan International Cooperation Agency

CTI Engineering International Co., Ltd.
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25-047

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Preface

We, JICA Dam Advisors, have been assessing the risks that have arisen in ongoing dam construction projects in Indonesia for two years. Based on the results of this assessment, we confident the necessity of "the Risk Management in Dam Design and Construction" to minimize the risks in dam construction. This idea was presented in the workshops as "Dam Risk Management" at the INACOLD Seminars 2023 and 2024.

The study has been carried out as following process:

1) Definition of risks in dam construction
2) Risk Analysis of Ongoing Dams in Indonesia: Preparation of a database and their analysis including several studies
3) Approach to application of "Dam Risk Management" in Indonesia

Currently, in Indonesia, to ensure the safety of dams, the Dam Safety Committee (KKB) and its unit conduct technical reviews at each stage of dam design, impoundment, and operation. This system is working very effectively.

However, during our visit to the dam construction site, we found that many risks have arisen at the site due to design oversights and misinterpretation of geological structures.

Dam construction is inherently risky because of the uncertainties and diverse factors involved in dam projects. To minimize risks in dam construction, it is believed that the current inspection system by the Dam Safety Committee and the introduction of a "risk management system" into local design and construction would be effective.

In the future, we wish that PU (DSC, DSU, BTB) will continue an activities discussing and establishing system how to improve the dam construction situation in Indonesia.

February 2025

Team Leader

Hiroshi SHIMIZU

Establishment of Risks Management System in Dam Construction

Follow up Study on "The necessity and Methods of Risk Management"
presented in Workshop, INACOLD Seminar in 2023 and 2024.

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Attachments

PART 1 DAM RISKS IN DAM DESIGN & CONSTRUCTION

1. Background of the Study

Indonesia is a country habitually suffered with water-related disasters due to its fragile volcanic geology and frequent floods caused by torrential rain, like Japan. In response to these disasters, the GOI has been constructing multi-purpose dams with technical assistance from foreign countries since the 1960s.

According to Rencana Strategi 2020-2024 (current plan), 61 dams are proposed in five years from 2015 to 2024. More than 20 dams have already been completed and 13 dams will be completed in this year. In addition, 11 new dam projects are planned to be implemented.

Most of the dam projects are handled by Indonesian engineers in survey, planning, design and construction stages taking advantage of past experience in the dam construction. However, at the dam construction sites, many issues on design, geological judgment and construction methods have arisen, and it has been confirmed that there are many cases in which these problems have not been dealt with appropriately.

In response to this situation, GOJ/JICA has dispatched the dam construction advisors to the Indonesia to support an improvement of the quality of dam construction in the Indonesia, in accordance with the request of the Government of Indonesia.

In the activities of the Advisors, the advisors have recognized that the lack of risk management at sites. This has convinced of the importance of a system for awareness, identifying and responding to risks during the design and construction stages.

1.1 Current Situations of Indonesian Dam Construction

More than 200 dams have been constructed in Indonesia in cooperation with Japan and other countries. Indonesian dam engineers have accumulated experience in these cooperation projects and inherited their skills. In recent years, most of the dams have been constructed by the Indonesian Engineers themselves and have been facing to many problems and settled them but there have been issues cannot be adequately addressed.

In order to timely and appropriately aware the various risks that need to be taken into account in safely and smoothly implementing dam projects, it is essential to establish "Techniques/Systems for awareness and dealing with risks in dam projects".

Indonesia has an approval application system for dam construction, where information and data on dams proposed for construction, impounding, operation and damage/repair are submitted to the Dam Technical Centre (Balai Teknik Bendungan, BTB) for each approval application. And the results of DSU technical review and DSC comments are also stored in BTB, so it is possible to browse basic information from that BTB.

Since these documents are digitized at the time of application for review, they will be obtained from BTB as information at each review stage.

Location of Objective 61 Dams (Progress as of Dec 2024)

1.2 Dam Safety Organization in Indonesia

As stated in Ministerial Regulation Number 72/PRT/1997, in order to carry out the dam safety, Minister of Public Works and Housing has been assisted by dam safety organization consisting of Dam Safety Commission and Dam Safety Unit.

The DSC and DSU have been monitoring the works at site and making comments and giving advises to settle issues occurred in the works. For details of their activities, see Appendix 1.

(1) Dam Safety Commission (DSC)

Dam Safety Commission (DSC) provides recommendation and suggestion to the minister. The tasks of dam safety commission are as follow:

a. Giving the recommendation about dam safety to the minister in every phase of dam development such as design, construction, operation, rehabilitation, and dam closure.

b. Evaluating Dam Safety Unit activities in order to suggest to the minister

c. Preparing the accountability report to the minister

(2) Dam Safety Unit (DSU, under SDA-PU)

Main duty of Dam Safety Unit is to provide technical support to DSC as below:

a. Analyzing and evaluating dam safety in every phase of dam development such as design, construction, operation, rehabilitation, and dam removal.

b. Collecting and managing data of dam

c. Inspecting dam in order to analyze dam behavior to evaluate the safety of the dam

(3) Risk Assessment in Indonesia

To avoid the dam risks, following "Risk Assessment" has been recommended to carry out in Indonesia.

(a) Risk Assessment at Feasibility Study Stage

Risk assessment at the feasibility study stage is very important for high-risk dam construction activities. Based on UURI No. 24 of 2007 and PP No. 21 of 2008, disaster risk analysis must be carried out for dams with a high hazard class. The hazard risk is influenced by the probability of dam failure and the impact of the failure, which can cause losses due to flooding downstream. Risk identification is carried out through topographic maps and local data, although flood inundation information is often not available at this stage. The main risks faced include floods, earthquakes, and seepage.

(b) Risk Assessment at the Detailed Design Stage

At the detailed design stage, a risk assessment is conducted to deepen the analysis that has been done at the feasibility study stage. More complete data allows for a more accurate risk assessment, including dam failure analysis. This assessment helps in making decisions regarding safety and improving the dam design.

(c) Risk Assessment at the Management Stage (Operation and Maintenance)

Risk assessment at the management stage aims to evaluate the risk profile and determine whether the risk is tolerable. If not, risk reduction options need to be planned. Risk assessment is also used to compare risks between several dams in the portfolio, assisting in prioritizing dam rehabilitation. An example of a dam that has undergone risk assessment at this stage is the Cirata Hydroelectric Dam.

(d) Risk Assessment at the Dam Removal Stage

Before removing the dam function, a risk assessment needs to be carried out to identify potential hazards and consequences of various treatment options. An example of a risk assessment at this stage is carried out on the Namuk Dam.

(e) Dam Risk Assessment Frequency

For dams that are already in operation, risk assessments need to be conducted periodically, recommended every 10 years, especially for dams with a height above 75 m or large storage volume. This aims to ensure that the risk remains within the tolerance limit and does not threaten the safety of the dam.

2. Risk Management in Dam Design and Construction

2.1 Necessity of Risk Management in Dam Project

Dam is constructed by maximum use of the regional geology, climate, and natural resources. Planning, design, and construction of dam are forced to carry out in the face to nature that is difficult to control, so there are almost always many issues that arise during construction stage.

In response to these challenges, dam engineers need to;

(1) Design Stage:

To predict risks that may arise during construction and operation in advance as much as possible and reflect them in the design.

(2) Construction Stage,

To establish a system that allows for rapid and timely response.

In order to promote awareness of these issues, one effective method would be to create a database of issues that have occurred at construction sites and how to deal with them, and a system that allows access to past cases.

If engineers are able to recognize expected risks during investigation and design, communicate with experts, and prepare countermeasures, the quality of the design will improve and risks will be avoided during construction.

3. Definition of Dam Risk

Prior to the discussion, it is important to point out that the Dam Risk to be presented herewith is different from the risk of dams in ICOLD.

(1) ICOLD

Since the mid-1990s, ICOLD has been discussing dam risk assessment in light of factors such as the aging of dams, the application of risk analysis to the nuclear and aircraft industries, and responses to climate change. However, the majority of papers focused on risks related to safety assessment of existing dams, rather than issues occurring in design and construction stage. After further discussions, in 2003 ICOLD published the ``ICOLD BULLETIN Risk Assessment in Dam Safety Management''.

ICOLD defines dam risk in its Bulletin as follows.

"The degree of probability and significance of an undesirable impact on human life, health, property or the environment. In the general case, risks are estimated by scenarios, probabilities of occurrence and consequences. In special cases, the average risk is It is estimated by the mathematical expectation of the outcome of an event (the product of the probability of occurrence and the outcome combined across all scenarios).

And also, the term “Dam Risks” in the ICOLD is defined as “the risk of dam collapse or malfunction that may occur after the construction of a dam.”

- The term risk when used in the context of dam safety is comprised of following three parts:
  - ✓ the likelihood of occurrence of a load (e.g. flood, earthquake, etc.),
  - ✓ the likelihood of an adverse structural response (e.g. dam failure, damaging spillway discharge, etc.), and
  - ✓ the magnitude of the consequences resulting from that adverse event (life loss, economic damages, environmental damages, etc.).

- Risk and Hazard: The definitions of risk and hazard given in the glossary are:
  - ✓ Risk: Measure of the probability and severity of an adverse effect to life, health, property or the environment.
  - ✓ Hazard: A threat or condition that may result from either an external cause (e.g. earthquake, flood or human agency) or an internal vulnerability with the potential to initiate a failure mode. A source of potential harm or a situation with the potential to cause loss.

Risk is a measure of the probability and severity of an adverse effect on life, health, property, or the environment.

In general, risk is estimated by combining the impact of all three combinations: scenarios, probabilities, and associated consequences. As a special case, the average (annual) risk can be estimated by the mathematical expectation of the outcome of an adverse event occurring (i.e., the combined probability and consequences across all scenarios).

(2) US Army

Risk is a function of three components:

- The potential hazards or future loading,
- the dams performance given that loading and
- the consequences of a dam breach if the dam does not perform as intended.

Potential hazards include large regional floods, earthquakes, landslides, rapid pool fluctuations, and other events. The expected performance of the dam is evaluated based on criteria used at the time of its design, construction documentation, historical performance, site investigations and advanced analysis. Consequences are estimated based on computer simulations of flood inundation extents, flood wave arrival times, warning times, the time of day at breach, and other factors.

(3) This Study

The risks to be discussed in this "Dam Risk Management System" are defined as "risks that arise during dam surveys, design, and construction. By identifying these risks in advance and taking measures to the greatest extent possible, we aim not only to ensure the safety of the dam after completion, but also to prevent accidents, delays, and rising construction costs during the construction period."

This is a proactive approach and different from the ideas of ICOLD and US Army.

3.2 Basic Policy on Risk Management

The risk management for dam project proposed here is a strategic approach to predict and minimize risks during design and construction. It can be clarified and evaluated risks and determining response policies.

The following points should be considered when implementing:

- ✧ To correctly grasp possible risks and their characteristics at each stage of conception/planning, investigation, design, construction, and maintenance, and respond at the most appropriate time
- ✧ To correctly grasp risks and their characteristics based on information available at each stage and process of the project, and information obtained by additional surveys, etc. as necessary

- ✧ To respond at the most appropriate project stage or process depending on the characteristics of the identified risks
- ✧ To implement risk management continuously in consideration of how to respond to risks, including reviewing organizations and structures, taking into account at which stage it is optimal to respond to risks

3.3 Approach to Establishing Risk Management System in Dam Construction Projects

Following considerations were carried out as preparatory work for establishing a risk management system in dam construction projects.

a. Collection and organization of Risks arising in Dam Projects
b. Proposal of a risk management system
c. Considerations for Risk Management for Dam Construction Project in particular practical geological issues

3.4 Effects Expected by "Risk Management"

In order to ensure the efficient implementation and safety of civil engineering projects, including dam projects, handling and response to the risks which are overlooked or unrecognized risks in particular geological risks, which used to be tacit knowledge, should be presented as explicit knowledge as much as possible, and risks should be appropriately evaluated. It is effective to introduce risk management system, which involves taking the optimal response. This can be expected to address the lack of experienced personnel and reduce human errors.

In addition, it is known that significant benefits can be expected if the appropriate timing for risk management is selected according to the type of risk. In particular, it has been confirmed that if risk management is carried out at the investigation and design stage, risks that occur during construction can be significantly reduced.

To avoid such human error risks, it is well known that Risk Management is functioned effectively.

Expected effects are;

<u>Effect 1: Adequate Response to Risks in Advance</u>

It is difficult to ensure the efficient and safety of dam Projects, since the uncertainty issues or geological issues has been handled depending on the experience of field engineers.

<u>Effect 2: Appropriate Evaluation of Uncertain Risks</u>

Supporting the lack of experienced personnel and reducing human errors.

<u>Effect 3: Appropriate Timing for Risk Response</u>

Conducting the risk response in appropriate timing (during survey and design stages), arising risks (during construction stage) can be significantly reduced.

3.5 Utilizing of Dam Risk Database in Risk Management

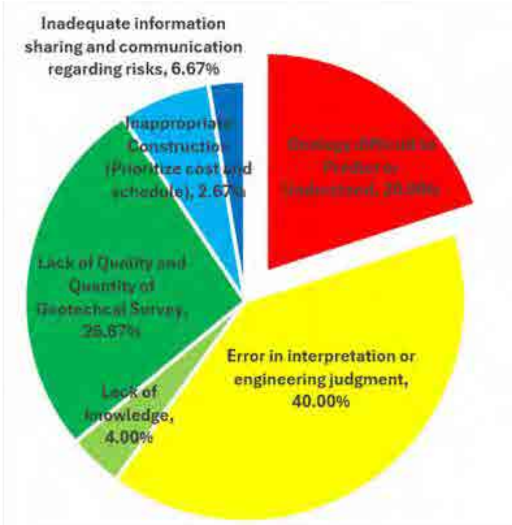
Database of Risk Cases that have occurred in past dam projects, can help reach a cases and common consensus on dam risks. To accumulate such risk Information, data shall be shared among the Engineers and reconfirm or update them at each phase (planning, investigation, design, construction and maintenance).

And such Database will help, in particular, to achieve early awareness of risks, reduction of oversight of risks, and rational response to risks in "Risk Management in dam construction projects".

3.6 Risk Factor: Human-Errors (Examples in Japan)

During project implementation, due to unexpected troubles/issues occurred at construction sites, a number of problems have occurred, such as accidents during construction, delays of construction work, increases in construction costs, and malfunctions after operation started.

To clarify the cause of such issues, in Japan, information from construction sites had been accumulated, analyzed, and assessed. It was verified that "Natural Factors" account for 20% of the overall issues, while "Human Factors" account for 80%.



As shown in this assessment results Project owner, Consultant and Contractors must recognize that "Human Factors play an important role in the occurrence of risk and to avoid such risks is own responsibility".

So, looking at the results of the assessment on risks of civil engineering projects in Japan, it is found that many risks can be prevented by:

a. recognizing risks during planning and design stages and

b. considering how to deal with them in advance (before construction starts) .

Risk Factors in Japanese Infrastructure Project (Geological Issues)

Risk Factors	Detailes of Risk Factor	Number	Sub-Total	Percentage
Risk factors that are difficult to avoid				
Geology difficult to Predict or Understand	Difficult to predict where risk will occur	2	15	20.0%
	Difficult to predict when risk will occur	10		
	Heterogenious and irregularity geology	3		
Risk factors that are considered to be human-caused				
Error in interpretation or engineering judgment	Overlooking risks related to terrain	11	30	40.0%
	Overlooking risks related to geological structure/characteristics	10		
	Insufficient investigation and evaluation of soil properties	1		
	Misjudging terrain risks	3		
	Misidentification of risk signs (events)	3		
	Misidentification of risks related to geological structures	2		
Lack of knowledge	Unsuitable design for geological conditions	1	3	4.0%
	Inappropriate Construction	2		
Lack of Quality and Quantity of Geotechcal Survey	Geological survey not conducted	7	20	26.7%
	Inadequate investigation plan	10		
	Insufficient accuracy of topographic maps	3		
Inadequate information sharing and communication regarding risks		5	5	6.7%
Inappropriate Construction (Prioritize cost and schedule)		2	2	2.7%
Total		75		100%

Source : Guidelines for geological and Foundation risk management in civil engineering projects ; 2020, MLIT (Ministry of Land, Infrastructure, Transport and Tourism) with PWRI (Public Works Research Institute)

3.7 Proposal of Establishment of Risk Management System in Indonesia

As mentioned above, many of the issues that arose at dam construction sites are due to human error and can be avoided in advance. Furthermore, it is considered that knowledge of past cases will enable quick and appropriate responses when problem occurred at the site. Therefore, by creating a database of past events that occurred during dam construction and building a risk management system that can utilize this database, it is expected that future dam construction in Indonesia will become safer and more efficient.

PART 2 Risks Analysis in Dam Projects

In order to prepare a dam risk database, 100 cases of issues that arose during the construction period and concerned by DSC as problematic issues in the 61 on-going dams were extracted and compiled, then analyzed and assessed in the type and location of the issues, their causes, and responses.

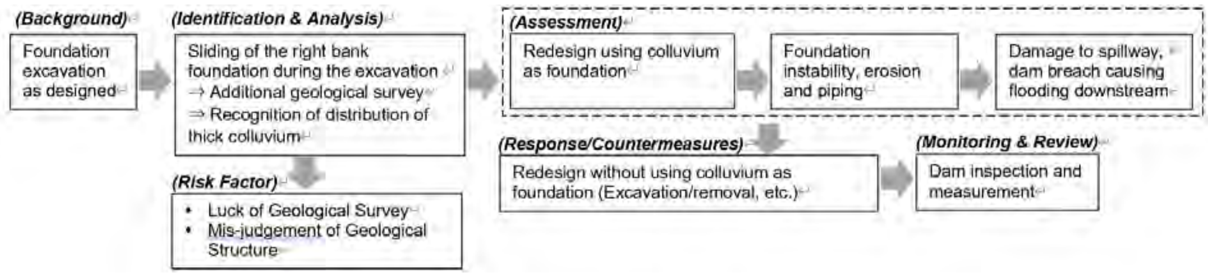
1. Method of Risk Analysis

Based on dam design documents and materials for technical session submitted to the Dam Safety Commission, 100 risk cases were extracted and assessed for 61 dams across Indonesia. However, it should be noted that the information is mainly limited to the DSC's comments made during technical sessions and site inspections, so that the amount of information is limited.

In sorting out the 100 risk cases, a format was filled for each identified risk. The items classified in this form were sorted into:

1) Risk factors,
2) Situation (location, occurrence), and
3) Response and problematic items.

These results will provide valuable information for identifying risks involved in proceeding with dam projects in Indonesia.



Example of Database Format

Note: In this case, during foundation excavation, it was found that the colluvium was distributed at a much thicker than estimated thickness at the time of design, raising concerns about the insufficient strength of the dam and spillway foundations and the leakage/piping through the colluvium.

However, it was not possible to judge accurately whether the cause of the risk occurrence was human-related or not based on the collected data like Japanese assessment case (for example, insufficient amount of investigation, insufficient technical ability, experience and knowledge of the engineers in charge, inadequate management, etc.).

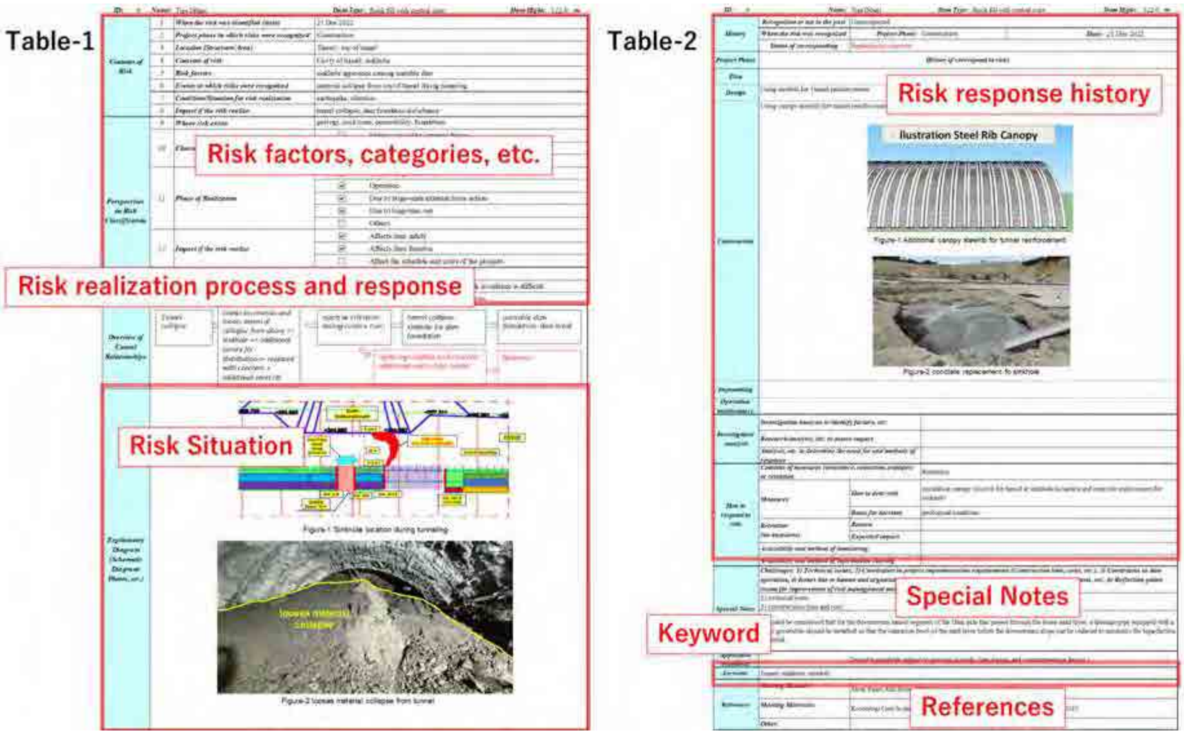
This entry form need be confirmed by engineers at each dam construction site who will know how the issue arose.

2. Collection and Organization of Cases in Indonesia

This study compiled major issues occurred at site and assessed possible risks at Indonesian dam construction sites, based on the results of reviews, inspections and discussions conducted by the Dam Safety Committee for dams completed or under construction since 2015.

2.1 Dam Risk Entry Form

The collected risk data was compiled in "Dam Risk Entry Form" shown in right figures. The completed form prepared in this survey is attached as Attachment 2. For reference, The Example of filling the form is shown in the following page:



Dam Risk Entry Form

Filling Example of Dam Risk Entry Form

ID: **Name:** Bagong **Dam Type:** Rock-fill dam with central core **Dam Hight:** 82.0 m

	No.	Item	Content
Contents of Risk	1	*When the risk was identified (date)*	7-Jul-22
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam / Foundation, Spillway / Foundation
	4	*Contents of risk*	Instability of the foundation, Piping of the foundation
	5	*Risk factors*	Sliding of colluvium (rock mass sliding) used as foundation, Unequal settlement
	6	*Events in which risks were recognized*	Sliding of the right bank cut slope occurred during the foundation excavation.
	7	*Condition/Situation for risk realization*	Foundation deterioration over time, Impounding, Heavy rains, Earthquakes
	8	*Impact if the risk realize*	Dam breach causing flooding downstream, Damage to spillway
Perspectives on Risk Classification	9	*Where risk exists*	Geology / Strength, Permeability, Design / Foundation treatment
	10	*Character*1*	B: Mainly due to technical factors
	11	*Phase of Realization*2*	Ⅱ: Operation, Ⅲ: Due to large-scale external force action, Ⅳ: Due to long-term use
	12	*Impact if the risk realize*3*	S: Affects dam safety / F: Affects dam function
	13	*Corresponding to risks*4*	α: Basically risk avoidance

Overview of Causal Relationships

Foundation excavation as designed ⇒ Sliding of the right bank cut slope occurred =>Additional geological survey => Recognition of the distribution of thick colluvium ⇒ Redesign using colluvium as foundation ⇒ Instability of the foundation, Piping of the foundation ⇒ Dam breach causing flooding downstream, Damage to spillway

Redesign without using colluvium as foundation (to be determined) ⇒ Risk avoidance

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Photo-1 Before the cut slope sliding (July 3, 2022)

Photo-2 After the cut slope sliding (July 7, 2022)

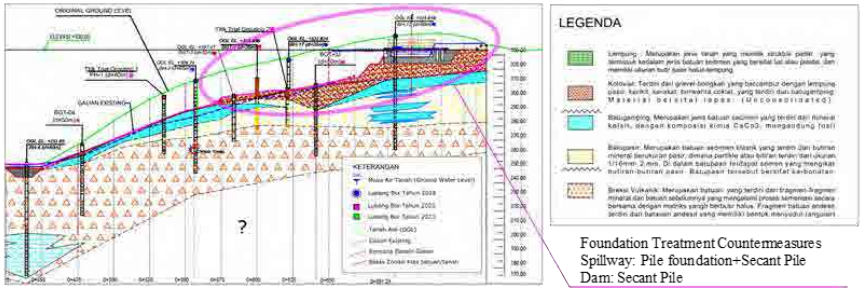


Figure-1 Right bank geologic cross section based on additional survey results

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ID: **Name:** Bagong **Dam Type:** Rock-fill dam with central core **Dam Hight:** 82.0 m

History	*Recognition or not in the past*	Unrecognized
	When the risk was recognized	*Project Phase:* Construction *Date:* 7-Jul-22
	Status of corresponding	Considering countermeasure methods
Project Phase	*History of correspond to risks*	
Plan		
Design	The design was to use bedrock as the foundation. As the distribution of thick colluvial soil was confirmed during foundation excavation, the use of colluvial soil as the foundation is being considered.	

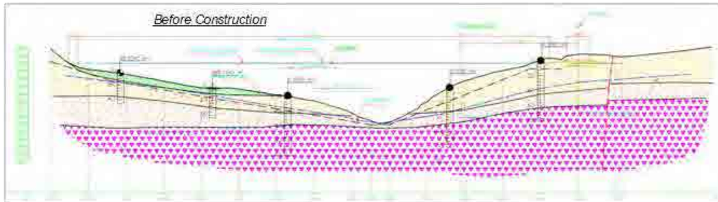


Figure-1 Dam axis geologic cross section (During investigation/design)

Construction

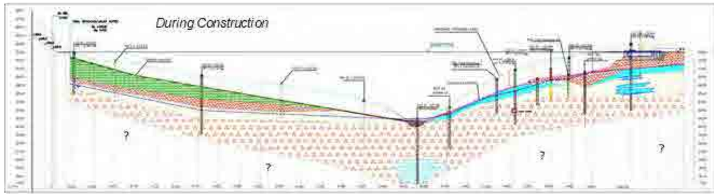


Figure-2 Geological cross section of the dam axis (Site plan after additional investigation)

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	<Foundation Treatment> Spillway: Pile foundation+Secant Pile Dam: Secant Pile
		Basis for decision	Ground conditions, Construction cost
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***		
	1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.)		
	The geological conditions at the dam site differed significantly between the geological investigation/design and construction phases. The following risks should be considered once again when adopting the current countermeasure plan. 1) Sliding along the boundary between the collapsed soil and bedrock 2) Piping at the foundation where the spillway meets the dam due to unequal settlement		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Colluvium, Weathering, Creep		
References	*Meeting Minutes:*	2023.09.21 RDTSpillway Bagong [Z-AF]+ CL (rev), Cap 226-KKB Laporan Inspeksi dlm rangka Pelaksanaan Konstruksi B. Bagong	
	Meeting Materials:	Paparan BTB shimitzu	
	Other:	LAPORAN AKHIR STUDY NEOTEKTONIK, Laporan Progress Pengeboran hasil MASW	

2.2 Summarizing Recognized Risks

The 100 collected risks are summarized as shown in the table below.

Summary of Observed Risks

No.	Dam Name	Dam Type	Dam Hight (m)	Risk Awareness: Location (Structure/Area) (3, 9)	Risk Awareness: Anticipated Events	Risk Awareness: Condition/Situation (6)	External: Flood / Heavy Rain	External: Earthquake	External: Society / Natural Environment	External: Differences from Standards	Geology: Geological Stratigraphy	Geology: Geological Structure	Geology: Strength / Deformability	Geology: Permeability	Geology: Existing / Potential Landslides	Geology: Groundwater (including spring)	Material: Volume	Material: Quality	Material: Deterioration	Internal: Design	Internal: Construction	Internal: Management	Phenomenon: Hydraulics	Phenomenon: Water Quality	Phenomenon: Sedimentation	*Factors are unclear	Stability (S): Dam Body	Stability (S): Foundation Strength	Stability (S): Foundation Permeability	Function (F): Water Use	Function (F): Reservoir (Water Storage)	Function (F): Discharge Facility	Function (F): Power Generation	(P): Project Efficiency	Others: Safety of Human Life	Others: Impact on Stakeholders
1	Tapin	Rockfill	70.0	Spillway	Leakage	Water leakage was observed at upper part of spillway with many crack during an inspection after dam impounding.										1				1												1			1	1
2	Tapin	Rockfill	70.0	Tunnel (Diversion)	Leakage	Water leakage was observed in top wall of diversion during an inspection after dam impounding.										1				1												1				
3	Tapin	Rockfill	70.0	Tunnel (Diversion)	Leakage	It was observed that tunnel floor is flooded due to clogged channel during an inspection after dam impounding.										1			1	1						1						1				
4	Tapin	Rockfill	70.0	Dam site	Sliding	The dam site is located relatively close to the active Meratus Fault.		1				1								1							1								1	1
5	Tukul	Rockfill	70.3	Dam foundation	Leakage	More faults were observed than estimated during the design phase during foundation excavation.						1		1													1		1						1	1
6	Tukul	Rockfill	70.3	Dam body	Leakage	Piezometer monitoring show that there is high pore water pressure in dam body (core zone).																				1	1								1	1
7	Tukul	Rockfill	70.3	Dam body	Subsidence	Multilayer settlement instrument show high settlement of dam body (>1%).																				1	1								1	1
8	Tukul	Rockfill	70.3	Reservoir	Sedimentation	It had been mentioned that Tukul Dam has high sedimentation potential during design phase.																			1						1					
9	Napun Gete	Rockfill	52.0	Dam body	Leakage	During inspection for operation permit, the leakage of dam body was observed in downstream of dam (toe and abutment).										1		1									1								1	1
10	Napun Gete	Rockfill	52.0	Dam body	Sliding	The zoning of the embankment differed between the design and construction. Stability analysis after impounding was carried out and show that sliding plane through the rock fill zone deeply.												1		1							1								1	1
11	Napun Gete	Rockfill	52.0	Dam body	Subsidence	Multilayer settlement instrument show sudden settlement of dam body.																				1	1								1	1
12	Kuningan	Rockfill	43.0	Dam body	Leakage	Piezometer monitoring at downsteam and upstream of grouting almost has same presure value.																				1	1								1	1

No.	Dam Name	Character*1 (10): A	B	C	Phase of Realization*2 (11): Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Impact*3 (12): S	F	P	Correspondence – Actual*4: α	β	γ	Outline	Better way*4 (13): α	β	γ	Certainty*5: a	b	c	d	Risk Recognition Phase: Actual (2)	Ideal*6		Expected Effects*7 (when actual and ideal differ)	Items to Consider: Major Divisions*8		Subdivision
1	Tapin		1			1				1				1		Grouting		1			1			Operation	4	Construction	D	8	Foundation Treatment	Grouting
2	Tapin		1			1					1			1		Additional drainage		1			1			Operation	5	Operation	-	9	Discharge Facility Design	Drainage
3	Tapin		1			1					1				1	Additional study of tunnel leakage (No countermeasures have been implemented)		1					1	Operation	3	Design	D	9	Discharge Facility Design	Material
4	Tapin	1						1		1			1			As the Meratus Fault is located more than 50 km from the dam site, its impact on the project is assessed as minor.	1				1			Operation	2	Dam site / Dam type selection	-	2	Earthquake	Active Fault
5	Tukul		1		1					1			1			Removal of the surface layer of the fault, replacement with concrete, and installation of instruments	1			1				Construction	4	Construction	-	8	Foundation Treatment	Concrete replacement
6	Tukul		1			1				1					1	Keeping a close eye on monitoring results			1			1		Operation	5	Operation	-	11	Monitoring Equipment	Pore pressure
7	Tukul		1			1				1					1	Keeping a close eye on monitoring results	1					1		Operation	4	Construction	D	11	Monitoring Equipment	Settlement
8	Tukul		1				1	1			1			1		Sabo or sediment control facility will be installed at upstream area.		1			1			Design	1	Plan	D	15	Operation / Maintenance Plan	Sedimentation
9	Napun Gete		1			1				1				1		Additional counter weight for controlling water pressure at abutment (under consideration)		1			1			Operation	4	Construction	D	8	Foundation Treatment	Grouting
10	Napun Gete		1				1			1				1		Additional counter weight (under confirmation of material condition)	1					1		Operation	3	Design	D	7	Embankment Design (Load / Foundation)	Stability analysis
11	Napun Gete		1			1				1					1	Keeping a close eye on monitoring results	1					1		Operation	4	Construction	D	11	Monitoring Equipment	Settlement
12	Kuningan		1			1				1			1			Blanket grouting was carried out.	1					1		Operation	4	Construction	-	11	Monitoring Equipment	Pore water pressure

No.	Dam Name	Dam Type	Dam Hight (m)	Risk Awareness: Location (Structure/Area) (3, 9)	Risk Awareness: Anticipated Events	Risk Awareness: Condition/Situation (6)	External: Flood / Heavy Rain	External: Earthquake	External: Society / Natural Environment	External: Differences from Standards	Geology: Geological Stratigraphy	Geology: Geological Structure	Geology: Strength / Deformability	Geology: Permeability	Geology: Existing / Potential Landslides	Geology: Groundwater (including spring)	Material: Volume	Material: Quality	Material: Deterioration	Internal: Design	Internal: Construction	Internal: Management	Phenomenon: Hydraulics	Phenomenon: Water Quality	Phenomenon: Sedimentation	*Factors are unclear	Stability (S): Dam Body	Stability (S): Foundation Strength	Stability (S): Foundation Permeability	Function (F): Water Use	Function (F): Reservoir (Water Storage)	Function (F): Discharge Facility	Function (F): Power Generation	(P): Project Efficiency	Others: Safety of Human Life	Others: Impact on Stakeholders
1	Tapin	Rockfill	70.0	Spillway	Leakage	Water leakage was observed at upper part of spillway with many crack during an inspection after dam impounding.										1				1												1			1	1
5	Tukul	Rockfill	70.3	Dam foundation	Leakage	More faults were observed than estimated during the design phase during foundation excavation.						1		1													1		1						1	1

No.	Dam Name	Character*1 (10): Natural (External)	Human	Others	Phase of Realization*2 (11): Project in progress	Operation	Large External Forces	Long-term Deterioration	Others	Impact*3 (12): Dam Safety	Dam Function	Schedule and Cost	Correspondence – Actual*4: Avoidance	Reduction	Retention	Outline	Better way*4 (13): Avoidance	Reduction	Retention	Certainty*5: High	Middle	Low	Special Cases	Risk Recognition Phase: Actual (2)	Ideal*6		Expected Effects*7 (when actual and ideal differ)	Items to Consider: Major Divisions*8		Subdivision	Check Item
1	Tapin		1			1				1				1		Grouting		1			1			Operation	4	Construction	D	8	Foundation Treatment	Grouting	Were records kept of spring locations and how they were dealt with during construction?
5	Tukul		1		1					1			1			Removal of the surface layer of the fault, replacement with concrete, and installation of instruments	1			1				Construction	4	Construction	-	8	Foundation Treatment	Concrete replacement	Have the foundation excavation surfaces been observed and recorded?

2.3 Assessment of Results of Risk Analysis

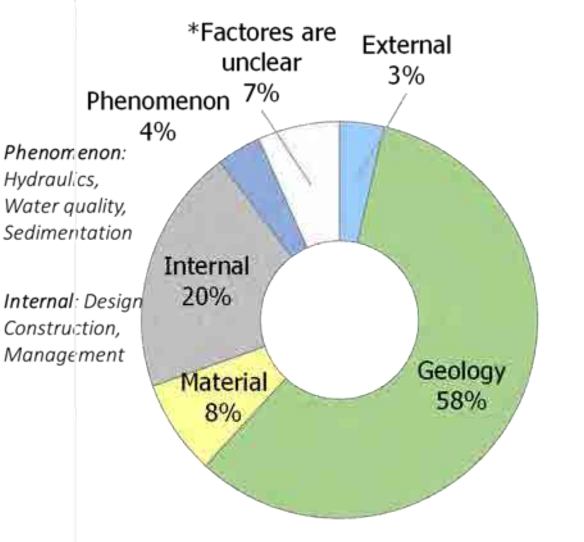
In order to understand the trends of risks that may arise in dam construction projects in Indonesia, we checked the frequency of occurrence of events for each item such as Risk Factor, Risk Location, Risk Content, Risk triggers, natural or human factors, and so on.

2.3.1 Risk Factor

Risk factors means factors that have the potential to realize a risk.

The results of risk analysis on Risk Factor, revealed that more than 60% of the risks at dam sites were related to the geology, including embankment materials, while 20% were related to design and construction management, and 3% were due to external factors such as floods and earthquakes.

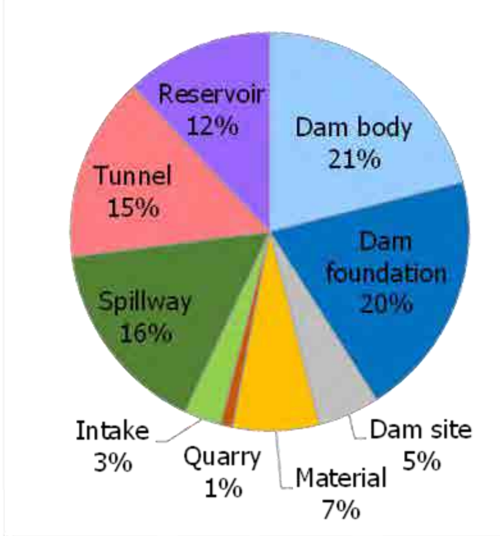
Of the internal factors, approximately 70% are design related.



2.3.2 Location of Risk Occurs

Risks observed in almost all areas of dam construction site, and the cause is largely related to geology.

Approximately 50% of the risk factors are identified in the dam body, foundations and materials, with the rest in spillways, tunnels and reservoirs.



2.3.3 Type of Risk

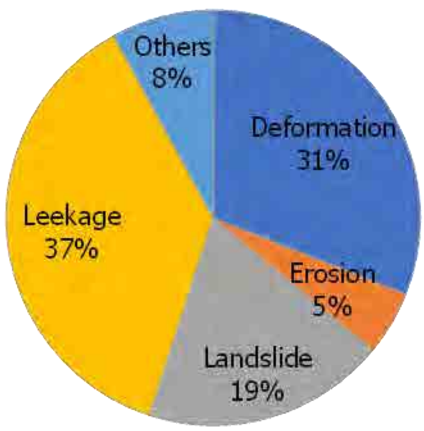
The risks are mainly classified into four types:

a. Water leakage and spring water (from dam foundation, dam body, tunnel and other structures),

b. Deformation (foundation, dam body (in particular core zone), tunnels and other structures including sliding at structural foundation),

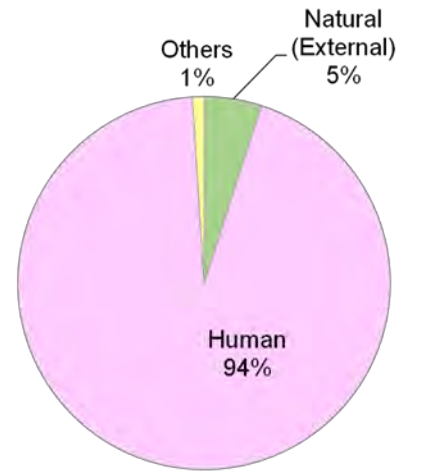
c. Landslides (collapse of natural slopes and cut slopes), and

d. Erosion at waterway.



The percentage of each type is as shown in right figure and three types of risks, namely Leakage, deformation and Landslide, account for just under 90% of the total.

2.3.4 Trigger: Human -related Factor



Risk triggers can be classified into natural and human factors. Natural factors include weather and earthquakes or unforeseen events, human factors include inadequate engineering and management judgement.

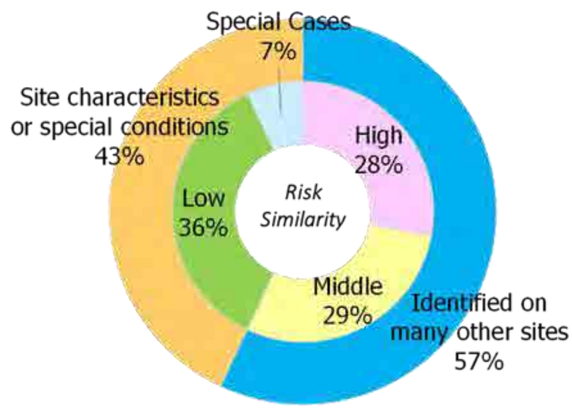
Through this study, it was assumed that most of risks (classified as Human-rerated factor) can be avoided (94%) in case carrying out adequate survey and design.

During each stage of survey and design, therefore, risk analysis and assessment, namely "RISK Management" should be conducted to recognize the potential risks and respond them.

Furthermore, It is expected that risks can be avoided or mitigated as each engineer accumulate their experience and improves their technical capabilities.

2.3.5 Risk Similarity

Many of the risks observed in each dam construction site are similar, so the risks were categorized and analyzed according to their similarities as follows:



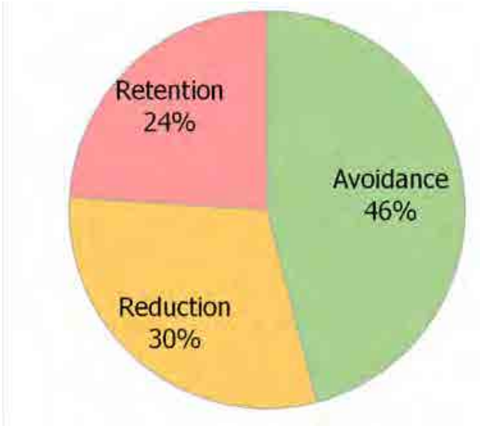
- ✧ Risks that can be recognized at other sites
  - ➢ High: Response methods have been established.
  - ➢ Middle: Response methods have not been established or responses vary from site to site
  - ➢ Low: Risks that be expected difficult (only similar topographical and geological conditions, etc.)
- ✧ Risks that arise due to special conditions at each site (special dam operations, etc.)

60% of the identified risks are similar to risks identified at other sites, so It is expected that risks will be respond efficiently based on similar risk cases.

40% of the identified risks are due to the characteristics of the site.

The goal is to respond to the risks efficiently by applying "learned from risk analysis".

2.3.6 Results of Response to Risk



Of the recognized risks, 46% are avoided, 30% are reduced, and 24% are retained.

Each term is defined as follows:

- ✧ Avoidance refers to redesign and providing countermeasures,
- ✧ Reduction refers to mainly repairs, and
- ✧ Retention involves only monitoring.

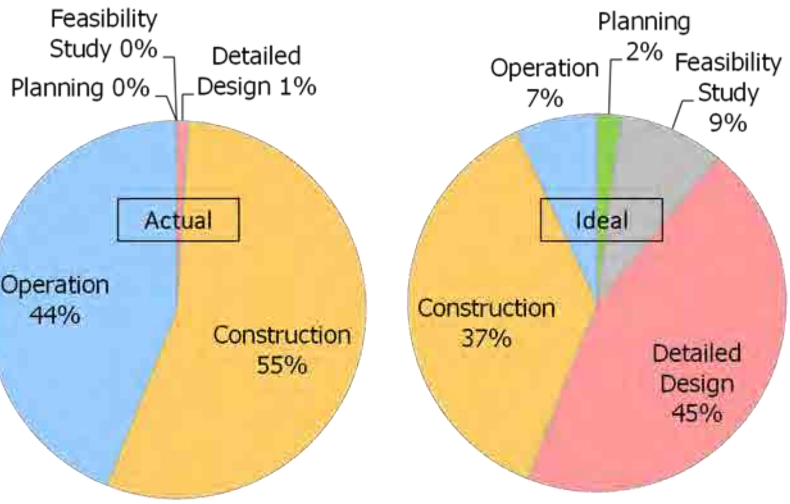
Even if these risks can be addressed after completion, it is essential that risks are eliminated before the dam is completed.

2.3.7 Project Phase for Risk Response

Most of the risk cases organized in this study were identified during the construction and operation phases, but from the perspective of risk management, many of them are better to identify ideally during the DD phase.

Because the cost of avoiding or reducing risks depends on the project phase. By identifying risks in an early phase and handling them at the appropriate phase, it is often possible to avoid increased costs.

By reassessing the project phase in which the risks collected this time could be addressed based on our opinion, it can be judged that more than 80% of the risks can be addressed during the survey, design, and construction phases.



Note : "Ideal" refers to a reevaluation result of events in construction stage whether it could be dealt with during planning and design stages.

2.4 Findings

Through the assessment of the dam risks occurred in Indonesian on-going dams, followings were founded:

- ✧ Geological Risks : more than 60%

- Importance of appropriate geological surveys, improvement of the capabilities of geological engineers and advice from experienced engineers.
- Most Risks are due to Human Factors (insufficient investigation, misinterpretation of geology, inappropriate design, etc.)
- Improve the capabilities of dam engineers and have experienced engineers' review.
- Of the identified risks, approximately 60% were Similar Risks that were observed in other dams.
- If risks are recognized earlier, measures can be taken .
- 55% of risks were Recognized during Construction Stage and 44% after completion.
- More than 50% of risks can be recognized at the time of survey and design stage. Many risks can be prevented if risks are recognized.

PART 3 Establishment of Dam Risk Management System

According to the results of risk analysis compiled here, the majority of risks in dam construction are caused by human related factors. In other words, if risks are recognized and addressed at the survey, design, and construction management stages, a significant number of risks occurring on-site can be prevented.

One method for achieving this is to introduce a risk management system.

There is a view that Risk Assessment is highly valuable as an supporting tool in decision-making regarding dam safety, and as a meaningful method of decision-making from both safety and economic standpoints when deciding on the modification/upgrading of existing dams or the development of new dam projects, and it is hopefully expected that risk assessment would be implemented in Indonesia's dam projects, in particular planning and design stages, in future. And such risk assessment should be conducted the engineer in charge of the work inviting experts.

To achieve this, it is essential to establish an organization and to prepare the guidelines for implementation.

1. Initiatives in Japan in Risk Management in Civil Engineering Project

1.1 Background of Japanese Guideline

In Japan, there are Damages/Accidents caused by Geological Issues in construction or after completion, same as in Indonesia, and many "Geological Risks", containing in dam projects, have been treated through so-called “Tacit Knowledge” of the well experienced engineers. However, currently, due to a “Lack of Experienced Engineers”, it has become difficult to expect this.

Furthermore, Social Monitoring has become stricter, because of several issues at site such as serious accidents, cost increases, delay of schedule, and modification/change of projects. So “More Efficient Project Implementation” is required,

In response to this, in 2020, MLIT (Ministry of Land, Infrastructure, Transport and Tourism) with PWRI (Public Works Research Institute) published the "Guidelines for Geological and Ground Risk Management in Civil Engineering Projects“*1).

This guideline aims “to Eliminate Undesirable Elements” that occur during construction and management by conducting risk management for uncertain elements in the promotion of civil engineering projects.

1.2 Concept of Risk Management Guideline

The guideline was prepared based on the following concepts:

- ✧ To make clear Procedure of Risk Recognition
  - ➢ To manage risks in the Projects, firstly recognizing expected risks.
  - ➢ how to handle various risks in projects;
  - ➢ how to respond to them, as well as the structure and process of general risk management.
- ✧ Practical Uses of Risk Management System in Project

- Implementation Procedures of risk management in recognition of risks
- Methods and Notable Points that can be applied during implementation.

1.3 Basic Policy for Preparation of Guideline

This guideline has been prepared with the following objectives:

a. To present the concept and basic ideas of risk management in civil engineering projects.

b. To propose the roles and functions of the project office and related parties implementing risk management, as well as the ideal form of collaboration.

c. To present the procedures and methodology for introducing and implementing geological/geotechnical risk management.

d. To indicate points to note when implementing geological/geotechnical risk management.

e. To refer to the concepts of ISO 31000 (Risk management - Guidelines) and apply them to civil engineering projects.

1.4 Focus Points

The guideline was prepared with a focus on the following two points:

a. Impact of Uncertainties on Projects

- Geology and ground are formed naturally, and their distribution and properties are nonuniformity and complex.
- This uncertainty causes an impact on project safety, such as the occurrence of accidents.

b. Handling of Uncertainties on Projects

- It is necessary to evaluate risks after understanding the estimation and uncertainty of geological and ground conditions.
- There is a need for a framework for stakeholders to recognize and share geological and ground uncertainties, and a mechanism for assessing the impact on projects and responding to risks.

1.5 Application of ISO31000 Risk Management

This guideline compiles the concepts of frameworks and procedures, as well as their introduction and operation, in accordance with the concepts of ISO 31000 (Risk Management - Guidelines).

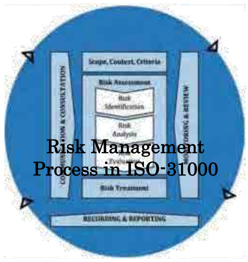
Risk management for civil engineering projects, including dam projects, has not only a purpose to avoid unfavorable impacts such as accidents and losses, but also to obtain advantageous opportunities such as to select a geologically advantageous damsite or dam type.

ISO 31000 (Risk Management - Guidelines) also defines risk management as “Creating and Protecting Value."

In other words, by creating an optimal plan and design for the entire project, we aim to create new value through efficient project Implementation so the goals of both are the same.

2. Implementation Method of Risk Management in Civil Projects

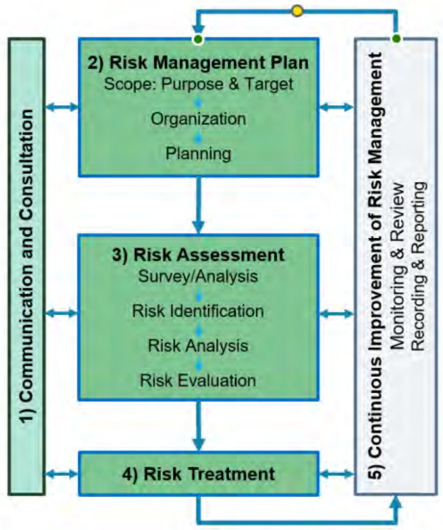
2.1 General



Risk management in projects is applied to various stages of the project and is implemented continuously throughout the project to optimize risk response. For this reason, it is necessary to establish clear policies not only for procedures such as risk assessment and risk response methods, but also for the operation of the management process, such as risk management planning, communication and discussion, and continuous improvement of management.

Therefore, the risk management will be implemented as shown in following ISO-31000 methodology.

2.2 Implementation Procedures



Risk management consists of the following five steps. By continually repeating this process for identified risks throughout the project, more effective results can be achieved.

1) Communication and consultation
2) Risk Management Plan
3) Risk Assessment
4) Risk Treatment
5) Continuous Improvement of Risk Management

2.3 Contents of Each Step

(1) Communication and Consultation

"Communication and Consultation" is the most important element in the risk management framework and process. It is important to continuously carry out "communication and Consultation" in the risk management process and keep risk awareness and response always up to date.

"Communication and consultation" consists of the following:

a. Internal communication and discussion

b. External communication and consultation

Notable Points for Communication and Consultation are;

- Carrying out communication continuously in Risk Assessment and Treatment,
- Estimating/Confirming the roles, abilities, and functions of those involved in system and organization,

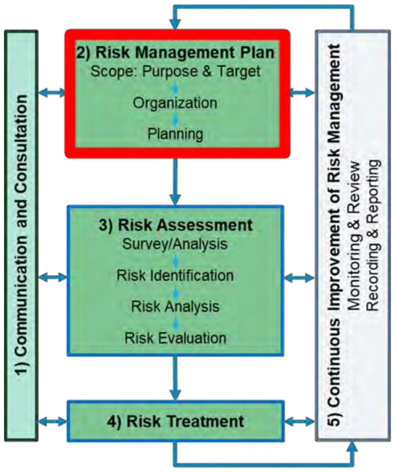
- It should be conducted prior to drafting a risk management plan.

Specifically, it will be as follows:

- confirmation of the relationship and uncertainty of the performance required for the design and construction of a project or structure,
- reorganization of the potential of risks from performance of foundation, geological structure and other conditions which obtained from surveys and analysis, etc., and
- share an understanding of aware risks.

Although such discussion have traditionally been set up for process adjustments and project execution, it is important to have communication and discussions with a clear purpose, rather than simply sharing information.

(2) Risk Management Plan



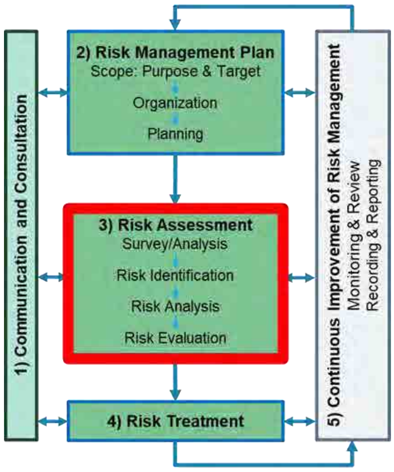
Establishment of a Management Policies and Processes in advance applicable to all stages.

Policies and management processes will need to be Modified/Updated in accordance with actual conditions of each project stages.

When risk management at each stage is planned, followings shall be considered and confirmed;

- Purpose and Role of Risk Management at objective stage in the whole project and Relationship with other stages,
- Management Plan shall be In line with the overall policy.

(3) Risk Assessment



The purpose of risk assessment in dam project is to evaluate;

a. What kind of results will occur as a result of the combination of the construction of dam with geological characteristics and other conditions or external forces, and

b. What kind of impact will there be on the project?

In other words, risk assessment is a task that provides materials for determining risk responses and their priorities. It is necessary to grasp the estimated performance of the dam based on the limited information required for the design and construction or structure has been obtained, and the degree of uncertainty. It is also necessary to clarify the prerequisites for information such as investigations and analyses as materials necessary for judgment.

Of the tasks of risk assessment, investigations are not always carried out prior to risk identification and risk analysis. Sometimes, it may be carried out as a result of risk identification and risk evaluation, or when it is determined that additional investigations are necessary as an option for risk response.

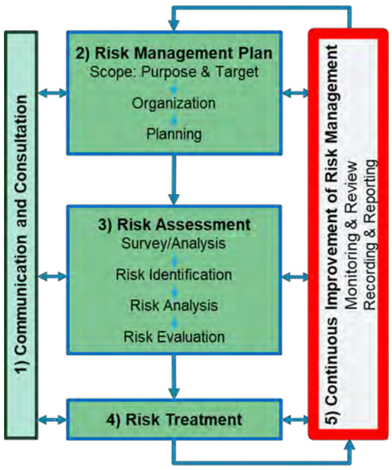
In order not to overlook risks with large impacts, it is important to recognize risks at an early stage of the project, confirm the necessity, and carry out additional investigations and analyses.

(4) Risk Treatment

Risk response is the process of modifying recognized risks by avoiding, reducing, transferring, retaining, etc. Risk response is the process of making decisions on response policies, in which the characteristics of the risks evaluated in the risk assessment and the magnitude of their impact are compared with the risk criteria, and the optimal response option is selected and implemented.

As the business progresses, information on these recognized risks is updated, and as the design progresses, their content and magnitude change. For this reason, it is necessary to revise risk responses, such as (1) making the response measures in the previous stage more detailed, (2) changing the response policy, or (3) selecting the response measures for the remaining risks in the previous stage at that time. For this reason, it is important that risk response does not simply select the response measures for the risks, but also indicates the risk response status and the monitoring concept, including cases where the selection of the response measures for the risks is postponed.

(5) Continuous Improvement of Risk Management



Proposed Process
Geological Risk Management

It is important to continue Risk Management throughout the entire project and at each stage of the project, and it is necessary to consider reviewing the organization and system in line with progress.

For continuous improvement of Risk Management in the Project;

a. Monitoring project progress, changes in external conditions, changes in risk information, and the current status of systems and organizations

b. Conducting Reviews to determine whether appropriate responses can be taken.

It is also necessary to record the whole works to ensure that the information obtained through risk management and its results are shared and passed on.

3. Organizing Risk Management Team

3.1 Implementation Team

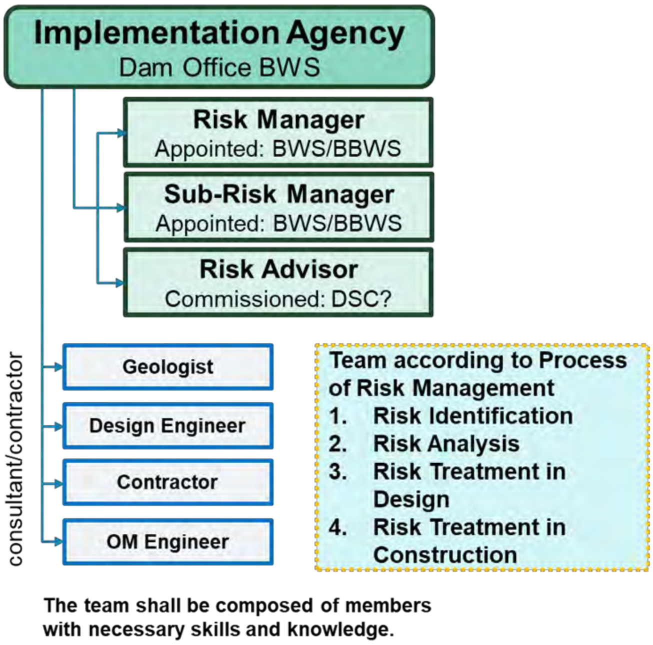
When implementing geological/ground risk management, the operator shall involve internal and external parties with the necessary skills and knowledge, and clarify the coordination system of these parties, their functions, roles, and responsibility divisions. shall be. In addition, all parties concerned shall confirm in advance the division of roles and responsibilities of each person, and endeavor to ensure that they have the necessary abilities and functions to fulfill their assigned roles.

In dam risk management, close cooperation between each party is important as well as the roles and responsibilities of each party. In particular, because geological conditions in damsite and reservoir (mountain Area) are uncertain, unexpected situations often occur. In doing so, it is important to note that there are many cases in which work that was not initially set out is required, and in such cases, gaps in roles and responsibilities arise, such as insufficient communication of information or insufficient sharing of information regarding risks, leading to undesirable results. is necessary.

Therefore, it is important to work together on a regular basis, closely share information on risks, have a common understanding, and handle risks in a ONE-TEAM system.

3.2 Team Composition and Its Role

Right figure shows an example of the structure of the team involved in geological/ground risk management proposed in the Japanese Guideline. Since this is based on the general project of the MLIT, Japan, the system in Indonesia may be implemented with a different system, structure, and role division depending on the Indonesian project implementation system.



Note: This is an example based on the general project of the MLIT Japan, so that arrangements would be required depending on the circumstances of each country.

Since Dam Risks cover multiple specialized technical fields, it is basically handled by a team made up of related specialists according to the process. The following are examples of things that play a role as a team within a risk management system.

Risk identification team:
A team to extract and identify risks without overlooking them.

Risk analysis team:
A team that analyzes risks

Risk assessment team:
A team that evaluates risks

Risk response review team:
Develops risk response measures based on risk assessment results.

Construction risk response team:
A team that responds to risks arised during construction.

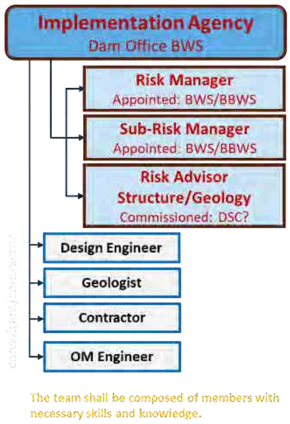
3.3 Proposed Dam Risk Management Team Composition in Indonesia

Following table shows a sample of members of dam risk management team in Indonesia.

In Indonesia, Dam Safety Commission

Table Sample of Members of Dam Risk Management Team

	Role
Implementing Agency (Dam Office / BWS)	A person who makes decisions of project implementation, planning and management of geological surveys, etc., and risk treatment.
Risk Manager (Appointed by IA)	A person in charge of overall dam engineering (structural/geological) risk management in/from the Implementing Agency.
Risk Sub-Manager (Appointed by IA)	A person who assists in the operation of risk management conducted by the risk manager.
Dam/geology Risk Advisors (Commissioned / DSC)	A dam and geology specialists who supports dam risk managers and risk management operations from a professional standpoint.
Dam Design Engineer (Consultant/dam engineer)	A person who designs dam/structures, etc.
Geotechnical Engineer (Consultant/geologist)	A person who conducts geological survey and analysis, etc.
Construction Engineer (Contractor)	A person who constructs structures, etc. based on the design.
OM Engineer (if necessary) (Consultant)	A person who conducts inspections in the maintenance and management of structures.



4. Timing of Risk Management

Risk management is a concept that can be applied at any stage of a project, but analysis of data collected to develop the guidelines in Japan has confirmed that implementing it early can have a greater impact.

The benefits of starting early are:

a. More Options for dealing with uncertainty and risk can be considered.

b. Damage can be minimized, and

c. Better Results can be achieved (even if starting midway through the project).

d. More benefits can be expected.

Example of Benefit

✧ a. In dam projects, there is a possibility to avoid a risky damsite in an early stage, but once the project has commenced, it becomes difficult to change the site, and due to countermeasures, there is a high risk of increasing of construction cost and extending of construction time.

✧ b. In case information would not be obtained sufficiently, decision making for finalizing the treatment may be postponed. Because an insufficient information or many assumptions, even though carrying out the precise design, the result will be in overdesign, or in the worst case, too optimistic assumptions may derive accidents.

By Identifying risks early which have a large impact and Responding strategically, the project may be implemented more efficiently.

5. Implementation Procedure of the Dam Risk Management System

Followings are idea of procedure for implementing with dam projects while being aware of risks, as well as methods that can be applied during implementation and points to keep in mind.

a. Timings of Risk Management are mainly set based on the technical session by dam safety commission (but the session maybe need more frequently).

b. Before the technical session, the dam implementation agency (such as BWS), etc.) shall conduct a ``Risk Recognition in the project using Event Summary Report and Database."

c. Prior to the technical session, Preliminary Discussions regarding the content of the check list shall be carried out with specialists (such as BTB (DSU), PUSAIR, BINTEK, etc.)

d. Applying this process, all dam implementing agencies can prepare the Individual Event Summary Report at the necessary stage.

6. Establishment of Indonesian Guideline for Dam Risk Management

The following points should be considered when establishing a dam risk management system in Indonesia.

6.1 Risk Management Plan

(1) No Need to built up a fixed system :

It is implemented using the most appropriate system available at the time, depending on the purpose and characteristics of the project. In Indonesia, a review system by the Dam Safety Committee has been established, so it is necessary to consider how to link the DSC with this dam risk management system and how to utilize the DSC.

(2) Maximum Use of Existing System:

If there is an existing management system, it may be possible to utilize and reorganize this and add or improve the necessary parts to the system.

6.2 Risk Assessment

Sets Up the Data Compiling and Display of Risk Level, based on the policy of risk assessment.

For setting them up

- to consider to be applicable in the risk assessment and risk treatment,
- “Communication and Consultation" within the team shall be held,
- Select applicable methods based on the purpose of the project and target structures.

7. Preparation of Guidelines of Risk Management

The Contents of Dam Risk Management Guideline may be as shown below:

Table of Content

Dam Construction Risk Management
Basic Concept of These Guidelines
1. Purpose of the Guidelines
2. Applicable Subjects
3. Definition of Terms
4. Basics of Dam Risk Management
    - 4.1 Basic Policy for Dam Risk Management
    - 4.2 Dam Risk Management System and Organization
    - 4.3 Structure and Process of Dam Risk Management
5. Dam Risk Management Implementation Methods
    - 5.1 General
    - 5.2 Communication and Consultation
    - 5.3 Risk Management Planning
        - 5.3.1 Setting Objectives and Targets
        - 5.3.2 Establishment of the System
        - 5.3.3 Planning
    - 5.4 Risk Assessment
        - 5.4.1 Survey of Geology, Ground Conditions, Design etc.
        - 5.4.2 Risk Identification
        - 5.4.3 Risk Analysis
        - 5.4.4 Risk Assessment
    - 5.5 Risk Response
    - 5.6 Monitoring and Review
    - 5.7 Continual Improvement of Risk Management
    - 5.8 Record-keeping and Reporting

8. Configuring the System in Other Countries (reference)

8.1 Risk Management System in Other Countries

A concept of risk management has been introduced and operated in civil engineering projects in overseas countries for a long time.

Table shows the technical methods of risk assessment and risk management systems used in overseas countries.

Various methods are used depending on the circumstances of each country.

However, in many cases, risk management systems are introduced for the purpose of "Avoiding Conflicts" between ordering parties".

Description			UK	U.S.A.	New Zealand	Swiss	Nether-lands	Canada	Nepal	Singapore
Assessment Method	Qualitative	Risk Matrix	✓	✓	✓	✓	✓			
		Failure mode and effect analysis		✓						
		Event tree analysis		✓						
	Quantitative	Markov chain Monte Carlo simulation		✓		✓				
		Uncertain analysis (@RISK)		✓					✓	
Management System	Management Tool	B/T B: Boling Length T: Tunnel Length						✓		
		Pessimistic/Optimistic Geological map				✓				
		Risk management table			✓					
		GBR :Geotechnical Baseline Report	✓	✓			✓			✓
		Geological risk								✓
	System	Ground certification	✓							
		Insurance system	✓							✓
		Geo - advisor (Geotechnical advisor)	✓							

8.2 Comparison with Japanese Guideline

The risk management systems in overseas countries are different from the risk management systems that take into account civil engineering projects that emphasize cooperative relationships, such as those in Japan.

Japanese guideline: proposes a Qualitative Method for assessment.

The concepts are as follows:

- ✧ Information shall be added and updated in the risk management applying the latest survey results and progress of construction.
- ✧ Risks and measures shall be re-evaluated the uncertainties and be compared with original design conditions.
- ✧ The implementation method of risk management shall be reviewed and modified from time to time in accordance with latest information.
- ✧ The system is based on ISO-31000 (Risk Mitigation and Creating Value).

In this presentation, the Japanese guidelines was introduced, but when introducing a risk management system to Indonesia, it is necessary to make a decision after detailed research and deep consideration.

9. Recommendation and Conclusion

9.1 Recommendation

Currently, in Indonesia, DSC/DSU is conducting technical studies at each stage of dam design, water storage, and operation to ensure dam safety. This system is working very effectively. However, when we inspected many dam construction sites with DSC, it was verified that there were many issues arising at the site due to oversights during the survey and design stages and misunderstandings due to insufficient geological investigation.

When constructing a dam, there are geological uncertainties, and risks cannot be avoided. But it is supposed that risks in dam construction can be minimized by incorporating the "Risk Management System for Civil Engineering Projects" proposed here into the current Dam Safety Committee review system.

Furthermore, by accumulating and creating a database of issues that arise, their responses, and results, it is possible to improve the risk management system one by one. This database can also be used as a reference for the next risk response. In particular, BTB has been storing data related to the risks of all dams in Indonesia, and the materials for establishing this system are already avairable.

By creating such a system, i.e., organizational structure, risk management methods, database and guidelines showing organizational structure, and utilizing it in the field, it is possible to minimize the damage currently occurring in the field.

Using the management system proposed here,

a. Identify risks and reflect them in the design once the dam survey is complete

b. As the design progresses, we take measures to address newly identified risks during the design process.

c. If construction is carried out and it is found that there is some deviation from the design, the risk will be reflected in changes in the design or construction method in advance.

This will likely lead to delays in construction, increased costs, and the prevention of accidents.

So, it is recommended introducing this system to design and construction sites in Indonesia.

9.2 Conclusion

- ✧ Currently, to ensure the safety of dams, Dam Safety Commission and Unit have been conducting technical reviews at each stage of dam design, impounding, and operation, in Indonesia. This system has been working very effectively.
- ✧ During my dam construction site inspection, however, I found many risks arising at site due to oversight in design, mis-interpretation of geological structure and so on.
- ✧ Risks are unavoidable in dam construction due to uncertain and diverse factors in Dam Project.
- ✧ It is supposed that adaptation of “Risk Management System" into the current review system by Dam Safety Commission as well as the design and construction on project site will help to minimize risks in dam construction.
- ✧ We hope that Indonesian dam-related parties (Benda, BTB, DSC etc.) will continue to discuss this concept and system and make efforts to make dam construction in Indonesia safer and smoother. We would like to continue to support them.

PART 4 Considerations on Geological Issues in Each Phase

1. Introduction

1.1 Background and Purpose of This Study

As a result of analyzing risk cases for 61 dams, the following was found.

- ✧ Many of the risk factors are geological.
- ✧ If many of the issues identified during the construction phase had been recognized before the detailed design stage, it may have been possible to reduce the costs of countermeasures against the risks, or to improve the safety and functionality of the completed structures.

Therefore, based on risk case studies and risk analysis results for 61 dams, this study proposes considerations for dam risk management at each project stage from a topographical and geological perspective.

1.2 Define and Identify Risk

The definition of risk in this study is as follows:

- ✧ In our study, risk refers to a situation/condition where the occurrence of an event may have significant undesirable impacts on the dam project.
- ✧ The impacts refer to dam breaches and the failure of dam functions, as well as negative effects of the projects on stakeholders.

Dam risk management aims to achieve the following goals by managing the above risks.

- ✧ Dam safety and functionality.
- ✧ Rationalization of Project Costs

1.3 Geological Risk Factor (Georisk Factor)

Risk is identified through issues or events in planning, investigation, design, construction, and operation phase. The risk identification, analysis, assessment, and response in our study are positioned in a cause-and-effect relationship as shown in the Figure 1.1.

This relationship is a case of dam foundation of Bagong dam. At the Bagong Dam site, foundation excavation during the construction phase revealed the "distribution of thick colluvium" which had not been estimated at the detailed design phase, and this was identified as a geological risk factor (hereafter referred to as georisk factor). To reduce or avoid the risks expected due to geological factors, additional geological surveys were carried out and the foundation treatment and foundation excavation lines were reconsidered. In this study, the considerations at each project phase were examined, focusing on the geological risk factors such mentioned above.

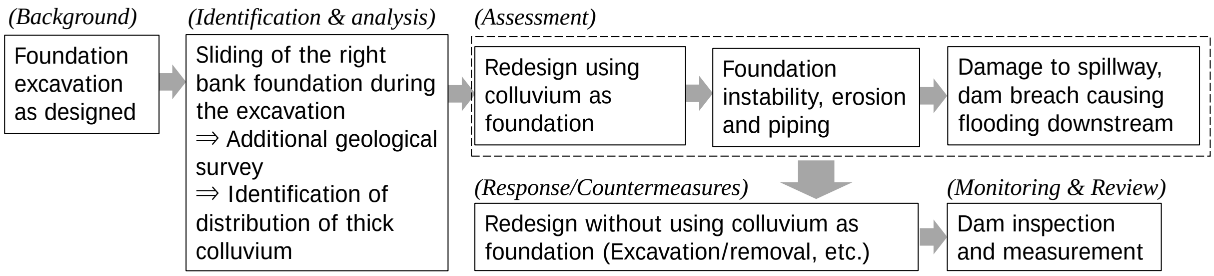


Figure 1.1 Cause-and-Effect Relationship for Risk Management (Bagong Dam)

2. Considerations for Each Phase

2.1 Planning & Preliminary Design

(1) Active Fault

Active faults have a significant impact on dam projects depending on their distribution. Furthermore, regarding the active faults distributed around the proposed dam site, it may not be sufficient to simply refer to existing active fault maps. For this reason, it is recommended that active fault study be carried out during the planning and preliminary design phase. Furthermore, active fault study also helps to identify the georisk factors of potential dam sites from the perspective of regional structural geology. Here, geological risk factors refer to loosening of rock mass, landslides, reservoir sedimentation, etc.

Figure 2.1 shows the flowchart of active fault study around reservoirs in Japanese dam projects. In this process, red text indicates judgment and evaluation.

(A) Literature Review, (B) Topographic Interpretation, (C) Site Inspection, (D) Comprehensive Evaluation based on the results of (A), (B) and (C). If there is a possibility of active faults existing at the dam site, go to (E) Geological Survey, (F) Comprehensive Evaluation based on the results of (E). When assessing that active faults are distributed at the dam site, Better to change the dam site.

However, there are a few cases overseas where fault displacement is considering in the design.

Here, the reason why lineaments and faults with a length of 10 km or more are targeted, because it is empirically believed that faults on the ground surface are formed by magnitude 6.5 or more and the length 10 km or more. The 3 km distance is based on the idea of a group of faults.

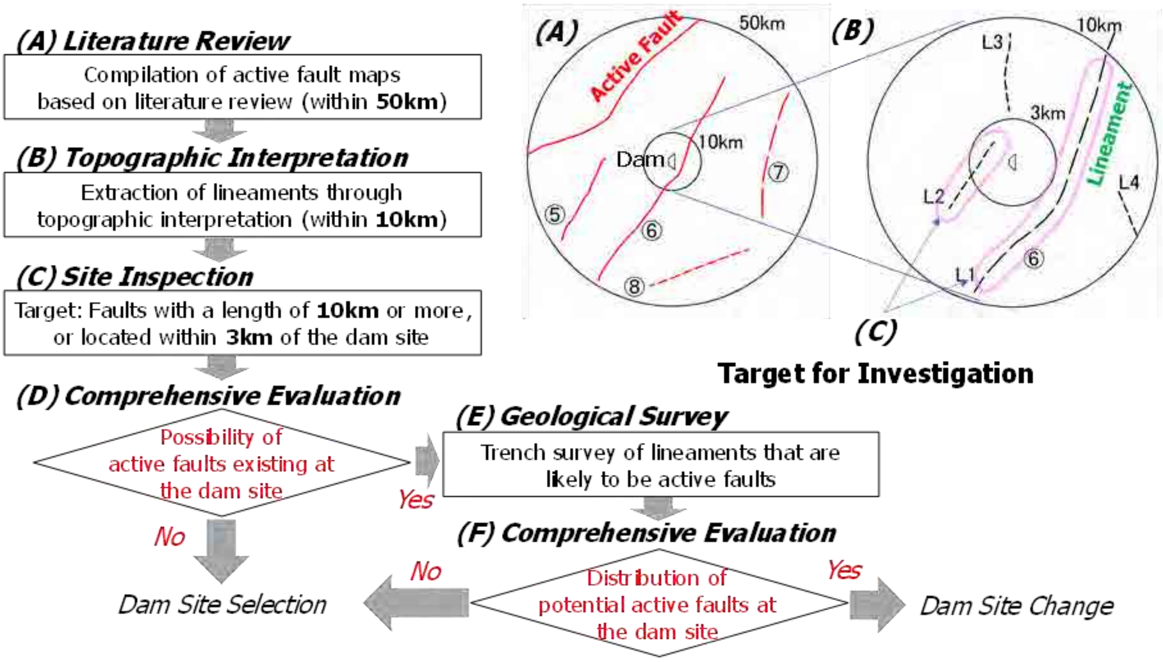


Figure 2.1 Flow of Active Fault Study for Dam Projects in Japan

Figure 2.2 is an example of photograph and sketch of trench in active fault surveys in Japan. A fault is considered active if it cuts or deforms strata that were formed within the past tens of thousands of years. In addition, samples are taken based on the fault's structure and C14 dating is carried out to study the activity history of the fault.

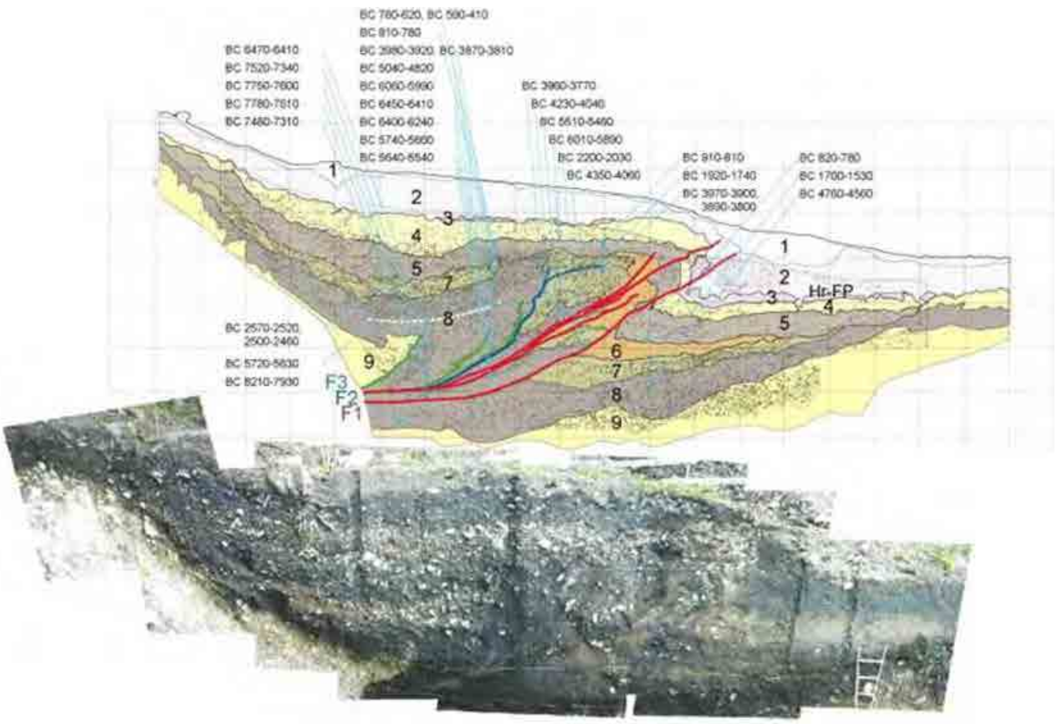
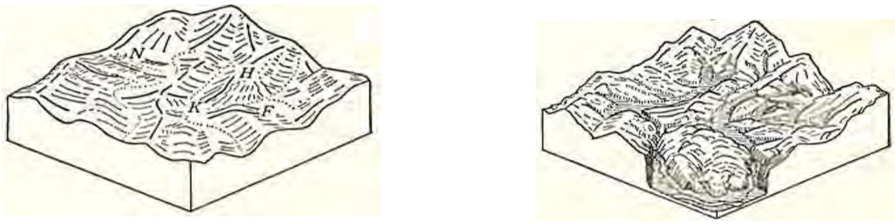


Figure 2.2 Example of Trench Survey of Active Fault in Japan

(2) Reservoir Sedimentation

Reservoir Sedimentation has a huge impact on maintaining the dam functions. For this reason, it is recommended that sediment yield study be carried out during the planning and preliminary design phase. Furthermore, since the topographical and geological conditions of the basin greatly affect sediment yield potential, it is effective to have geological engineers involved in reservoir sediment management (Figure 2.3). For reference, a literature shows the suspended sediment yield around Indonesia as shown in the Figure 2.4.



(a) Low Sediment Yield *(b) High Sediment Yield*

Figure 2.3 Different Topography of Sediment Yield

Figure 2.4 Suspended Sediment Yield around Indonesia

Source: Walling & Web (1983)

【Reference】 Sediment Yield Intensity Map

In Japan, the sediment volume for dam design is determined based on the actual sediment volumes of existing dams that have similar topography and geology to the basin of the proposed dam. Figure 2.5 estimates the potential sediment yield of Japan using an estimation formula developed based on the actual sediment volumes of existing dam reservoirs. The estimation formula uses the topography and geology of the basin as parameters. Such studies are useful for planning new dams.

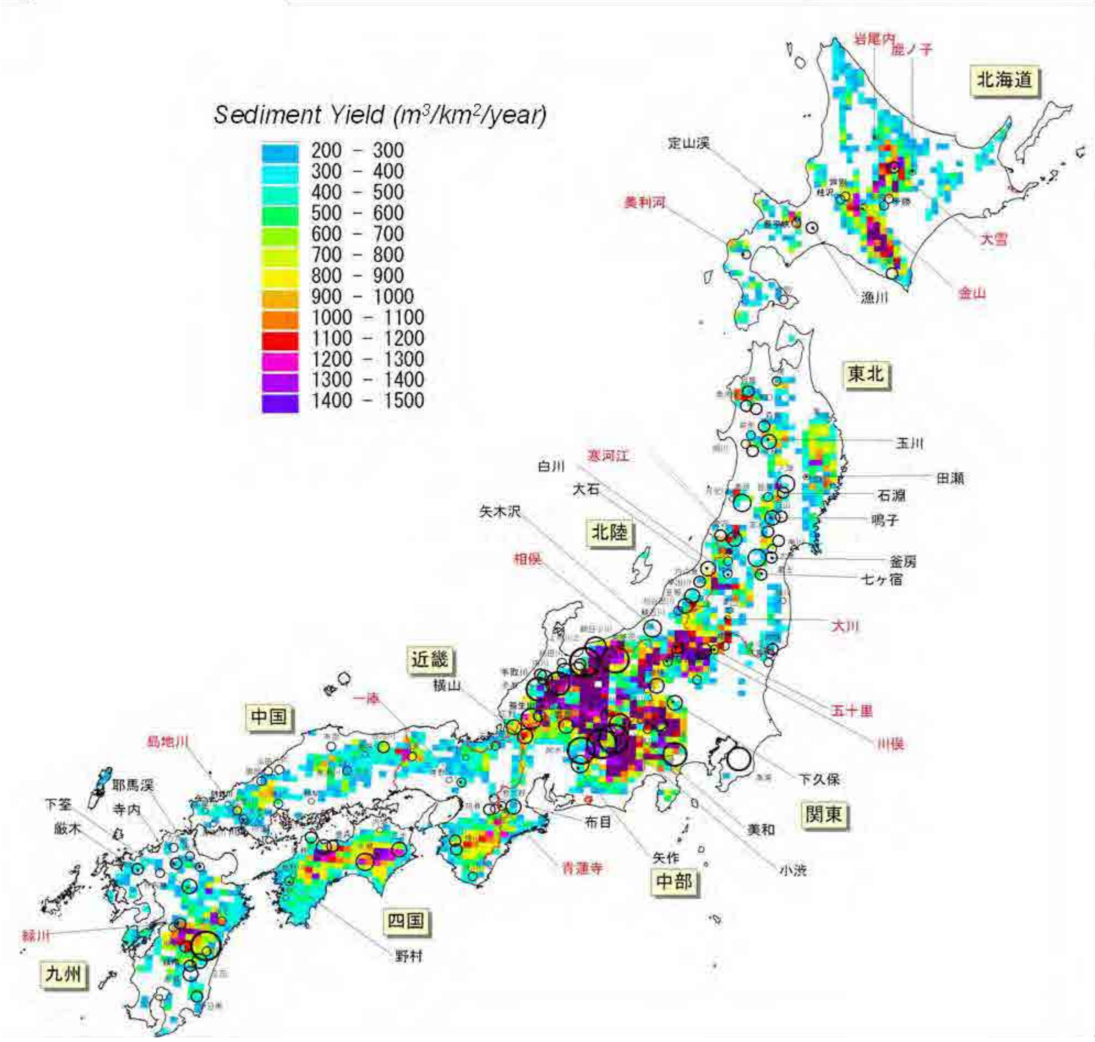


Figure 2.5 Example of Sediment Yield Map of Japan

Note : This potential sediment yield is the long-term annual average value, and the amount of sediment runoff during floods would be much greater.

(3) Landslides around Reservoir

The occurrence of large-scale landslides or many landslides around the reservoir would have a huge impact on the safety and functionality of the dam. The construction of countermeasures after impounding often results in increased costs. For this reason, it is recommended that potential landslide study around the reservoir be carried out during the planning and preliminary design phase.

Figure 2.6 shows the flowchart of potential landslide study around reservoirs in Japanese dam projects. In this process, red text indicates judgment and evaluation. (A) Literature Review, (B) Topographic Interpretation, (C) Site Inspection, (D) Comprehensive Evaluation based on the results of (A), (B) and (C), determine the need for additional geological surveys and analysis, if necessary, go to (E), in (F), determine the need for countermeasures based on the results of process (E).

Furthermore, it is important to prepare ledgers of potential landslides based on the site inspection results shown in Figure 2.7, and to update the ledger after geological study, design of countermeasures, and construction them, and use them for monitoring after impounding.

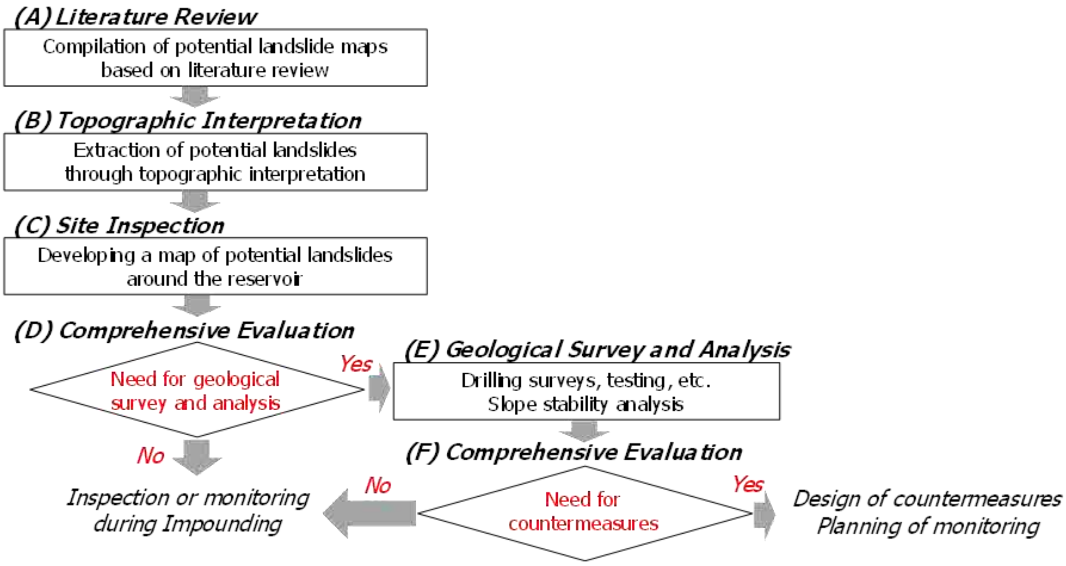


Figure 2.6 Flow of Potential Landslide Study for Dam Projects in Japan

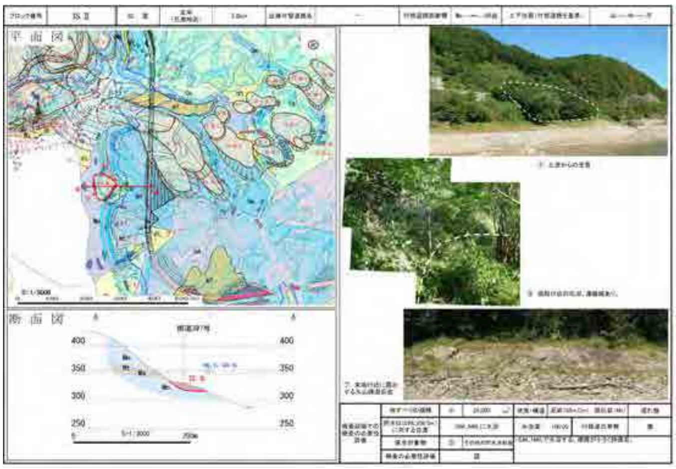


Figure 2.7 Ledger of Potential Landslide

Figure 2.8 shows a large landslide that occurred in a dam reservoir in Japan in 2008 by a magnitude 7.2 earthquake. The landslide was about 900m wide and 1,300m long, 67 million m3 volume. Fortunately, this landslide occurred about 1 km upstream from the dam, so the dam breach did not occur.

This landslide had been identified as a potential landslide before the earthquake, but the risk of a landslide was retained, considering the likelihood of occurrence and the countermeasure cost. After the landslide, countermeasures were carried out to stabilize the cliff, suppression of sediment runoff, and stabilize the end block of the landslide.

(a) Before Countermeasure *(b) After Countermeasure*

Figure 2.8 Large-scale Landslide in the Dam Reservoir in Japan

Figure 2.9 shows a large landslide that occurred in a dam reservoir in Japan in 2008 by a magnitude 7.2 earthquake. The landslide was about 900m wide and 1,300m long, 67 million m3 volume. Fortunately, this landslide occurred about 1 km upstream from the dam, so the dam breach did not occur.

This landslide had been identified as a potential landslide before the earthquake, but the risk of a landslide was retained, considering the likelihood of occurrence and the countermeasure cost. After the landslide, countermeasures were carried out to stabilize the cliff, suppression of sediment runoff, and stabilize the end block of the landslide.

Figure 2.9 Large-scale Landslide in the Upstream of Bili-Bili Dam (2004)

(4) Keep in Mind

These are things to keep in mind during the planning and preliminary design phase.

- Consider how to deal with the risks identified in the planning and preliminary design phase.

- All information regarding risks identified in the planning and preliminary design phase will be carried over to the detailed design phase without exception.
- During the detailed design phase, investigations and considerations will be carried out on risks that cannot be avoided during the planning and preliminary design phase.

2.2 Detailed Design

(1) Dam Foundation

The risks located in the dam foundation have a huge impact on the safety of the dam body. Redesigning a dam foundation during construction would delay the project schedule and increase costs. For this reason, during the detailed design phase, it is important that the geological conditions of the site are interpreted properly, and reasonable excavation line are designed.

Figure 2.10 is a geological cross section of Bagong Dam. The above figure is design phase, and the below is construction phase. On both the left and right banks, the thickness of the colluvial layer distribution was significantly different between the detailed design phase and the construction phase.

It is estimated that the cause of this was a lack of geological surveys and incorrect geological interpretation in design phase.

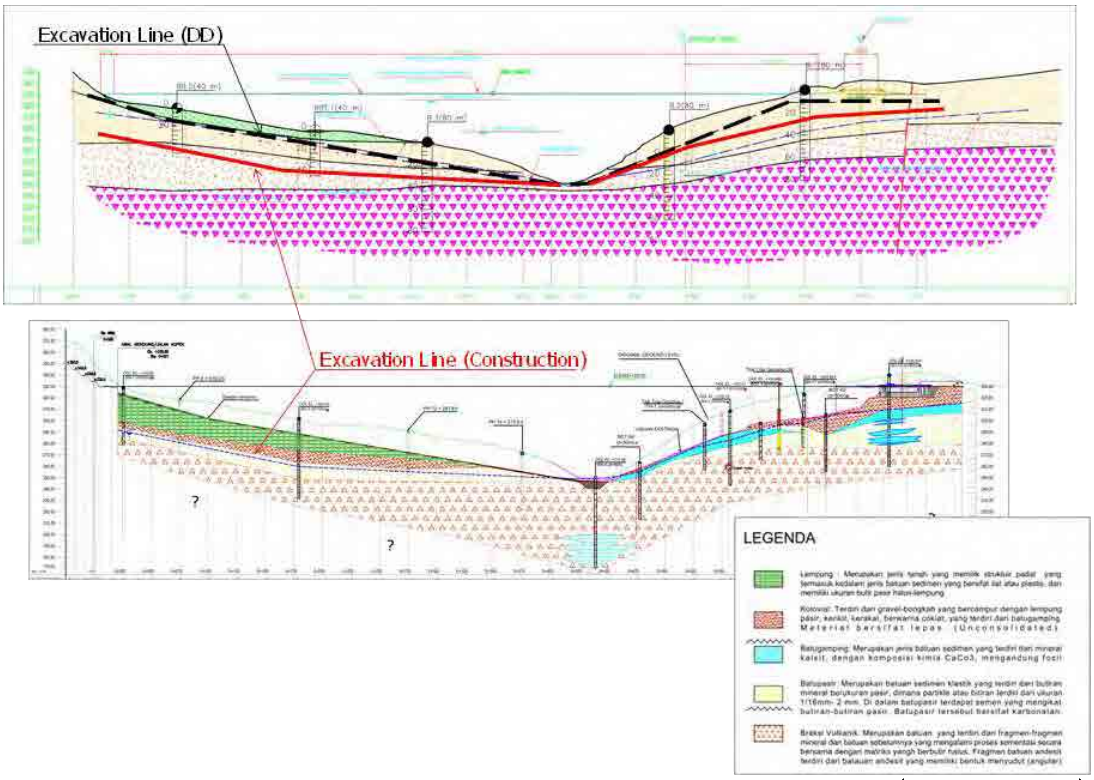


Figure 2.10 Example of Change in Foundation Excavation Line (Bagong Dam)

The following are some considerations for designing a rational foundation excavation line.

(a) Seismic Exploration

Seismic exploration is also called elastic wave exploration. Generally, rock foundations can be evaluated using P waves, while soil foundations can be evaluated using S waves. Figure 2.11 shows a seismic exploration analysis result of rock mass foundation. There is a correlation like this between P-wave velocity and rock grade (D to CH).

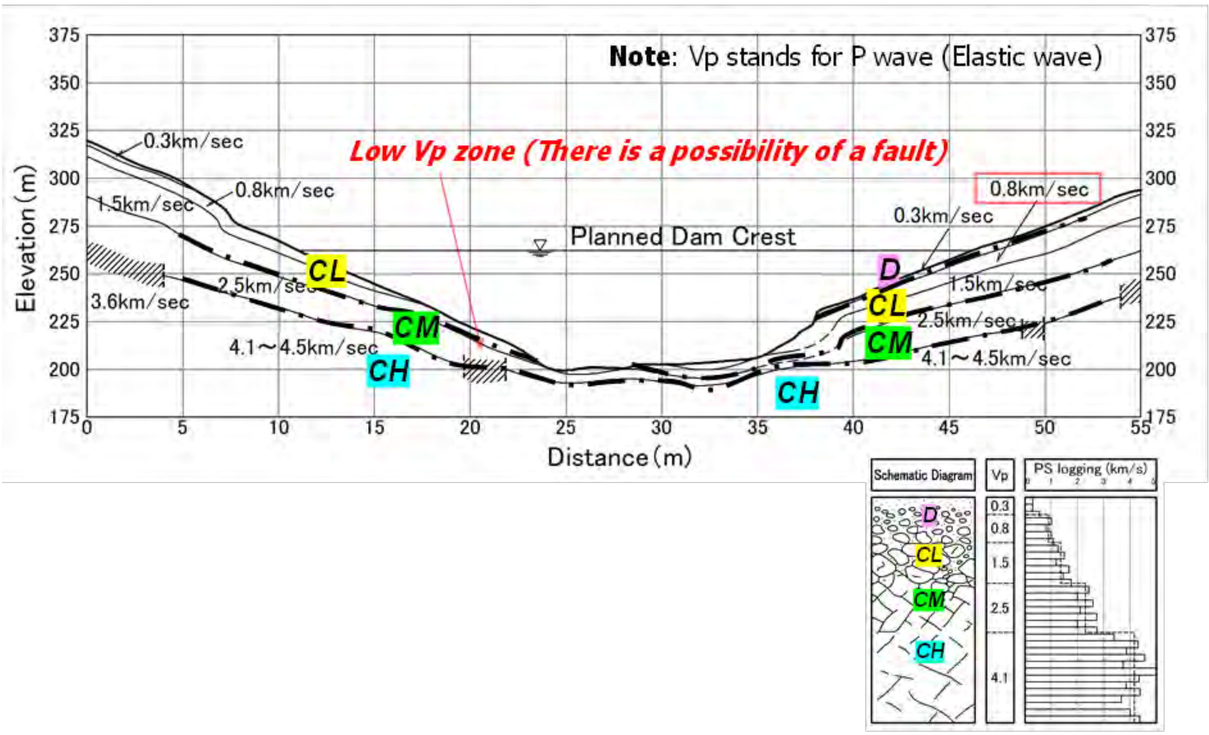


Figure 2.11 Schematic Analysis Result of Seismic Exploration Dam)

(b) Grouting: Characteristics of Each Geology

According to the results of our risk case analysis, the main risk factors for leakage are extrusive rocks and pyroclastic rocks. For this reason, grouting will be adopted and designed considering such geological characteristics shown in Table 2.1.

Table 2.1 Grouting: Characteristics of Each Geology

Rock Type	Geological Characteristics	Precautions for Grouting
Pre-Neogene sedimentary rocks	Intact rocks are hard, but because the bedrock has many faults, open cracks develop in the weathered areas. Limestone areas have cavities and are highly permeable.	Improvement is relatively easy. Cement milk with a high mortar concentration is often used to fill cavities in limestone.
Crystalline schist	The fractures are highly anisotropic and often involve large fault zones parallel to the foliation.	The improvement effect is often dependent on the schistosity. It is necessary to consider a method for seaming the schistosity of the surface.
Granite	Weathering occurs deep down to form decomposed sand. The strongly weathered zone is thick on the gently sloping ridge. Some fault fracture zones are large in scale.	Weathered granite has a permeability of 10 Lu or more and a low critical pressure. In embankment dams, there are many issues with excavation lines and grouting methods.
Neogene sedimentary rocks	Sandstone and conglomerate are relatively well consolidated, but mudstone and tuff are prone to weathering and slaking. Large-scale faults can be seen in tuffs.	Since the properties of strata vary depending on the rock type, the improvement effect varies widely, and improvement may be difficult in some areas.
Quaternary strata	The strata are generally unconsolidated to lowly consolidated, and there are cases where the gravel layer is thick.	There are many highly permeable layers. Careful consideration is required regarding methods and materials.
Extrusive rocks	It is accompanied by columnar and tabular joints, autofracture and autoalteration. The intrusive rock may be accompanied by alteration zones.	Generally, the permeability is high, a large amount of grouting material is required, and the total grouting hole length is long. Setting improvement areas is relatively difficult.
Pyroclastic rocks	The agglomerates and tuff breccias are heterogeneous with soft and brittle matrices. The welded tuff is heterogeneous and interbedded with unconsolidated layers. The volcanic gravel layer is unconsolidated and highly permeable.	There are many issues with deformation of the unconsolidated layer and piping, and large-scale treatment is required. When the critical pressure is low and the Lugeon value is high, improvement is difficult.

(c) Grouting: Lugeon Map

To design a reasonable curtain grouting, it is necessary to study the Lugeon map considering the geological stratigraphy, geological structure, and rock grade.

This is because the permeability of rock mass depends on the distribution and continuity of fractures.

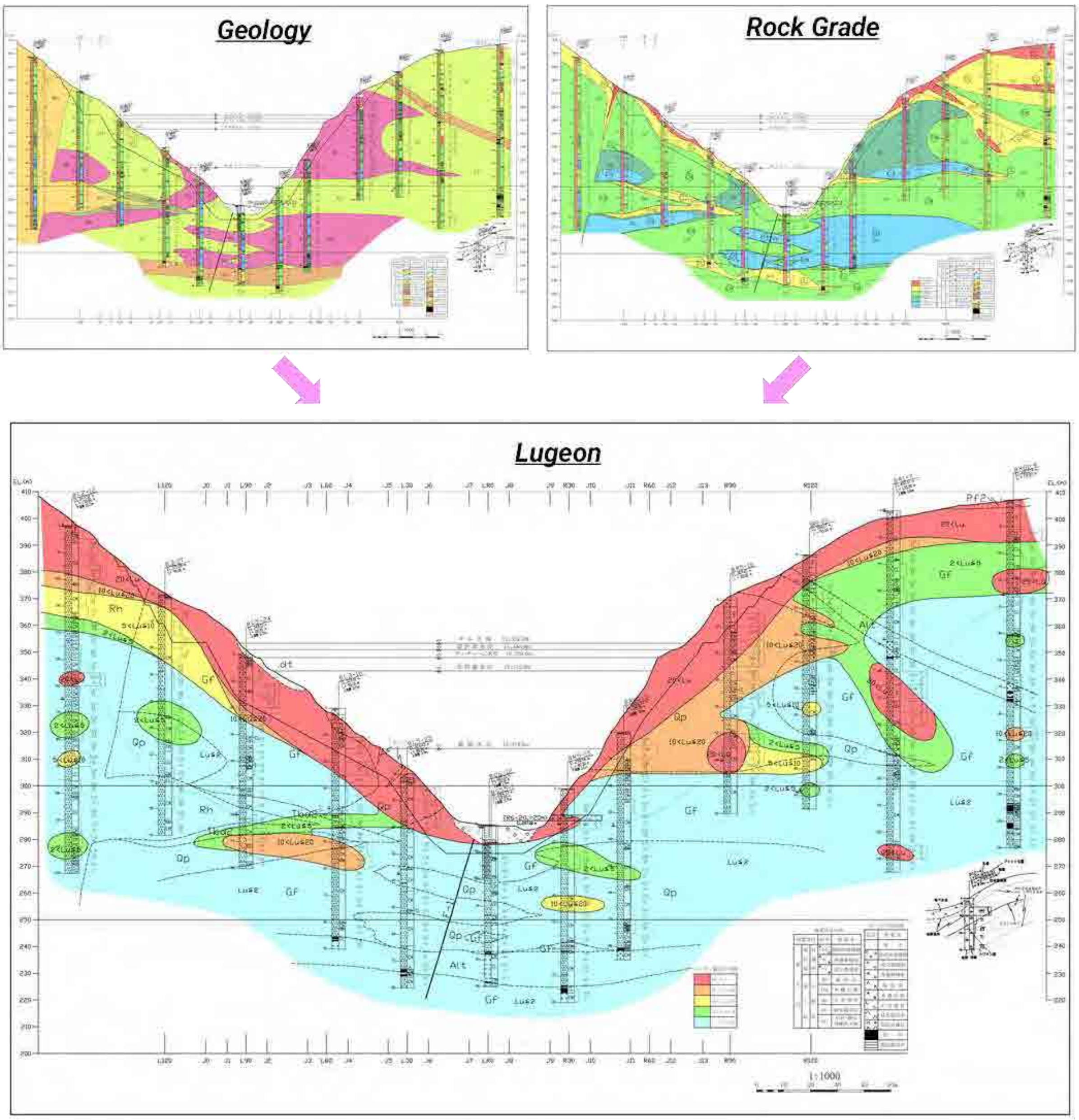


Figure 2.12 Grouting : Lugeon Map

(d) Grouting: Curtain Grouting Area

The area of the curtain and rim grouting is designed so that the dam body and foundation work together to provide watertightness.

(i) Width (Rim)

From the foundation to the intersection of the groundwater level with the reservoir water level or with the low permeability zone (Figure 2.13).

(ii) Depth (Curtain)

From the foundation to the low permeability zone. However, empirically, the depth is set to between half the dam height and the equivalent of the dam height.

In addition, to carry out reasonable grouting work, it is important to conduct a review of the improvement areas based on the results of pilot hole grouting during the construction phase.

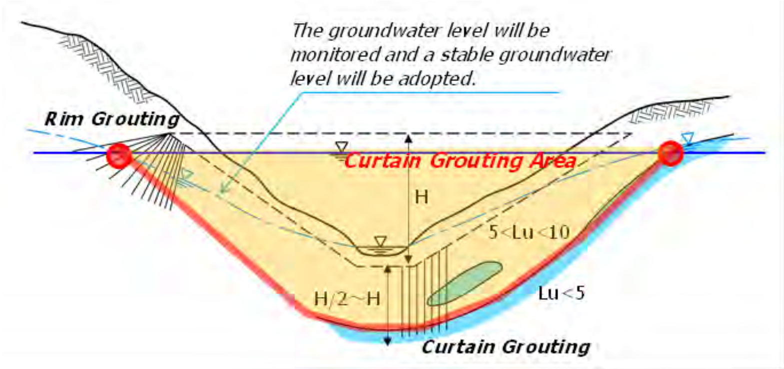


Figure 2.13 Basic Concept of Curtain Grouting Area

(e) Reasonable Excavation Line

The foundation excavation line is examined comprehensively based on the strength and deformability required for the foundation (refer to Rock grade), water permeability (refer to Lugeon map) and improvement by grouting (refer to Grouting test results).

For example, in Figure 2.14, CL class is selected as the foundation from the perspective of strength and deformability. If it is appropriate to excavate rock mass with 10 Lu or more as much as possible from the perspective of grouting improvement and cost, the excavation line may be designed like this.

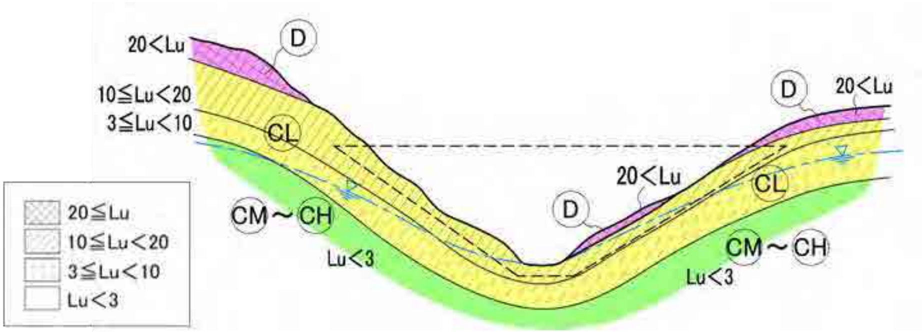


Figure 2.14 Example of Excavation Line Setting for Impervious Zone Foundation

(2) Cut Slope

At dam sites, large cut slopes are often constructed around spillways, intake towers, and tunnel entrances. The occurrence of a landslide on a large cut slope can have a huge impact on the safety and functionality of a dam. For this reason, during the detailed design phase, the layout of facilities*, the cutting gradient, drainage facilities and protective works are designed considering the loosening and strength reduction due to excavation and georisk factors. Here, the layout of the facilities is related to the scale and direction (Relationship with geological structure: dip slope, reverse dip slope, etc.) of the cut slope.

(a) Geological Study Flow

Geological study to design large cut slope is carried out using the process shown in Figure 2.15 in Japan. (A) Literature Review, (B) Topographic Interpretation, in process (B), it is necessary to focus on the such topographical risk factors shown in the Figure 2.16, (C) Site inspection, (D) Comprehensive Evaluation, based on the results of (A), (B) and (C), determine the need for geological surveys, if necessary, go to (E), (F), determine the need for countermeasure works based on the results of process (E).

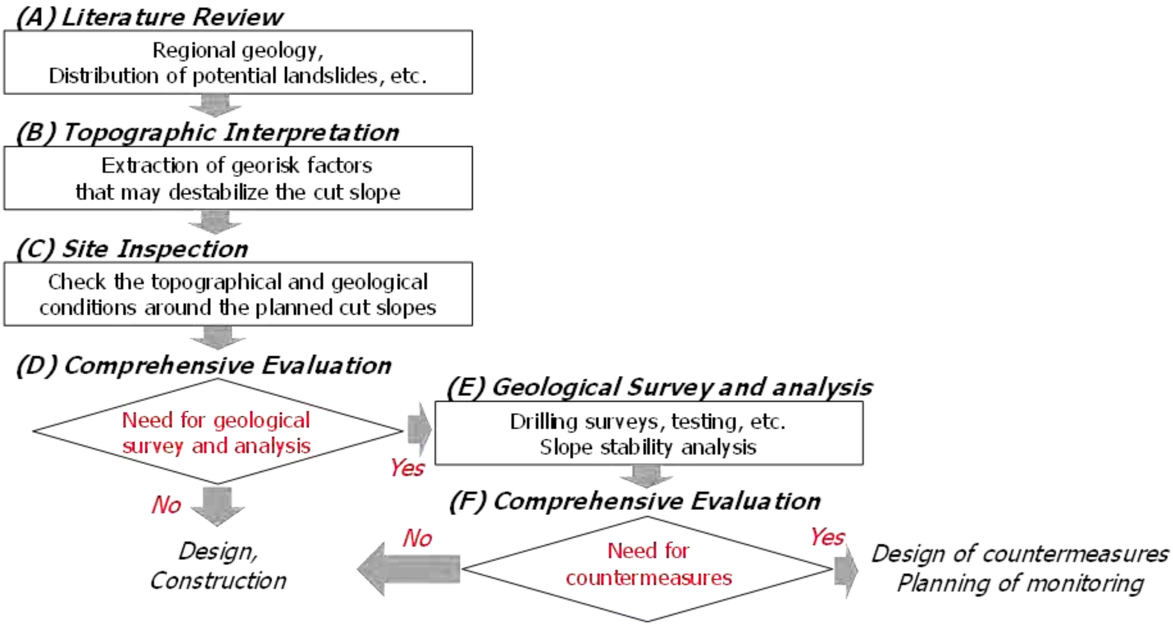


Figure 2.15 Geological Study Flow for Large Cut Slope Design in Japan

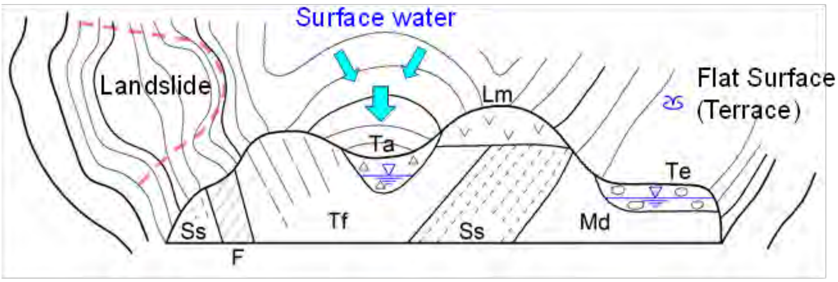


Figure 2.16 Examples of Topographical Factors to be Focused

(b) Loosening due to Excavation

According to the idea of SRR (Stress Release Ratio), empirically, sliding of a maximum thickness equivalent to the cutting thickness is estimated in the middle part of the cut slope. This indicates that the impact of loosening due to excavation is large.

SRR=σV0/σV1
Here,
σ V0: Overburden pressure before cutting.
σ V1: Overburden pressure after cutting.

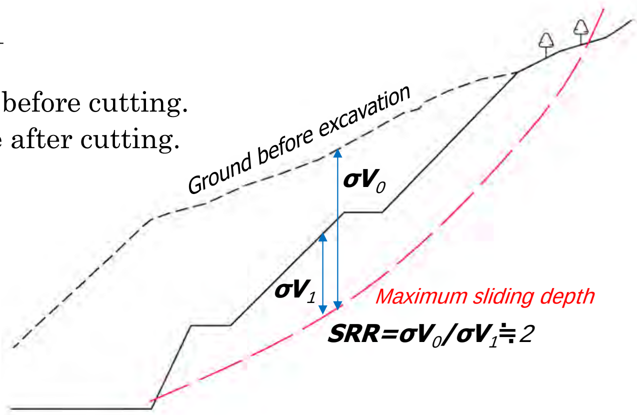


Figure 2.17 Idea of SRR (Stress Release Ratio)
Source: Kimura et.al (2015)

(c) Georisk Factors

Cut slopes will be designed considering the following georisk factors.

(i) Discontinuity

The strength of the surface layer reduces due to the opening of cracks caused by stress release during excavation, the infiltration of groundwater into the cracks, and the progression of weathering along the cracks (Figure 2.18 a)).

(ii) Hydrogeological Structure

Water easily seeps into the slope, causing the phreatic surface to rise and the strength of the hydraulic boundary to decrease (Figure 2.18 b)).

(iii) Slaking/Swelling

The swelling of clay minerals and repeated drying and wetting destroy the rock structure and significantly reduce its strength (Figure 2.18 c)).

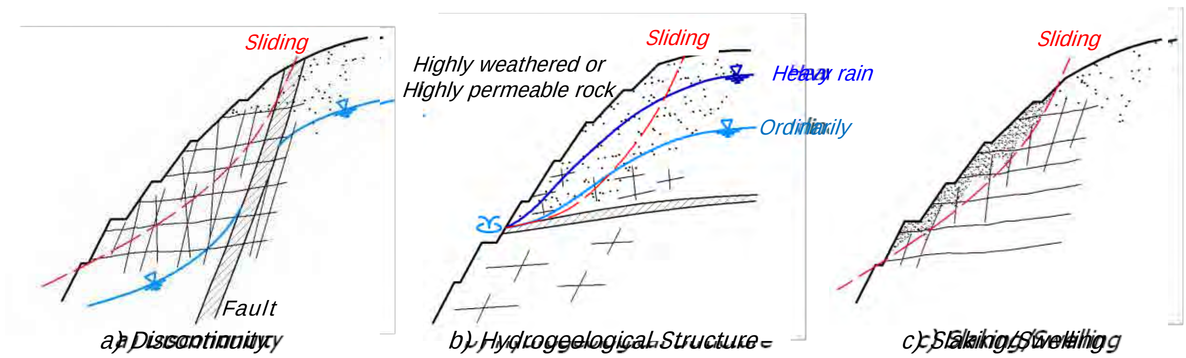


Figure 2.18 Georisk Factors of Cut Slope

(d)

(i) Discontinuity

Figure 2.19 shows a case of a landslide caused by discontinuities. This landslide occurred at the intake tower site of Rukoh Dam. The scale of the sliding has grown over time. Fold structures have developed around the dam site, and the sandstone-dominated alternation distributed at the dam site are inclined at high angles. It is estimated that under such geological conditions, high-angle faults have also developed in the bedrock, which led to this large-scale collapse.

Considering these geological conditions, it is necessary to change the shape of the cut slope during the excavation or measures are needed to prevent the bedrock from loosening.

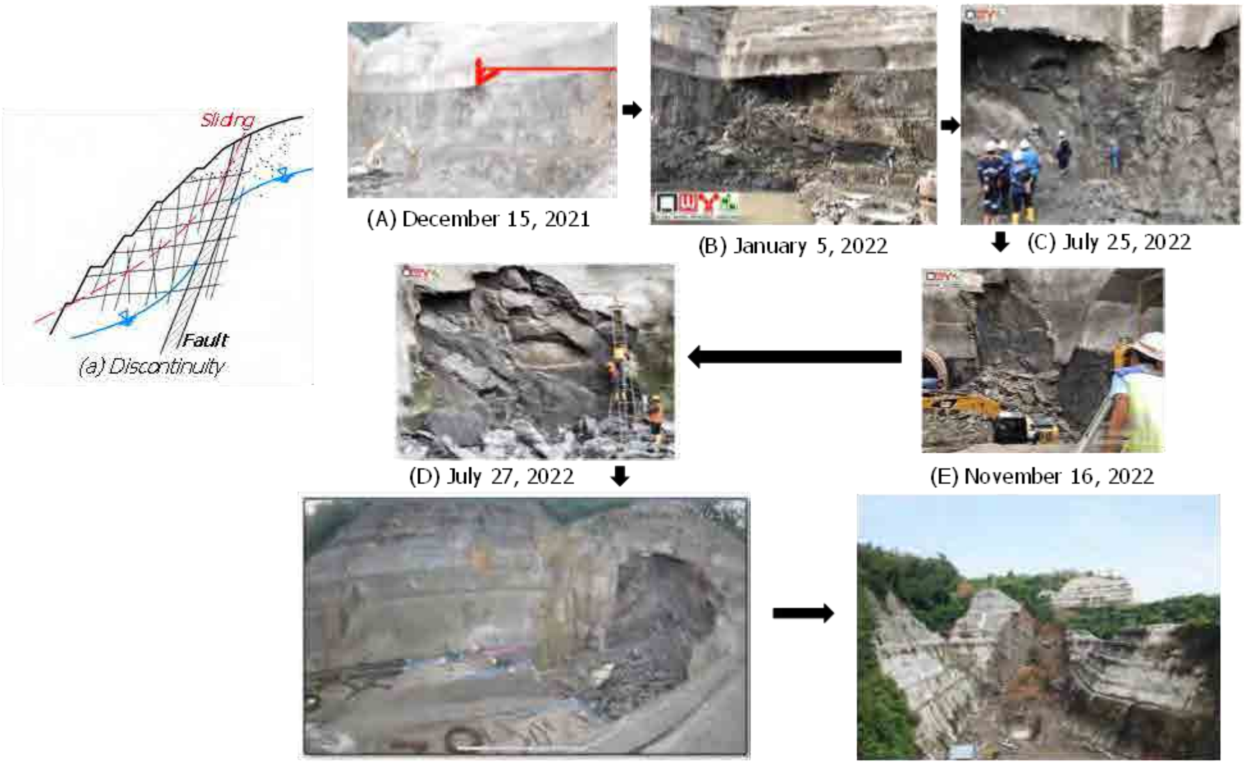


Figure 2.19 Large-scale Sliding Occurred on Cut Slope (Rukoh Dam)

(ii) Hydrogeological Structure

Figure 2.20 shows a case of a landslide caused by hydrogeological structures. This landslide occurred at the spillway site of Temef Dam. The geology of the cut slope is a claystone layer with an overlying limestone layer. In addition to the hydrogeological structure, the claystone layer was also a cause of the landslide because it was scaly clay. Considering these geological conditions, measures are needed to prevent the bedrock from loosening and to remove groundwater from the slope as much as possible.

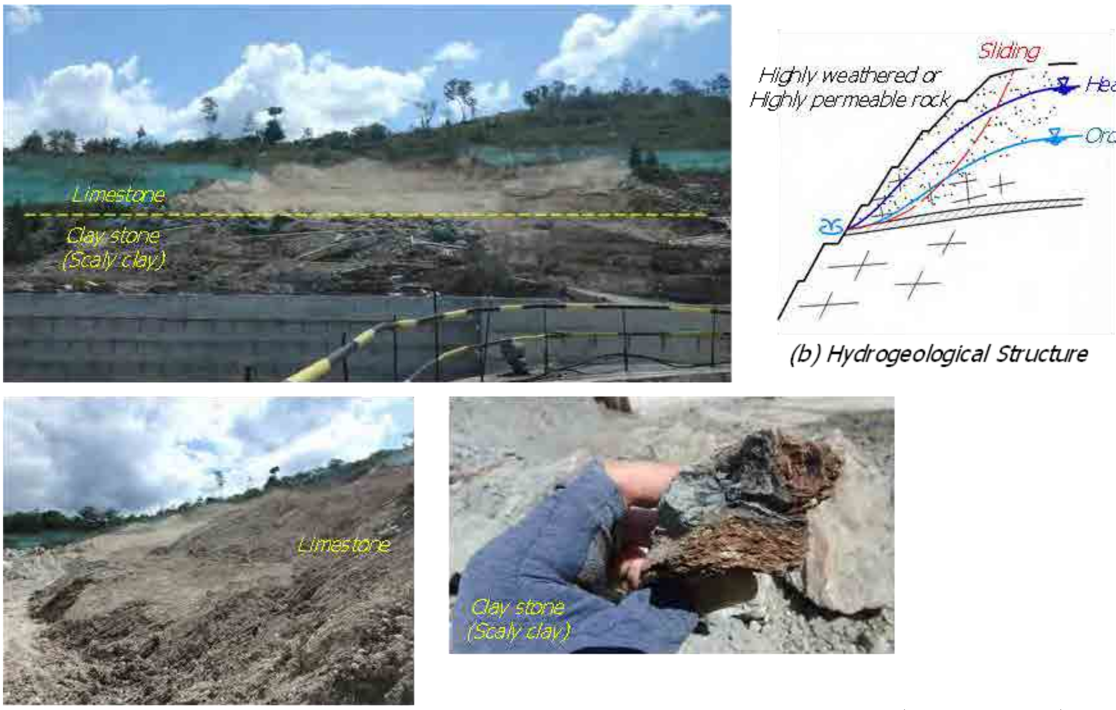


Figure 2.20 Large-scale Sliding Occurred on Cut Slope (Temef Dam)

(iii) Slaking/Swelling

Figure 2.21 shows a case of a landslide caused by slaking. This landslide occurred at the intake tower site of Jragung Dam. The geology of the cut slope is claystone. There is also a folded structure around the dam site, with small high-angle faults as shown in the photo. I believe this was also a cause of the landslide. Considering these geological conditions, measures are needed to prevent deterioration of the bedrock and to prevent the infiltration of surface water into the cut slope.

Figure 2.21 Large-scale Sliding Occurred on Cut Slope (Jragung Dam)

【Reference】 Slope Countermeasure Method

Figure 2.22 shows some countermeasures that are commonly used in Japan. Anchors can withstand higher earth pressure than rock bolts.

(a) Anchor & Framework

(b) Rock Bolts & Framework

Figure 2.22 Slope Countermeasure Method

(3) Tunnel

Deformation or collapse of the intake and discharge tunnels has a significant impact on the schedule and cost during construction, maintaining the dam's functions after impounding. For this reason, during the detailed design phase, reasonable supports system will be designed, considering deformability of the ground and georisk factors.

For reference, geological study to design tunnel is carried out using this process shown in Figure 2.23 in Japan. (A) Desk Study, (B) Site Inspection, (C) Geological Survey, in (D) Comprehensive Evaluation, based on the results of (A), (B) and (C), determine the need for additional geological surveys, if necessary, go to (E), in (F), determine the need for special or auxiliary measures based on the results of process (E).

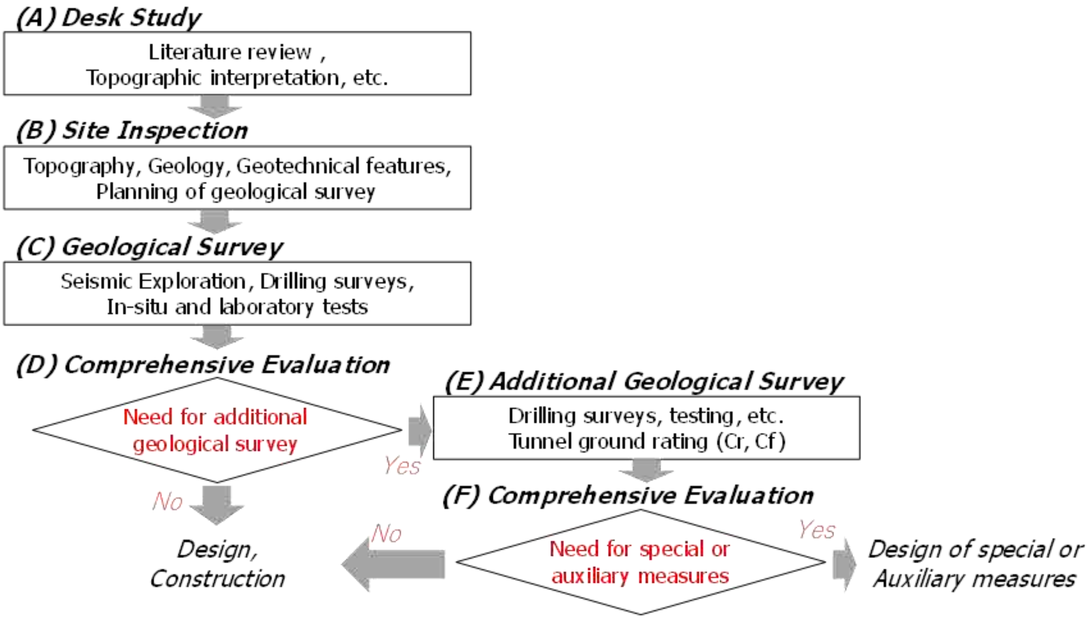


Figure 2.23 Geological Study Flow for Tunnel Design in Japan

The following are some points to consider for rational support design.

(a) Seismic Exploration

To obtain sufficient geological information along the planned tunnel, seismic exploration will be used in addition to drilling surveys (Figure 2.24). If possible, it is more efficient to determine the locations of drilling survey based on the results of seismic exploration. In addition, the tunnel entrance must be designed considering thin ground and distribution of weathered rock.

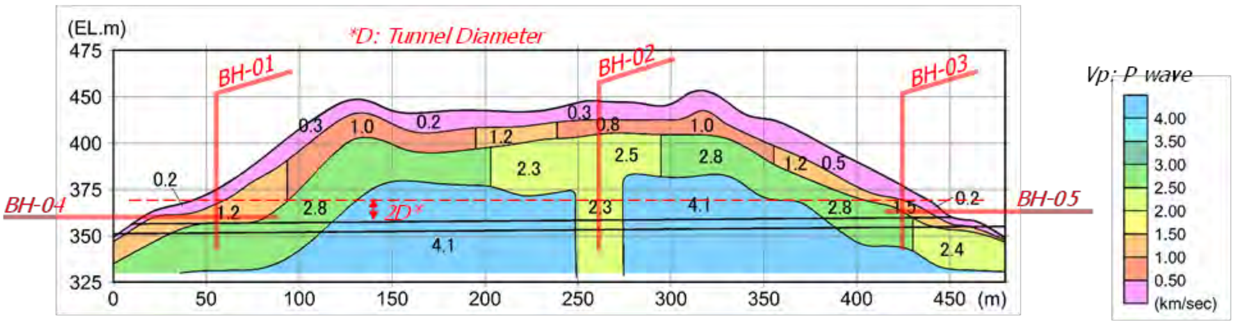


Figure 2.24 Seismic Exploration Results and Drilling Survey Layout

(b) Crack Coefficient and Competence Factor

To evaluate the tunnel ground, "Crack coefficient (Cr)" is useful as an index for cracked rock mass, while "Competence factor (Cf)" is useful as an index for soft rock mass. The crack coefficient Cr is calculated from the ratio of the elastic wave velocity of the ground to that of intact rock. Table 2.2 shows the Cr index depending on the rock condition.

The competence factor Cf is calculated from the ratio of the compressive strength of the rock mass to the overburden pressure. If the rock mass is without cracks, the compressive strength is almost equal to that of intact rock. The compressive strength of rock mass with many cracks can be calculated using that of intact rock and the crack coefficient Cr. The Cf index less than 2 indicates a high risk of deformation due to plastic pressure (Table 2.3).

Crack coefficient: $\boldsymbol{Cr=1-(Vp_1/Vp_0)^2}$
Competence factor: $\boldsymbol{Cf=qu/P}$
for Fissured rock mass: $\boldsymbol{Cf=qu'/P}$
$\boldsymbol{qu'=(1-Cr) \times qu,\ P=\gamma H}$
Here, $\boldsymbol{Vp_1}$*: P-wave velocity of rock mass*
$\boldsymbol{Vp_0}$*: P-wave velocity of rock*
qu: *Compressive strength of rock*
qu': *Compressive strength of fissured rock mass*
P: *Overburden pressure*
$\boldsymbol{\gamma}$*: Unit Weight*
H: *Overburden height*

Table 2.2 Relationship between Cr and Rock mass condition

Cr (%)	*Rock mass condition*
< 25	Fresh with almost no cracks.
25 - 50	Fresh and with few cracks.
50 - 70	Slightly weathered and has some cracks.
70 - 80	Weathered and has relatively many cracks.
> 80	Strongly weathered and has many cracks.

Table 2.3 Relationship between Cf and Earth Pressure Characteristics

Cf	*Earth pressure characteristics*
> 10	Soft rock mass stands up well.
4 - 10	No plastic earth pressure occurs.
2 - 4	Plastic earth pressure may occur.
< 2	Plastic earth pressure often occurs.

(c) Georisk Factors

The tunnel will be designed considering the following georisk factors same as the cut slopes.

- ✓ Discontinuity: Direction of development of discontinuities
- ✓ Hydrogeological Structure: Large amounts of spring water
- ✓ Swelling: Deformation due to swelling (swelling pressure)

However, since it is difficult to estimate in advance whether a large amount of spring water will occur, if the risk is high, ahead survey can be carried out during construction. The next chapter describes a geological survey method (ahead exploration) that can help solve this problem. The survey methods are presented in the next section.

(i) Discontinuity

Figure 2.25 shows a case of roof collapse in the diversion tunnel of Bagong Dam. The cause of the collapse, the georisk factor, was a low-angle discontinuity developed along the bedding plane. Since such geological structures can be predicted in advance, it is possible to design auxiliary works such as fore poling at the design phase.

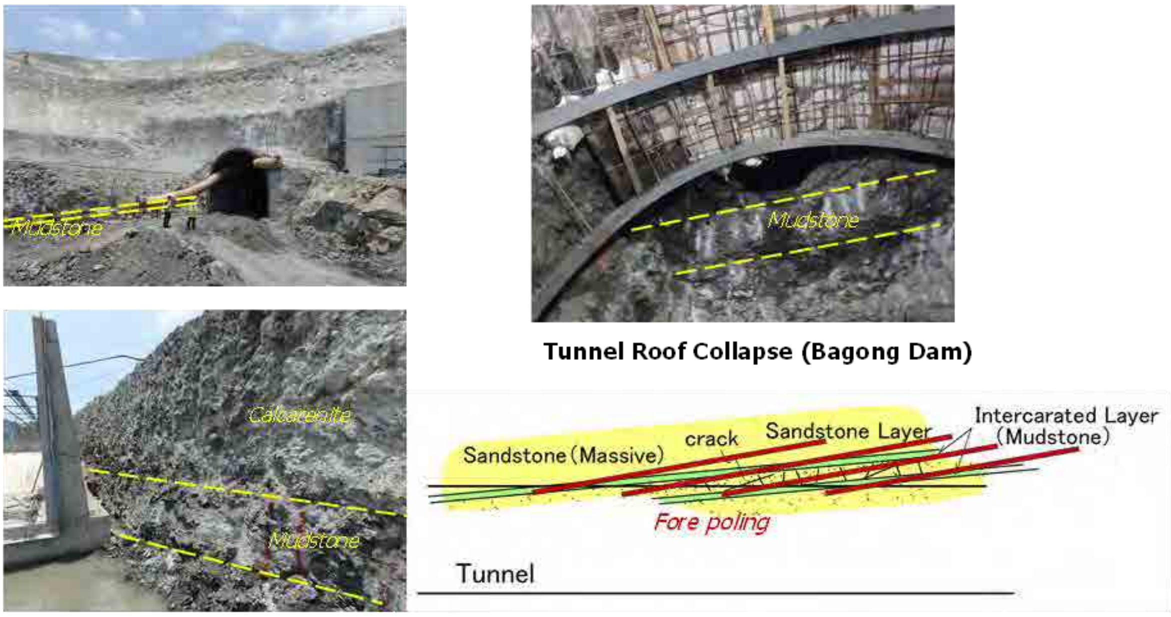
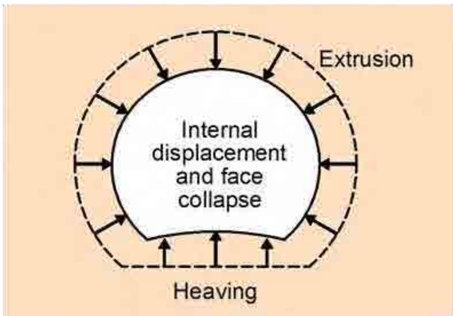


Figure 2.25 Auxiliary Construction for Tunnel Roof Collapse

(ii) Slaking/Swelling

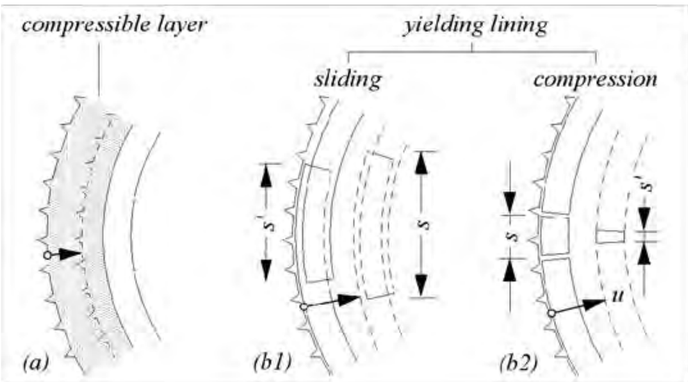
Figure 2.26 shows a case of the deformation in the spillway tunnel of Manikin Dam. The cause is the swelling pressure of scaly clay.

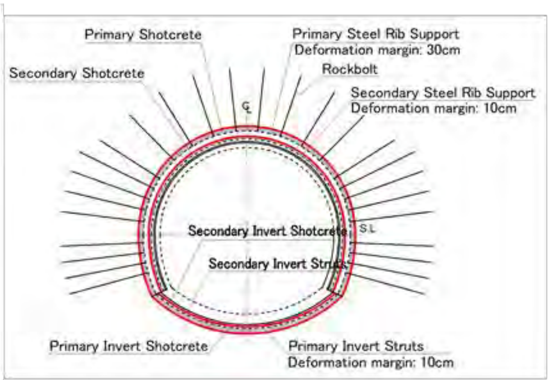


Conceptual Diagram of Tunnel Deformation due to Swelling

Figure 2.26 Tunnel Deformation due to Swelling (Manikin Dam)

There are two main types of support systems that respond to swelling pressure (Figure 2.27). One is a flexible support system that can follow deformation, and the other is a heavy support system that can resist swelling pressure. The left image shows a flexible support system called a Yielding Support, and the right image shows a Multiple Steel Rib Support used in NATM.





a) Yielding Support *b) Multiple Steel Rib Support (NATM)*

Figure 2.27 Tunnel Deformation due to Swelling (Manikin Dam)

(d) Keep in Mind

These are things to keep in mind during the detailed design phase.

- ✓ Consider how to deal with the risks identified in the detailed design phase.
- ✓ All information regarding risks identified in the detailed design phase will be carried over to the construction phase without exception.

- ✓ During the construction phase, additional investigations and considerations will be carried out on risks that were carried over from the detailed design phase to avoid or reduce risks.

2.3 Construction

(1) Dam Foundation: Checking Excavation Surface

Geological engineers will check the excavation surface and evaluate its suitability as a dam foundation in terms of strength, deformability, and permeability, and will propose the implementation of dental work and auxiliary grouting if necessary.

For reference, geological checking, and response to excavate foundation is carried out using this process shown in Figure 2.28 in Japan.

(A) Checking Excavation Surface, Record (sketch) the geology and rock conditions and compare them with the estimates at the design phase, in (B) Based on the results of (A), Determine the need for additional geological survey and analysis, if necessary, go to (C), in (D), Determine the need for additional measures based on the results of process (C).

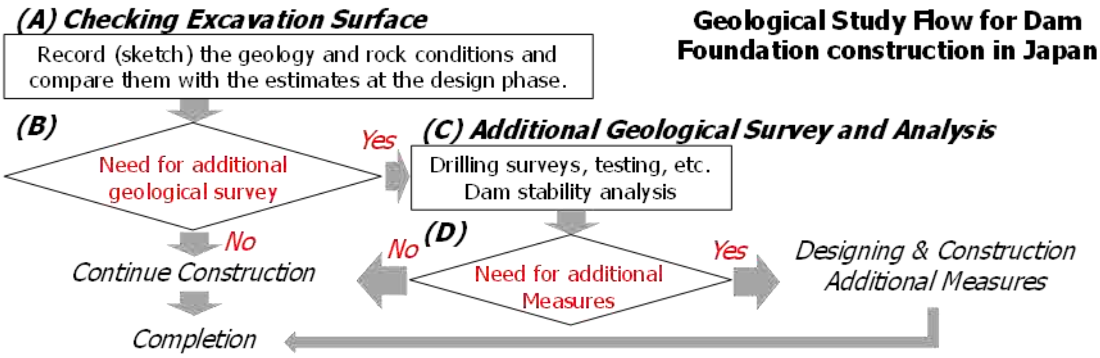


Figure 2.28 Dam Foundation: Checking Excavation Surface

For reference, Figure 2.29 shows a sketch of a rockfill dam foundation in Japan. The orange and yellow parts are bedrock, mainly dacite. The light blue parts are terrace deposits.

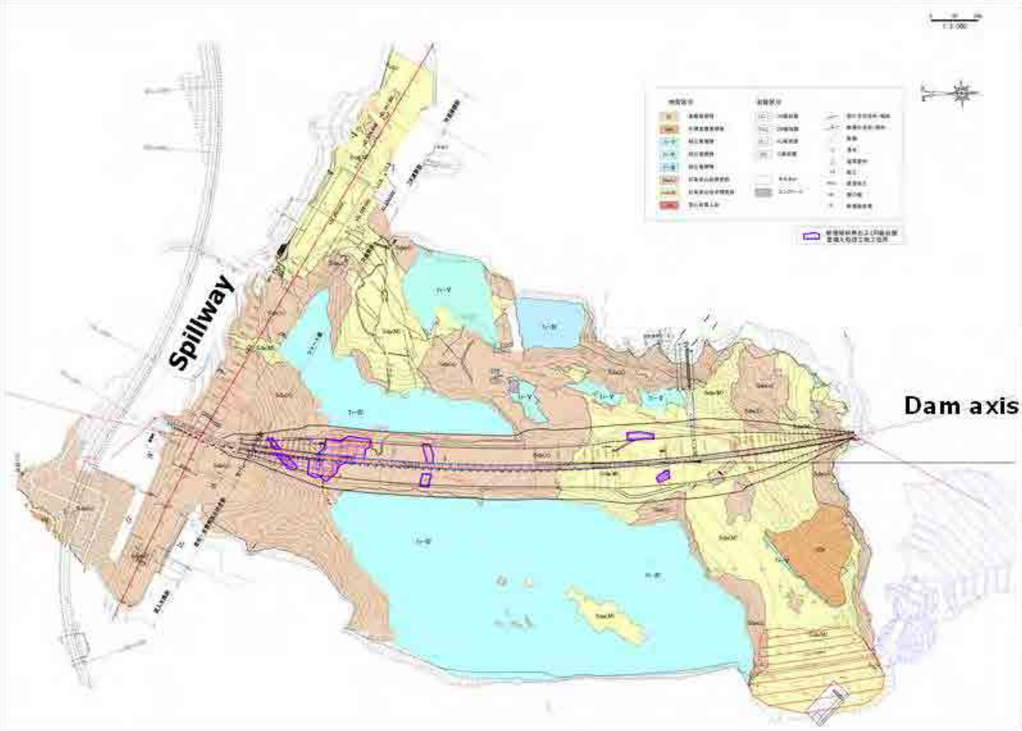


Figure 2.29 Geotechnical Sketch of Rockfill Dam Foundation (Geology)

Figure 2.30 shows a sketch of a rockfill dam foundation in Japan. Green is CM class, yellow is CL class and red is D class. The blue box here is the dental work area of the fault zone.

In Japan, dam foundations are traditionally recorded in detail for cracks and spring points. Such information is used for monitoring after impounding. Sketching not only the dam foundation but also the spillway foundation can help investigate the cause of leakage confirmed after impounding.

Figure 2.30 Geotechnical Sketch of Rockfill Dam Foundation (Rock Grade)

(2) Cut Slope: Checking Excavation Surface

Geological engineers will check the excavation surface and evaluate the suitability of the cut slope design. If necessary, they will propose countermeasures such as re-excavation, or the slope protection.

It is recommended for large cut slopes to measure the surface displacement by surveying during construction. If a large surface displacement is confirmed, underground displacement will also be measured using borehole inclinometers etc. to design the countermeasures.

For reference, geological checking and response to excavate slope is carried out using this process same as foundation excavation surface (Figure 2.31).

(A) Checking Excavation Surface, Record (sketch) the geology and rock conditions and compare them with the estimates at the design phase, in (B) Based on the results of (A), determine the need for additional geological survey and analysis, if necessary, go to (C), in (D), determine the need for additional measures based on the results of process (C).

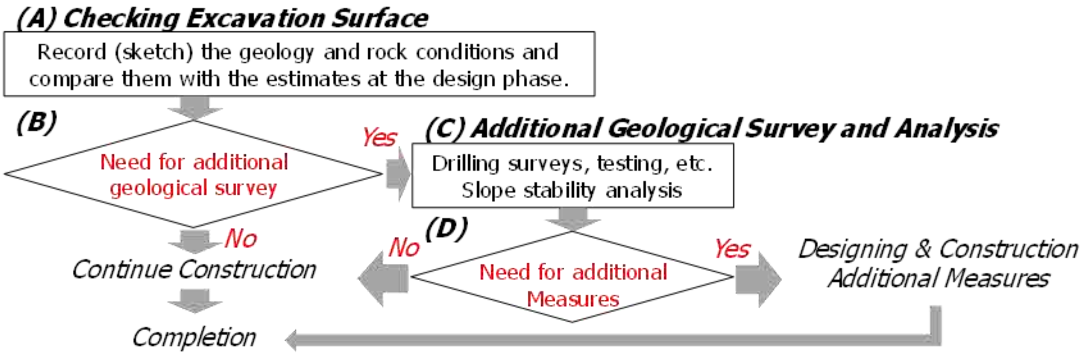


Figure 2.31 Geological Study Flow for Large Cut Slope construction in Japan

For reference, Figure 2.32 shows a geological sketch of a large cut slope in Japan. At this site, framework was constructed in the green area, considering the direction of the faults on the cut slope and the bedrock conditions. By having geologists check the excavation surface and implementing countermeasures based on the results, the safety of the completed cut slope can be further increased.

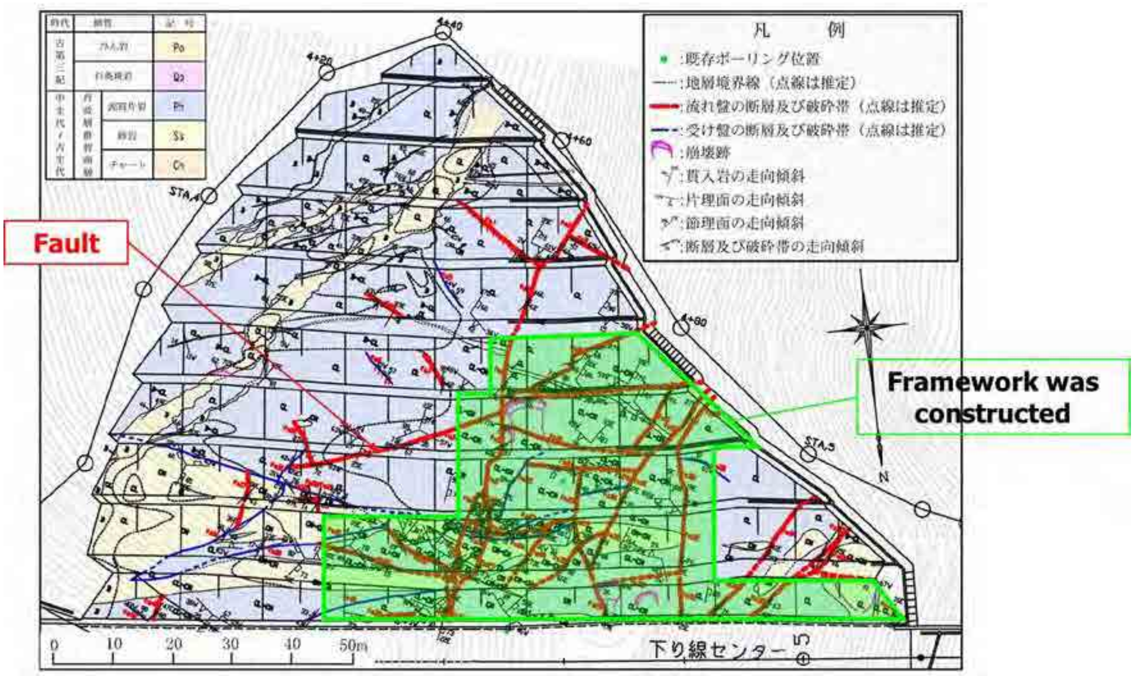


Figure 2.32 Geotechnical Observations of a Large Cut Slope

Source: Okazaki et al. (2005)

Figure 2.33 shows a large cut slope of the spillway of Ameroro Dam. This is an example where the excavation surface was checked well by geological engineers. At this site, Geo-net was used in the upstream area where fresh bedrock is distributed, and shotcrete (10 cm thick) and concrete walls (15 cm thick) were constructed in the downstream area where weathered rock is distributed, based on the condition of the cut slope (rock grade).

Figure 2.33 Construction of Countermeasures based on Geotechnical Observations (Ameroro Dam)

(3) Tunnel: Ahead Survey

For the safety of construction and the selection of a reasonable support system, it is useful to understand the geological conditions ahead of the tunnel face in advance. There are the following survey methods.

(a) Drilling Survey

Horizontal drilling is used to take core samples to confirm the geology ahead of the face, and if there is confined groundwater, this drilling can reduce the confined water pressure to prevent the collapse of the tunnel face (Figure 2.34).

Figure 2.34 Drilling Survey (Horizontal)

Source: https://www.kajima.co.jp/gallery/const_museum/tunnel/gijutsu/article/tunnel_g_06.html

(b) Drilling Exploration

This method includes drilling horizontally, similar to drilling surveys, but instead of taking core samples, the ground conditions are evaluated based on the drilling speed and drilling resistance (Figure 2.35).

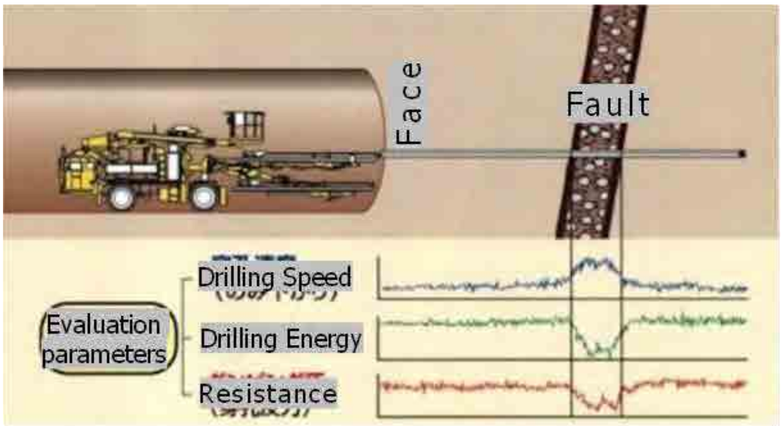


Figure 2.35 Drilling Exploration

Source: https://kensetsu.ipros.jp/product/detail/2000557827

(c) Elastic Wave Exploration

This is conducted using the excavation vibrations of a hydraulic breaker as the vibration source and using the heads of rock bolts installed at regular intervals on the tunnel wall as the receiving points for reflected waves (Figure 2.36).

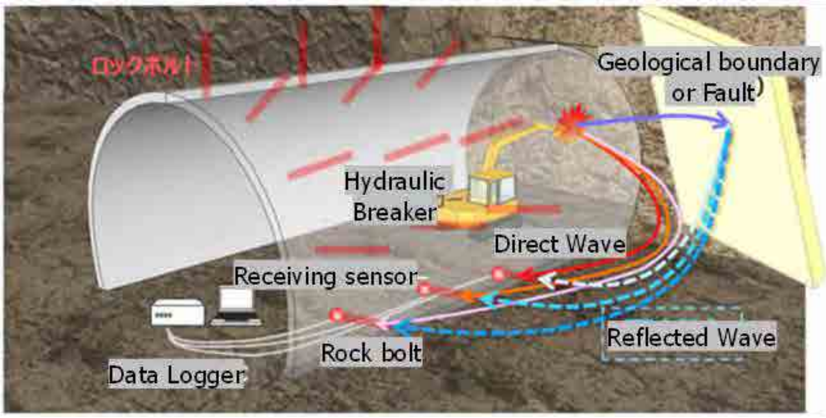


Figure 2.36 Elastic Wave Exploration

Source: https://www.shimz.co.jp/company/about/about/news-release/2019/2019034.html

(4) Keep in Mind

These are things to keep in mind during the construction phase.

- All information regarding the results of risk responses during the construction phase, as well as any newly identified risks, will be carried over to the operation phase.
- All records of design changes and quality control during construction will be carried over to the operation phase.

2.4 Operation

(1) Reservoir Sedimentation

The progression of reservoir sedimentation, which far exceeds the initial plan, could have a significant impact on the dam function in the future. For this reason, Regular surveys of reservoir sedimentation are recommended as part of dam operation and maintenance.

As shown in the Figure 2.37, early response to the progression of sedimentation reduces costs and technical difficulty.

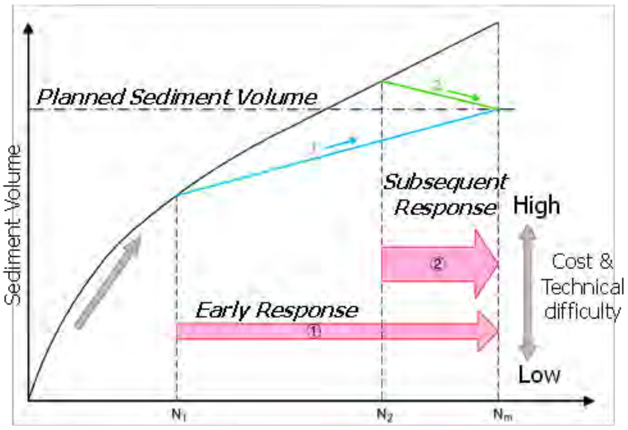
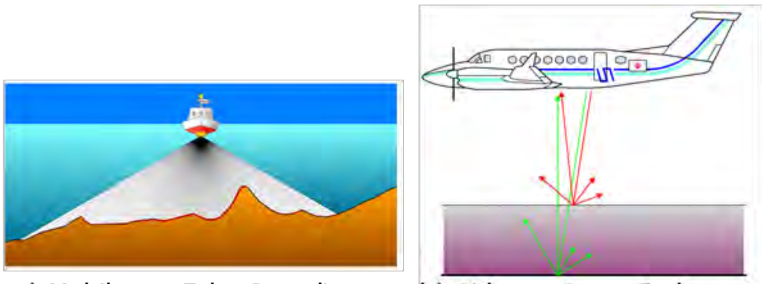


Figure 2.37 Changes in Sediment Volume Over Time

Figure 2.38 show recent bathymetry technology, Multibeam Echo Sounding and Airborne Laser Bathymetry. In Multibeam Echo Sounding, water depth is measured in three dimensions by transmitting sound waves in a fan shape (Figure 2.38 a)). In Airborne Laser Bathymetry, water depth is calculated based on the difference in reflection time between a green laser and an infrared laser (Figure 2.38 b)).



a) Multibeam Echo Sounding b) Airborne Laser Bathymetry

Figure 2.38 Recent Bathymetry Technology

(2) Landslides around Reservoir

The inflow of large amounts of sediment into a reservoir due to a large landslide can have a significant impact on the dam function. For this reason, it is desirable to develop methods that can monitor efficiently the movement of slopes around reservoirs.

As shown in Figure 2.39, large-scale slope movements can be measured using SAR (Synthetic Aperture Radar) mounted on a satellite, and this technology is expected to be useful for monitoring the landslide around the reservoir. In the Figure 2.40, blue indicates subsidence and red indicates uplift. It is estimated to be rotational movement caused by a large landslide.

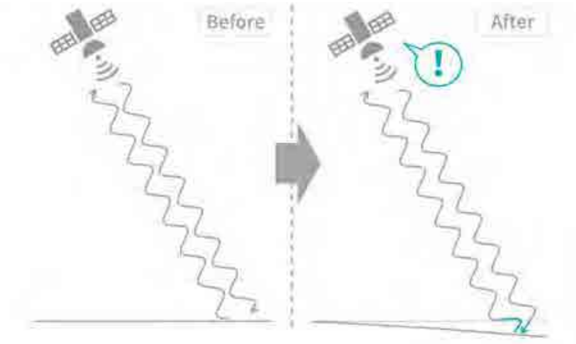


Figure 2.39 Conceptual Diagram of Measurement by SAR (Synthetic Aperture Radar)

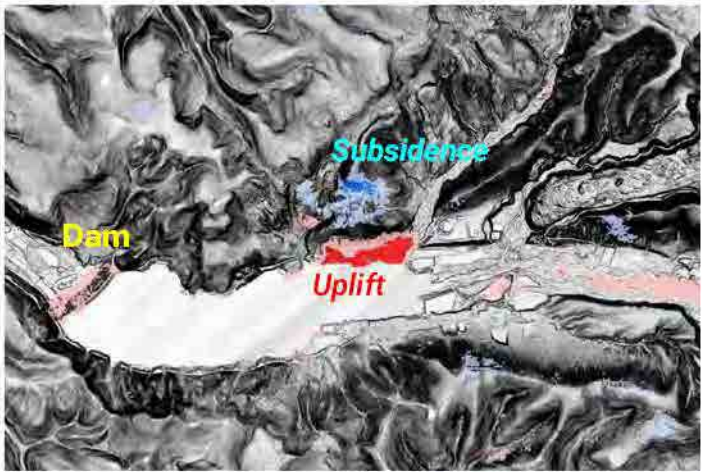


Figure 2.40 Displacement Distribution Map by SAR

Source:

3. Engineering Sense

This chapter describes the keep in mind that geological engineers should have to contribute to risk management (Figure 3.1).

Figure 3.1 Displacement Distribution Map by SAR

Source: https://www.istockphoto.com/jp/

3.1 Perspective and Imagination

It is recommended to imagine the geological conditions of the site not only at the normal scale but also at the macro-scale and micro-scale to avoid overlooking the georisks of the project site.

- ✧ Macro-scale: Wide-area topographical and geological features, distribution of active faults, as well as the arrangement of plates and the formation of islands, etc.
- ✧ Micro-scale: The rocks that make up the bedrock, the minerals that make up those rocks, the types of minerals and their chemical properties, etc.
- ✧ Normal-scale: Site and outcrop inspections consideration macro- and micro-scale site geology.

3.2 Integrated interpretation.

Geological analysis requires integrated interpretation of findings from different types and scales, and this interpretation is essential for identifying and assessing georisks (Figure 3.2). Appropriate geological interpretation and collaboration between geologists and design engineers are essential for reasonable design. Thinking the distribution of strata and geological structures in three dimensions is one of the good practices for integrated interpretation.

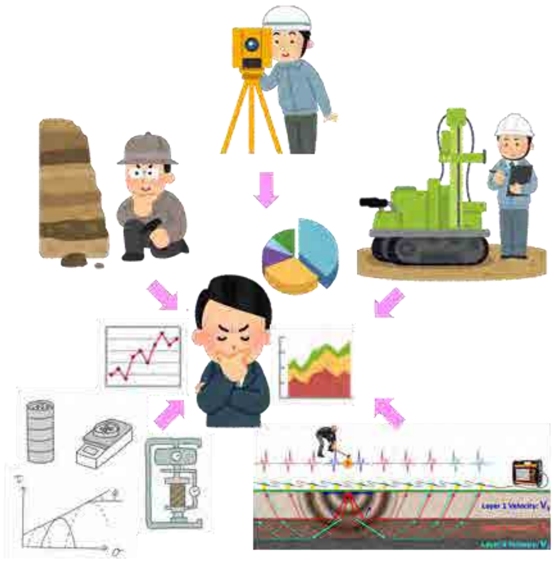


Figure 3.2 Image of Integrated Interpretation

【Reference】CIM: Construction Information Modeling/Management

In relation to three-dimensional analysis, for reference, we would like to introduce the Construction Information Modeling/Management in Japan. We believe that CIM can also be used for risk management.

In recent years, CIM has been introduced into the design of civil engineering structures in Japan to improve the efficiency of construction and maintenance. CIM has the following main features:

- ✧ It is a three-dimensional model, and survey and test results can also be stored as attribute data (Figure 3.3).
- ✧ CIM can be shared among stakeholders, and information can be easily carried over to the design, construction, and operation phases (Figure 3.4).

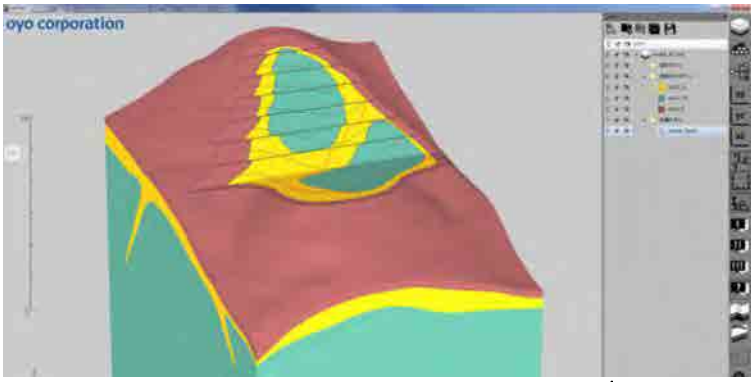


Figure 3.3　3D Model of Cut Slope for Design (Rock Grade)

Source: https://www.oyogeotools.com/products/octas.html

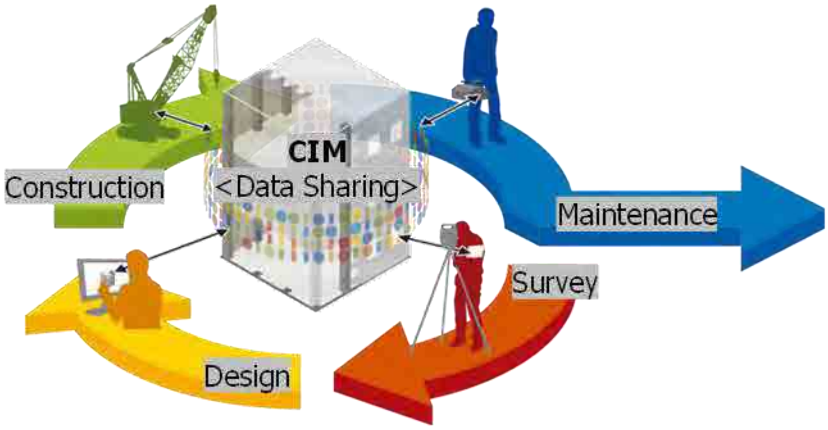


Figure 3.4　Basic Concepts of CIM

Attachments

Attachment 1	Dam Safety System in Indonesia: Dam Safety Commission
Attachment 2	Completed Dam Risk Entry Form
Attachment 3	Minuets of Discussion on Dam Risk Management

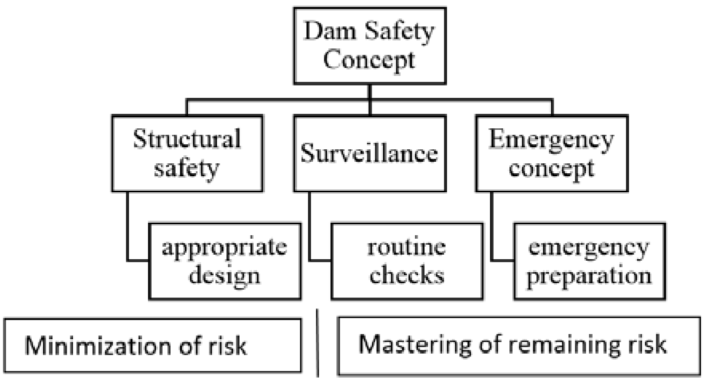
Attachment 1 Dam Safety System in Indonesia: Dam Safety Commission

Dam Safety System in Indonesia

1. Dam Project Approval System in Indonesia

In Indonesia, the safety management of dam construction was introduced in 1989 by the Ministry of Public Works with the publication of the Dam Safety Guideline (SNI No.1731-1989-F). This guideline describes the establishment of a commission in charge of approving dam safety assessments, including technical assessments on construction, impounding, operation, and dam removal. In 1997, the Ministry of Public Works also issued Ministerial Regulation 72/PRT/1997 on Dam Safety. This dam safety regulation requires that technical assessments to minimize damage caused by dams at each stage of dam development (design, construction, impounding, operation, rehabilitation, and dam removal) must be conducted by the Dam Safety Commission (DSC) and the Dam Safety Unit (DSU) and approved by the Minister. In addition, regulations on dams were issued in Water Resources Law No. 7 of 2004 and Government Regulation No. 37 of 2010 on Dams. The regulation clearly states the requirement for licensing at all stages of dam development and management and also includes the need for Emergency Action Plans as part of the dam safety concept.

In this way, the concept of dam safety in Indonesia is not limited to technical aspects of safety before construction but also takes into consideration post-construction maintenance and responses to unexpected events, and is legally regulated.



✧ **Figure 2-1 Dam safety concept**

1.1 Legal background (Ministerial Order on dam construction approval)

Ministerial Decree of the Ministry of Public Works and Housing of the Republic of Indonesia on Dams No. 27/PRT / M/ 2015 BENDUNGAN DENGAN RAHMAT TUHAN YANG MAHA ESA MENTERI PEKERJAAN UMUM DAN PERUMAHAN RAKYAT The Indonesian Republic (Republik Indonesia) enacted the 2015 Act (Document 1) , which reiterates the requirements for dam construction.

The translation of the preamble to this Act is as follows:

a. As per Article 15 of the Government Rules 35 of 1991 on Rivers, for the purpose of public welfare and safety, it is necessary to construct reservoirs to store water as part of water resources development, to store excess water during rainy season and to meet the demand for water as required and also to control the destructive power of water.

b. The environmental and safety reservoirs in question include dams for storing water, as well as **dams for storing mine waste** (tailings dams) and dams for handling sludge.

c. In order to store the water, mine waste and mud mentioned in a and b, dams need to be built.

d. In order to construct a dam that functions in line with development objectives, technical regulations are necessary to ensure the safety of the dam.

e. It is essential to maintain and manage the reservoir in order to ensure the sustainability of its function in line with the development objectives under Article 16 of the 1991 Government Decree on Rivers, Article 35.

f. Pursuant to Articles a, b, c, d and Law No. 11 of 1974 on Irrigation, the Minister of Public Works and Housing has the authority and responsibility to manage the operation of water resources and carry out projects;

g. In order to provide a basis and guidance for the construction and management of the reservoirs mentioned in a and e, it is necessary to formulate guidelines for the construction and management of dams and their reservoirs.

h. Based on considerations a, b, c, d, e, f and g , the Minister of Public Works and Housing has formulated regulations regarding this dam.

The following six laws have been established as relevant laws.

1. Law No. 11 of 1974 on Irrigation (Supplement to the Annual Report of the Republic of Indonesia No. 65 of 1974, National Gazette No. 3046).
2. Law No. 23 of 2014 on Local Government (Supplement to the National Gazette of the Republic of Indonesia No. 244 of 2014, No. 5587 of the National Gazette of the Republic of Indonesia);
3. Government Regulation No. 22 of 1982 on Water Management (Supplement to Article 37, No. 3225 of the National Gazette of the Republic of Indonesia of 1982).
4. Article 7 of the Presidential Regulation of the Republic of Indonesia on the Organization of the Ministry of State (Ministry of State of the Republic of Indonesia No. 8 of 2015).
5. Article 15 of the Presidential Regulation of the Republic of Indonesia of 2015 on the Minister of Public Works and Housing (National Gazette of the Republic of Indonesia No. 16 of 2015).

6. Regulation of the Minister of Public Works No. 08/PRT/M/2010 on the organization and working procedures of the Ministry of Public Works (Ministry of State of the Republic of Indonesia Year 2010 No. 1304);

1.2 Dams subject to approval

Dams that are eligible for approval are large dams that meet the following criteria. Furthermore, eligible for approval are large dams that meet the following criteria including not only reservoir dams, but also tailings dams, erosion control dams, and mudflow storage dams.

1) The dam capacity is more than 100,000 m3 and the dam height is more than 15 meters

2) A dam with a reservoir capacity of more than 500,000 m3 even if the dam height is less than 15 m

3) Dams that qualify as water infrastructure as separately defined by the Dam Safety Committee

1.3 Overview of dam construction approval

The dam construction approval review is carried out by the Dam Safety Commission (DSC) , which is governed by Ministerial Decree No. 72/PRT/1997 on Dam Safety, and covers the design, construction, operation, maintenance, redevelopment and demolition of dams.

The details of the implementation are summarized in the Presentation on Dam Safety Concept & Regulation prepared by the Dam Safety Committee. Although this document was prepared in 2008, the Department of Dams of the Ministry of Public Works and Housing has confirmed that there have been no changes to the content other than the members of the committee.

Anissa Mayangsari and Mr. Tri Bayu Adji, who were members of the Dam Safety Unit in 2015 , gave a brief overview of dam approval in Indonesia to Hydropower. The report was presented at the 2015 Symposium on Dam Safety in Indonesia held in Stavanger, Norway on June 15-16, 2015 (Document 3).

The outline of the dam construction approval is as follows:

(1) Types of Dam Safety Approvals

dam safety approvals:

(a) Design Certification (Design Certification/Construction Permit)

A review of the design, required for construction work to commence. Obtained before placing an order for construction work.

(b) Initial Impounding Certification

At the end of construction, the construction work (especially the quality control and progress control results) is reviewed to ensure that impoundment (or disposal of tailings in the case of tailings dams) will not cause any problems. Once construction has progressed to a certain extent, an application for approval can be submitted. Impoundment can begin only after approval has been issued.

(c) Operation Certificate

impoundment is completed (the reservoir reaches the designed water level) or two years have passed since impoundment began, the results of test impoundment (including an analysis of the dam's behavior) will be obtained to determine whether the dam can be operated safely.

(d) Abandonment Certification

When a dam is to be abandoned, a dam abandonment plan, including removal methods, must be presented in advance and an application for dam removal permission must be filed before the dam can be removed.

(2) Organization

The following two organizations are responsible for a series of inspections and approvals related to dam safety, and their activities are supported by the Ministry of Public Works and Housing.

a) Dam Safety Commission (DSC)

b) Dam Safety Unit (DSU)

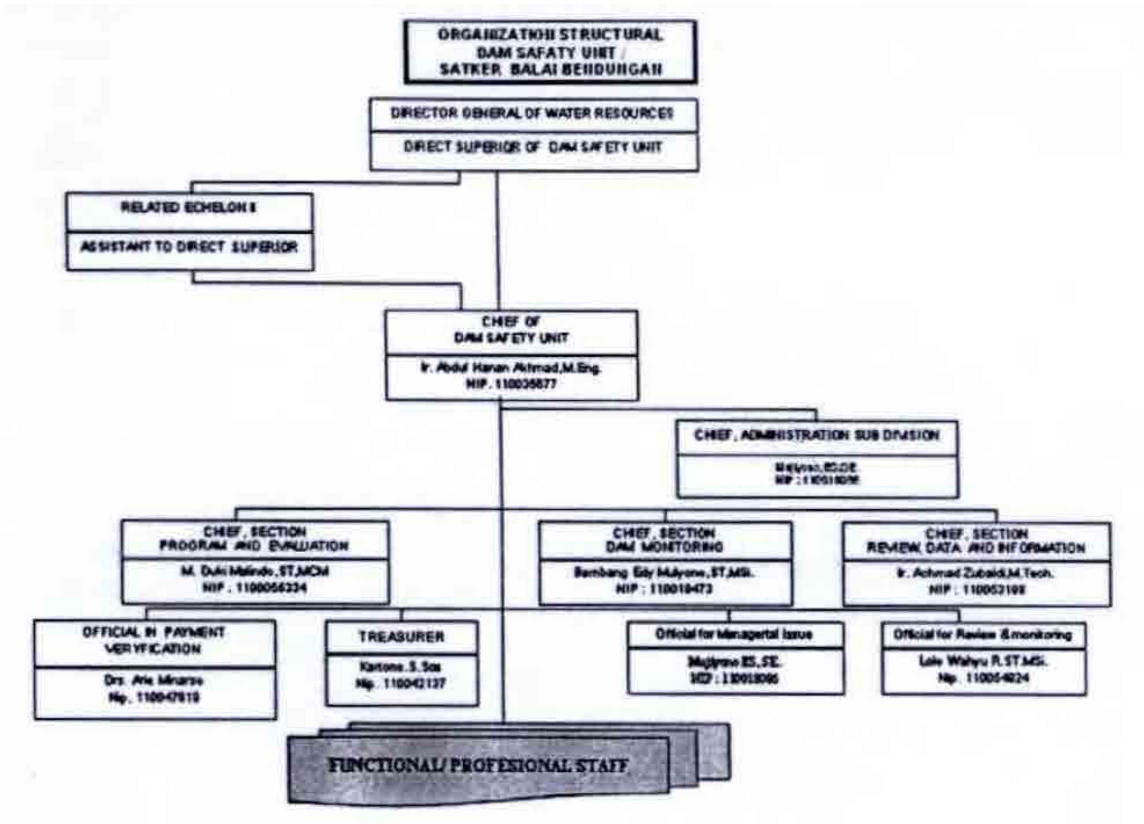
The DSC is the body that assists the Minister in managing dam safety, and the Dam Safety Unit is an organization established to provide technical assistance to the DSC and to carry out technical reviews (specifically, members of the PU-PR Balai Bendungan (Ministry of Public Works and Housing's Department of Dams)).

In addition, if a dam development is deemed to require technical studies on dam safety such as those listed below, the dam owner (project implementer) must establish a "Dam Panel" as proposed by the DSC and DSU. The Dam Panel will function during the design, construction and impoundment of the dam reservoir.

a. When new technologies are applied in the design and construction of dams;

b. Dams with a height of 75 m or more and a storage capacity of 100 million cubic meters or more and

c. Dams deemed to be at high risk



✧ **Figure 2-2 Organizational chart of the Dam Safety Committee**

Ministerial Decree No. 1234/KPTS/M/2023 appointed the members of the Dam Safety Committee from 2023 onwards. The members of the committee are as shown in Table 2-1.

Table 2-1 DSC Members

. Tim Inti/Anggota Tetap

NO	INSTANSI/NAMA	JABATAN/BIDANG KEAHLIAN	KEDUDUKAN DALAM KOMISI
1	2	3	4
1	Kementerian Pekerjaan Umum dan Perumahan Rakyat, Direktorat Jenderal Sumber Daya Air	Direktur Jenderal Sumber Daya Air	Ketua merangkap Anggota
2	Kementerian Pekerjaan Umum dan Perumahan Rakyat, Direktorat Bendungan dan Danau	Direktur Bendungan dan Danau	Wakil Ketua merangkap Anggota
3	Kementerian Pekerjaan Umum dan Perumahan Rakyat, Balai Teknik Bendungan	Kepala Balai Teknik Bendungan	Sekretaris merangkap Anggota
4	Kementerian Pekerjaan Umum dan Perumahan Rakyat, Direktorat Bina Teknik	Direktur Bina Teknik Sumber Daya Air	Anggota
5	Kementerian Pekerjaan Umum dan Perumahan Rakyat, Direktorat Bina Operasi dan Pemeliharaan	Direktur Bina Operasi dan Pemeliharaan	Anggota
6	Dr. Ir. Hari Suprayogi, M.Eng	Ahli Hidrologi, KNIBB, HATHI	Anggota
7	Ir. Bambang Hargono, DIPL.HE, M.Eng	Ahli Hidrolika, KNIBB, HATHI	Anggota
8	Dr. Ir. Ni. Made Sumiarsih, M.Eng	Ahli Teknik Bendungan Besar, KNIBB, HATHI	Anggota
9	Ir. Tri Bayu Adji, MA	Ahli Hidromekanikal, KNIBB	Anggota
10	Dr. Ir. Paulus Kurniawan, MBA	Ahli Geologi, HATTI, IAGI	Anggota
11	Duki Malindo, ST. MCM.	Ahli Project Manajement, KNIBB	Anggota
12	Dr. Ir. Aries F. Firman, M.Sc	Ahli Geoteknik, KNIBB	Anggota
13	Ir. Agus Djatiwiryono, ME	Ahli Operasi dan Pemeliharaan Bendungan, KNIBB, HATHI	Anggota

In addition to these two organizations, the Indonesian Association of Dam Engineers and the Indonesian Council for Large Dams (INACOLD) (also members of the DSC) provide technical support when necessary.

The technical review of the dam itself will be carried out by experts from INACOLD and HATHI as well as technical staff from the Dam Bureau.

(3) Criteria used in the review

The criteria applied to the review are as follows, but are not limited to these as necessary.

Table 2-2 Criteria applicable to the review

No.	Document	Status	Decree
A.	***General Guidelines***		
1.	Ministerial Regulation on Dam Safety [1/]	OV	Kep Men PU No.296/KPTS/M/2001
2.	Government Regulation on Dams & Reservoirs	UP	RPP Waduk dan Bendungan
3.	Organization & Management of Dam Safety	OV	SNI No. 1731 – 1989 F
4.	Registration and Inventory of Dams	I/OV	Prakata Ketua KKB Okt 2002
5.	Guidelines & Operational Procedures for DSC	I	Keputusan Ketua KKB No.01/KPTS/2002
6.	Guidelines for Development & Decommissioning of Dams	I	Prakata Ketua BKB, Okt 2002
B.	***Technical Guidelines***		
1.	General Guidelines on Dam Development	D	Kata Sambutan Direktur Bina Teknik, Des 2003
2.	General Dam Design Criteria	R	Keputusan Ketua KKB : 05/KPTS/2003
3.	Filling of Reservoirs	I	Keputusan KKB : 03/KPTS/2002
4.	Safety Inspection & Evaluation of Dams	I	Keputusan KKB : 05/kpts/2003
5.	Dam Safety Review	I	Keputusan KKB : 05/KPTS/2003
6.	Revision of Guideline on Downstream Hazard Classification of Dams	OV/D	Keputusan Dirjen SDA 108/KPTS/A/1998
7.	Revision of Emergency Action Plans	UP	Keputusan Dirjen SDA 94/KPTS/A/1998
8.	Dam Safety Unit (DSU) Development Plan	OV/UP	COLENCO 1998
9.	Guidelines & Operational Procedures for DMUs	UP	COLENCO 1996
10.	Operations, Maintenance & Surveillance of Dams: Phase 1-General	I	Keputusan Dirjen SDA No. 199/KPTS/D/2003
11.	Operations, Maintenance & Surveillance of Dams: Phase II- Management	I	Keputusan Dirjen SDA No. 199/KPTS/D/2003
12.	O&M & Surveillance of Dams: Phase III- Dam Instrumentation & Monitoring Systems	I	Keputusan Dirjen SDA No. 199/KPTS/D/2003
13.	O&M & Surveillance: Phase IV- Inspection of Hydro-Mechanical and Electrical Equipment	I	Keputusan Dirjen SDA No. 199/KPTS/D/2003
14.	O&M & Surveillance: Phase V- Standard Operating Procedures for Hydro-Mechanical and Electrical Equipment	I	Keputusan Dirjen SDA No. 199/KPTS/D/2003
15.	Selection of Hydro-Mechanical Equipment	I	Keputusan Dirjen SDA No. 199/KPTS/D/2003
16.	Calculation of Flood Handling Capacity of Reservoirs & Spillways	D	COLENCO 2002
17.	DAMOSY Manual	D/OV	COLENCO 2002
18.	Guideline for Tailings Dams	D	Kata Pengantar Direktur Bina Teknik, Nov 2004
19.	Construction of Earth Dams	D	Kata Pengantar Direktur Bina Teknik, Nov 2004
20.	Dam Sedimentation Control & Mitigation	D	Kata Pengantar Direktur Bina Teknik, Nov 2004
21.	Visual Inspection Manual	D	Kata Pengantar Direktur Bina Teknik, Nov 2004
22.	Guidelines for Tunneling	-	
23.	Grouting Manual	D	Kata Pengantar Direktur SDW, Des 2004
24.	Cut-Off Wall/Trench Guidelines	D	Kata Pengantar Direktur SDW, Des 2004
25.	Design Criteria for Concrete Dams	U	Kata Pengantar Direktur SDW, Des 2004
26.	Roller Compacted Concrete Dams	-	
27.	Concrete Face Rockfill Dams	-	
28.	Dam Development on Soft Soils	D	SK KKB 04/KPTS/D/2007
29.	Testing of Earth Dam Embankments During Construction	-	

In addition to the above, the following standards are typically used in design, and technical discussions are based on these standards:

- 03-PRT-M-2009 The Social Engineering Guidelines for dam development
- Pd T-08-2004-A The Instrumentation of Dam Body for Earth -fill and Embankment type
- Pd T-14-2004-A The Stability Analysis of Fill Dam type due to Earthquake loads
- Pd. M-01-2004-A Construction Quality Tests for Dam Body for Fill type Dam
- Pt-M-03-2000-A The Quantification Capillarity Method for Reservoir Storage
- RSNI M-02-2002 Analysis Method of Water Seepage Control Way for fill (Urugan) Type Dam
- RSNI M-03-2002 Static Slope Stability Analysis Method of Fill (Urugan) Type Dam
- RSNI T-01-2002 The Body Design of Fill (Urugan) Type Dam
- Pdm-18-1995-03 Data Processing Methods of Climatology
- Pd T-02-2005-A Carrying capacity analysis of shallow foundation soils in the hydrological structure
- Pd T-03.1-2005-A Geotechnical Investigation for the foundation of hydrological structure vol. 1 to 3
- Pd T-03-2005-A Geotechnical Investigation Guidelines for the foundation of hydrological structure vol. 1
- Pd T-06-2004-A River Discharge Forecasting
- Pd T-10-2004-A measurement and mapping of Terrestris River
- Pd T-40-2000-A Procedures of descripting and investigating field conditions in soil project
- Pd. M-01-2004-A quality test for dam body in fill (urugan) type Dam
- Pd T-44-2000-A Soil Compaction Procedures
- RSNI M-01-2002 Method of measuring the potential of land collapse in the laboratories
- SNI 03-1724-1989 Planning procedures for hydrology and hydraulics for structure on the river
- SNI 03-2415-1991 Flood discharge calculation method
- SNI 03-2435-1991 Method of laboratory testing for soil samples
- SNI 03-2849-1992 Procedures of geological mapping technique
- SNI 03-3422-1994 Testing method for soil shrinkage threshold
- SNI 03-3637-1994 Method of soil testing for weight mold with fine-grained objects test
- SNI 03-3637-1994 Method of testing the strong cohesive soil-free press
- Pd M-22-1996-03 Triaxial testing methods of cohesive soil in the absence of drainage and consolidation
- SNI 03-3961-1991 Testing methods of sediment content laying levels using gravimetric
- with precipitation
- SNI 03-3962-1995 Testing methods of distribution of grains of sediment laying using
- gravimetric with sieve
- SNI 03-4145-1996 Testing method of weight types of sediment laying with pycnometer
- Dynamic analysis guidelines-of Fill (Urugan) Type Dam, Ditjen SDA, 2008
- Construction Guidelines for Rockfill Type dam with concrete membrane (CFRD), Ditjen SDA, 2011
- Guidelines for dams hazard classification, Ditjen SDA, 2011.
- Planning criteria-Irrigation planning standard, Ditjen of Water Resources December 1986 and its revisions.
- Technical requirements section of the PT 01, 02, 03 and 04, Irrigation standard planning, Ditjen of Water Resources , December 1986 and its revisions.
- Structure Standard for Irrigation BI-01 and irrigation structure type BI-02, Irrigation standard planning, Ditjen of Water Resources, December 1986 and those revisions.
- Construction guidelines for Fill (urugan) Type Dam: An hydrological analysis, Ditjen of Water Resources, July 1999.
- Feasibility study guidelines for irrigation development, Ditjen of Water Resources, September 1998.
- Seismic map in Indonesia for dynamic analysis of hydrological structure, the Center for research and development of water resources, Ministry of Public Work, December 2012.

1.4 Documents to be Submitted

The documents to be submitted for design approval are as follows:

(1) Permissions (prepared by the owner)

(a) Permissions for Dam Location and Water Use

Dam site permission from local government

(b) Environmental Impact Assessment (AMDAL)

Certificate of Approval from the Local Government Environment Agency (BAPEDALDA) for the Environmental Impact Assessment and Environmental Monitoring Plan

(2) Feasibility Study Report (Business plan: loaned by the owner to the contractor)

(3) Finalized Design Reports (Technical documents related to design: Prepared by the contractor. However, past survey and design documents are provided by the client)

(a) Main Report

(b) Executive Summary Report

(c) Supporting Report

Design Criteria (Design criteria applied to the project)

Geotechnical Investigation Report

Hydrological Analysis

Measurement Report

Model Test (Flood spillway hydraulic model test report: <u>prepared by test contractor)</u>

Design Calculation (specially stability analysis and seismic design of dams are discussed)

Design Note (Design background data collection)

Operation and Initial Maintenance (Maintenance Manual)

Technical Specification (Tender Documents)

Design Drawings

BoQ (Bulk of Quantity), etc.

(d) Review Design (If a design review is performed: The owner will prepare the optimum design revisions. The contractor will provide support.)

(e) Executive Summary on Environmental Analysis (ANDAL), Environmental Management Plan (RKL) , Environmental Monitoring Plan (RPL) (Environmental Impact Assessment, Environmental Management Plan, Monitoring Plan: <u>Prepared by the Owner</u>).

These documents are required for the Environmental Authorization (AMDAL) issued by the Environment Agency.

(f) Brief description on matters related to design, including the items as attached is ”Daftar Simak”

A checklist of documents to be submitted and a summary of their outline. Also, a list of questions, etc. For example, a plan to conduct additional design studies (a document proving the plan to conduct additional necessary studies and the start of their implementation)

(g) Dam Technical Data (Project Feature of the Dam)

A dam plan outline in accordance with the Dam Safety Committee format

(h) Prospective Location for Dam Body

Photo collection of dam sites, reservoirs, quarries, etc.

Soft copies of these documents will also be required at the time of filing. A sample of list of submitted documents for dam construction is shown in table below:

Table 2-3 Documents to be submitted and responsible person

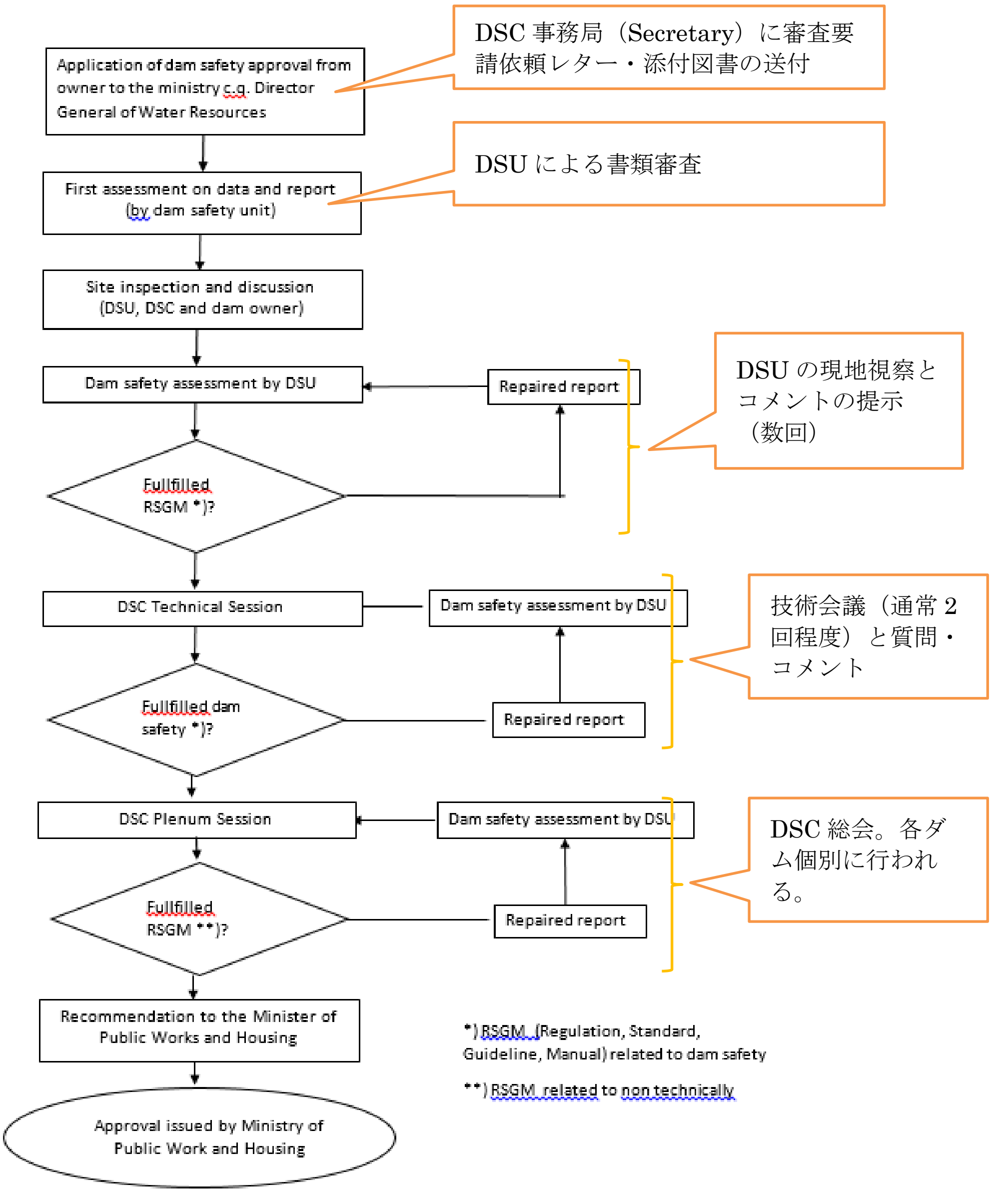
Required Documents	Remarks
(1) Permissions	
(a) Permissions for Dam Location and Water Use	地方政府によるダムサイトの使用許可
(b) Environmental Impact Assessment (ANDAL)	環境影響評価と環境モニタリングプランの地方政府の環境局(BAPEDALDA)による承認証
(2) Feasibility Study Report	事業計画書:施主が請負者に貸与
(3) Finalized Design Reports	(設計にかかる技術資料:請負者が準備。但し、過去の調査・設計資料は施主が提供)
(a) Main Report	
(b) Executive Summary Report	
(c) Supporting Report	
• Design Criteria	事業に適用した設計基準
• Geotechnical Investigation Report	地質調査報告書。ボーリングログ・試験データ含む。
• Hydrological Analysis	水文解析報告書
• Measurement Report	測量結果
• Model Test	洪水吐水理模型実験報告書:実験請負者が準備。実験結果に基づく設計修正必要
• Design Calculation	
• Design Note	
• Operation and Initial Maintenance	
• Technical Specification	技術特記仕様書のみで入札図書は、おそらく不要。
• Design Drawings	
• BoQ	工事数量表
(d) Review Design	設計のレヴューを行っている場合に必要。VE による修正は、施主が準備。請負者がサポート
(e) Executive Summary on Environmental Analysis (ANDAL), • Environmental Management Plan (RKL), • Environmental Monitoring Plan (RPL)	環境影響評価(ANDAL)、環境管理計画(PKL)、モニタリング計画(RPL)。 これらの図書は、環境局が発行する環境認可(AMDAL)に必要。
(f) Brief description on matters related to design, including the items as attached is ”Daftar Simak”	提出書類のチェックリストとその概要をまとめたものト質問事項などのリスト。例えば、設計の追加検討の実施予定(追加で必要な検討の実施予定 と 実施にとりかかることを証明する物。
(g) Dam Technical Data (Project Feature of the Dam)	ダム安全委員会の書式に則ったダムの計画概要書
(h) Prospective Location for Dam Body	ダムサイトや貯水池、採石場などの写真集

1.5 Process for Certificate Acquisition

The process leading up to design approval is shown in the flowchart created by DSU in Figure 2-2. Specifically, the following procedures are to be followed:

1. Preliminary meeting with DSU, presentation of dam plan and design
2. Send a letter of request for review to the DSC Secretary
3. Submit documents, reports and data to DSU

4. Document review by DSU
5. DSU site visits and comments submitted (several times)
6. Responses from project implementers
7. Technical Session (usually 2 sessions) and Q&A
8. Repeatedly modify the design and explain to DSU to create and submit the final answer
9. Plenary Session (DSC General Meeting. Held at each dam)
10. Design modification (0.5 months). DSC made recommendation to the Minister of PUPR for certification.
11. Planning approval (subject to Ministerial agenda)



✧ **Figure 2-3 Screening Flowchart**

2. Implementation Schedule for Certificate Acquisition

As mentioned above, the approval process involves a site inspection by the Dam Safety Committee, a technical conference, and a general meeting, so even if the application is submitted with all the necessary documents, past examples show that it takes at least four months at the earliest, and usually six months to a year.

An example of an implementation schedule that has actually been obtained is shown in Table 3-1. In this case, AMDAL (environmental impact assessment) and spillway hydraulic model tests were conducted in parallel with the approval process. In this way, even if all documents are not available, the review can begin if the implementation schedule is clear.

The general process is as follows:

① First comment received in about two months from submission

② About one month has passed since the first Technical Session, which was held after the reply and correction to the comments.

③ About one month has passed since the second technical session started.

④ about one month after replying to comments and making corrections

⑤ Minor revisions to the report and approval by the Minister of PUPR (not finalized due to the Minister's circumstances) will take approximately one month.

Table 3-1 Example of dam approval application implementation process

No	Activity Description	Concern Bodies	April	May	June	July	Augustus	Septmber	October	November	December
1	DD. Doc submitted To: DSC & Dit DGWR	Project/ Consultant	△ Apr. 14								
2	Presentation to Directorate SDW	Project/ Consultant	△ Apr. 24								
3	Request to DSU	Project/ Consultant	△ Apr. 24								
4	Site visit & discussion	DSU/ Project/ Consultant		= = = = = =	= △ Jun. 12						
5	Issuance question during site visit	DSU			△ Jun. 13						
6	Dam Safety Evaluation	DSU			△ Jun. 26						
7	Answering the question	Project/ Consultant				△ Jul. 7					
8	Technical Meeting DSU I	DSU/ Project/ Consultant				△ Jul. 18					
9	Improvement	Project/ Consultant				= = = =	= = =				
10	Improvement	DSU					= = =				
11	Technical Meeting DSU II	DSU/ Project/ Consultant					△ Aug. 27				
12	DSU report to DSC Preparation	DSU						△ Sep. 5			
13	DSC Technical Meeting	DSU/DSC/Project/ Consultant						△ Sep. 11			
14	Improvement	DSU/Project									
15	Report to DSC	DSU						△ Sep. 11			
16	Plenary Meeting	DSC/DSU/ Project						△ Sep. 18			
17	Issue Certificate	DSC									△ Dec. 18

Note: Implementation process up to approval of reservoir dams in Indonesia

Attachment 2 Completed Dam Risk Entry Form

LIST OF CONTENTS
Risk Awareness

ID: 1 **Name:** Tapin **Dam Type:** Rock-filled dam with central core **Dam Hight:** 70,0 **m**

	No.	Item	Content
Contents of Risk	1	*When the risk was identified (date)*	April 2022
	2	*Project phase in which risks were recognized*	2 years after impounding
	3	*Location (Structure/Area)*	Upper Spillway and spillway weir
	4	*Contents of risk*	Water flow, crack of spillway
	5	*Risk factors*	Scouring of spillway, Spillway failure
	6	*Events in which risks were recognized*	When water reservoir under spillway threshold elevation
	7	*Condition/Situation for risk realization*	groundwatter pressure, Dam reservoir pressure, flooding discharge
	8	*Impact if the risk realize*	Unstable water flow, Scouring due to water flow, Demage to spillway
Perspectives on Risk Classification	9	*Where risk exists*	Material quality, Water presssure
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☐ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Inspection after dam impounding ⇨ *Water leakage at upper part of spillway with many crack* ⇨ *Water flow, crack of spillway* ⇨ *Scouring of spillway, Spillway failure* ⇨ *Spillway failure, dam break, flooding downstream*

Grouting on spillway ⇨ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

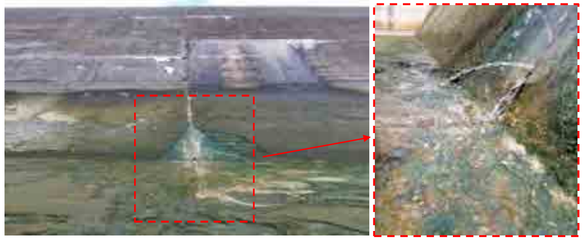


Photo-1 Condition of spillway crack before improvement

Photo-2 Condition of spillway crack after grouting improvement

1

ID: 1 **Name:** Tapin **Dam Type:** Rock-filled dam with central core **Dam Hight:** 70,0 **m**

History	*Recognition or not in the past*	Recognized
	When the risk was recognized	*Project Phase:* After impounding — *Date:* Aprill 2022
	Status of corresponding	Grouting Improvement had been conducted
Project Phase	*History of correspond to risks*	
Plan		
Design		
Construction	(see figures below)	
Impounding	Leakage was found on the downstream wall of the spillway toe through the segment connection gap with a discharge of 0.1 liter/s.	
Operation/ maintenance		

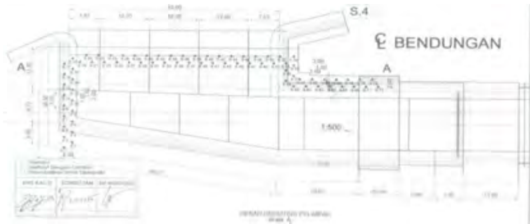


Figure-1 Grouting location of spillway during construction (shop drawing construction)

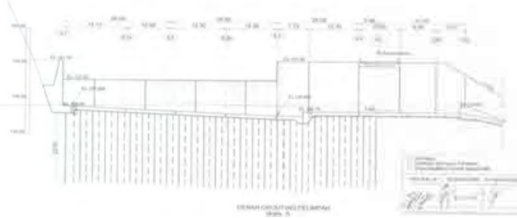


Figure-2 Grouting Depth of spillway during construction (shop drawing construction)

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	Grouting
		Basis for decision	Safety issues
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) Technical issues, 2) Spillway function		
	1) There may be a significant difference in settlement between the embankment and the concrete spillway structure 2) Depth of the crack reaches the reservoir water level, reservoir water will flow into the damage 3) Intensified monitoring of the area should be carried out 4) Investigation should be conducted to ensure the depth of crack		
Applicable standards			
Keywords	Grouting, Spillway		
References	*Meeting Minutes:*	Risalah Sidang Pleno Pelaksanaan Pengisian Awal Waduk dan Kesiapan Operasi, 9 SePTember 2022	
	Meeting Materials:	Sidang Pleno Sertifikasi Operasi dan Pemeliharaan, 13 Januari 2023 Sidang Pleno Sertifikasi Operasi dan Pemeliharaan, 24 Agustus 2022	
	Other:	Shop Drawing Spillway	

2

ID: 1 Name: Tapin Dam Type: Rock-filled dam with central core Dam Hight: 70,0 m

	No.	Item	Content
Contents of Risk	1	*When the risk was identified (date)*	April 2022
	2	*Project phase in which risks were recognized*	2 years after impounding
	3	*Location (Structure/Area)*	Conduit of diversion
	4	*Contents of risk*	Water flow, Cement dissolution
	5	*Risk factors*	Conduit/tunnel collapse
	6	*Events in which risks were recognized*	leaks at the top wall of the tunnel with a discharge of 1.67 liters/s
	7	*Condition/Situation for risk realization*	groundwatter pressure, Material dissolution,
	8	*Impact if the risk realize*	Unstable top wall diversion, demage to intake channel
Perspectives on Risk Classification	9	*Where risk exists*	Material strengh
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☐ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

observed leakage water in top wall of ⇒ *seepage at lining concrete of diversion* | *Water flow, Cement dissolution* ⇒ *decreasing concrete quaality, diversion collapse* ⇒ *demage pipe, operation distruption*

additional drainage ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Photo-1 Stalagtisation on tunnel and seepage on deivertion plugging

Photo-2 Dilatation seepage at the lining concrete

ID: 1 Name: Tapin Dam Type: Rock-filled dam with central core Dam Hight: 70,0 m

History	*Recognition or not in the past*	Unrecognized	
	When the risk was recognized	*Project Phase:* After Impouding	*Date:* April 2022
	Status of corresponding	Additional Study	
Project Phase	*History of correspond to risks*		
Plan			
Design			
Construction	(Figure-1)		
Impounding			
Operation/ maintenance			

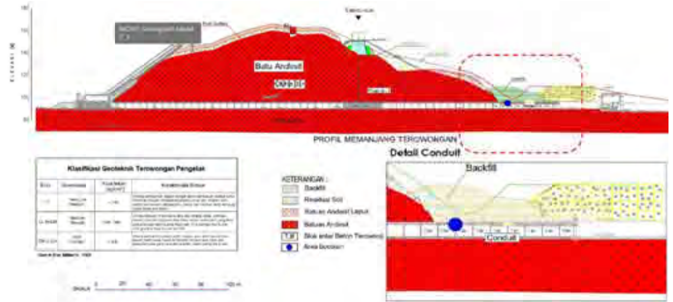


Figure-1 Geological profile of diversion and leakage location (blue dot)

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		reduction, retention
	Measures	*How to deal with*	special study of tunnel leakage
		Basis for decision	safety, operation
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) Operation issue 2) Dificullity in maintainace		
	1) correlation between the leak and the reservoir water level fluctuations should be studied 2) equip the backfill with drainage 3) The conduit contains hydromechanical equipment, so the leaks can disrupt operations and maintenance		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Diversion, leakage, seepage, cement dissolution		
References	*Meeting Minutes:*	Risalah Sidang Pleno Pelaksanaan Pengisian Awal Waduk dan Kesiapan Operasi, 9 SePTember 2022	
	Meeting Materials:	Sidang Pleno Sertifikasi Operasi dan Pemeliharaan, 13 Januari 2023 Sidang Pleno Sertifikasi Operasi dan Pemeliharaan, 24 Agustus 2022	
	Other:	Shop Drawing Spillway	

ID: 1 **Name:** Tapin **Dam Type:** Rock-filled dam with central core **Dam Hight:** 70,0 **m**

Contents of Risk	1	***When the risk was identified (date)***	April 2022
	2	***Project phase in which risks were recognized***	2 years after impounding
	3	***Location (Structure/Area)***	Conduit of diversion
	4	***Contents of risk***	Tunnel collapse
	5	***Risk factors***	Water leakage from tunnel, decresing material quality
	6	***Events in which risks were recognized***	During inspection
	7	***Condition/Situation for risk realization***	concrete dissolve by time, water flow
	8	***Impact if the risk realize***	Instrument demage
Perspectives on Risk Classification	9	***Where risk exists***	Material strengh
	10	***Character***	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	***Phase of Realization***	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	***Impact if the risk realize***	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	***Corresponding to risks***	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Dissolve material clogging ⇒ *Tunnel floor is flooded due to clogged channel* ⇒ *The water flow at tunnel form material from concrete dissolve* ⇒ *Tunnel collapse* ⇒ *Instrument demage*

Control water flow, stop water ⇒ *Risk reduction /*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Photo-1 Croncrete disolve material from tunnel

ID: 1 **Name:** Tapin **Dam Type:** Rock-filled dam with central core **Dam Hight:** 70,0 **m**

History	***Recognition or not in the past***	Unrecognized	
	When the risk was recognized	***Project Phase:*** After Impouding	***Date:*** April 2022
	Status of corresponding	Considering counster measurement methode	

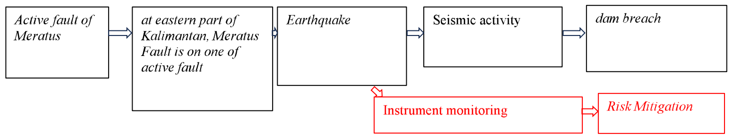
Project Phase	***History of correspond to risks***
Plan	-
Design	-
Construction	-
Impounding	After 2 year inpounding, several water leakages were obseved in the tunnel. The concrete materials are disolved with water
Operation/ maintenance	-

Investigation /analysis	***Investigation/analysis to identify factors, etc.***		Water sampling
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	***Contents of measures (avoidance, reduction, transfer) or retention***		reduction, transfer
	Measures	***How to deal with***	special study of tunnel leakage
		Basis for decision	safety, operation
	Retention (no measures)	***Reason***	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***		
	1) technical issue 2) Dificullity in operation and mantenance		
	a. Periodic measurements and monitoring of calcite volume or dimensions should be carried out. The results of measurements of the volume of calcite formed in the plugging should be separated from the results of measurements of the volume of calcite from the tunnel lining.b. The calcite formation indicates the dissolution of lime cement from the tunnel concrete structure. The effect of dissolution on the quality of tunnel structure concrete should be evaluated.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	leakage, seepage, cement dissolution		
References	***Meeting Minutes:***	Risalah Sidang Pleno Pelaksanaan Pengisian Awal Waduk dan Kesiapan Operasi, 9 SePTember 2022	
	Meeting Materials:	Sidang Pleno Sertifikasi Operasi dan Pemeliharaan, 13 Januari 2023 Sidang Pleno Sertifikasi Operasi dan Pemeliharaan, 24 Agustus 2022	
	Other:	Shop Drawing Spillway	

ID: 1 **Name:** Tapin **Dam Type:** Rock-filled dam with central core **Dam Hight:** 70,0 **m**

Contents of Risk	1	*When the risk was identified (date)*	Jan 2023
	2	*Project phase in which risks were recognized*	2 years after impounding
	3	*Location (Structure/Area)*	Dam structure building
	4	*Contents of risk*	seismicity activity
	5	*Risk factors*	Active fault
	6	*Events in which risks were recognized*	During technical discussion
	7	*Condition/Situation for risk realization*	Earthquake
	8	*Impact if the risk realize*	dam breach
Perspectives on Risk Classification	9	*Where risk exists*	Geology / strengh, sismicity
	10	*Character*	☑ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☑ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships



Explanatory Diagram (Schematic Diagram/ Photos, etc.)

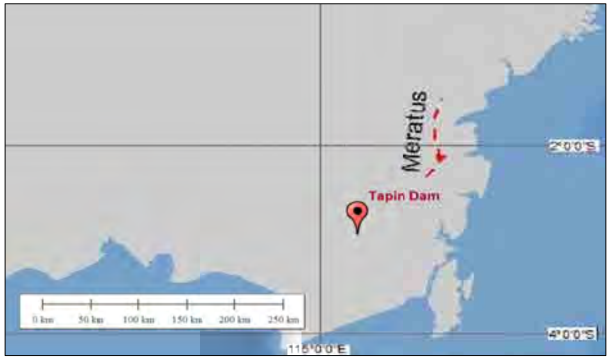


Figure-1 Location of Meratus Fault and Tapin Dam (PUSGEN, 2017)

ID: 1 **Name:** Tapin **Dam Type:** Rock-filled dam with central core **Dam Hight:** 70,0 **m**

History	*Recognition or not in the past*	Unrecognized
	When the risk was recognized	*Project Phase:* After Impouding — *Date:* April 2022
	Status of corresponding	-
Project Phase	*History of correspond to risks*	
Plan	-	
Design	the information of design report there was no fault obeserver, only joint was observed around the tapin dam	
Construction		

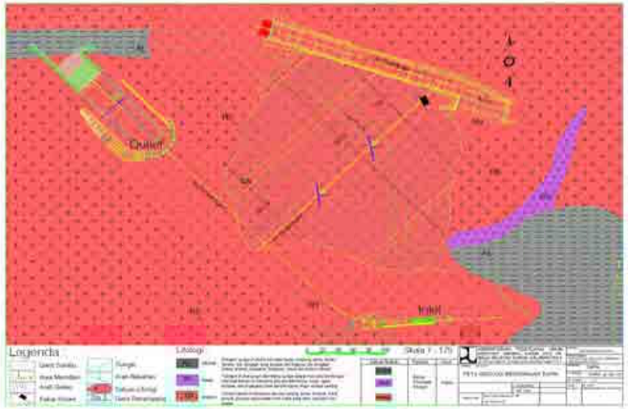


Figure-1 Geological map of Tapin Dam

Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Retention
	Measures	*How to deal with*	-
		Basis for decision	-
	Retention (no measures)	*Reason*	active fault metatus is >100 km away from Tapin dam
		Expected impact	No direct impack from meratus fault, small seismicity activity
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) technical issue		
	It should be checked and ascertained the distance between the active Meratus fault and the Tapin Dam location and evaluated for its effect on the dam's safety. If the dam's location is close enough to the Meratus Fault, a comprehensive seismic study of the Tapin Dam should be carried out, including seismic hazard assessment, seismic hazard analysis and dynamic analysis.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords	leakage, seepage, cement dissolution		
References	*Meeting Minutes:*	Risalah Sidang Pleno Pelaksanaan Pengisian Awal Waduk dan Kesiapan Operasi, 9 SePTember 2022	
	Meeting Materials:	Sidang Pleno Sertifikasi Operasi dan Pemeliharaan, 13 Januari 2023 Sidang Pleno Sertifikasi Operasi dan Pemeliharaan, 24 Agustus 2022	
	Other:	Shop Drawing Spillway	

ID: 2 **Name:** Tukul **Dam Type:** Rock random zonal with central core **Dam Hight:** 70,3 **m**

Contents of Risk	1	***When the risk was identified (date)***	2012
	2	***Project phase in which risks were recognized***	Design, Investigation
	3	***Location (Structure/Area)***	Dam foundation
	4	***Contents of risk***	Piping of foundation
	5	***Risk factors***	Dam material leaching
	6	***Events in which risks were recognized***	Many fault obseerved during foundation clearing and excavation
	7	***Condition/Situation for risk realization***	Earthquarke, Impounding
	8	***Impact if the risk realize***	Dam break causing flooding
Perspectives on Risk Classification	9	***Where risk exists***	Geology, Permeability, water pressure
	10	***Character***	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	***Phase of Realization***	☐ Project Implementation
			☐ Operation
			☐ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	***Impact if the risk realize***	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	***Corresponding to risks***	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

some faults were observed during design investigation ⇒ *during excavation for construction more much fault were observed => detailled geological mapping* ⇒ *fault throgh foundation => exavation for soft material and replaced by* ⇒ *Grouting and insatalling tools on a fault* ⇒ *piping, dam break and flooding*

additional instrument for other fauld for monitoring ⇒ *early warning for mitigation*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Photo-1 Fault at dam foundation (F3 Fault)

Figure-1 Geological profile of Tukul Dam cross section

ID: 2 **Name:** Tukul **Dam Type:** Rock random zonal with central core **Dam Hight:** 70,3 **m**

History	***Recognition or not in the past***	Unrecognized	
	When the risk was recognized	***Project Phase:*** Design	***Date:*** 2012
	Status of corresponding		
Project Phase	***History of correspond to risks***		
Plan			
Design	grouting recommendation for dam improvement		
Construction			
Impounding	Instrument installation for all fault to monitor		
Operation/ maintenance			

Investigation /analysis	***Investigation/analysis to identify factors, etc.***		visual outcrop
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		additional instrument installation
How to respond to risk	***Contents of measures (avoidance, reduction, transfer) or retention***		
	Measures	***How to deal with***	clearing the weak material and replaced with dental concrete
		Basis for decision	Dam safety
	Retention (no measures)	***Reason***	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***		
	1) piezometer can be installed from upstream to downstream so that a thorough observation can be carried out.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Fault, piping		
References	***Meeting Minutes:***	Evaluasi Pelaksanaan Awal Waduk dan Kesiapan Operasional, 25 Agustus 2022	
	Meeting Materials:	Paparan Persiapan OP, 25 Agustus 2022	
	Other:	Laporan Akhir (PT Global Parasindo Jaya, 2012) Dd Pembangunan Waduk Tukul	

ID: 2 **Name:** Tukul **Dam Type:** Rock random zonal with central core **Dam Hight:** 70,3 m

Contents of Risk	1	***When the risk was identified (date)***	2012
	2	***Project phase in which risks were recognized***	Impounding
	3	***Location (Structure/Area)***	Dam core material
	4	***Contents of risk***	Piping of dam
	5	***Risk factors***	Pore water pressure
	6	***Events in which risks were recognized***	Piezometer monitoring show that there is high pore water pressure in dam body
	7	***Condition/Situation for risk realization***	Impounding
	8	***Impact if the risk realize***	Dam break causing flooding
Perspectives on Risk Classification	9	***Where risk exists***	Geology, Permeability, water pressure, core material
	10	***Character***	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	***Phase of Realization***	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	***Impact if the risk realize***	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	***Corresponding to risks***	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

high water pressure at piezometer reading ⇨ *Monitoring after impouding, there is indacation of high pressure in dam body* ⇨ *high water level increase the pore pressure* ⇨ *piping occure due to pore pressure* ⇨ *dam break and flooding*

Monitoring instrument of dam body ⇨ *early warning for mitigation*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

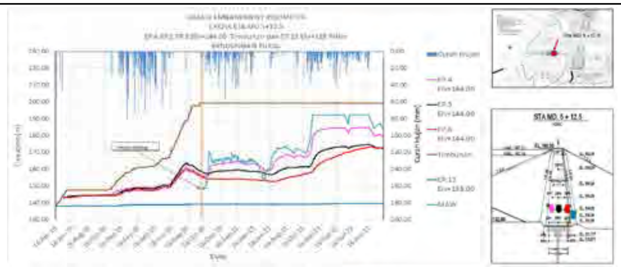


Figure-1 Graphic of piezometer monitoring at dam body STA MD 5+12,4

Figure-2 Graphic of piezometer monitoring at dam body STA MD 6+12.4

ID: 2 **Name:** Tukul **Dam Type:** Rock random zonal with central core **Dam Hight:** 70,3 m

History	***Recognition or not in the past***	Unrecognized	
	When the risk was recognized	***Project Phase:*** Impounding	***Date:*** August 2022
	Status of corresponding	Continuing monitoring	

Project Phase	***History of correspond to risks***		
Plan	-		
Design	-		
Construction	During dam embakment (construction), piezometer installed at the lowest elevation shows a fairly high pore water pressure		
Impounding	no information of quality control during construction		
Operation/ maintenance	-		
Investigation /analysis	***Investigation/analysis to identify factors, etc.***		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	***Contents of measures (avoidance, reduction, transfer) or retention***		Retention
	Measures	***How to deal with***	-
		Basis for decision	-
	Retention (no measures)	***Reason***	-
		Expected impact	Deformation of dam
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***		
	Technical issues		
	The reading data should be ensured and re-evaluated based on material data (compact moisture content, OMC, plasticity index, material that passes sieve no. 200, and other properties indexes). Likewise with the results of other piles of piezometer readings.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Pore pressure, cracking		
References	***Meeting Minutes:***	Evaluasi Pelaksanaan Awal Waduk dan Kesiapan Operasional, 25 Agustus 2022	
	Meeting Materials:	Paparan Persiapan OP, 25 Agustus 2022	
	Other:	Laporan Akhir (PT Global Parasindo Jaya, 2012) Dd Pembangunan Waduk Tukul	

ID: 2 **Name:** Tukul **Dam Type:** Rock random zonal with central core **Dam Hight:** 70,3 m

Contents of Risk	1	*When the risk was identified (date)*	August 2022
	2	*Project phase in which risks were recognized*	Impounding
	3	*Location (Structure/Area)*	Dam core material
	4	*Contents of risk*	Dam deformation, cracking
	5	*Risk factors*	Dam settlement, core material
	6	*Events in which risks were recognized*	Multilayer settlement instrument show high settlement of dam body (>1%)
	7	*Condition/Situation for risk realization*	Overburden
	8	*Impact if the risk realize*	Water leakage, dam break
Perspectives on Risk Classification	9	*Where risk exists*	Core material
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Immediate settlement ⇒ *Multilayer settlement instrument show high settlement of dam body (~1%)* ⇒ *Overburden, cosolidation of core material* ⇒ *Dam deformation, cracking* ⇒ *Water leakage, dam break*

Monitoring instrument of dam body ⇒ *early warning for mitigation*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

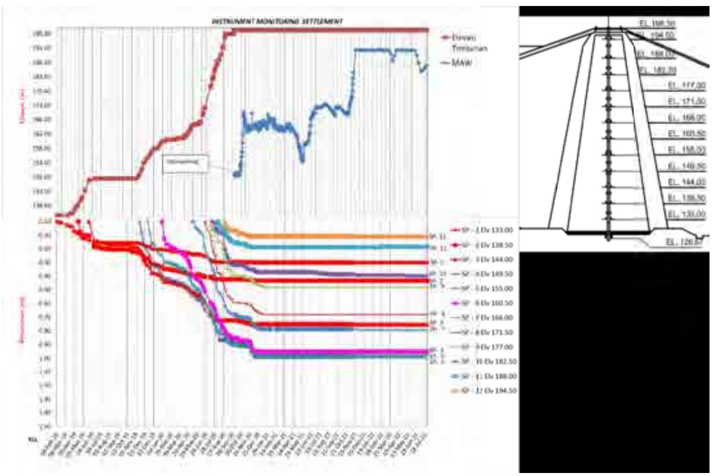
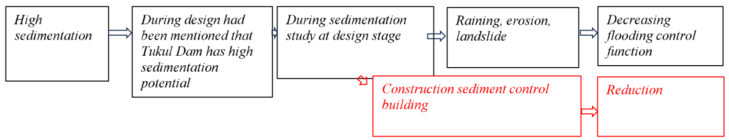


Figure-1 Graphic of multilayer settlement at dam body

ID: 2 **Name:** Tukul **Dam Type:** Rock random zonal with central core **Dam Hight:** 70,3 m

History	*Recognition or not in the past*	Unrecognized		
	When the risk was recognized	*Project Phase:* Impounding		*Date:* August 2022
	Status of corresponding	Continuing monitoring		
Project Phase	*History of correspond to risks*			
Plan	-			
Design	no wet core material inditation during design stage			
Construction	no information			
Impounding	there is indication of wet core for core material from the dam settlement more than 1%.			
Operation/ maintenance	-			
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-	
	Research/analysis, etc. to assess impact		-	
	Analysis, etc. to determine the need for and methods of response		-	
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Retention	
	Measures	*How to deal with*	-	
		Basis for decision	-	
	Retention (no measures)	*Reason*	Improvement implementation	
		Expected impact	Deformation of dam, core cracing	
	Availability and method of monitoring		-	
	Availability and method of information sharing		-	
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*			
	Technical issues			
	The condition during construction should be studied in detail			
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)			
Keywords.	Settlement, dam deformation			
References	*Meeting Minutes:*	Evaluasi Pelaksanaan Awal Waduk dan Kesiapan Operasional, 25 Agustus 2022		
	Meeting Materials:	Paparan Persiapan OP, 25 Agustus 2022		
	Other:	Laporan Akhir (PT Global Parasindo Jaya, 2012) Dd Pembangunan Waduk Tukul		

ID: 2 Name: Tukul Dam Type: Rock random zonal with central core Dam Hight: 70,3 m

Contents of Risk	1	When the risk was identified (date)	2012
	2	Project phase in which risks were recognized	Design
	3	Location (Structure/Area)	Reservoir area
	4	Contents of risk	Decreasing storage capacity
	5	Risk factors	Sedimentation
	6	Events in which risks were recognized	
	7	Condition/Situation for risk realization	Raining, erosion, landslide
	8	Impact if the risk realize	Decreasing flooding control function
Perspectives on Risk Classification	9	Where risk exists	Core material
	10	Character	☑ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	Phase of Realization	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	Impact if the risk realize	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	Corresponding to risks	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions
Overview of Causal Relationships			
Explanatory Diagram (Schematic Diagram/ Photos, etc.)			

ID: 2 Name: Tukul Dam Type: Rock random zonal with central core Dam Hight: 70,3 m

History	Recognition or not in the past	Recognized	
	When the risk was recognized	Project Phase: Design	Date: 2012
	Status of corresponding	Considering to built sediment control at the dam upstream	
Project Phase	History of correspond to risks		
Plan	-		
Design	-		
Construction	-		
Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	Investigation/analysis to identify factors, etc.	-	
	Research/analysis, etc. to assess impact	-	
	Analysis, etc. to determine the need for and methods of response	-	
How to respond to risk	Contents of measures (avoidance, reduction, transfer) or retention	Reduction	
	Measures	How to deal with	Sabo or sediment control building at upstream area
		Basis for decision	Dam function
	Retention (no measures)	Reason	-
		Expected impact	-
	Availability and method of monitoring	-	
	Availability and method of information sharing	-	
Special Notes	Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.		
	Technical issues		
	a. Prepare a program for the construction of the Sabo dam system to reduce the discharge of sediment entering the reservoir; b. Coordinate with related agencies to carry out integrated upstream watershed conservation by involving various related agencies and the community.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Sedimentation, sediment control		
References	Meeting Minutes:	Evaluasi Pelaksanaan Awal Waduk dan Kesiapan Operasional, 25 Agustus 2022	
	Meeting Materials:	Paparan Persiapan OP, 25 Agustus 2022	
	Other:	Laporan Akhir (PT Global Parasindo Jaya, 2012) Dd Pembangunan Waduk Tukul	

ID: 3 | Name: Napun Gete | Dam Type: Rock-filled dam with central core | Dam Hight: 52,0 m

	No.	Item	Content
Contents of Risk	1	*When the risk was identified (date)*	Jun-22
	2	*Project phase in which risks were recognized*	After Impounding
	3	*Location (Structure/Area)*	Dam body
	4	*Contents of risk*	Dam stability
	5	*Risk factors*	Sliding of dam body
	6	*Events in which risks were recognized*	Inspection after impounding for dam operation permit
	7	*Condition/Situation for risk realization*	heavy rain, flooding
	8	*Impact if the risk realize*	dam break causing flooding
Perspectives on Risk Classification	9	*Where risk exists*	Dam body, Dam material
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☐ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Dam design ⇒ *during inspection for operation permit, the leakage of dam body was observed in downstream of dam (dam toe and abutment)* ⇒ *Discharge monitoring => further study* ⇒ *uplift by water pressure* ⇒ *dam break*

additional counter weight, controling, water pressure at abutment ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Figure-1 Water leakage location at downstream of dam body (blue dot)

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ID: 3 | Name: Napun Gete | Dam Type: Rock-filled dam with central core | Dam Hight: 52,0 m

History	*Recognition or not in the past*	Unrecognized
	When the risk was recognized	*Project Phase:* after inpounding — *Date:* June 2022
	Status of corresponding	Further study to indentified water source

Project Phase	History of correspond to risks
Plan	
Design	
Construction	During the excavation of the foundation (construction phase), there were several springs/seepage formed due to excavation of the main dam foundation. Along with the cement curtain injection of gouting work on the foundation footprint, some seepage that originally appeared on the surface of the maindam excavation began to disappear, leaving 2 locations at sta. 340 and sta. 540.
Impounding	
Operation/ maintenance	

Photo-1 Spring at STA 340 during construction of Napun Gete Dam

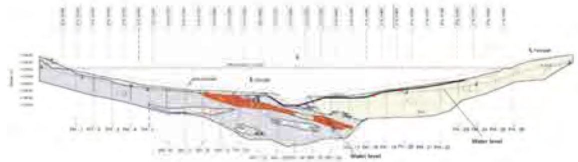

Figure-1 Engineering geology profile of Napun Gete Dam show shallow water level and cut by slope excavation

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	Counter Weight (consideratting)
		Basis for decision	Water source, uplift
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) technical issue		
	1) Routine monitoring of seepage or leak should be carried out. 2) a cross-section should be made for further analysis of the creep length and the amount of uplift at the leak points in the downstream part of the dam body. 3) Consultant should also recommend treatment, for example, by adding a counterweight to the downstream part		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Leakage, Dam Body		
References	*Meeting Minutes:*	Risalah Sidang Pleno Pembahasan Pengisian Awal Waduk dalam rangka Izin Operasi, 12 Januari 2023 Risalah Sidang Teknis Pelaksanaan Pengisian Awal Waduk dan Kesiapan Operasi, 31 Oktober 2022	
	Meeting Materials:	Paparan Sidang Pleno Pembahasan Pengisian Awal Waduk dalam rangka Izin Operasi, 12 Januari 2023	
	Other:	Laporan Akhir (PT. Indra Karya, 2016): Detail Desain dan Model Test Bendungan Napun Gete	

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ID: 3 **Name:** Napun Gete **Dam Type:** Rock-filled dam with central core **Dam Hight:** 52,0 **m**

Contents of Risk	1	***When the risk was identified (date)***	October 2022
	2	***Project phase in which risks were recognized***	Impounding
	3	***Location (Structure/Area)***	Dam body
	4	***Contents of risk***	Dam stability
	5	***Risk factors***	Condition of construction material
	6	***Events in which risks were recognized***	during technical discussion the dam stability analysis show sliding in large zone
	7	***Condition/Situation for risk realization***	Earthquake, impounding
	8	***Impact if the risk realize***	Dam breach
Perspectives on Risk Classification	9	***Where risk exists***	Dam smaterial, strenght,
	10	***Character***	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	***Phase of Realization***	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	***Impact if the risk realize***	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	***Corresponding to risks***	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Dam stability analisis after impounding ⇒ *After impounding stability analysis was carried out and show that sliding plane through the rock fill zone deeply* ⇒ *Rock material of construction need to be studied in more detail* ⇒ *Unstable dam body* ⇒ *Dam break*

additional conter weight ⇒ *Risk reduction,*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

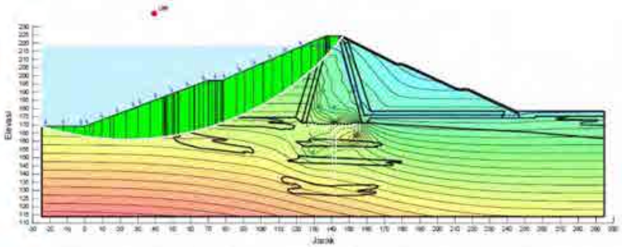


Figure-1 Dam stability analysis for upstream slop of napun gete dam (FK=1.29 with seismic load)

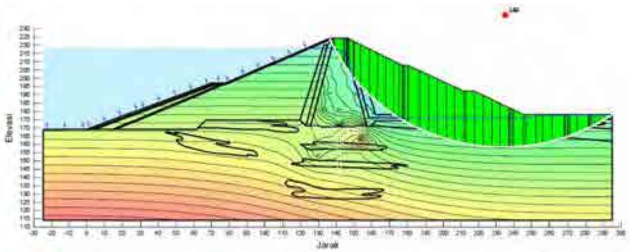


Figure-2 Dam stability analysis for downstream slop of napun gete dam (FK=1.40 with seismic load)

ID: 3 **Name:** Napun Gete **Dam Type:** Rock-filled dam with central core **Dam Hight:** 52,0 **m**

History	***Recognition or not in the past***	Unrecognized		
	When the risk was recognized	***Project Phase:*** Impounding		***Date:*** October 2022
	Status of corresponding	Further study		
Project Phase	***History of correspond to risks***			
Plan				
Design	During Design there was random zone (zone 4)			
Construction	In the construction phase there is no random zone, but in the stability analysis almost the entire landslide plane goes through the rockfill zone.			
Impounding	the safety factor of dam stability is above the specifical requirements			
Operation/ maintenance	-			
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-	
	Research/analysis, etc. to assess impact		-	
	Analysis, etc. to determine the need for and methods of response		-	
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction	
	Measures	*How to deal with*	under confirmation of material condition	
		Basis for decision	dam material, dam safety	
	Retention (no measures)	*Reason*	-	
		Expected impact	-	
	Availability and method of monitoring		-	
	Availability and method of information sharing		-	
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*			
	Technical issue			
	It is necessary to ensure that zone 4 is a rock-fill zone or random rock.			
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)			
Keywords.	Dam stability, rock fill dam			
References	***Meeting Minutes:***	Risalah Sidang Pleno Pembahasan Pengisian Awal Waduk dalam rangka Izin Operasi, 12 Januari 2023 Risalah Sidang Teknis Pelaksanaan Pengisian Awal Waduk dan Kesiapan Operasi, 31 Oktober 2022		
	Meeting Materials:	Paparan Sidang Pleno Pembahasan Pengisian Awal Waduk dalam rangka Izin Operasi, 12 Januari 2023		
	Other:	Laporan Akhir (PT. Indra Karya, 2016): Detail Desain dan Model Test Bendungan Napun Gete		

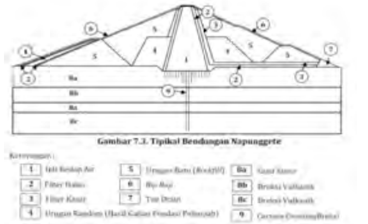


Figure-1 Typical design of napun gete dam during design stage

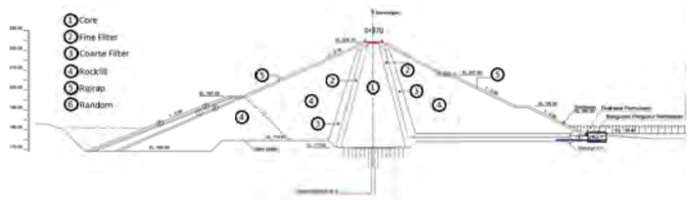


Figure-2 Asbuild drawing of napun gete dam

ID: 3 **Name:** Napun Gete **Dam Type:** Rock-filled dam with central core **Dam Hight:** 52,0 **m**

Contents of Risk	1	***When the risk was identified (date)***	August 2021
	2	***Project phase in which risks were recognized***	Impounding
	3	***Location (Structure/Area)***	Dam body / core zone
	4	***Contents of risk***	Dam deformation
	5	***Risk factors***	Internal cracking
	6	***Events in which risks were recognized***	during monitoring of multi layer settlement, sudden settlement was observed
	7	***Condition/Situation for risk realization***	Impounding, loading
	8	***Impact if the risk realize***	Water leakage, dam breach
Perspectives on Risk Classification	9	***Where risk exists***	Dam material, construction
	10	***Character***	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	***Phase of Realization***	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	***Impact if the risk realize***	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	***Corresponding to risks***	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Sudden settlent occuron dam ⇒ *Monitoring of multi layer settlement => sudden settlement was observed* ⇒ *Impounding, loading above the dam* ⇒ *Sudden dam deformation can cause cracks* ⇒ *Water leakage, dam breach*

Monitoring and additional investigation retaten the kind of core material ⇒ *Riskmitigation*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

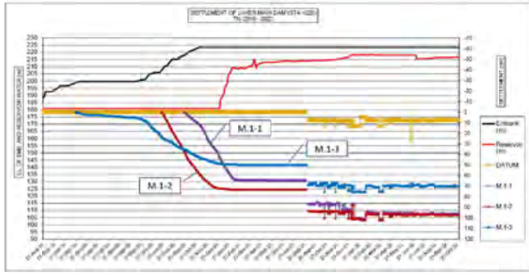


Figure-1 Multi layer settlement reading of napun gete dam

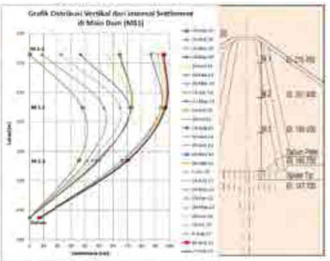


Figure-2 Vertical distribution graph of internal settlement in main dam (MS1)

ID: 3 **Name:** Napun Gete **Dam Type:** Rock-filled dam with central core **Dam Hight:** 52,0 **m**

History	***Recognition or not in the past***	Unrecognized
	When the risk was recognized	***Project Phase:*** Impounding ***Date:*** August 2021
	Status of corresponding	Considering investigaion and continuing monitoring of dam body and instrumentation
Project Phase	***History of correspond to risks***	
Plan		
Design	based on investigation during design, the borrow area has clay material that charactirized by most of dry dencity is less 1.2 gram/cm2 and liquid limit more than 70%	
Construction	The implementation of core material embankment during construction in accordance with specifications (see Table-1)	
Impounding	sudden settlement occurred 8 month after impounding	
Operation/ maintenance	-	

Table-1 Specification and laboratory test result of core zone material

No	Uraian		Satuan	Spesifikasi	Hasil Uji Laboratorium Borrow Area	Jumlah Pengujian	Hasil Uji Pelaksanaan	Jumlah pengujian	Keterangan
1	Maksimum Size		mm	50	38,10	12	38,10	6	SNI-03-1970-1990
2	Gravel Content		%	-	0.92 - 8.43	12	0.62 - 14.57	6	
3	Sand Content		%	-	17.94 - 31.01	12	34.45 - 48.31	6	
4	Silt Content		%	-	23.61 - 36.98	12	24.68 - 27.1	6	SNI-03-3423-1994
5	Clay Content		%	-	31.01 - 47.53	12	24.30- 30.42	6	
6	LL (Liquid Limit)		%	<70	64.01 - 73.61	12	61.94 - 66.01	6	SNI-03-1966-2008
7	Plastic Limit (PL)		%	<50%(Desain Note)	32.07 - 47.1	12	34.99 - 39.53	6	
8	Plastic Index (PI)		%	15-45	21.01 - 34.41	12	23.20 - 32.06	6	
9	Lab Compaction (OMC)		%	-	30 - 36	12	34.56 - 47.73	6	SNI-03-1742-1989
10	Lab Maximum Dry Density (MDD)		gr/cm2	-	1.38 -1.41	12	1.12 - 1.25	6	SNI-1743-2008
11	Field Dry Density (γd)		gr/cm2	1.072(Desain Note)	-	-	1.22 - 1.39	165	SNI-03-2828-1992
12	Deviasi Kadar Air (%)			-1 (OMC) +1	-		-1.15 - 1.83	165	
13	Field Water Content		%	-	-	-	30.00 - 36.74	165	SNI-01-2891-1992
14	Degree of Density (dd)		%	> 95	-	-	95.17 - 99.58	165	SNI-03-2828-1992
15	Field Permeability (K)		cm/sec	≤1x10⁻⁵(Desain Note)	-	-	3.80E-06 - 7.00E-06	165	ASTM D2424-1989
16	Sudut Geser dan Kohesi	ϕ	°	14.25(Design Note)	-	-	17,86	3	CUBP
		c	Kg/cm²	0.330(Design Note)	-	-	0,544	3	
		ϕ'	°		-	-	28,87	3	
		c'	Kg/cm²		-	-	0,461	3	
17		ϕ	°		-	-	30,82	3	CD
		c	Kg/cm²		-	-	0,563	3	

Investigation /analysis	***Investigation/analysis to identify factors, etc.***		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	***Contents of measures (avoidance, reduction, transfer) or retention***		Mitigation
	Measures	***How to deal with***	Monitoring
		Basis for decision	design condition
	Retention (no measures)	***Reason***	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***		
	Technical issues		
	An inspection should be carried out whether the dam body material includes collapsible soil. Collapsible soil is kind of soil that is very susceptible to collapse due to saturation.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Settlement, crack		
References	***Meeting Minutes:***	Risalah Sidang Pleno Pembahasan Pengisian Awal Waduk dalam rangka Izin Operasi, 12 Januari 2023 Risalah Sidang Teknis Pelaksanaan Pengisian Awal Waduk dan Kesiapan Operasi, 31 Oktober 2022	
	Meeting Materials:	Paparan Sidang Pleno Pembahasan Pengisian Awal Waduk dalam rangka Izin Operasi, 12 Januari 2023	
	Other:	Laporan Akhir (PT. Indra Karya, 2016): Detail Desain dan Model Test Bendungan Napun Gete	

ID: 4 **Name:** Kuningan **Dam Type:** Zonal with vertical core **Dam Hight:** 43,0 m

Contents of Risk	1	*When the risk was identified (date)*	June 2022
	2	*Project phase in which risks were recognized*	Impounding
	3	*Location (Structure/Area)*	Dam Foundation
	4	*Contents of risk*	Piping of foundation, uplift of dam body
	5	*Risk factors*	Ineffective grouting indication
	6	*Events in which risks were recognized*	Piezometer monitoring of foundation
	7	*Condition/Situation for risk realization*	High water level of reservoir
	8	*Impact if the risk realize*	Dam break causing flooding
Perspectives on Risk Classification	9	*Where risk exists*	Geology, Permeability, Design / Foundation treatment
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Gouting of dam foundation ⇒ Piezometer monitoring at downsteam and upstream of grouting almost has same presure value

longterm of high water level of reservoir ⇒ uplift of dam body, piping of foundation ⇒ dam break causing flooding

monitoring of instrument and dam deformation => socialization of warning system ⇒ mitigation

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

at the time of dam construction the dam foundation piezometer pressure in the downstream section has a smaller value, but at the time of impounding the downstream and upstream piezometer readings are almost the same.

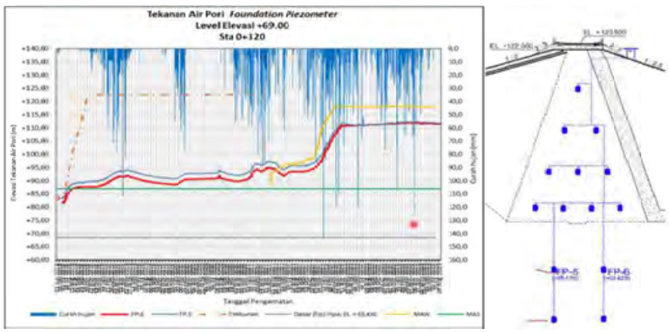


Figure-1 Piezometer reading at dam foundation (dowstrean and upstream of grouting)

ID: 4 **Name:** Kuningan **Dam Type:** Zonal with vertical core **Dam Hight:** 43,0 m

History	*Recognition or not in the past*	Unrecognized
	When the risk was recognized	*Project Phase:* Impounding — *Date:* June 2022
	Status of corresponding	-
Project Phase	**History of correspond to risks**	
Plan		
Design	using grouting to improve permeability of dam foundation	
Construction	During construction grouting was conducted for foundation improvement	

Figure-1 Layout of grouting during construction

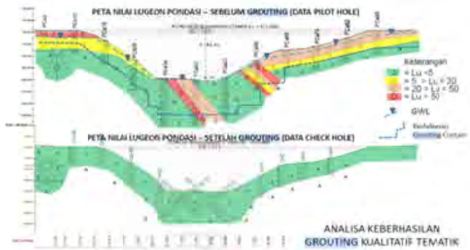


Figure-1 Lugeon value before (top) and after (bottom) grouting

Impounding	inefective grouting indicatioin from piezometer monitoring		
Operation/ maintenance	-		
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		
	Measures	*How to deal with*	
		Basis for decision	
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) technical issues 2) dam safety		
	• The uplift potential in the dam foundation should be checked to ensure that the dam body is in a safe/stable condition from the potential uplift.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Grouting, dam foudation		
References	*Meeting Minutes:*	Draf Risalah Diskusi Teknis pelaksanaan Pengisian Awal Waduk dan Kesiapan Operasi, 21 September 2023	
	Meeting Materials:	Paparan Sidang Pleno Impounding, 10 Juni 2021	
	Other:	Laporan Akhir (PT. Tata Guna Patria, 20 Oktober 2009) :Detail Desain Waduk Cileuweung di Kabupaten Kuningan	

ID: 4 Name: Kuningan Dam Type: Zonal with vertical core Dam Hight: 43,0 m

Contents of Risk	1	When the risk was identified (date)	January 2019
	2	Project phase in which risks were recognized	Construction
	3	Location (Structure/Area)	Dam body, core material
	4	Contents of risk	Settlement
	5	Risk factors	Material / core consolidation
	6	Events in which risks were recognized	Multi layer settlement instrument monitoring
	7	Condition/Situation for risk realization	Material consolidation, embankment load
	8	Impact if the risk realize	Dam body deformation, overtopping, cracking on dam
Perspectives on Risk Classification	9	Where risk exists	Dam material, dam body
	10	Character	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	Phase of Realization	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	Impact if the risk realize	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	Corresponding to risks	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Monitoring of dam deformation ⇒ Multi layer settlement monitoring during construction and after impounding ⇒ Consolidatiin of core material ⇒ High settlement ⇒ Overtopping, cracking on dam

Monitoring and warning system ⇒ Retention

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Settlement that occurred on Kuningan Dam is more than 60 cm where the dam is 43 m. The amount of settlement that occurs is highly correlated with the condition of the material at the time it is filled and the way it is filled.

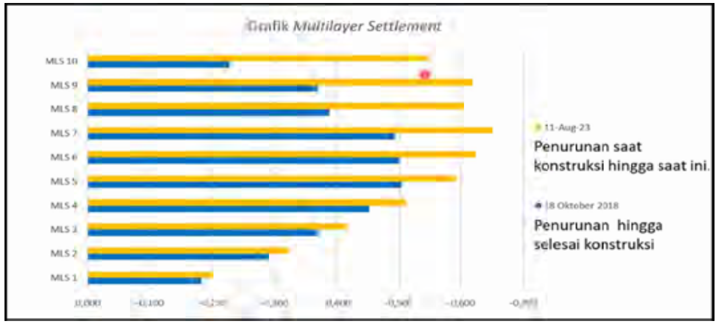


Figure-1 Settlement graph of Kuningan dam

ID: 4 Name: Kuningan Dam Type: Zonal with vertical core Dam Hight: 43,0 m

History	Recognition or not in the past	Recognized	
	When the risk was recognized	Project Phase: Construction	Date: January 2019
	Status of corresponding		
Project Phase	History of correspond to risks		
Plan			
Design	-		

Construction

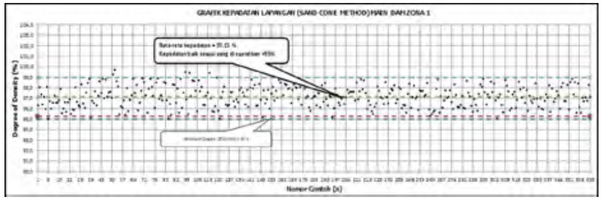


Figure-1 graphic of field density test of Kiningan Dam (core zone)

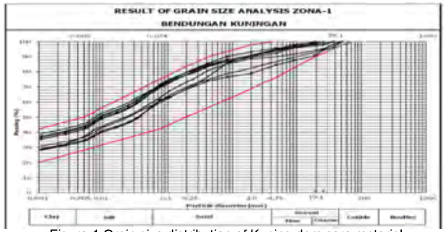


Figure-1 Grain size distribution of Kuning dam core material

Impounding	High settlement was observed after impounding		
Operation/ maintenance	-		
Investigation /analysis	Investigation/analysis to identify factors, etc.		Multi layer settlement monitoring
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	Contents of measures (avoidance, reduction, transfer) or retention		Retention
	Measures	How to deal with	-
		Basis for decision	-
	Retention (no measures)	Reason	Further investigation will be conducted
		Expected impact	water lekage from dam body
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.		
	1) Technical issue 2) Operation issue		
	• The cause of the high settlement at the dam's left abutment should be evaluated, examining the possibility of the embankment slope being too steep. • The amount of settlement should be calculated at the time of completion of construction until completion of consolidation to confirm the accuracy of the camber height that has been installed.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Settlement, core material		
References	Meeting Minutes:	Draf Risalah Diskusi Teknis pelaksanaan Pengisian Awal Waduk dan Kesiapan Operasi, 21 September 2023	
	Meeting Materials:	Paparan Sidang Pleno Impounding, 10 Juni 2021	
	Other:	Laporan Akhir (PT. Tata Guna Patria, 20 Oktober 2009) :Detail Desain Waduk Cileuweung di Kabupaten	

ID: 5 **Name:** Way Sekampung **Dam Type:** Rock-filled dam with central core **Dam Hight:** 47,0 m

	No.	Item	Content
	1	*When the risk was identified (date)*	2022
	2	*Project phase in which risks were recognized*	Inspection after impounding for operation permit
	3	*Location (Structure/Area)*	Outlet channel
	4	*Contents of risk*	Unstable slope, Slope sliding
	5	*Risk factors*	Slope without protection
	6	*Events in which risks were recognized*	Some erotion and surface slidding were found after impounding
	7	*Condition/Situation for risk realization*	Rain, water run off
	8	*Impact if the risk realize*	landslide at downtream of outlet channel, disturbed funcion
Perspectives on Risk Classification	9	*Where risk exists*	Slope stability, slope protection
	10	*Character*	[ ] Mainly caused by external forces
			[x] Mainly due to technical factors
			[ ] Factors other than the above
	11	*Phase of Realization*	[ ] Project Implementation
			[x] Operation
			[ ] Due to large-scale external force action
			[x] Due to long-term use
			[ ] Others
	12	*Impact if the risk realize*	[ ] Affects dam safety
			[x] Affects dam function
			[ ] Affect the schedule and costs of the projects
	13	*Corresponding to risks*	[ ] Basically risk avoidance
			[ ] Consider mitigation measures as risk avoidance is difficult.
			[x] Risk retention under certain conditions

Overview of Causal Relationships

slope excavation for channel ⇒ *erosion and surface sliding when inspection for operational permit* ⇒ *no action* ⇒ *unstable slope due to surface erosion* ⇒ *slope failure, material fill up the channel*

protection for slope surface=> minimazed erosion ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

rock conditions are weathered and are tuff sandstones which is sensitive to air

Photo-1 Condition of slope at outlet channel

ID: 5 **Name:** Way Sekampung **Dam Type:** Rock-filled dam with central core **Dam Hight:** 47,0 m

History	*Recognition or not in the past*	Recognized	
	When the risk was recognized	*Project Phase:* Inspection (impounding)	*Date:* 2022
	Status of corresponding	recommended to protec the slope and instal the drainage	
Project Phase	*History of correspond to risks*		
Plan			
Design			
Construction	the unstabe slope is sandstone-conglomerate lithology unit (yellow color), with moderately to highly weathered and rock class D at upper part and CL at lower part		
Impounding			
Operation/ maintenance			

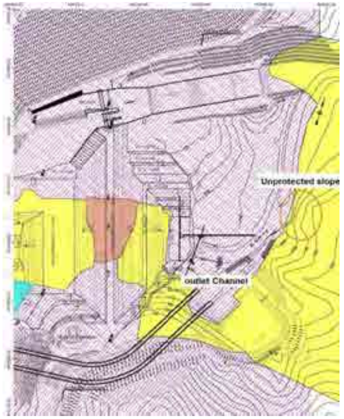


Figure-1 Situation surrouding outlet channel on geological map

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	protected the slope with sortcrete on slope surface
		Basis for decision	rock condition
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) Technical issue		
	The rock conditon is easly eroded by water and sentitive to the air, surface protection should be conduted to minimalise erosion. The location that landslide had occure can be filled with rock material and surface drainnge should be installed too.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords	Landslide, Slope Stability, Weathered		
References	*Meeting Minutes:*	-	
	Meeting Materials:	Paparan Sidang Teknis Persiapan Operasi dan Pemeliharaan, : 13 April 2022	
	Other:	Laporan Ringkasan (PT Indra Karya, 2016): Sertifikasi Desain Bendungan Way Sekampung	

ID: 5 **Name:** Way Sekampung **Dam Type:** Rock-filled dam with central core **Dam Hight:** 47,0 m

Contents of Risk	1	When the risk was identified (date)	2017
	2	Project phase in which risks were recognized	Construction
	3	Location (Structure/Area)	downstream of main dam, dam abutment, near to outlet tunnel
	4	Contents of risk	Sliding, outlet tunnel demage
	5	Risk factors	Water seepage
	6	Events in which risks were recognized	During excavation around the tunnel
	7	Condition/Situation for risk realization	ground water level.
	8	Impact if the risk realize	Tunnel structure demage, channel/ instrument demage
Perspectives on Risk Classification	9	Where risk exists	Geology, groundwater
	10	Character	☑ Mainly caused by external forces
			☐ Mainly due to technical factors
			☐ Factors other than the above
	11	Phase of Realization	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	Impact if the risk realize	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	Corresponding risks	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Seepage during excavation ⇨ spring comes out at excavation area around outlet tunnel; ⇨ Cutting slope seepage ⇨ Sliding, outlet tunnel demage ⇨ Tunnel structure demage, channel / instrument demage

Controlling water flow ⇨ Risk retention

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Figure-1 Location of seepage/ spring

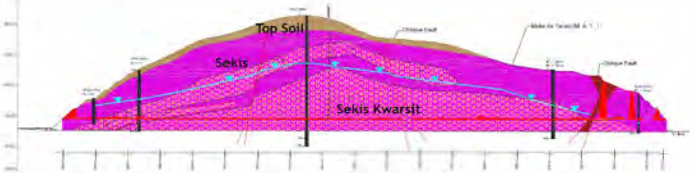
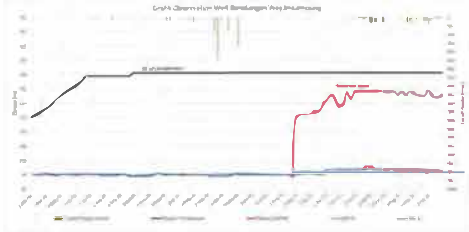


Figure-2 Geology profile of tunnel from inlet to outlet

ID: 5 **Name:** Way Sekampung **Dam Type:** Rock-filled dam with central core **Dam Hight:** 47,0 m

History	Recognition or non in the past	Recognized	
	When the risk was recognized	Project Phase: Construction	Date: 2017
	Status of corresponding	Retention but controling the flow	
Project Phase	History of corresponding to risks		
Plan			
Design	-		
Construction	During excavation on surrounding the outlet tunnel location, spring come out and measurement or monitoring of the spring never be done		
Impounding	Seepage at the right abutment site was measured with flow rate of 7.1 0 l/s. Comparing to reservoir fluvuation of dam there no relation / discharge chaninging of spring. The sping is concluded comes from ground water. 		
Operation/ maintenance	-		
Investigation / analysis	Investigation/analysis to identify factors, etc.		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	Contents of measures (avoidance, reduction, transfer) or retention		
	Measures	How to deal with	
		Basis for decision	
	Retention (no measures)	Reason	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	Challenges: 1) Technical issues, 2)Constraints in project implementation requirements (Construction, cost, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, reasons of risks phase - 5) Impact on processes, costs, etc., 6) Reflection points (on improvement of risk management and risks), etc		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords			
References	Meeting Minutes :		
	Meeting Materials:		
	Other:		

ID: 6 **Name:** Bendo **Dam Type:** Zonal with vertical core **Dam Hight:** 74,0 **m**

	No.	Item	Content
Contents of Risk	1	*When the risk was identified (date)*	Jun-21
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Intake
	4	*Contents of risk*	Unstable slope
	5	*Risk factors*	Intake slope failure, Intake demage
	6	*Events in which risks were recognized*	Many crack and discontunuity on intake slope so doubfull during technical season
	7	*Condition/Situation for risk realization*	Impounding, Earthquake
	8	*Impact if the risk realize*	Lanslide, Intake demage, Intake malfunction
Perspectives on Risk Classification	9	*Where risk exists*	Discontinuity, Foundation
	10	*Character*	[x] Mainly caused by external forces
			[ ] Mainly due to technical factors
			[ ] Factors other than the above
	11	*Phase of Realization*	[ ] Project Implementation
			[x] Operation
			[x] Due to large-scale external force action
			[x] Due to long-term use
			[ ] Others
	12	*Impact if the risk realize*	[ ] Affects dam safety
			[x] Affects dam function
			[ ] Affect the schedule and costs of the projects
	13	*Corresponding to risks*	[ ] Basically risk avoidance
			[ ] Consider mitigation measures as risk avoidance is difficult.
			[x] Risk retention under certain conditions

Overview of Causal Relationships

Incline shaft intake located on steep slope with many ⇒ *During technical season, intake slope was doubfull about the stability* ⇒ *protection using sortcrete and reinforcement* ⇒ *unstabel slope causing sliding* ⇒ *demage to intake, malfunction of intake*

additional reinforcement by sealing grout and surface drainage ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Photo-1 Location of sliiding potential near to intake

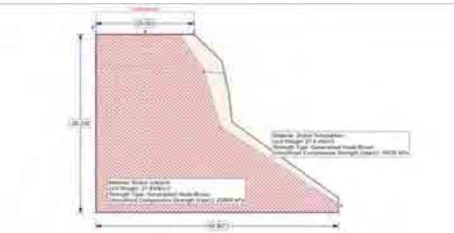


Figure-1 Geogical profile of intake slope

ID: 6 **Name:** Bendo **Dam Type:** Zonal with vertical core **Dam Hight:** 74,0 **m**

History	*Recognition or not in the past*	Unrecognized
	When the risk was recognized	*Project Phase:* Construction — *Date:* June 2021
	Status of corresponding	Sortcrete and anchor installation
Project Phase	*History of correspond to risks*	
Plan		
Design	first intake design is drop inlet and revice to Incline shaft considering several conditions	
Construction	Based on consultan analysis: - SMR value 49 (Partially Stabilized) - Method Parameters Rock collapse criteria Hoek Brown - Slope Analysis with Morgenstern Price method and Spencer - Unit Weight 21.6 Kn /m3 - GSI 70 (Volcanic Breccia) and 45 (Volcanic Breccia Weathered - Seismicity Factor 0.142 (100 return period)	
Impounding	Dam initial impounding was carried out in July 2021	
Operation/ maintenance		

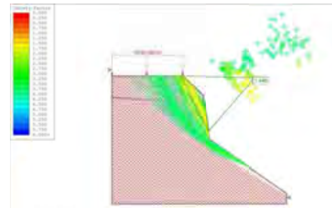


Figure-1 Stability analysis of intake slope

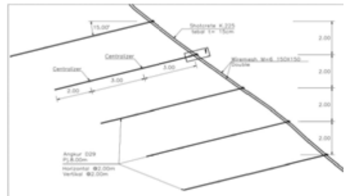


Figure-2 Protection and reinforcement of slope

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		Slope stability analysis
	Research/analysis, etc. to assess impact		Morgenstern Price method and Spencer
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	Conducting sortcrete for surface slope and achoring to 8 m depth for reinforcement
		Basis for decision	Intake safety, dam function
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) Technical issue		
	It is recommended that all cracks and rock cracks on the intake slopes and the platforms above should be covered with sealing grout. Adequate and permanent surface drainage should be arranged.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.			
References	*Meeting Minutes:*		Sidang Teknis Pembahasan Konstruksi Bendungan Bendo, 21 Juni 2021 Sidang Pleno Pembahasan Konstruksi Bendungan Bendo, 29 Juli 2021
	Meeting Materials:		Persiapan Impounding Waduk Bendo
	Other:		Laporan Akhir (PT. Indra Karya,2004): Details Design Bendungan Bendo

ID: 6 **Name:** Bendo **Dam Type:** Zonal with vertical core **Dam Hight:** 74,0 m

Contents of Risk	1	*When the risk was identified (date)*	Mar-21
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Spillway
	4	*Contents of risk*	Landslide, rockfall, spillway function
	5	*Risk factors*	Steep slope with many discontunuity
	6	*Events in which risks were recognized*	During excavation of spillway, unstable slope was observed
	7	*Condition/Situation for risk realization*	earthquake, heavy rain
	8	*Impact if the risk realize*	disturbance of spillway building, spillway malfuction
Perspectives on Risk Classification	9	*Where risk exists*	Rock strenght, Slope stability
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Slope stability around spillway ⇨ *Slope of hill arround spillway was obseved steep with many discontinuities => Additional investigation and rock sampling* ⇨ *allowing the existence of cliffs with monitoring* ⇨ *unstable slope due to heavy rain / earthquake* ⇨ *slope failure, rock fall, demage to spillway*

excavating slope to gentle slope ⇨ *Risk avoideance*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

During construction monitoring of the slope, after shear stakes were installed, no change in the position or movement of the slope was observed. No movement of slope after blasting of the spillway, earthquake, and rainy season.

Photo-1 Steep slope with many discontinuity at upstream of spillway

Figure-1 Location of the slope (blue color)

ID: 6 **Name:** Bendo **Dam Type:** Zonal with vertical core **Dam Hight:** 74,0 m

History	*Recognition or not in the past*	Recognized	
	When the risk was recognized	**Project Phase:** Construction	**Date:** Mar-21
	Status of corresponding	Installatio of shear stakes for movement monitoring	

Project Phase	**History of correspond to risks**
Plan	
Design	during design stage, only slope protection is recommended
Construction	detail condition of the slope had beed conducted, shear stake was installed at the top of slope to monitor the slope movement.
Impounding	
Operation/ maintenance	

Photo-1 wide discontinuity of the slope

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		
	Measures	*How to deal with*	Instalation of shear stake for movement monitoring
		Basis for decision	slope condition.
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		shear stake monitoring
	Availability and method of information sharing		

Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*
	1) Technical issue 2) Potential of dam function disturbance
	If necessary, instruments can be installed, such as inclinometers and sliding stakes, to monitor movement in areas prone to landslides upstream of the spillway that have the potential for landslides. Because of the dimention of landslide is not to wide, cutting the slope and weak zone to gentle slope is better.
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)
Keywords.	Slope stability, landslide, slope cutting

References	*Meeting Minutes:*	Sidang Teknis Pembahasan Konstruksi Bendungan Bendo, 21 Juni 2021 Sidang Pleno Pembahasan Konstruksi Bendungan Bendo, 29 Juli 2021
	Meeting Materials:	Persiapan Impounding Waduk Bendo
	Other:	Laporan Akhir (PT. Indra Karya,2004): Details Design Bendungan Bendo

ID: 6 **Name:** Bendo **Dam Type:** Zonal with vertical core **Dam Hight:** 74,0 m

Contents of Risk	1	*When the risk was identified (date)*	-
	2	*Project phase in which risks were recognized*	Impounding
	3	*Location (Structure/Area)*	Dam body
	4	*Contents of risk*	hydroulic fracture, piping
	5	*Risk factors*	Drilling pressure, air/water pressure
	6	*Events in which risks were recognized*	malfuction of inclinometer and will be installed the new one
	7	*Condition/Situation for risk realization*	pressure during drilling
	8	*Impact if the risk realize*	instable dam, dam break
Perspectives on Risk Classification	9	*Where risk exists*	Dam material, method
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☐ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Malfunction of inclinometer ⇒ *Drilling on dam body will be conducted to monitor the dam* ⇒ *pressure during drilling may cause material condition changing of dam* ⇒ *Drilling near to previous inclinometer* ⇒ *Instable dam, dam break*

Changing drilling location to avoid deep drilling ⇒ *Risk transfer or and reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Photo-1 Inclinometer instalation at construction

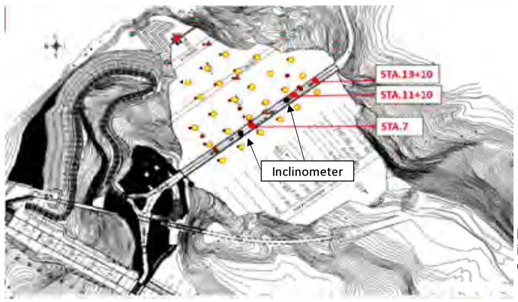
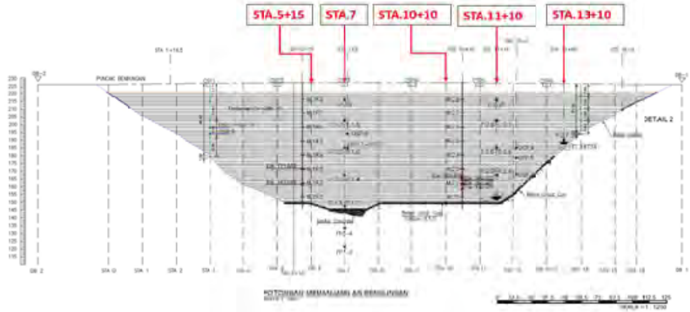


Figure-1 Location of inclinometer instalation during construction (2 loctions)

ID: 6 **Name:** Bendo **Dam Type:** Zonal with vertical core **Dam Hight:** 74,0 m

History	*Recognition or not in the past*	Unrecognized	
	When the risk was recognized	*Project Phase:* Impounding	*Date:* -
	Status of corresponding	considering of changing the drilling location	

Project Phase	***History of correspond to risks***
Plan	-
Design	-
Construction	Inclino mater had been installed in 2 location
Impounding	The inspection after inpounding inform that the inclinometer is not working proprely due to the bottom of inclinometeri is not installed deep enough in foundation.  Figure-1 Long section of Bendo dam
Operation/ maintenance	-

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Transfer and reduction
	Measures	*How to deal with*	Changing drilling location around the abutment to avoid depth drilling
		Basis for decision	Dam safety
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	Technical issue		
	To avoid deep drilling, consider installing inclinometer pipes near the left and right abutment or in areas with geological structures and/or weak zones where the embankment height is less than the maximum height of the dam. Drilling in the dam body poses a very high risk to the dam's safety. Before drilling for installation of the inclinometer and OSP is carried out, a Drilling Program Plan (P3) should be prepared.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Drilling, inclinometer, hydraulic fracture		
References	*Meeting Minutes:*	Sidang Teknis Pembahasan Konstruksi Bendungan Bendo, 21 Juni 2021 Sidang Pleno Pembahasan Konstruksi Bendungan Bendo, 29 Juli 2021	
	Meeting Materials:	Persiapan Impounding Waduk Bendo	
	Other:	Laporan Akhir (PT. Indra Karya,2004): Details Design Bendungan Bendo	

ID: 6 Name: Bendo Dam Type: Zonal with vertical core Dam Hight: 74,0 m

Contents of Risk	1	When the risk was identified (date)	2021
	2	Project phase in which risks were recognized	Impounding
	3	Location (Structure/Area)	Dam body
	4	Contents of risk	Mechanical parameter changes of dam material
	5	Risk factors	Fine grained material at the top of coarse grained material
	6	Events in which risks were recognized	During tecknical discussion
	7	Condition/Situation for risk realization	Rain
	8	Impact if the risk realize	Changing stabilitas parameter of dam
Perspectives on Risk Classification	9	Where risk exists	Dam material,
	10	Character	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	Phase of Realization	☐ Project Implementation
			☐ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	Impact if the risk realize	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	Corresponding to risks	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Dam design ⇨ *During technical discussion at zone 3a (gravel) located under zone 3b (silt-gravel)* ⇨ *Rain may cause silt material transfer from zone 3b to zone 3 a* ⇨ *changing material properties* ⇨ *Changing stabilitas parameter of dam*

(Contents of measures) ⇨ *(Risk avoidance, reduction, transfer or retention)*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Figure-1 Bendo dam design

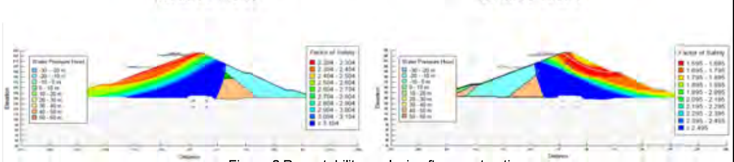


Figure-2 Dam stability analusis after construction

ID: 6 Name: Bendo Dam Type: Zonal with vertical core Dam Hight: 74,0 m

History	Recognition or not in the past	Unrecognized		
	When the risk was recognized	Project Phase: Construction		Date: 2021
	Status of corresponding	Considering the stability analysis take zone 3a parameter same as 3b parameter		
Project Phase	History of correspond to risks			
Plan				

Design

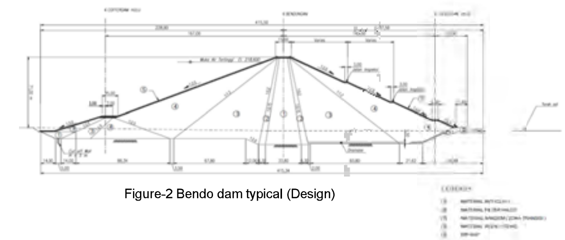


Figure-2 Bendo dam typical (Design)

Construction

Figure-2 Bendo dam typical (construction)

Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	Investigation/analysis to identify factors, etc.		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	Contents of measures (avoidance, reduction, transfer) or retention		Retention
	Measures	How to deal with	-
		Basis for decision	-
	Retention (no measures)	Reason	as long as stability of dam is meet the requirement
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.		
	Technical issue		
	This value should be evaluated. If there is a change in the material during landfilling, a vibrating table test should be carried out following the material change so that the density test of the different materials is compared with the new vibrating table test results. A slope stability analysis should be carried out with zone 3A conditions having the same parameters as zone 3B to evaluate the dam's safety in these conditions.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Dam stability,		
References	Meeting Minutes:	Sidang Teknis Pembahasan Konstruksi Bendungan Bendo, 21 Juni 2021 Sidang Pleno Pembahasan Konstruksi Bendungan Bendo, 29 Juli 2021	
	Meeting Materials:	Persiapan Impounding Waduk Bendo	
	Other:	Laporan Akhir (PT. Indra Karya,2004): Details Design Bendungan Bendo	

ID: 7 **Name:** Paselloreng **Dam Type:** Earth-filled zonal with central core **Dam Hight:** 42,0 m

Contents of Risk	1	*When the risk was identified (date)*	June 2023
	2	*Project phase in which risks were recognized*	Inspection after impounding
	3	*Location (Structure/Area)*	Spillway wall, spillway floor
	4	*Contents of risk*	Material quality
	5	*Risk factors*	Scouring of spillway, Spillway failure
	6	*Events in which risks were recognized*	Inspection for operation permit
	7	*Condition/Situation for risk realization*	Watter pressure, flooding discharge, water runoff
	8	*Impact if the risk realize*	Unstable water flow, Scouring due to water flow, Demage to spillway
Perspectives on Risk Classification	9	*Where risk exists*	Material strenght, permeability
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Inspection after dam impounding → Spillway material scouring, water leakage, sattlement on right bank of spillway wall → Water flow → Scouring of spillway, Spillway failure → Spillway failure, dam break,

Grouting on spillway → Risk reduction

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

At the connection of the left wall and spillway floor during visual inspection, seepage and scour were found at the elevation touching the appron (elv 46.00m) seepage was seen especially after rain, this scour eroded the surface of the left wall of the spillway, while the next finding was that the right bank or drainage channel downstream of the dam did not functioning properly, due to the blockage of the drainage channel, so that water flow through the drainage spilled over the right bank wall. While the next finding on the the right wall of the chute channel looks sattle dimensions and an average depth of 1.00 to 1.5 meters.

Photo-1 Condition of spillway of Paselloreng Dam

ID: 7 **Name:** Paselloreng **Dam Type:** Earth-filled zonal with central core **Dam Hight:** 42,0 m

History	*Recognition or not in the past*	Unrecognized	
	When the risk was recognized	*Project Phase:* After impounding	*Date:* June 2023
	Status of corresponding		
Project Phase	*History of correspond to risks*		
Plan			
Design			
Construction	 Figure-1 Cross section of spillway		
Impounding			
Operation/ maintenance			

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	Grouting
		Basis for decision	Safety issues
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) Technical issues, 2) Spillway function		
	improvements need to be carried out immediately because there have been traces of scouring that occur. Locaation where scouring occur, material replesment should be carried out to prevent scouring area become wider		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Scourinf, spillway		
References	*Meeting Minutes:*		
	Meeting Materials:	Diskusi Sertifikasi Izin Operasi, 4 Juli 2023 Sidang teknis izin operasi 17 Oktober 2023	
	Other:	Basic Design On Paselloreng Dam, Nippon Koei 2000	

ID: 7 Name: Paselloreng Dam Type: Earth-filled zonal with central core Dam Hight: 42,0 m

Contents of Risk	1	*When the risk was identified (date)*	June 2023
	2	*Project phase in which risks were recognized*	After impounding
	3	*Location (Structure/Area)*	diversion tunnel
	4	*Contents of risk*	Water flow, Cement dissolution
	5	*Risk factors*	tunnel collapse
	6	*Events in which risks were recognized*	during inspection leakege almost bserved along the tunnel
	7	*Condition/Situation for risk realization*	Water pressure, Material dissolution.
	8	*Impact if the risk realize*	Unstable wall tunnel, Tunnel collpse
Perspectives on Risk Classification	9	*Where risk exists*	Material strenght
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☐ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

observed leakage water of tunnel ⇒ *seepage at lining concrete of tunnel* ⇒ *water pressure* ⇒ *Water flow, Cement dissolution* ⇒ *diversion collapse, operation distruption*

additional drainage, grouting ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Seepage to Leakage along the tunnel was observed. Seepage was observed at every joint of the tunnel. The largest leak was encountered at 3 points, at upstream of the tunnel of former airvane and the tunnel connection there are 2 largest leak points.

Photo-1 Water leakage at tunnel of Paselloreng Dam

ID: 7 Name: Paselloreng Dam Type: Earth-filled zonal with central core Dam Hight: 42,0 m

History	*Recognition or not in the past*	Recognized	
	When the risk was recognized	*Project Phase:* After impounding	*Date:* June 2023
	Status of corresponding	no information	
Project Phase	*History of correspond to risks*		
Plan			
Design			
Construction			
Impounding	most of the leakage was observed at the conection beetwen tunnel and grouting hole plugging		
Operation/ maintenance			

Figure-1 Location of largest water leakage in tunnel of Paselloreng Dam

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	no information
		Basis for decision	water pressure
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) Technical issue 2) Disturbance of dam operation		
	Leaking conditions if left unchecked will become a problem in the long term, eroding cement dissolution will occur and reduce its quality. In low reservoir water conditions, grouting can be considered to avoid large pressures. However, further studies should also be conducted.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Tunnel, Water leakage, Material dissolution		
References	*Meeting Minutes:*		
	Meeting Materials:	Diskusi Sertifikasi Izin Operasi, 4 Juli 2023 Sidang teknis izin operasi 17 Oktober 2023	
	Other:	Basic Design On Paselloreng Dam, Nippon Koei 2000	

ID: 8 **Name:** Keureuto **Dam Type:** Zonal random rock with central core **Dam Hight:** 74,0 m

Contents of Risk	1	*When the risk was identified (date)*	June 2023
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Spillway floor/foundation
	4	*Contents of risk*	Uplift of spillway, Foundation piping
	5	*Risk factors*	Gound water / Water pressure
	6	*Events in which risks were recognized*	after spillway was constucted several water leakage observed
	7	*Condition/Situation for risk realization*	Impounding. Heavy rain
	8	*Impact if the risk realize*	Damege to spillway, spillway fuction
Perspectives on Risk Classification	9	*Where risk exists*	Rock strenght, Permeability
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

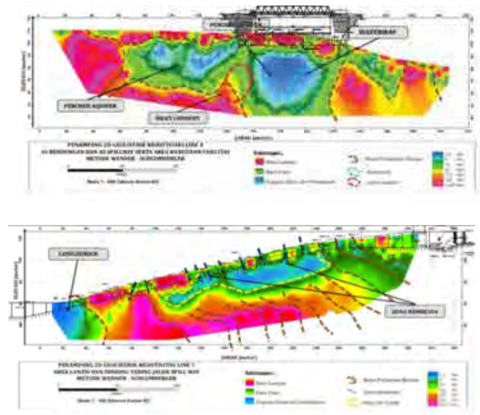
- Inspection after dam impounding → Several spot of water leakage at spillway → Water presuure, → Uplift of spillway, decrease quality of material → spillway failure, spillway malfuction
- Grouting on spillway, drainage installation → Risk reduction

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Seepage occurred at the Spillway launcherand the spillway's side walls. based on geophysic survey, there is water accumulation under it.

Photo-1 water leakage on chute of spillway (dash red mark) and spring water location (dash black mark)

ID: 8 **Name:** Keureuto **Dam Type:** Zonal random rock with central core **Dam Hight:** 74,0 m

History	*Recognition or not in the past*	Recognized		
	When the risk was recognized	*Project Phase:* Construction		*Date:* June 2023
	Status of corresponding	geophysics survey surrounding spillway location		
Project Phase	*History of correspond to risks*			
Plan				
Design				
Construction				
Impounding				
Operation/ maintenance				
Investigation /analysis	*Investigation/analysis to identify factors, etc.*			
	Research/analysis, etc. to assess impact			
	Analysis, etc. to determine the need for and methods of response			
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*			
	Measures	*How to deal with*		
		Basis for decision		
	Retention (no measures)	*Reason*		
		Expected impact		
	Availability and method of monitoring			
	Availability and method of information sharing			
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*			
	1) Technical issue			
	considerate of groundwater relations in case of impounding. There is no drainage system behind the side walls, additional discharge pipes is needed.			
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)			
Keywords.				
References	*Meeting Minutes:*	diskusi teknis pembahasan hidromekanikal bendungan keureto, 27 Juni 2023		
	Meeting Materials:	Proyek Penyelesaian Pembangunan Bendungan Keureuto, 20 Juni 2023		
	Other:			

ID: 9 **Name:** Tiga Dihaji **Dam Type:** Rock fill with central core **Dam Hight:** 122,0 **m**

Contents of Risk	1	*When the risk was identified (date)*	21 Des 2022
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Tunnel / top of tunnel
	4	*Contents of risk*	Cavity of tunnel, sinkhole
	5	*Risk factors*	sinkhole apperence causing unstable dam
	6	*Events in which risks were recognized*	material collapse from top of tunnel during tunneling
	7	*Condition/Situation for risk realization*	earthquake, vibration
	8	*Impact if the risk realize*	tunnel collapse, dam foundaton disturbance
Perspectives on Risk Classification	9	*Where risk exists*	geology, rock mass, permeability, foundation
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☑ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Tunnel collapse ⇨ *tunnel excavation and looses material collapse from above => Sinkhole => additional survey for distribution=> replaced with concrete + additional steel rib* ⇨ *machine vibration during constru tion* ⇨ *tunnel collapse, sinkhole for dam foundation* ⇨ *unstrable dam foundation, dam break*

⇦ *replecing sinkhole with concrete, additional steel rib for tunnel* ⇨ *Retention*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

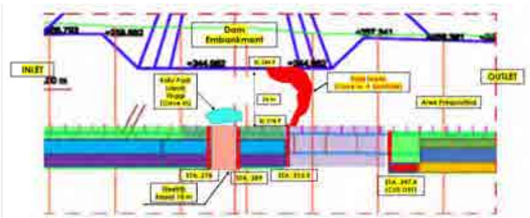


Figure-1 Sinkhole location during tunneling

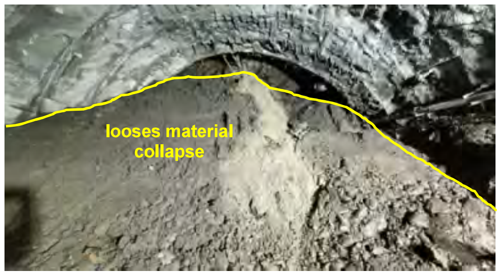


Figure-2 looses material collapse from tunnel

ID: 9 **Name:** Tiga Dihaji **Dam Type:** Rock fill with central core **Dam Hight:** 122,0 **m**

History	*Recognition or not in the past*	Unrecognized
	When the risk was recognized	*Project Phase:* Construction — *Date:* 21 Des 2022
	Status of corresponding	Replacing by concrete
Project Phase	*History of correspond to risks*	
Plan		
Design	Using steelrib for Tunnel reinforcement	
Construction	Using canopy steelrib fort tunnel reinforcement and replaced sinkhole with concrete	
Impounding		
Operation/ maintenance		

Figure-1 Additional canopy steelrib for tunnel reinforcement

Figure-2 conctete replecement fo sinkhole

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Retention
	Measures	*How to deal with*	instalation canopy steelrib for tunnel at sinkhole locaation and concrete replecement for sinkhole
		Basis for decision	geological condition
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) technical issue 2) construction time and cost		
	It should be considered that for the downstream tunnel segment of the Dam axle that passes through the loose sand layer, a drainage pipe equipped with a filter/geotextile should be installed so that the saturation level of the sand layer below the downstream slope can be reduced to minimize the liquefaction potential.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Tunnel, sinkhole, steelrib		
References	*Meeting Minutes:*	Saran Panel Ahli Bebas (HME, Bottom Outlet), 16 Mei 2023	
	Meeting Materials:	Kronologi Cave In dan Sinkhole, Penanganan Pasir Lepas pada Pondasi, Maret 2023	
	Other:	-	

Contents of Risk	1	When the risk was identified (date)	April 2021
	2	Project phase in which risks were recognized	Design
	3	Location (Structure/Area)	Dam / dam foundation
	4	Contents of risk	Instability of foundation, liquefaction, reservoir leakage
	5	Risk factors	loose sand as foundation
	6	Events in which risks were recognized	during design investigation thick loose sand was obseved
	7	Condition/Situation for risk realization	earthquake, impounding
	8	Impact if the risk realize	liquefaction, instable foundation, dam break,
Perspectives on Risk Classification	9	Where risk exists	Foundation, geology, permeability
	10	Character	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	Phase of Realization	☑ Project Implementation
			☑ Operation
			☐ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	Impact if the risk realize	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	Corresponding to risks	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Geologi of dam foundation ⇒ loose sand was observed during investigation at design stage => foundation treatment by dynamic compaction ⇒ Earthquake causing unstable foundation ⇒ liquefaction of foundaton, foundation leakage ⇒ unstable foundation, uplift foundation, dam

deep mixing method ⇒ Risk reduction

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

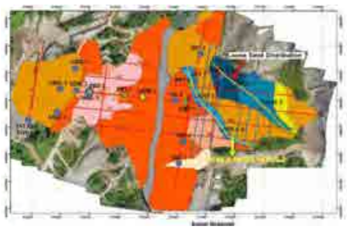


Figure-1 Distribution of loose sand at dam foundation (blue and light blue color)

Figure-2 Foundation treatment of loose sand by cyclop concrete replacing

History	Recognition or not in the past	Recognized	
	When the risk was recognized	Project Phase: Design	Date: April 2021
	Status of corresponding	Considering deep mixing methode or grouting	
Project Phase	History of correspond to risks		
Plan			
Design	Using dynamic compaction for thick layer of loose sand		
Construction	during construction grouting trial for loose sand was conduted		
Impounding			
Operation/ maintenance			

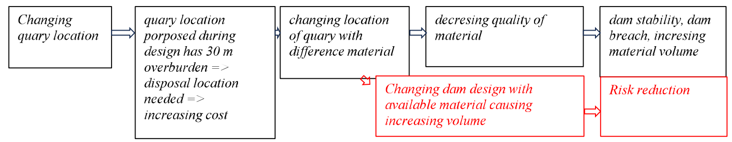
Figure-1 geological profile of dam foundation at STA+700

Investigation /analysis	Investigation/analysis to identify factors, etc.		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	Contents of measures (avoidance, reduction, transfer) or retention		reduction by conducting grouting for loose sand
	Measures	How to deal with	grouting for loose sand
		Basis for decision	time and cost
	Retention (no measures)	Reason	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.		
	Technical issues		
	To anticipate this condition, the contact area between the loose sand surface and the downstream rockfill base should be coated with a relatively thick transition zone. Cyclops concrete may be porous, so it has the potential to be a source of seepage. To anticipate this, cyclops concrete should be grouted until it meets the required Lugeon value.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Grouting, liquefaction, loose sand		
References	Meeting Minutes:	Saran Panel Ahli Bebas (HME, Bottom Outlet), 16 Mei 2023	
	Meeting Materials:	Kronologi Cave In dan Sinkhole, Penanganan Pasir Lepas pada Pondasi, Maret 2023	
	Other:	-	

ID: 9 **Name:** Tiga Dihaji **Dam Type:** Rock fill with central core **Dam Hight:** 122,0 **m**

Contents of Risk	1	***When the risk was identified (date)***	April 2022
	2	***Project phase in which risks were recognized***	Construction
	3	***Location (Structure/Area)***	Dam body, dam material
	4	***Contents of risk***	Decreasing material quality
	5	***Risk factors***	Rock properties
	6	***Events in which risks were recognized***	The quarry location at design stage has 30 m overburden that cause cost increasing
	7	***Condition/Situation for risk realization***	Dam construction
	8	***Impact if the risk realize***	Dam stability, dam breach, incresing material volume
Perspectives on Risk Classification	9	***Where risk exists***	Geology, dam material
	10	***Character***	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	***Phase of Realization***	☑ Project Implementation
			☑ Operation
			☐ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	***Impact if the risk realize***	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	***Corresponding to risks***	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships



Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Table-1 Rockfill material changing from initial design

No.	Perihal	Desain Awal	Perubahan
1	Lokasi Quarry Area	Berdasarkan laporan perencanaan Quarry Area berada di Desa Perean dengan jarak sekitar 11-15 km.	Lokasi rencana Quarry ada 2 yaitu: a. Bukit Siki : Bukit Tumpuan Kiri b. Hulu Selabung : Area Genangan
2	Jenis Material	Material tujuan sebagai timbunan batu berupa Breksi Vulkanik pada Formasi Kikim	Material tujuan sebagai bahan timbunan batu a. Bukit Siki : Batuan Sedimen (Perlapisan batupasir, batupasir sisipan batulempung, dan breksi) b. Hulu Selabung : Batuan Sedimen (Perlapisan batupasir, dan batupasir sisipan batulempung), dan Welded Tuff
3	Potensi Volume	Material tujuan memiliki estimasi volume 44,5 Juta m3	Material tujuan sebagai bahan timbunan batu memiliki potensi volume a. Bukit Siki : 14 juta m3 b. Selabung Hulu : 7,4 juta m3
4	Volume Overburden	Overburden pada Quarry Perean memiliki ketebalan hingga 30 m dengan estimasi volume 8,5 Juta m3	Overburden pada Quarry Baru: a. Bukit Siki : Ketebalan 9-30 m, volume 4,48 juta m3 b. Hulu Selabung : Ketebalan 3-40 m, volume 6,25 juta m3
5	Jalan Akses	Harus membuat jalan akses Desa Perean menuju Dam Site yang harus melewati Hutan Lindung (Perlu pembebasan lahan)	a. Bukit Siki : berada di Bukit Tumpuan Kiri (Lokasi sudah dibebaskan) b. Hulu Selabung : Area Genangan yang telah bebas
6	Parameter Kualitas	a. Kuat tekan : >400 Kg/cm2 (Untuk semua timbunan batu) b. Specific Gravity : 2,6 c. Abrasi : Loss Percentage <40% d. Soundness: Loss Percentage <10% e. Sudut geser : >35 (Transisi) dan >40 (Rockfill)	a. Kuat Tekan : 15-25 MPa (Zona Transisi/3b), >25 MPa (Zona Rockfill/3a) b. Specific Gravity : 2,3 c. Slake Durability Index (Id2) >65% d. Sudut geser : >31 (Transisi), dan >37 (Rockfill)

ID: 9 **Name:** Tiga Dihaji **Dam Type:** Rock fill with central core **Dam Hight:** 122,0 **m**

History	***Recognition or not in the past***	Unrecognized	
	When the risk was recognized	***Project Phase:*** Construction	***Date:*** April 2022
	Status of corresponding		
Project Phase	***History of correspond to risks***		
Plan			
Design	During design, the rockfill material will use breccia		
Construction	the investigation during construction the location of breccia has 30 m overburden that cause incresing excavation volume and disposal needed, then the rockfill material location is chaged to sandstone material with lower design parameter quality.		
Impounding	-		
Operation/ maintenance	-		

Investigation /analysis	***Investigation/analysis to identify factors, etc.***		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	***Contents of measures (avoidance, reduction, transfer) or retention***		redcution
	Measures	***How to deal with***	Changing dam design
		Basis for decision	Material location, implemetation cost
	Retention (no measures)	***Reason***	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-

Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***	
	Technical issue	
	Based on SNI 8062:2015, the compressive strength of rock for high dams is around 35 - 45 MPa. a dam body stability analysis according to the stone material parameters to be used and ensure that the dam body stability safety factors meet SNI requirements. It should be noted that if the technical specifications for rock fill material are not met following SNI requirements, there is a possibility that the slope of the dam body will need to be leveled, which will result in an increase in the volume of the dam body and an increase in the area of the dam site.	
Applicable standards	SNI 8062:2015	
Keywords.	Rockfill material, material changing, dam design	
References	***Meeting Minutes:***	Saran Panel Ahli Bebas (HME, Bottom Outlet), 16 Mei 2023
	Meeting Materials:	Kronologi Cave In dan Sinkhole, Penanganan Pasir Lepas pada Pondasi, Maret 2023
	Other:	-

ID: 10 **Name:** Lausimeme **Dam Type:** Zonal Rock-filled Dam with Centre Core **Dam Hight:** 77,0 m

Contents of Risk	1	***When the risk was identified (date)***	2022
	2	***Project phase in which risks were recognized***	Construction
	3	***Location (Structure/Area)***	Dam foundation
	4	***Contents of risk***	Piping of foundation
	5	***Risk factors***	uplift of dam, material leaching
	6	***Events in which risks were recognized***	a weak zone was obseved during excation of foundation u/s to d/s foundation
	7	***Condition/Situation for risk realization***	high reservoir water level, impounding, earthquake
	8	***Impact if the risk realize***	dam break
Perspectives on Risk Classification	9	***Where risk exists***	geology, permeability
	10	***Character***	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	***Phase of Realization***	☑ Project Implementation
			☐ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	***Impact if the risk realize***	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	***Corresponding to risks***	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

weak observed during foundation excavation ⇒ *during excavation for construction a weak zone was observed => detailled geological mapping* ⇒ *impounding, earthquake* ⇒ *piping of dam foundation, uplift of dam* ⇒ *dam break, flooding*

replacing grouting with secant pile ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

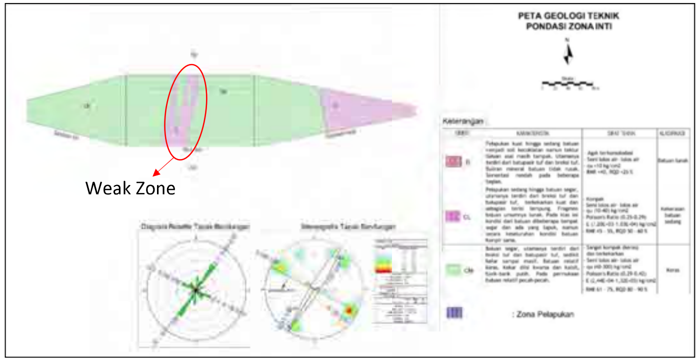


Figure-1 Engineering geology map of core foundation

ID: 10 **Name:** Lausimeme **Dam Type:** Zonal Rock-filled Dam with Centre Core **Dam Hight:** 77,0 m

History	***Recognition or not in the past***	Unrecognized	
	When the risk was recognized	***Project Phase:*** Construction	***Date:*** 2022
	Status of corresponding	Considering additional / extending gouting	
Project Phase	***History of correspond to risks***		
Plan			
Design	grouting recommendation for dam foundation improvement		
Construction	During construction the grouting depth considered is insufficient to cover the cracks in the weak zone completely		
Impounding			
Operation/ maintenance			

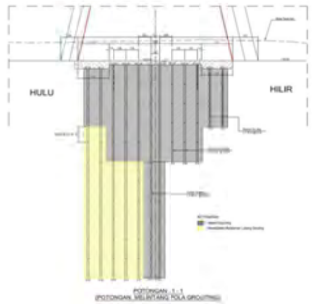


Figure-1 Additional grouting depth (yellow color)

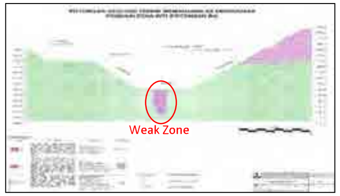


Figure-2 Engineering geology profile of main dam

Investigation /analysis	***Investigation/analysis to identify factors, etc.***		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	***Contents of measures (avoidance, reduction, transfer) or retention***		Reduction
	Measures	***How to deal with***	Aditional depth of grouting
		Basis for decision	Ground condition, dam safety
	Retention (no measures)	***Reason***	-
		Expected impact	-
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***		
	1) Technical issue		
	weak zones or faults that are not too wide, can be improve by excavating weak zone material/squeeze material to a depth of 1.5 the width of the weak/fault zone, then backfilling with wedge-shaped concrete and combining it with grouting. To monitor the pore water pressure in the weak zone, at least 2 (two) piezometers should also be installed		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords	Grouting		
References	***Meeting Minutes:***	Diskusi Teknis Pembahasan Pelaksanaan Konstruksi, 24 Maret 2023	
	Meeting Materials:	Pembangunan Bendungan Lausimeme, 16 Mei 2023 Geologi dan Grouting Pondasi Zona Inti, 19 Mei 2023	
	Other:	Detail Desain Pendahuluan, November 2015, PT. Wahana Adya KSO, PT. Teknika CiPTa Konsultan Detail Desain Geoteknik, November 2015, PT. Wahana Adya KSO, PT. Teknika CiPTa Konsultan	

ID: 10 **Name:** Lausimeme **Dam Type:** Zonal Rock-filled Dam with Centre Core **Dam Hight:** 77,0 **m**

Contents of Risk	1	*When the risk was identified (date)*	-
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam body
	4	*Contents of risk*	Fine material displacement
	5	*Risk factors*	Material gradation
	6	*Events in which risks were recognized*	Deference sieve when material is confirmed by laboratory testing
	7	*Condition/Situation for risk realization*	Reservoir water fluctuation
	8	*Impact if the risk realize*	Dam deformation, dam slope sliding
Perspectives on Risk Classification	9	*Where risk exists*	Dam material, design
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☑ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

The fine material is designed 7-50% ⇒ *The core material has differece grain size distribution when construktion implementation* ⇒ *Impounding => water level of reservoir* ⇒ *Fine material displacement* ⇒ *Dam deformation, dam slope sliding*

Changing design of filter zone material grain size distribution ⇒ *Risk avoidance*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

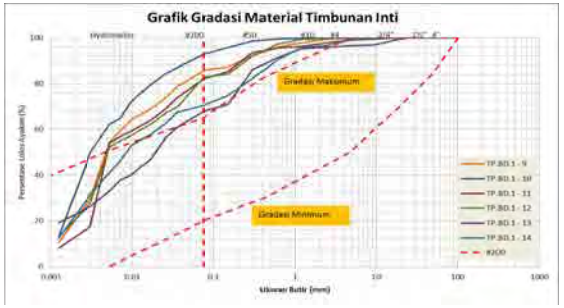


Figure-1 Gradation of core material of Lausimeme Dam

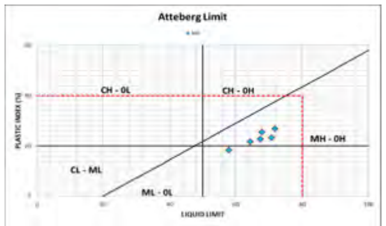


Figure-2 Plastic index and Liquid limit of material

ID: 10 **Name:** Lausimeme **Dam Type:** Zonal Rock-filled Dam with Centre Core **Dam Hight:** 77,0 **m**

History	*Recognition or not in the past*	Unrecognized	
	When the risk was recognized	*Project Phase:* Construction	*Date:* -
	Status of corresponding	Redesign by adjusting filter to core material condition	
Project Phase	*History of correspond to risks*		
Plan			
Design	The core material requirement at design stage is 7%-50% for fine material contain		
Construction	The core material properties during construction is confirmed that the fine material contain is more than 70%		

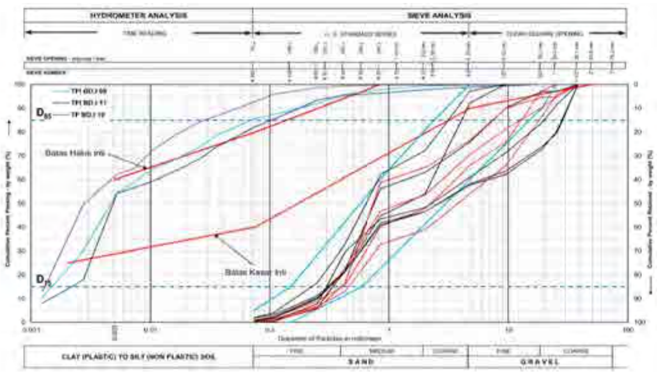


Figure-1 Comparation of core and filter gradation

Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		Soil properties test
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Avoidance
	Measures	*How to deal with*	Changing filter criteria for construction
		Basis for decision	Basis material condition
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	Technical issue Design criteria		
	These conditions indicate that the core material is not following the design assumptions. A gradation curve for the core zone material should be made according to the soil category. Furthermore, the gradation of filter material should be redesigned according to the base material.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.			
References	*Meeting Minutes:*	Diskusi Teknis Pembahasan Pelaksanaan Konstruksi, 24 Maret 2023	
	Meeting Materials:	Pembangunan Bendungan Lausimeme, 16 Mei 2023 Geologi dan Grouting Pondasi Zona Inti, 19 Mei 2023	
	Other:	Detail Desain Pendahuluan, November 2015, PT. Wahana Adya KSO, PT. Teknika CiPTa Konsultan Detail Desain Geoteknik, November 2015, PT. Wahana Adya KSO, PT. Teknika CiPTa Konsultan	

ID: 11 **Name:** Margatiga **Dam Type:** gravity concrete-rock-fill dam, central core **Dam Hight:** 20,0 **m**

	No.	Item	Content
Contents of Risk	1	*When the risk was identified (date)*	December 2022
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Reservoir
	4	*Contents of risk*	Local seismic hazard (Reservoir Induced Seismicity)
	5	*Risk factors*	Fault
	6	*Events in which risks were recognized*	There is a fault on regional geology map
	7	*Condition/Situation for risk realization*	Impounding, water pressure
	8	*Impact if the risk realize*	Earthquake in small scale, foundation demage
Perspectives on Risk Classification	9	*Where risk exists*	Geology, Fault
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Fault based on regional geology map ⇒ *There is a fault on regional geology map that recognized during technical discussion* ⇒ *Impounding and water pressure of reservoir causing reservoir induced* ⇒ *Earthquake in small scale (local earthquake* ⇒ *Foundation demage*

Instrument instalation for fault manitoring ⇒ *Early warning system, mitigation*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Figure-1 Estimated Fault base on regional geology map of surround Margatiga Dam (S. Andi Mangga, et al, 1993)

ID: 11 **Name:** Margatiga **Dam Type:** gravity concrete-rock-fill dam, central core **Dam Hight:** 20,0 **m**

History	*Recognition or not in the past*	Unrecognized
	When the risk was recognized	*Project Phase:* Impounding *Date:* December 2022
	Status of corresponding	-
Project Phase	*History of correspond to risks*	
Plan		
Design		
Construction	Based on investigation during design and construction of Margatiga Dam, no fault was observed around the site, because of the dam foundation mosly soil.	
Impounding		
Operation/ maintenance		

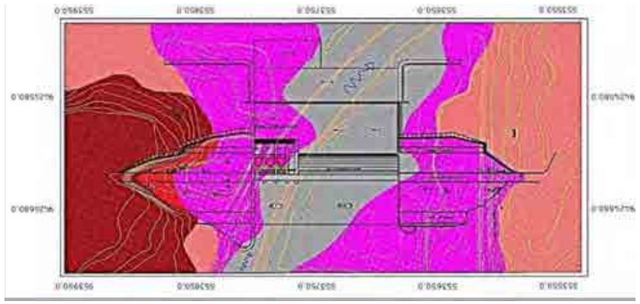


Figure-1 Geological map of Margatiga Dam

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Retention
	Measures	*How to deal with*	-
		Basis for decision	-
	Retention (no measures)	*Reason*	no fault was observed in the dam site
		Expected impact	local earthquake, foundation demage
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	Technical issue		
	One should be aware of the occurrence of reservoir-induced seismicity due to the presence of these faults during and after the initial impounding of the reservoir and during the operation and maintenance period by checking the lineaments that have seismic potential.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.			
References	*Meeting Minutes:*	Risalah Sidang Pleno Pelaksanaan Konstruksi dan Kesiapan Pengisian Awal, 5 Desember 2022	
	Meeting Materials:	Paparan Sidang Pleno, 28 November 22	
	Other:	Laporan Utama Review Desain (PT. Virama Karya, 2015)	

ID: 11 **Name:** Margatiga **Dam Type:** gravity concrete-rock-fill dam, central core **Dam Hight:** 20,0 **m**

Contents of Risk	1	*When the risk was identified (date)*	
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam body
	4	*Contents of risk*	Dam deformation, Instability of dam
	5	*Risk factors*	Material quality / quality control
	6	*Events in which risks were recognized*	Some material doesn't meet requirement
	7	*Condition/Situation for risk realization*	Impoundisng, material loading
	8	*Impact if the risk realize*	Cracking on core material, dam break
Perspectives on Risk Classification	9	*Where risk exists*	Core material, quality control
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Quality of core masterial ⇒ *Some water contain of material does not meet the requirement of water contain percentages* ⇒ *High settlement may occur at high water content material* ⇒ *cracking on core material* ⇒ *Water out through core material, dam break*

Monitoring instrumentation on material ⇒ *Risk retention*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

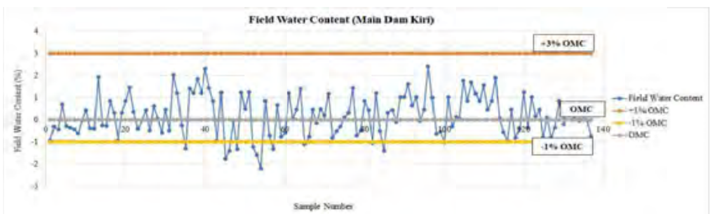


Figure-1 field water content of core material at Margatiga Dam

ID: 11 **Name:** Margatiga **Dam Type:** gravity concrete-rock-fill dam, central core **Dam Hight:** 20,0 **m**

History	*Recognition or not in the past*	Unrecognized		
	When the risk was recognized	*Project Phase:* Construction		*Date:* -
	Status of corresponding	Monitoring the instrumentation at core material		
Project Phase	*History of correspond to risks*			
Plan				
Design	-			
Construction	Some field water content for core material at matgatiga dam does not meet requirement that exceed of specification. The guideline for core material should be not less -1% of OMC and not higher +3% of OMC (optimum mouisture containt)			
Impounding	-			
Operation/ maintenance	-			
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-	
	Research/analysis, etc. to assess impact		-	
	Analysis, etc. to determine the need for and methods of response		-	
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Retention	
	Measures	*How to deal with*	-	
		Basis for decision	-	
	Retention (no measures)	*Reason*	Cost	
		Expected impact	High settlement	
	Availability and method of monitoring		Piezometer and inclinometer	
	Availability and method of information sharing		-	
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*			
	Technical issue			
	The number and percentage of test results that do not meet the requirements should be mapped (station and elevation), even though improvements have been made so that they meet the requirements.			
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)			
Keywords.	Core material, Construction requirement, monitoring			
References	*Meeting Minutes:*	Risalah Sidang Pleno Pelaksanaan Konstruksi dan Kesiapan Pengisian Awal, 5 Desember 2022		
	Meeting Materials:	Paparan Sidang Pleno, 28 November 22		
	Other:	Laporan Utama Review Desain (PT. Virama Karya, 2015)		

ID: 12 **Name:** Gongseng **Dam Type:** Rock-filled dam with central core **Dam Hight:** 34,0 **m**

	No.	Item	Content
Contents of Risk	1	*When the risk was identified (date)*	Jan 2019
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam foundation
	4	*Contents of risk*	Piping of foundation, uplift of dam body
	5	*Risk factors*	Ineffective grouting indication
	6	*Events in which risks were recognized*	Piezometer monitoring of foundation
	7	*Condition/Situation for risk realization*	High water level of reservoir
	8	*Impact if the risk realize*	Dam break causing flooding
Perspectives on Risk Classification	9	*Where risk exists*	Geology, Permeability, Design / Foundation treatment
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Gouting of dam foundation ⇒ *Piezometer monitoring at downsteam and upstream of grouting almost has same presure value* ⇒ *longterm of high water level of reservoir* ⇒ *uplift of dam body, piping of foundation* ⇒ *dam break causing flooding*

monitoring of instrument and dam deformation => socialization of warning system ⇒ *mitigation*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

During Construction, monitoring of VW piezometer at AD 04+7.5 that installed in dam foundation show the pressure is almost same.

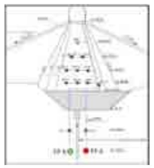


Figure-1 Piezometer reading at dam foundation during construction

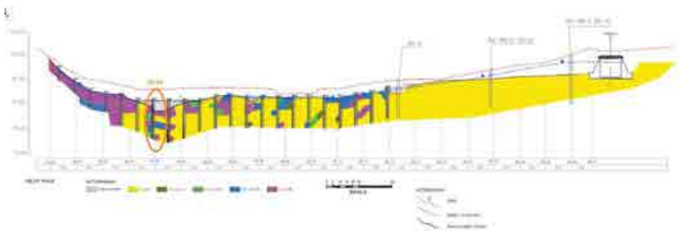


Figure-2 Lugeon profile of main dam at AD-04 based on pilot hole (before grouting)

ID: 12 **Name:** Gongseng **Dam Type:** Rock-filled dam with central core **Dam Hight:** 34,0 **m**

History	*Recognition or not in the past*	Recognized
	When the risk was recognized	*Project Phase:* Construction *Date:* Jan 2019
	Status of corresponding	-
Project Phase	**History of correspond to risks**	
Plan		
Design	using grouting to improve permeability of dam foundation	
Construction	ineffective grouting was observed during dam embankment imprementation from piezometer monitoring at foundation	

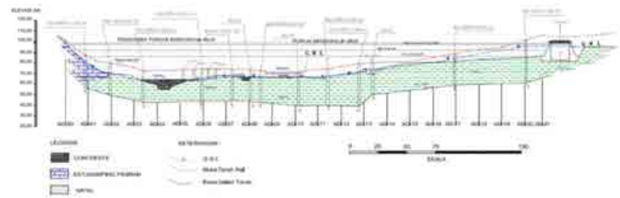


Figure-2 Geological profile of dam axis

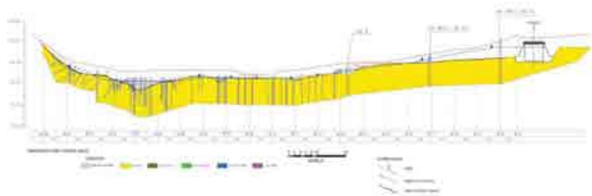


Figure-2 Lugeon profile of main dam at AD-04 based on check hole (after grouting)

Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		
	Measures	*How to deal with*	
		Basis for decision	
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) technical issues 2) dam safety		
	a. The contour depiction should be rechecked. b. Check the effectiveness of the grouting that has been done c. Check for possible seepage or springs from the foundation downstream of the dam.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords			
References	*Meeting Minutes:*	Pelaksanaan Konstruksi Bendungan Gongseng, 14 September 2021	
	Meeting Materials:	Pembahasan Konstruksi untuk pengisian awal waduk	
	Other:	Laporan Akhir (2013): Sertifikasi Desain Bendungan Gongseng	

ID: 13 **Name:** Pidekso **Dam Type:** Random earth-fill with central core **Dam Hight:** 44,0 m

Contents of Risk	1	*When the risk was identified (date)*	October 2021
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam Foundation
	4	*Contents of risk*	Piping of foundation, dam instability
	5	*Risk factors*	Piping potential due to concrete pad instalation
	6	*Events in which risks were recognized*	During discussion, dimension concrete pad instalation considered causing uplift
	7	*Condition/Situation for risk realization*	Impounding, ground water pressure
	8	*Impact if the risk realize*	Instablity of dam body may casusing dam breach
Perspectives on Risk Classification	9	*Where risk exists*	Dam stability, geology, foundation treatment, dam design
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Changing design of foundation improvement ⇒ *grouting treatment for scree deposit => Grouting Cannot be implemented (very high permeability => using secant pile for dam improvement* ⇒ *instalation secant pile for dam and concrete pad on it* ⇒ *uplift of dam due to wide dimention of concrete pad* ⇒ *instability of dam, dam breack causing flooding*

Routine monitoring instrumentation which had been installed around the concrete pad ⇒ *early warning for mitigation*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

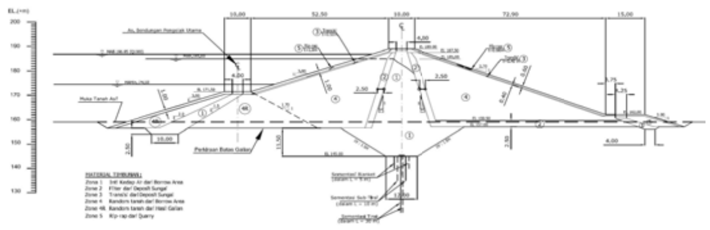


Figure-1 Initial design (DED) of Pidekso dam (PT. Mettana, 2011)

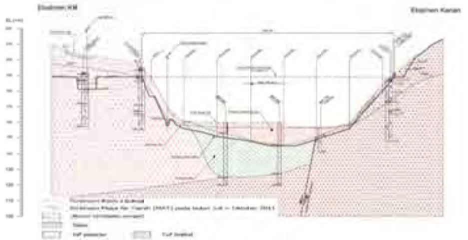


Figure-2 Geological profile of pidekso Dam using scree deposit for foundation (green color) with grouting treatment

ID: 13 **Name:** Pidekso **Dam Type:** Random earth-fill with central core **Dam Hight:** 44,0 m

History	*Recognition or not in the past*	Unrecognized	
	When the risk was recognized	*Project Phase:* Construction	*Date:* October 2021
	Status of corresponding	Changing design using secant pile for dam improvement with concrete cap instalation	
Project Phase	*History of correspond to risks*		
Plan	-		
Design	Using grouting for dam improvement		
Construction	grouting could not be carried out due to the very high permeability of the foundation so the design was replaced by using secant piles which concrete was installed on top. however, the presence of concrete is considered to have the potential for uplift due to its large dimensions and the foundation rock which has high porosity.		

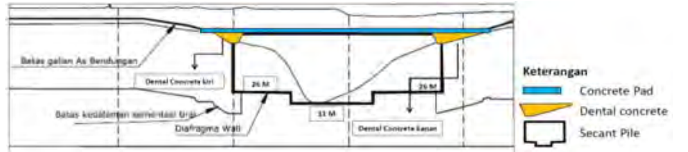


Figure-1 cross section of secant pile installation

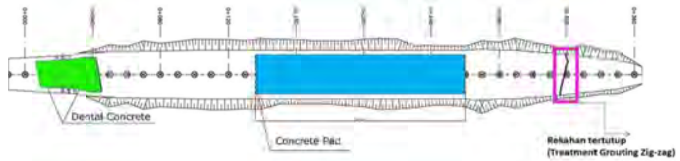


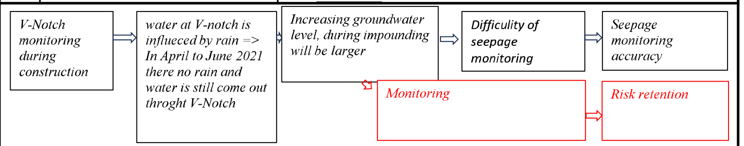
Figure-2 Dimension of concrete pad instalation (blue color)

Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Mitigation
	Measures	*How to deal with*	Monitoring instrument that had been installed around
		Basis for decision	-
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	Technical issue		
	Regular monitoring of the zone should be carried out through instrumentation installed on the dam body. The potential for uplift and accumulation of high pores water pressure in this area should also be included in the dam's OP guidelines		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Uplift, concrete pad		
References	*Meeting Minutes:*	Draft- Risalah Siang Pleno, 4 Oktober 2021	
	Meeting Materials:	Sidang Pleno Pelaksanaan Konstruksi dalam Rangka Izin Pengisian Awal, 4 Oktober 2021	
	Other:	Laporan Akhir, 28 Maret 2011, PT. Mettana: Review FS dan DD Waduk Pidekso	

ID: 13 **Name:** Pidekso **Dam Type:** Random earth-fill with central core **Dam Hight:** 44,0 **m**

Contents of Risk	1	***When the risk was identified (date)***	2021
	2	***Project phase in which risks were recognized***	Construction
	3	***Location (Structure/Area)***	Intrumentation, V-Notch
	4	***Contents of risk***	Dam seepage
	5	***Risk factors***	Water / groundwater
	6	***Events in which risks were recognized***	Monitoringn V-notch before impounding water come throgh V-notch
	7	***Condition/Situation for risk realization***	Groundwater level condition, seepage during construction
	8	***Impact if the risk realize***	Seepage monitoring accuracy
Perspectives on Risk Classification	9	***Where risk exists***	Dam body, permeability
	10	***Character***	☑ Mainly caused by external forces
			☐ Mainly due to technical factors
			☐ Factors other than the above
	11	***Phase of Realization***	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	***Impact if the risk realize***	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	***Corresponding to risks***	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships



Explanatory Diagram (Schematic Diagram/ Photos, etc.)

ID: 13 **Name:** Pidekso **Dam Type:** Random earth-fill with central core **Dam Hight:** 44,0 **m**

History	***Recognition or not in the past***	Unrecognized		
	When the risk was recognized	***Project Phase:*** Construction		***Date:*** 2021
	Status of corresponding	Monitoring		
Project Phase	***History of correspond to risks***			
Plan				
Design	-			
Construction				
Impounding				
Operation/ maintenance				
Investigation /analysis	***Investigation/analysis to identify factors, etc.***			
	Research/analysis, etc. to assess impact			
	Analysis, etc. to determine the need for and methods of response			
How to respond to risk	***Contents of measures (avoidance, reduction, transfer) or retention***			
	Measures	***How to deal with***		
		Basis for decision		
	Retention (no measures)	***Reason***		
		Expected impact		
	Availability and method of monitoring			
	Availability and method of information sharing			
Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***			
	Technical issue			
	The origin of the seepage water should be explained, including whether it is also influenced by foundation seepage, or whether there are springs during construction that come out at the current v-notch. This condition needs to be correlated with the foundation piezometer readings, to determine the pore water pressure at the time of construction completion prior to inundation.			
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)			
Keywords.	V-Notch, seepage, ground water			
References	***Meeting Minutes:***	Draft- Risalah Siang Pleno, 4 Oktober 2021		
	Meeting Materials:	Sidang Pleno Pelaksanaan Konstruksi dalam Rangka Izin Pengisian Awal, 4 Oktober 2021		
	Other:	Laporan Akhir, 28 Maret 2011, PT. Mettana: Review FS dan DD Waduk Pidekso		

ID: 13 Name: Pidekso Dam Type: Random earth-fill with central core Dam Hight: 44,0 m

	No.	Item	Content
Contents of Risk	1	*When the risk was identified (date)*	-
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam foundation / rock foundation of core
	4	*Contents of risk*	Water leakage from foundation
	5	*Risk factors*	Cracking along the core foundation
	6	*Events in which risks were recognized*	During foundation excavation long crack was observed
	7	*Condition/Situation for risk realization*	Impounding, water pressure
	8	*Impact if the risk realize*	core material leached, dam stability, dam breach,
Perspectives on Risk Classification	9	*Where risk exists*	Geology, permeability, foundation treatment
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

long crack along the foundation ⇒ *During foundation excavation long crack was observed but no information about long crack at design stage* ⇒ *water can flow through the crack during impounding* ⇒ *Water leakage from foundation* ⇒ *core material leached, dam stability, dam breach*

Conducting special grouting for crack ⇒ *Risk reduction,*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

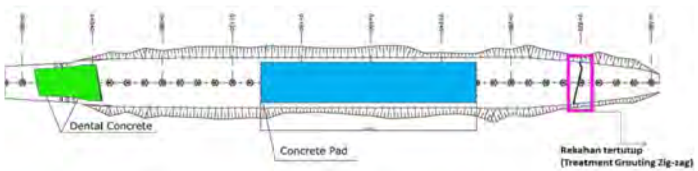


Figure-1 Location of long craking (magenta rectangle)

Photo-1 Crack condition during construktion implementation

ID: 13 Name: Pidekso Dam Type: Random earth-fill with central core Dam Hight: 44,0 m

History	*Recognition or not in the past*	Unricognized	
	When the risk was recognized	*Project Phase:* Construction	*Date:* -
	Status of corresponding		

Project Phase	History of correspond to risks
Plan	
Design	long crack is not identified when design investigation
Construction	Long crack was obseved during foundation excavation, zig-zag groting was conduction to improve the dam foundation.
Impounding	
Operation/ maintenance	

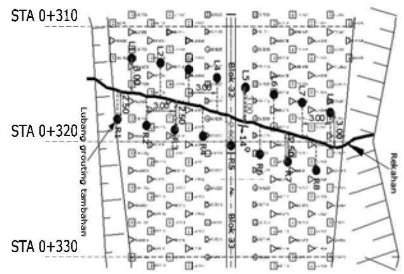


Figure-1 Zig-zag grouting that was conducted for foundation improvement at pidekso dam

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		Piezometer instalation
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	Conducting grouting along the cracking zone
		Basis for decision	Geological condition, permeability improvement
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		Piezometer
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	Technical issue		
	There is seepage at downstream of the dam at elevation +163 m, check the possible continuity of the fracture at the dam to the point where the seepage occurs. To determine the effectiveness of handling and correlation of seepage downstream, measurement data of OW (Observation Well) 7 downstream of the fracture should also be presented, especially when the reservoir water level is already at MAN +185 m.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Crack, grouting		
References	*Meeting Minutes:*	Draft- Risalah Siang Pleno, 4 Oktober 2021	
	Meeting Materials:	Sidang Pleno Pelaksanaan Konstruksi dalam Rangka Izin Pengisian Awal, 4 Oktober 2021	
	Other:	Laporan Akhir, 28 Maret 2011, PT. Mettana: Review FS dan DD Waduk Pidekso	

ID: 14 **Name:** Tugu **Dam Type:** Zonal with vertical core **Dam Hight:** 89,9 m

Contents of Risk	1	*When the risk was identified (date)*	Feb 2021
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Spillway hill / right bank
	4	*Contents of risk*	Spillway clogging
	5	*Risk factors*	Sliding of excavation hill
	6	*Events in which risks were recognized*	Sliding occur at right hill of spillway during excavation of spillway construction
	7	*Condition/Situation for risk realization*	Heavy rain, earthquake
	8	*Impact if the risk realize*	Landslide material clogging spillway, demage to spillway building
Perspectives on Risk Classification	9	*Where risk exists*	Geology, rock mass, erosion
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☐ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Slope cutting at spillway bank ⇒ *sliding occur at colluvium and weathered rock* ⇒ *heavy rain, earthquake, step cutting may trigger the landslide* ⇒ *sliding material to spillway channel causing clogging on channel* ⇒ *disturbance spillway channel and demage to it*

Gentle slope excavation, draineage, surface protection ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Photo-1 spillway bank slope condition with no protection at "C" zone

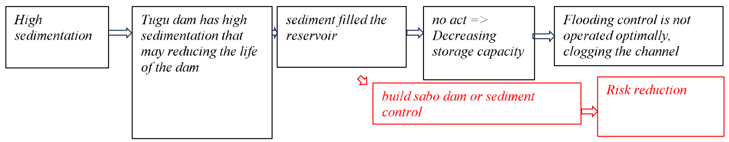
ID: 14 **Name:** Tugu **Dam Type:** Zonal with vertical core **Dam Hight:** 89,9 m

History	*Recognition or not in the past*	Unrecognized		
	When the risk was recognized	*Project Phase:*		*Date:* Feb 2021
	Status of corresponding	partial protection		
Project Phase	*History of correspond to risks*			
Plan				
Design				
Construction	 Photo-1 Sliding at right spillway during construction.			
Impounding	partially slope was protected, water erosion was observed at unprotected slope  Photo-2 Trace of landslide and patial protection of slope			
Operation/ maintenance				
Investigation /analysis	*Investigation/analysis to identify factors, etc.*			-
	Research/analysis, etc. to assess impact			-
	Analysis, etc. to determine the need for and methods of response			-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*			Retention
	Measures	*How to deal with*		
		Basis for decision		
	Retention (no measures)	*Reason*		
		Expected impact		erosional surface that can trigger landslide at spillway bank slope
	Availability and method of monitoring			
	Availability and method of information sharing			
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*			
	Technical issue			
	It should be handled comprehensively and designed for long-term stability, including improvements to the surface system and its "sub-surface drainage"			
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)			
Keywords				
References	*Meeting Minutes:*	Kajian Keamanan Bendungan, 13 SePTember 2021		
	Meeting Materials:	Monitoring dan Evaluasi Pasca Impounding, 15 SePTember 2022		
	Other:	Laporan Akhir, 27 Agustus 2013		

ID: 14 **Name:** Tugu **Dam Type:** Zonal with vertical core **Dam Hight:** 89,9 **m**

Contents of Risk	1	***When the risk was identified (date)***	-
	2	***Project phase in which risks were recognized***	Design
	3	***Location (Structure/Area)***	Reservoir area
	4	***Contents of risk***	Decreasing storage capacity
	5	***Risk factors***	Sedimentation in reservoir
	6	***Events in which risks were recognized***	the sedimentation calculation show that tugu dam has high sedimentation
	7	***Condition/Situation for risk realization***	River stream, lanslide, erosion
	8	***Impact if the risk realize***	Flooding control is not operated optimally, clogging the channel
Perspectives on Risk Classification	9	***Where risk exists***	Material sedimentation, landused
	10	***Character***	☑ Mainly caused by external forces
			☐ Mainly due to technical factors
			☐ Factors other than the above
	11	***Phase of Realization***	☐ Project Implementation
			☑ Operation
			☐ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	***Impact if the risk realize***	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	***Corresponding to risks***	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships



Explanatory Diagram (Schematic Diagram/ Photos, etc.)

ID: 14 **Name:** Tugu **Dam Type:** Zonal with vertical core **Dam Hight:** 89,9 **m**

History	***Recognition or not in the past***	Recognized	
	When the risk was recognized	***Project Phase:*** design	***Date:*** -
	Status of corresponding	Budget proposal	
Project Phase	***History of correspond to risks***		
Plan			
Design	No sediment control building		
Construction	No sediment control building		
Impounding	considering sedimentation control building like sabo dam		
Operation/ maintenance	-		
Investigation /analysis	***Investigation/analysis to identify factors, etc.***		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	***Contents of measures (avoidance, reduction, transfer) or retention***		Reduction
	Measures	***How to deal with***	Considering sedimentation building
		Basis for decision	Dam function, budged proposal
	Retention (no measures)	***Reason***	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***		
	Technical issues		
	To reduce the rate of reservoir sedimentation, integrated watershed conservation efforts should be carried out involving various related agencies and the community.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Sedimentation, reservoir, sabo dam		
References	***Meeting Minutes:***	Kajian Keamanan Bendungan, 13 SePTember 2021	
	Meeting Materials:	Monitoring dan Evaluasi Pasca Impounding, 15 SePTember 2022	
	Other:	Laporan Akhir, 27 Agustus 2013	

ID: 15 **Name:** Karian **Dam Type:** Central Cored Rockfill Dam **Dam Hight:** 65,6 **m**

Contents of Risk	1	When the risk was identified (date)	2014
	2	Project phase in which risks were recognized	Design
	3	Location (Structure/Area)	Dam body / core zone
	4	Contents of risk	High settlement of dam
	5	Risk factors	Wet core material for core zone
	6	Events in which risks were recognized	During technical discussion for impounding permit
	7	Condition/Situation for risk realization	Soil consolidation
	8	Impact if the risk realize	Dam body deformation, overtopping, cracking on dam
Perspectives on Risk Classification	9	Where risk exists	Dam material
	10	Character	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	Phase of Realization	☑ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	Impact if the risk realize	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	Corresponding to risks	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Using wet core for core zone ⇒ *during desain investigation core material was recognized has high attenberg index* ⇒ *Soil consolidation* ⇒ *high settlement of dam body* ⇒ *Dam body deformation, overtopping, cracking on dam*

Instrument monitoring ⇒ *Warning system => mitigation*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Table-1 Test Results of Embankment Material of Main Dam (Zone 1)

No	Soil Parameters		Technical specifications	Test results Maximum	Minimum	Average	Number of Tests	Remarks
1	Maximum Size	mm	100					
2	Gravel Content	%		0.9	0	0.3	15	
3	Clay Content	%		65.6	33.44	43.09	15	
4	Liquid Limit (LL)	%	< 90	77.13	60.33	68.65	15	Meet the Specifications
5	Plastic Limit (PL)	%	38.4 - 69.06	51.91	39.23	42.97	15	Meet the Specifications
6	Plastic Index (PI)	%	15 - 28	33.44	16.11	25.66	15	Meet the Specifications
7	Lab. Compaction (OMC)	%	30.16 - 44.85	42.6	36.4	38.8	15	Meet the Specifications
8	Lab. Max. Dry Density (MDD)	gr/cl	1.163 - 1.335	1.268	1.178	1.235	15	Meet the Specifications
9	Field Dry Density (γd)	gr/cl	1.12	1.273	1.104	1.184	1826	Meet the Specifications
10	Field Water Content (WC)	%	46.67 +, < 56.67 41.47 < , < 51.47	58.98	43.25	49.56	1826	Meet the Specifications
11	Degree of Density (Dd)	%	>95%	107.01	92.77	97.57	1820	Meet the Specifications
12	Field Permeability (k)	cm/sec	<1.00E-05	9.97E-06	1.15E-07	2.84E-06	991	Meet the Specifications

Photo-1 Documentation of core material compaction (left) and fiield density test (right)

ID: 15 **Name:** Karian **Dam Type:** Central Cored Rockfill Dam **Dam Hight:** 65,6 **m**

History	Recognition or not in the past	Recognized	
	When the risk was recognized	Project Phase: Design	Date: 2014
	Status of corresponding	Instrument monitoring	
Project Phase	History of correspond to risks		
Plan	-		
Design	In the design stage, mixing with with coarse material is recommended		
Construction	in the construction there is no information about mixing material for core.		

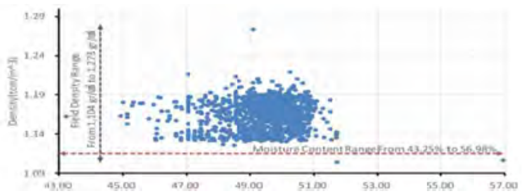


Figure-1 Relationship Between Dry Density & Water Content

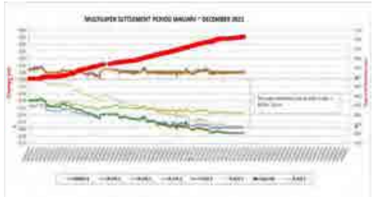


Figure-2 Multilayer settlement reading period January to December 2021

Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	Investigation/analysis to identify factors, etc.		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	Contents of measures (avoidance, reduction, transfer) or retention		retention
	Measures	How to deal with	Instrument installatoin and monitoring
		Basis for decision	Material condition
	Retention (no measures)	Reason	
		Expected impact	
	Availability and method of monitoring		Multilayer settlement instrument
	Availability and method of information sharing		-
Special Notes	Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.		
	Technical issue		
	Construction method of wet core should be explained, especially compaction method at the site. Consolidation in the wet core is usually relatively high (can reach 3% of the embankment height) and should be in the installation of instrumentation by considering the length of cable or tubing, etc		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Settlement, core material		
References	Meeting Minutes:	Pembahasan Pelaksanaan Konstruksi dan Kesiapan Pengisian Awal Waduk Bendungan Karian, 21 Maret 2022	
	Meeting Materials:	Diskusi Teknis Pengisian Awal Waduk, 21 Maret 2023	
	Other:	Review Design Report (PT. Korea Rural, 2015): Consulting Supervision For Construction Of Karian Multipurpose Dam Project	

ID: 16 **Name:** Ciawi **Dam Type:** Zonal with inclined core **Dam Hight:** 55,0 **m**

Contents of Risk	1	*When the risk was identified (date)*	18 Juli 2022
	2	*Project phase in which risks were recognized*	construction
	3	*Location (Structure/Area)*	Stilling Basin Slope
	4	*Contents of risk*	Spillway function, spillway demage
	5	*Risk factors*	Slidding of slope, slope failure
	6	*Events in which risks were recognized*	Slidding occur at excavation slope of stilling basin that had been protected
	7	*Condition/Situation for risk realization*	Heavy rain, flooding, high water level of dam
	8	*Impact if the risk realize*	Spillway malfuction due to clogged of landslide material
Perspectives on Risk Classification	9	*Where risk exists*	Rock strenght, Slope stability
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Rock excavation of slope ⇒ *Sliding of the slope upper the stilling basin => identification of landslide causes* ⇒ *Ground water pressure incresing* ⇒ *instability of cutting slope, spillway function* ⇒ *demage to spillway, spillway malfunvtion*

Additional horizontal drainage ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Photo-1 Landslide buried stilling basin

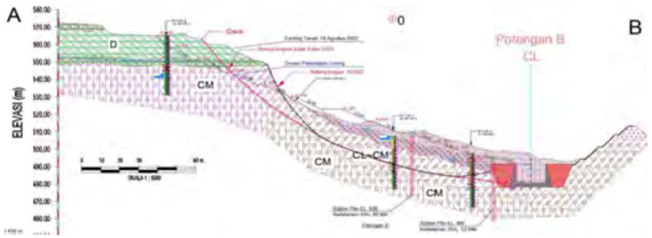


Figure-1 Engineering geology profile of spillway slope (landslide)

ID: 16 **Name:** Ciawi **Dam Type:** Zonal with inclined core **Dam Hight:** 55,0 **m**

History	*Recognition or not in the past*	Unrecognized	
	When the risk was recognized	**Project Phase:** Construction	**Date:** 18 Juli 2022
	Status of corresponding	Additional horizontal drainage, reinforcement, sloping	
Project Phase	**History of correspond to risks**		
Plan			
Design			
Construction	slope improvement is done in 3 ways: - Slope Reduction 1:2 - Installation of 2 lanes Soldier Pile - Horizontal construction		

Figure-1 Slope improvement at spillway of Ciawi Dry Dam

Impounding			
Operation/ maintenance			
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		Drilling and geophysical suvey
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		landslide occur due to pore water pressure
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	Slope reduction, drainage instalation, pile instalation
		Basis for decision	Ground condition, water level condition
	Retention (no measures)	*Reason*	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) Technical issue 2) Intisipation of flooding		
	Ensure that areas with the potential for landslides have an adequate drainage system to direct surface flow. This reduces slope loads due to high groundwater levels, reducing landslide potential. To release uplift, consider that downstream the spillway is equipped with a relief well which can also function as an observation well. To monitor slope movement, consider adding inclinometer instruments and observation wells around the landslide location.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords	Stilling basin, landslide, slope stability		
References	*Meeting Minutes:*		Sidang Pleno Pemahasan Pelaksanaan Konstruksi Dan Kesiapna Pengisian Awal Waduk, 13 Desember 2022
	Meeting Materials:		Pelaksanaan Pembangunan Bendungan Ciawi (13 Desember 2022)
	Other:		-

Name: Ciawi **Type:** Zonal with inclined core **Dam Hight:** 55,0 **m** **m**

Contents of Risk	1	**When the risk was identified (date)**	-
	2	**Project phase in which risks were recognized**	Construction
	3	**Location (Structure/Area)**	Reservoir area
	4	**Contents of risk**	Slope stability, Sedimentation
	5	**Risk factors**	Landslide
	6	**Events in which risks were recognized**	After construction
	7	**Condition/Situation for risk realization**	Impounded, rain, ground water
	8	**Impact if the risk realize**	Slope failure, decresing of storage capacity
Perspectives on Risk Classification	9	**Where risk exists**	Geology, permeability, cutting slope
	10	**Character**	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	**Phase of Realization**	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	**Impact if the risk realize**	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	**Corresponding to risks**	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions
Overview of Causal Relationships		Landslide potential ⇒ During construction many lanslide occured => strudy and improvement are carried out ⇒ heavy rain, risisng ground water level ⇒ Slope stability, Sedimentation ⇒ Slope failure, decresing of storage capacity	
		Intrument installation for monitoring ⇒ Risk retention	
Explanatory Diagram (Schematic Diagram/ Photos, etc.)			

ID: 16 **Name:** Ciawi **Dam Type:** Zonal with inclined core **Dam Hight:** 55,0 **m**

History	**Recognition or not in the past**	Unrecognized	
	When the risk was recognized	**Project Phase:** Construction	**Date:** -
	Status of corresponding	Considering instrument monotoring	
Project Phase	**History of correspond to risks**		
Plan			
Design			
Construction			
Impounding			
Operation/ maintenance			
Investigation /analysis	**Investigation/analysis to identify factors, etc.**		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	**Contents of measures (avoidance, reduction, transfer) or retention**		
	Measures	**How to deal with**	
		Basis for decision	
	Retention (no measures)	**Reason**	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***		
	Technical issue		
	a. Slopes with potential landslides should be depicted on the dam and reservoir basin layout map, with each location numbered. b. In the vicinity of these locations, intensive visual inspections and instrument monitoring should be carried out, with greater frequency, in conditions before and during the initial filling of the reservoir later. The need for intensive monitoring should be included in the OP Guidelines. c. The existence of the potential for landslides should be included as an indication of danger in the RTD Document. d. The monitoring plan to be carried out and the evaluation procedures should be included in the OP guidelines.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Dry dam, lanslide		
References	**Meeting Minutes:**	Sidang Pleno Pemahasan Pelaksanaan Konstruksi Dan Kesiapna Pengisian Awal Waduk, 13 Desember 2022	
	Meeting Materials:	Pelaksanaan Pembangunan Bendungan Ciawi (13 Desember 2022)	
	Other:	-	

ID: 17 **Name:** Sukamahi **Dam Type:** zonal random filled with incline core **Dam Hight:** 50,0 **m**

	No	Item	Content
Contents of Risk	1	***When the risk was identified (date)***	2016
	2	***Project phase in which risks were recognized***	Design
	3	***Location (Structure/Area)***	Dam body / core zone
	4	***Contents of risk***	High settlement of dam
	5	***Risk factors***	Wet core material for core zone
	6	***Events in which risks were recognized***	During technical discussion for impounding permit
	7	***Condition/Situation for risk realization***	Soil consolidation
	8	***Impact if the risk realize***	Dam body deformation, overtopping, cracking on dam
Perspectives on Risk Classification	9	***Where risk exists***	Dam material
	10	***Character***	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	***Phase of Realization***	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	***Impact if the risk realize***	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	***Corresponding to risks***	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

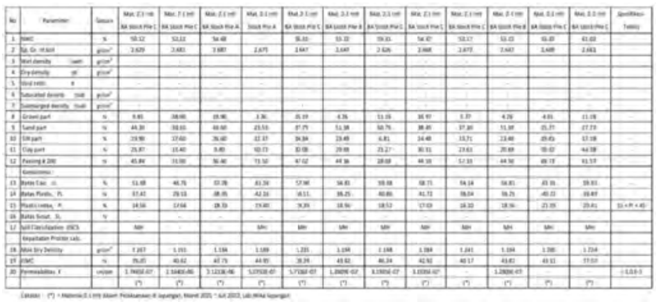
Overview of Causal Relationships

Using wet core for core zone ⇒ *during desain investigation core material was recognized has high attenberg index* ⇒ *Soil consolidation* ⇒ *high settlement of dam body* ⇒ *Dam body deformation, overtopping, cracking on dam*

Instrument monitoring ⇒ *Warning system => mitigation*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Table-1 Test Results of Embankment Material of Main Dam (Zone 1)



ID: 17 **Name:** Sukamahi **Dam Type:** zonal random filled with incline core **Dam Hight:** 50,0 **m**

History	***Recognition or not in the past***	Recognized	
	When the risk was recognized	***Project Phase:*** Design	***Date:*** 2016
	Status of corresponding	Instrument monitoring	
Project Phase	***History of correspond to risks***		
Plan			
Design	The material has a difference in NWC and OMC values between 4-12%, where the NWC value is higher than the OMC value, the core material should be dried before compaction.		
Construction	No information about embankment implementation of method of sukamahi dam		
Impounding	Sukamahi dam is dry dam		
Operation/ maintenance	Based on the multilayer settlement graph there is a settlement up to 63 cm, where the height of the Sukamahi dam is 50 m, a settlement occurs. more than 1%		

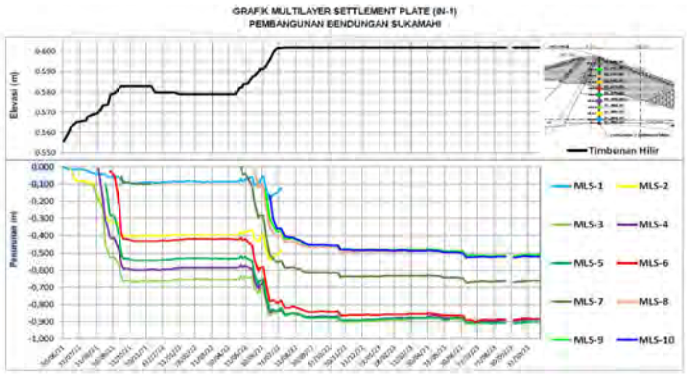


Figure-1 Multilayer sattlement graph monitoring of Sukamahi Dam

Investigation /analysis	***Investigation/analysis to identify factors, etc.***		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	***Contents of measures (avoidance, reduction, transfer) or retention***		Retention
	Measures	***How to deal with***	-
		Basis for decision	-
	Retention (no measures)	***Reason***	Soil condition
		Expected impact	High settlement
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***		
	Technical issue		
	a. To be aware, in embankments of soft (wet) soil material, embankment settlement exceeding 1% is very likely to occur; only the extent to which this settlement can exceed the plastic limit of the embankment material requires a more detailed evaluation. b. A deformation analysis should be carried out to determine the dam body's plastic and elastic limit values , then compared with the dam deformation instrumentation readings (multilayer settlement, inclinometer, and shear stakes).		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords			
References	***Meeting Minutes:***	Risalah Diskusi Teknis Pembahasan Pelaksanaan Konstruksi Dlam Kesiapan Pengisian Awal Waduk, 25 November 2022	
	Meeting Materials:	Rencana Operasi dan Pemeliharaan, 24 Nopember 2022	
	Other:	Laporan Akhir, PT. Indra Karya, Agustus 2016	

ID: 18 **Name:** Leuwikeris **Dam Type:** Rock-filled Dam, with central core **Dam Hight:** 84,9 **m**

	No.	Item	Content
Contents of Risk	1	*When the risk was identified (date)*	2023
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam foundation
	4	*Contents of risk*	Constraint in embankment, dam seepage, water pressure
	5	*Risk factors*	Ground water
	6	*Events in which risks were recognized*	in the implementation of embankment materials a lot of groundwater comes out
	7	*Condition/Situation for risk realization*	Impounding, raining
	8	*Impact if the risk realize*	core material cannot be compacted, incresing water pressure, dam stability
Perspectives on Risk Classification	9	*Where risk exists*	Geology, permeability, water pressure,
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☑ Project Implementation
			☑ Operation
			☐ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Ground water level ⇒ *a lot of groundwater comes out => Geophysical survey* ⇒ *Impounding, raining* ⇒ *Constraint in compact, dam seepage, water pressure* ⇒ *uncompacted material, water pressure, dam*

Concrete pad instalation, dewatering system ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

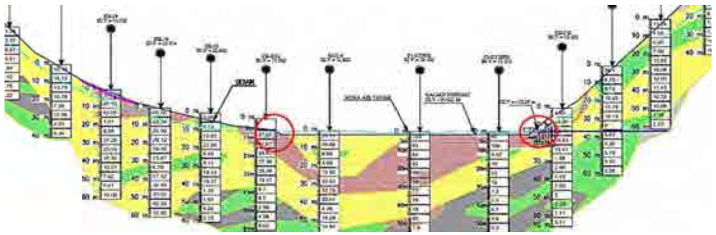


Figure-1 Lugen profile show slope cut water level

Photo-1 Water seepage at right abutment

ID: 18 **Name:** Leuwikeris **Dam Type:** Rock-filled Dam, with central core **Dam Hight:** 84,9 **m**

History	*Recognition or not in the past*	Unrecognized	
	When the risk was recognized	***Project Phase:*** Construction	***Date:*** 2023
	Status of corresponding	concrete pad instalation and dewatering system	

Project Phase	History of correspond to risks
Plan	
Design	-
Construction	After geophysical survey concete pad at left and right abutment is installed to withhold the water seepage and dewatering well is constructed to lowering gound water level.
Impounding	-
Operation/ maintenance	-

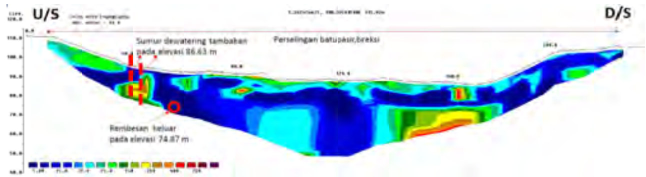


Figure-1 resistivity test at right abutment of Leuwikeris Dam


Photo-1 Concrete pad instalation at righ and left abutment

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		Geophysical survey
	Research/analysis, etc. to assess impact		Ground water level near to surface
	Analysis, etc. to determine the need for and methods of response		dewatering well additional
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	concrete pad instalation and dewatering system
		Basis for decision	Water level condition, contruction time
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	Technical issues		
	For controlling the water on foundation can be done with making a pit on base Foundation and pump it then lowering the water level. The water pressure is posible to increse after impounding, te drainage system can be considered		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Ground water, water seepage		
References	*Meeting Minutes:*	-	
	Meeting Materials:	Pembangunan Bendunagan Leuwikeris, Site visit 9 Agustus 2023	
	Other:	-	

ID: 19 **Name:** Cipanas **Dam Type:** Rock-filled dam with central core **Dam Hight:** 71,7 m

Contents of Risk	1	*When the risk was identified (date)*	-
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam Foundation
	4	*Contents of risk*	Water seepage, foundation deformation
	5	*Risk factors*	Fault, foundation deformation
	6	*Events in which risks were recognized*	during excavation of dam foudation
	7	*Condition/Situation for risk realization*	Earthquake
	8	*Impact if the risk realize*	Foundation seepage, Dam breach
Perspectives on Risk Classification	9	*Where risk exists*	Geology, permeability, faoundation treatment
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Foult on dam foundation ⇒ *excavation of dam foundation => fault identivication* ⇒ *Earthquake considering the site is near to active* ⇒ *Water seepage, foundation deformation* ⇒ *Foundation seepage, Dam breach*

Gorouting for fault ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

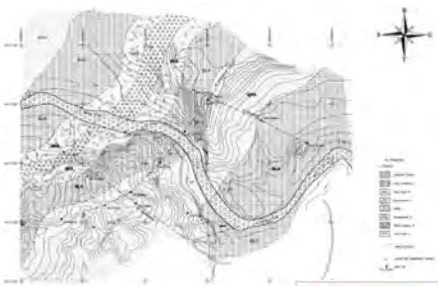


Figure-1 No fault was observed during design investigation (PT. Indrakarya 2016)

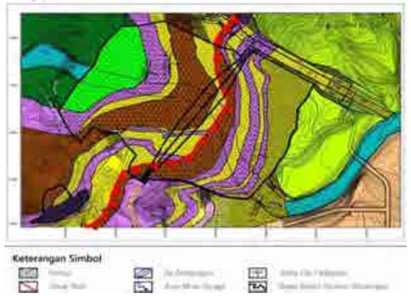


Figure-2 fault was observed during construction (PT. Rayakonsult KSO)

ID: 19 **Name:** Cipanas **Dam Type:** Rock-filled dam with central core **Dam Hight:** 71,7 m

History	*Recognition or not in the past*	Unrecognized	
	When the risk was recognized	*Project Phase:* Construction	*Date:* -
	Status of corresponding		
Project Phase	*History of correspond to risks*		
Plan			
Design	no fault is mentioned at dam foundation at design stage		
Construction	fault was observed during excavation of dam foundation at construction stage. The was improved by grouting (Stitch grouting).		

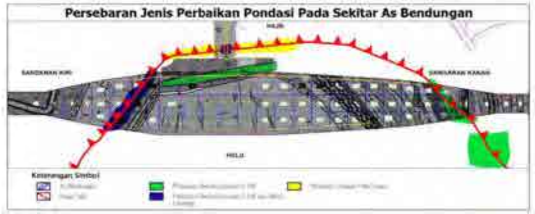


Figure-1 Foundation improvement at Cipanas Dam with dental concrete-*Stitchgrouting* (blue) and dental

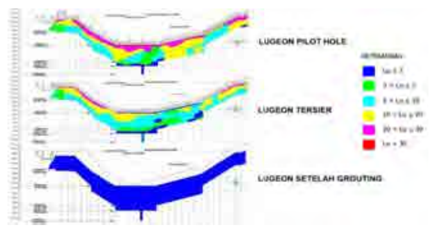


Figure-1 Lugeon profile of main Dam for pilot hole(top), tersier (middle) and check hole (bottom)

Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	conducting grouting fault at core zone foundation along the fault
		Basis for decision	geological condition
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	Technical issues		
	It should be explained that the existence of the fault regarding, outcrop at the field, brecciation zone, width of fracture etc. Considering cipanas dam is located around to active of Baribis, it could has high seismicity		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Fault, seismic hazard		
References	*Meeting Minutes:*	Risalah Sidang Pleno Pembahasan Konstruksi Dan Kesiapan Pengisian Awal Waduk , 12 April 2023	
	Meeting Materials:	Penyiapan Daerah Genangan Waduk	
	Other:	Laporan Ringkas (PT. Indra Karya,2017): Sertifikasi Desain Bendungan Cipanas (Tahap II)	

ID: 19 **Name:** Cipanas **Dam Type:** Rock-filled dam with central core **Dam Hight:** 71,7 **m**

Contents of Risk	1	**When the risk was identified (date)**	March 7, 2020
	2	**Project phase in which risks were recognized**	Construction
	3	**Location (Structure/Area)**	Saddle dam foundation, saddle dam body
	4	**Contents of risk**	Saddle breach
	5	**Risk factors**	Sliding on saddle body and foundation
	6	**Events in which risks were recognized**	Sliding was occurred during embannkment implementaion of saddle dam
	7	**Condition/Situation for risk realization**	Incresing embankment height, rain, earthquake, impounding
	8	**Impact if the risk realize**	Saddle dam breack, flooding at downstream
Perspectives on Risk Classification	9	**Where risk exists**	Geology, dam materail, foundation
	10	**Character**	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	**Phase of Realization**	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	**Impact if the risk realize**	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	**Corresponding to risks**	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Flat excavation for saddle dam → *Sliding was occurred during embannkment implementaion of saddle dam* → *Incresing embankment height, rain, earthquake, impounding* → *Sliding on saddle body and foundation* → *Saddle dam failure*

lengthen or deepen the upstream foundation foot with zone 3 (rock) embankment → *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

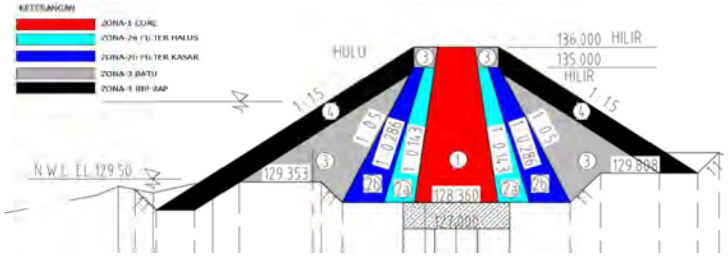


Figure-1 typical design of saddle dam

Photo-1 Sliding on saddle dam during construction

ID: 19 **Name:** Cipanas **Dam Type:** Rock-filled dam with central core **Dam Hight:** 71,7 **m**

History	**Recognition or not in the past**	Unrecognized	
	When the risk was recognized	**Project Phase:** Construction	**Date:** March 7, 2020
	Status of corresponding		
Project Phase	**History of correspond to risks**		
Plan			
Design	During design the foundation cutting is flat for saddle dam		
Construction	after sliding occur on saddle dam, consultant improved saddle dam foundation by lengthen or deepen the upstream foundation foot with zone 3 (rock) embankment		

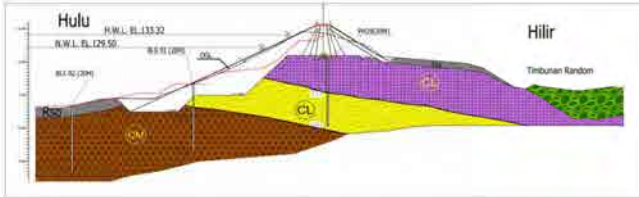


Figure-1 Geological profile of saddle dam of Cipanas Dam

Photo-1 Condition of cipanas dam after improvement

Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	**Investigation/analysis to identify factors, etc.**		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	**Contents of measures (avoidance, reduction, transfer) or retention**		Risk reduction
	Measures	**How to deal with**	lengthen or deepen the upstream foundation
		Basis for decision	Ground condition.
	Retention (no measures)	**Reason**	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		
Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***		
	Technical issue		
	In the saddle dam the installation other instruments should be considerate, for example V-notch, piezometer, etc.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.			
References	**Meeting Minutes:**	Risalah Sidang Pleno Pembahasan Konstruksi Dan Kesiapan Pengisian Awal Waduk , 12 April 2023	
	Meeting Materials:	Penyiapan Daerah Genangan Waduk	
	Other:	Laporan Ringkas (PT. Indra Karya,2017): Sertifikasi Desain Bendungan Cipanas (Tahap II)	

ID: 19 **Name:** Cipanas **Dam Type:** Rock-filled dam with central core **Dam Hight:** 71,7 m

Contents of Risk	1	**When the risk was identified (date)**	-
	2	**Project phase in which risks were recognized**	Construction
	3	**Location (Structure/Area)**	Spillway foundation
	4	**Contents of risk**	Uplift of spillway floor, spillway deformation, scouring
	5	**Risk factors**	Unconformity of rock foundation
	6	**Events in which risks were recognized**	Unconfirty was observed during excavation for spillway foundation
	7	**Condition/Situation for risk realization**	Impounding, rising of ground water level
	8	**Impact if the risk realize**	Damage to spillway, foundation failure
Perspectives on Risk Classification	9	**Where risk exists**	Geology, permeability, design
	10	**Character**	☑ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	**Phase of Realization**	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	**Impact if the risk realize**	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	**Corresponding to risks**	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Unconformity under spillway ⇒ *Unconformity was observed during spillway foundation excavation* ⇒ *Impounding, ground water level rising* ⇒ *Uplift of spillway floor, spillway deformation, scouring* ⇒ *Damage to spillway*

Drainage under spillway ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

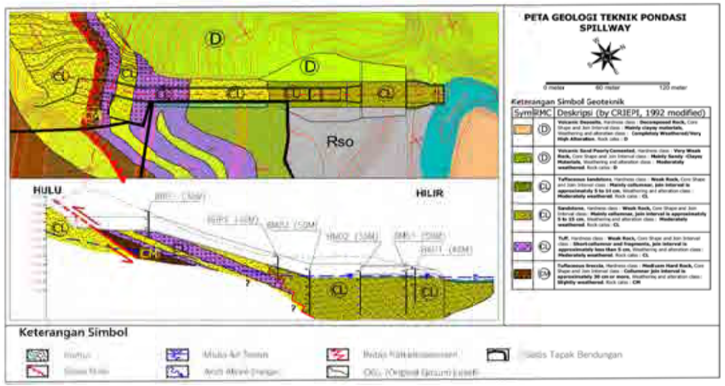


Figure-1 Geological map and profile of Cipanas dam spillway

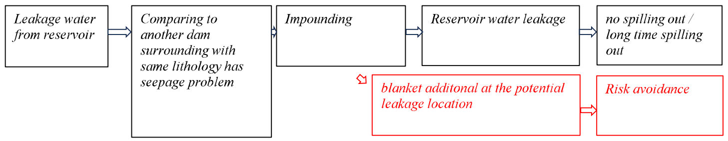
ID: 19 **Name:** Cipanas **Dam Type:** Rock-filled dam with central core **Dam Hight:** 71,7 m

History	**Recognition or not in the past**	Unrecognized	
	When the risk was recognized	**Project Phase:** Construction	**Date:** -
	Status of corresponding	to be confirmed	
Project Phase	**History of correspond to risks**		
Plan			
Design	No information about unconformity at design stage		
Construction	Unconformity was observed during excavation of spillway foundation.		
Impounding	Impounding had been conduction in May 2023, no further information after impounding		
Operation/ maintenance	-		
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		-
	Measures	*How to deal with*	-
		Basis for decision	-
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	Technical issues		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Unconformity, spillway		
References	*Meeting Minutes:*	Risalah Sidang Pleno Pembahasan Konstruksi Dan Kesiapan Pengisian Awal Waduk , 12 April 2023	
	Meeting Materials:	Penyiapan Daerah Genangan Waduk	
	Other:	Laporan Ringkas (PT. Indra Karya,2017): Sertifikasi Desain Bendungan Cipanas (Tahap II)	

ID: 20 **Name:** Semantok **Dam Type:** Zonal Earth-Filled Dam, Central core **Dam Hight:** 30,0 **m**

Contents of Risk	1	***When the risk was identified (date)***	-
	2	***Project phase in which risks were recognized***	Construction
	3	***Location (Structure/Area)***	Dam foundation, reservoir area
	4	***Contents of risk***	Water leakage
	5	***Risk factors***	Permeable reservoir rock, permeable dam foundation
	6	***Events in which risks were recognized***	Comparing to another dam surrounding has seepage problem
	7	***Condition/Situation for risk realization***	Impouding
	8	***Impact if the risk realize***	no spilling out / long time spilling out
Perspectives on Risk Classification	9	***Where risk exists***	permeability, geology / rock condition
	10	***Character***	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	***Phase of Realization***	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	***Impact if the risk realize***	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	***Corresponding to risks***	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships



Explanatory Diagram (Schematic Diagram/ Photos, etc.)

ID: 20 **Name:** Semantok **Dam Type:** Zonal Earth-Filled Dam, Central core **Dam Hight:** 30,0 **m**

History	***Recognition or not in the past***	Unrecognized	
	When the risk was recognized	***Project Phase:*** Construction	***Date:*** -
	Status of corresponding		

Project Phase	***History of correspond to risks***
Plan	
Design	No information about reservoir leakage during design stage
Construction	there was reservoir water leakage potential
Impounding	the current condition, Semantrok dam can be impounded (to be comfirmed of first spillout)  Photo-1 Condition of Semantok (image by Google, picture taken feb 2024)
Operation/ maintenance	

Investigation /analysis	***Investigation/analysis to identify factors, etc.***		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	***Contents of measures (avoidance, reduction, transfer) or retention***		-
	Measures	***How to deal with***	-
		Basis for decision	-
	Retention (no measures)	***Reason***	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-

Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***
	Technical issues
	It should be paid Attention to the possibility of a similar incident at the Semantok Dam due to the similarity of the geological conditions with the foundations of the Bening or Widas Dam and the Pacal Dam
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)
Keywords.	Reservoir leakage

References	***Meeting Minutes:***	Risalah sidang pleno pelaksanan konstruksi, 26 Agustus 2022
	Meeting Materials:	Sidang Pleno Pelaksanaan Konstruksi, 28 Juni 2022
	Other:	Laporan Utama, Juli 2017, PT. Virama Karya

ID: 21 **Name:** Bener **Dam Type:** Congrete faced rock-filled dam (CRFD) **Dam Hight:** 169,0 **m**

Contents of Risk	1	*When the risk was identified (date)*	March 2023
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam foundation
	4	*Contents of risk*	Uplift, slab demage, seepage through foundation
	5	*Risk factors*	No grouting
	6	*Events in which risks were recognized*	Regarding the lithology of foundation, it is estimated no grouting needed
	7	*Condition/Situation for risk realization*	Impounding
	8	*Impact if the risk realize*	dam breach, water leakage, flooding
Perspectives on Risk Classification	9	*Where risk exists*	Geology, permeability, dam material
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☑ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Foundation improvement by grouting at ⇒ *grouting is needed at design stage => supervisor construction convey no need for grouting due to lithology condition* ⇒ *impounding* ⇒ *Uplift, slab demage, seepage through foundation* ⇒ *dam breach, water leakage, flooding*

conducting grouting ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Figure-1 Lugeon profile of Bener dam (mostly lugeon is more than 5)

Figure-2 The trial grouting configuration to confirm permeability of rock foundation

ID: 21 **Name:** Bener **Dam Type:** Congrete faced rock-filled dam (CRFD) **Dam Hight:** 169,0 **m**

History	*Recognition or not in the past*	Recognized
	When the risk was recognized	*Project Phase:* Design — *Date:* March 2023
	Status of corresponding	Trial grouting to confirm rock condition
Project Phase	*History of correspond to risks*	
Plan		
Design	curtain grouting is recomenden to improve permeability of foundation. Aquifer layer was observed during investigation of design, the debit of aquifer is 7-30 liter/second, the aqufer indicates that the rock is permeable.	
Construction	During construction, supervicor consultan consider to do not conducting grouting for foundation and trial grouting is carried out. Based on trial grouting test, grouting is necersary.	

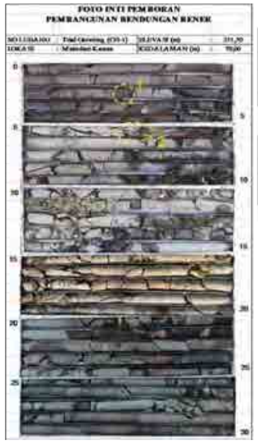


Table-1 Result of trial grouting test

No. Lubang	Nilai Lugeon / stage													
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
G1 (sebelum grouting)	5.1	24.9	-1.8	25.1	30.7	17.8	22.2	2.4	1.6	2.07	2.36	2.29	1.60	2.25
CH 1 (sesudah Grouting)	7.05	11.86	18.8	7.1	5.2	5.1	4.9	2.4	0.84	0.99	3	1.28	2.8	2.8
Efektifitas (%)	-38,24	51,19	-927,71	69,26	84,10	71,51	78,08	no grout	no grout	no grout	no grout	no grout	no grout	no grout

No. Lubang	Nilai Lugeon Rata rata / stage													
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Rata2 (G1+G2+G3)/3	14.65	18.65	18.54	15.97	14.60	16.00	15.28	5.69	1.19	2.43	2.83	2.56	2.57	2.61
CH 1 (sesudah Grouting)	7.05	11.86	18.8	7.1	5.2	5.1	4.9	2.4	0.84	0.99	3	1.28	2.8	2.8
Efektifitas (%)	51,95	36,41	-0,84	55,55	64,48	69,83	67,99	58,23	no grout	no grout	no grout	no grout	no grout	no grout

Photo-1 Drilling log result of CH-1 at depth 0 to 25 meter, shows that some joints was observed and had oxidation color, oxidation color indicated that water can flow through the rock joint

Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		Trial grouting test
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		Conducting grouting
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Risk reduction
	Measures	*How to deal with*	Conducting grouting along the plint of dam
		Basis for decision	ground condition, permeable rock
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	Technial issue		
	a) The RQD value of the foundation rock should be explained to provide an overview of the geotechnical condition of the rock foundation. b) The grouting criteria need to be determined first, taking into account the condition of the foundation rock mass based on the reference or NSPK regarding foundation repairs.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Grouting, Dam foundation, Plint		
References	*Meeting Minutes:*	Diskusi Teknis Pembahasan Konstruksi Bendungan Bener, 27 Maret 2023	
	Meeting Materials:	Power Point Trial Grouting -Kkb Maret 23 Progress Pembangunan Bendungan 20 Maret 2023	
	Other:	Laporan ringkasan (PT. Indra Karya,2015): Desain Lajutan dan Sertifikasi	

ID: 21 **Name:** Bener **Dam Type:** Congerete faced rock-filled dam (CRFD) **Dam Hight:** 169,0 **m**

Contents of Risk	1	*When the risk was identified (date)*	2015
	2	*Project phase in which risks were recognized*	Design
	3	*Location (Structure/Area)*	Dam body / dam material
	4	*Contents of risk*	Water leakage, dam stability
	5	*Risk factors*	Cracking on impermeable membrance (concrete slab)
	6	*Events in which risks were recognized*	During technical disscussion of construction implementaion
	7	*Condition/Situation for risk realization*	Dam deformation, earthquake, impounding
	8	*Impact if the risk realize*	Dam breach, water leakage through dam body
Perspectives on Risk Classification	9	*Where risk exists*	Dam material, permeability
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Bener dam is design to be concrete face rockfilled dam ⇒ *During technical discussion CRFD is risk for crack due to deformation of dam body or from the concrete its self* ⇒ *Dam deformation, earthquake, impounding* ⇒ *Water leakage, dam stability* ⇒ *Dam breach, water leakage through dam body*

proper quality control of dam material ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

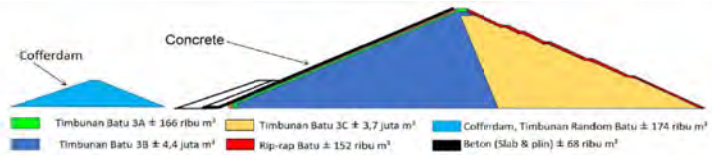


Figure-1 Typical design of bener dam (169 m dam height)

Table-1 Laboratory Testing Results of Rock Quarry Materials and allowed criteria rock fill material for CRFD (Design, 2015)

No.	Jenis Pengujian	Contoh Batuan Dari Sekitar lokasi *Quarry* (*Hand specimen*)						Kriteria Yang diizinkan
		Q-1	Q-2	Q-3	Q-4	Q-5	Q-6	
1.	Specific grafity	2,648	2,662	2,697	2,722	2,730	2,176	> 2,5
2.	Absorption (%)	2,06	1,97	1,63	1,24	1,03	7,13	< 3%
3.	Soundness (%)	1,01	0,97	1,02	1,05	0,96	9,91	< 12%
4.	Abration (%)	18,72	15,80	17,83	18,30	15,90	45,33	< 40%
5.	Compressive Strength (Kg/cm²)	707,52	822,96	708,32	755,57	845,26	247,73	> 700 kg/cm²

ID: 21 **Name:** Bener **Dam Type:** Congerete faced rock-filled dam (CRFD) **Dam Hight:** 169,0 **m**

History	*Recognition or not in the past*	Recognized		
	When the risk was recognized	**Project Phase:** Design		**Date:** 2015
	Status of corresponding			
Project Phase	*History of correspond to risks*			
Plan				
Design	At the design stage the material of rockfilled was explained. considering Bener dam has height upto 169 m that classified to very high dam.			
Construction	For construction of concrete membrance, the supervisor consultan will use Curb method. For rock material no information about the trial embankment			
Impounding				
Operation/ maintenance				

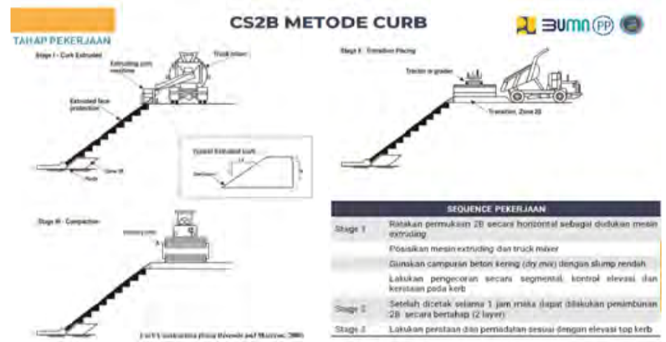


Figure-1 Curb Method for concrete membrance construction

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	High quality control for rock fill material of embankment
		Basis for decision	Dam safety, construction implementation
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) Technial issue 2) Dam material requirement		
	- gradation of embankment material (adjust to the spec/gradation prepared based on embankment experiments), - granular shape (avoid flat shapes), - use fresh and hard rock (avoid using weathered or soft rock), - use heavy vibrator rollers or impact compaction rollers, which are commonly used in high CFRD and optimum compaction layer thickness (stone size does not exceed 2/3 of the compaction layer thickness), - Watering requirements during compaction (around 100~250 l/m3).		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	CRFD, Concrete membrance		
References	*Meeting Minutes:*	Diskusi Teknis Pembahasan Konstruksi Bendungan Bener, 27 Maret 2023	
	Meeting Materials:	Power Point Trial Grouting -Kkb Maret 23 Progress Pembangunan Bendungan 20 Maret 2023	
	Other:	Laporan ringkasan (PT. Indra Karya,2015): Desain Lajutan dan Sertifikasi	

ID: 22 **Name:** Sadawarna **Dam Type:** Earth-filled dam, central core **Dam Hight:** 40,0 m

Contents of Risk	1	*When the risk was identified (date)*	2019-2022
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Spillway, conduit, dam foundation"
	4	*Contents of risk*	Dam building structure demage
	5	*Risk factors*	Fault reaktivation
	6	*Events in which risks were recognized*	Fault was observed surrounding dam sit during excavation
	7	*Condition/Situation for risk realization*	Earthquake
	8	*Impact if the risk realize*	Foundation deformation, Dam break
Perspectives on Risk Classification	9	*Where risk exists*	Geology / Strength, Permeability, Design / Foundation treatment
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Many faults were observed ⇒ during excavation for construction more much fault were observed => Special study dam's fault to the nearest active fault (Baribis Fault) ⇒ fault throgh foundation => exavation for soft material and replaced by dental concrete and filter ⇒ Deformation of dam foundation ⇒ break and flooding

special studi for fault and instrument for other fauld for monitoring ⇒ early warning for mitigation

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Figure-1 Geological Map of Sadawarna Dam that many thrust fault was observed

Photo-1 Thursh fault of Sadawarna Dam at Conduit channel

ID: 22 **Name:** Sadawarna **Dam Type:** Earth-filled dam, central core **Dam Hight:** 40,0 m

History	*Recognition or not in the past*	Recognized		
	When the risk was recognized	**Project Phase:** Consruction		**Date:** 2019-2022
	Status of corresponding	Consideriing Special study of fault		
Project Phase	***History of correspond to risks***			
Plan	-			
Design	The fault was identified during design and fault threatment was explained			
Construction	(see figures below)			
Impounding	-			
Operation/ maintenance	-			
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-	
	Research/analysis, etc. to assess impact		-	
	Analysis, etc. to determine the need for and methods of response		-	
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Mitigation	
	Measures	*How to deal with*	conducting special study regarding to the fault	
		Basis for decision	Source of active fault	
	Retention (no measures)	*Reason*	-	
		Expected impact	-	
	Availability and method of monitoring		-	
	Availability and method of information sharing		-	
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*			
	1) Technical issues			
	a) Further investigation should be carried out regarding this part of the baribis fault and its influence on the safety of the Sadawarna Dam. b) In identified locations as potentially affected by faults, intensive visual inspection and instrument monitoring should be carried out. c) The potential effect of the fault on the dam's safety should be included as an indication of the hazard in the RTD Document.			
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)			
Keywords				
References	*Meeting Minutes:*	Draft-Risalah Sidang Pleno Pelaksanaan Konstruksi dan Kesiapan Pengisian Awal Waduk, 19 Oktober 2022		
	Meeting Materials:	Sidang Pleno Impounding, 19 Oktober 2022		
	Other:	Laporan Akhir, Desember 2016, PT. Tata Guna Patria : Pekerjaan Review Desain Dan Sertifikasi Bendungan Sadawarna (Myc)		

Construction:

Figure-1 typical of Fault threatment of Sadawarna Dam

Figure-2 Fault threatment implementation during construction

ID: 23 **Name:** Bagong **Dam Type:** Rock-fill dam with central core **Dam Hight:** 82,0 m

Contents of Risk	1	*When the risk was identified (date)*	7-Jul-22
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam / Foundation, Spillway / Foundation
	4	*Contents of risk*	Instability of the foundation, Piping of the foundation
	5	*Risk factors*	Sliding of colluvium (rock mass sliding) used as foundation, Unequal settlement
	6	*Events in which risks were recognized*	Sliding of the right bank cut slope occurred during the foundation excavation.
	7	*Condition/Situation for risk realization*	Foundation deterioration over time, Impounding, Heavy rains, Earthquakes
	8	*Impact if the risk realize*	Dam breach causing flooding downstream, Damage to spillway
Perspectives on Risk Classification	9	*Where risk exists*	Geology / Strength, Permeability, Design / Foundation treatment
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Foundation excavation as designed ⇒ *Sliding of the right bank cut slope occurred =>Additional geological survey => Recognition of the* ⇒ *Redesign using colluvium as foundation* ⇒ *(ContentInstability of the foundation, Piping of the foundation* ⇒ Dam breach causing flooding

⇒ *Redesign without using colluvium as foundation (to be determined)* ⇒ *Risk avoidance*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Photo-1 Before the cut slope sliding (July 3, 2022)

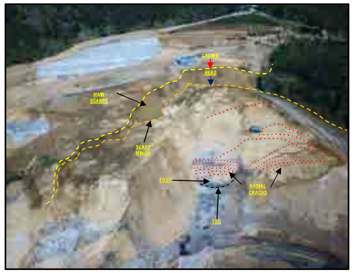


Photo-2 After the cut slope sliding (July 7, 2022)

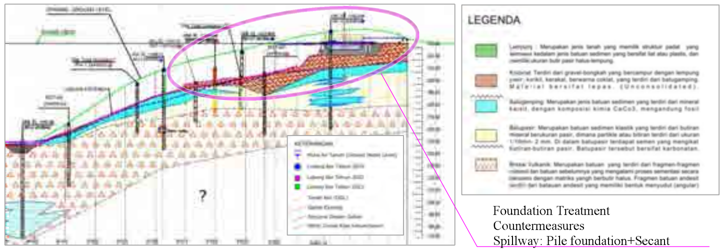


Figure-1 Right bank geologic cross section based on additional survey results

ID: 23 **Name:** Bagong **Dam Type:** Rock-fill dam with central core **Dam Hight:** 82,0 m

History	*Recognition or not in the past*	Unrecognized	
	When the risk was recognized	*Project Phase:* Construction	*Date:* 7-Jul-22
	Status of corresponding	Considering countermeasure methods	

Project Phase	*History of correspond to risks*
Plan	
Design	The design was to use bedrock as the foundation.
Construction	As the distribution of thick colluvial soil was confirmed during foundation excavation, the use of colluvial soil as the foundation is being considered.
Impounding	
Operation/ maintenance	

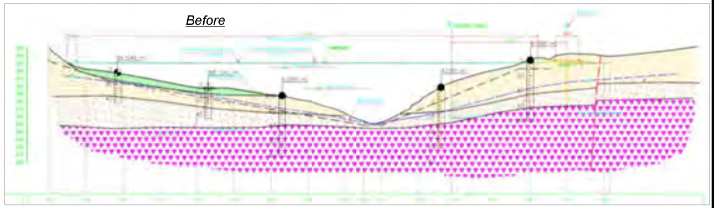


Figure-1 Dam axis geologic cross section (During investigation/design)

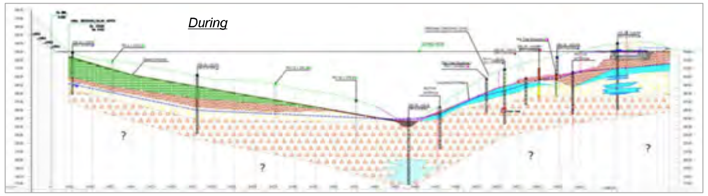


Figure-2 Geological cross section of the dam axis (Site plan after additional investigation)

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	<Foundation Treatment> Spillway: Pile foundation+Secant Pile Dam: Secant Pile
		Basis for decision	Ground conditions, Construction cost
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-

Special Notes

Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.

1) Technical issues,
2) Constraints in project implementation requirements (Construction time, costs, etc.)

The geological conditions at the dam site differed significantly between the geological investigation/design and construction phases.
The following risks should be considered once again when adopting the current countermeasure plan.
1) Sliding along the boundary between the collapsed soil and bedrock
2) Piping at the foundation where the spillway meets the dam due to unequal settlement

Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)	
Keywords	Colluvium, Weathering, Creep	
References	*Meeting Minutes:*	2023.09.21 RDT Spillway Bagong [Z-AF] + CL (rev), Cap 226-KKB Laporan Inspeksi dlm rangka Pelaksanaan Konstruksi B. Bagong
	Meeting Materials:	Paparan BTB shimizu
	Other:	LAPORAN AKHIR STUDY NEOTEKTONIK, Laporan Progress Pengeboran hasil MASW

ID: 23 Name: Bagong Dam Type: Rock-fill dam with central core Dam Hight: 82,0 m

Contents of Risk	1	When the risk was identified (date)	7-Jul-22
	2	Project phase in which risks were recognized	Construction
	3	Location (Structure/Area)	Dam / Foundation
	4	Contents of risk	Piping of the foundation, Instability of the foundation
	5	Risk factors	Sliding of colluvium used as foundation, Unequal settlement
	6	Events in which risks were recognized	Sliding of the right bank cut slope occurred during the foundation excavation
	7	Condition/Situation for risk realization	Foundation deterioration over time, Impounding, Heavy rains, Earthquakes
	8	Impact if the risk realize	Dam breach causing flooding downstream
Perspectives on Risk Classification	9	Where risk exists	Geology / Strength, Permeability, Design / Foundation treatment
	10	Character	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	Phase of Realization	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	Impact if the risk realize	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	Corresponding to risks	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Foundation excavation as designed ⇒ Sliding of the right bank cut slope occurred =>Additional geological survey => Recognition of the ⇒ Redesign using colluvium as foundation ⇒ Content Instability of the foundation, Piping of the foundation ⇒ Dam breach causing flooding

Redesign without using colluvium as foundation (to be determined) ⇒ Risk avoidance

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

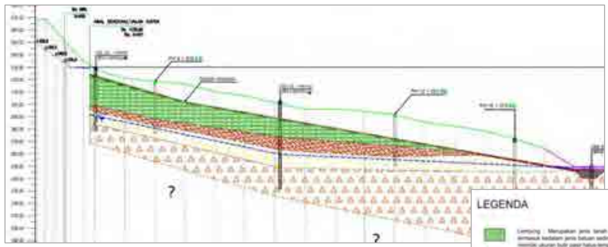


Figure-1 Left bank geologic cross section based on additional survey

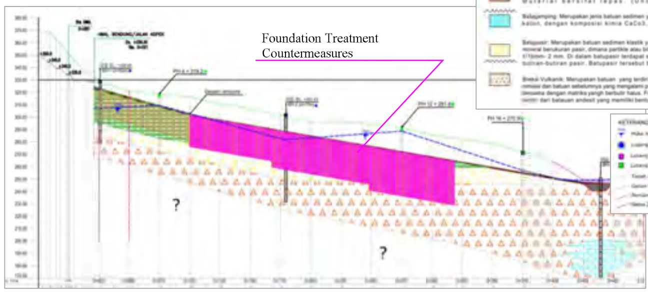


Figure-2 Secant pile construction plan

ID: 23 Name: Bagong Dam Type: Rock-fill dam with central core Dam Hight: 82,0 m

History	Recognition or not in the past	Unrecognized	
	When the risk was recognized	Project Phase: Construction	Date: 7-Jul-22
	Status of corresponding	Considering countermeasure methods	
Project Phase	History of correspond to risks		
Plan			
Design	The design was to use bedrock as the foundation.		
Construction	As the distribution of thick colluvial soil was confirmed during foundation excavation, the use of colluvial soil as the foundation is being considered.		

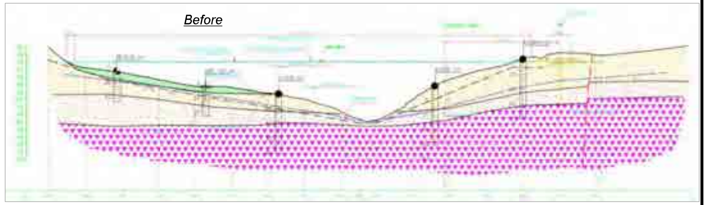


Figure-1 Dam axis geologic cross section (During investigation/design)

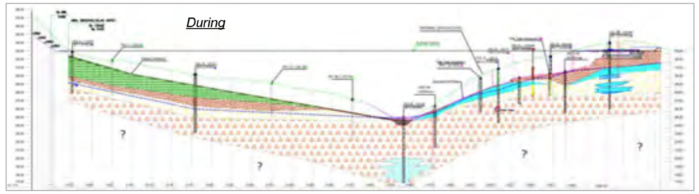


Figure-2 Geological cross section of the dam axis (Site plan after additional investigation)

Impounding			
Operation/ maintenance			
Investigation /analysis	Investigation/analysis to identify factors, etc.		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	Contents of measures (avoidance, reduction, transfer) or retention		Reduction
	Measures	How to deal with	Installation of an impervious wall with a secant pile in the collapsed soil of the foundation.
		Basis for decision	Ground conditions, Construction cost
	Retention (no measures)	Reason	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.		
	1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.)		
	The geological conditions at the dam site differed significantly between the geological investigation/design and construction phases. It should be noted that unequal settlement between the core zone foundation and the rock zone foundation should be taken into account. It is also recommended to extend the construction area of the secant pile to the top of the dam.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Colluvium, Weathering, Topographical interpretation		
References	Meeting Minutes:	2023.09.21 RDT Spillway Bagong [Z-AF] + CL (rev), Cap 226-KKB Laporan Inspeksi dlm rangka Pelaksanaan Konstruksi B. Bagong	
	Meeting Materials:	Paparan BTB shimitzu	
	Other:	LAPORAN AKHIR STUDY NEOTEKTONIK, Laporan Progress Pengeboran hasil MASW	

Contents of Risk	1	When the risk was identified (date)	"Jan 2022
	2	Project phase in which risks were recognized	Impounding
	3	Location (Structure/Area)	Reservoir area
	4	Contents of risk	Dam function disruption
	5	Risk factors	Sliding at reservoir
	6	Events in which risks were recognized	Sliding potential was observed during inspection after inpounding
	7	Condition/Situation for risk realization	Rain, earthquake, impounding (water fluctiation)
	8	Impact if the risk realize	Damage to building facility
Perspectives on Risk Classification	9	Where risk exists	
	10	Character	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	Phase of Realization	☐ Project Implementation
			☑ Operation
			☐ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	Impact if the risk realize	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	Corresponding to risks	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Sliding potential was observed at reservoir are a near to building facility ⇒ Sliding potential was observed during inspection after inpounding ⇒ Rain, earthquake, water fluctiation ⇒ Dam function disruption ⇒ Damage to building facility

Reinforcement and protection of slope ⇒ Risk reduction

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Photo-1 Location of sliding potential

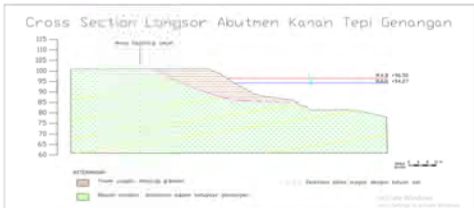


Figure-1 Geological Section of sliding potential surrounding building facility

History	Recognition or not in the past	Unrecognized	
	When the risk was recognized	Project Phase: Impounding	Date: 1-Jan-22
	Status of corresponding	Considering sloping, reinforcement and prtection	
Project Phase	History of correspond to risks		
Plan			
Design	-		
Construction	-		
Impounding	The slope has been sloped (gentle slope), but the open slope still allows landslides due to reservoir water fluctuations. The consultant recommended slope needs to be reinforced with concrete retaining walls as well as sloping the slope and re-vegetating.		
Operation/ maintenance	-		

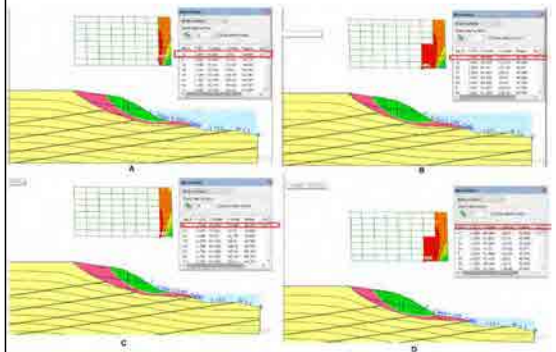


Figure-1 Slope stability analysis of sliding potential
A. Stability without earthquake (SF=1.68)
B. Stability with OBE earthquake (SF=1.47)
C. Rapid drowdown without earthquake (SF=1.62)
D. Rapid drowdown with earthquake (SF=1.48)

Investigation /analysis	Investigation/analysis to identify factors, etc.		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	Contents of measures (avoidance, reduction, transfer) or retention		Reduction
	Measures	How to deal with	
		Basis for decision	
	Retention (no measures)	Reason	
		Expected impact	
	Availability and method of monitoring		
	Availability and method of information sharing		
Special Notes	Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.		
	Technical issue		
	Considering that reservoir inundation is affected by the rise and fall of the reservoir water level, which can reduce the strength of the rock on the surface, the input material parameters used should be reduced concerning the high water level considering this in the analysis of slope stability in critical conditions.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Slope stability, sliding		
References	Meeting Minutes:	Risalah Sidang Pleno Pengisian Awal Waduk dan Kesiapan Operasi, 20 Februari 2023	
	Meeting Materials:	Pembahasan Sidang Teknis, 20 Februari 2023	
	Other:	-	

ID: 25 **Name:** Jlantah **Dam Type:** Gravel Pebble Random, Central Core **Dam Hight:** 70,0 **m**

Contents of Risk	1	*When the risk was identified (date)*	-
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam Foundation
	4	*Contents of risk*	Material leaching / washout, Foundation seepage
	5	*Risk factors*	Permeable foundation
	6	*Events in which risks were recognized*	After check hole of grouting, the lugeon value doesn't reach requirement
	7	*Condition/Situation for risk realization*	Impounding
	8	*Impact if the risk realize*	Dam breach, instability dam, posibillity doesn't determineted water level
Perspectives on Risk Classification	9	*Where risk exists*	Geology / Strength, Permeability, Design / Foundation treatment
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☑ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

using grouting for foundation improvement ⇒ *Lugeon value doesn't meet requirement, comfirmed by check hole of grouting* ⇒ *Impounding of dam* ⇒ *Material leaching / washout, Foundation seepage* ⇒ *instability dam, unreached water level determinated, dam break*

⇘ *additional cut-off wall* ⇒ *Risk avoidance*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Figure-1 Lugeon profile of pilot hole

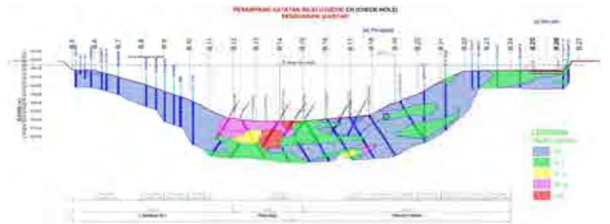


Figure-2 Lugeon profile of check hole (after grouting)

ID: 25 **Name:** Jlantah **Dam Type:** Gravel Pebble Random, Central Core **Dam Hight:** 70,0 **m**

History	*Recognition or not in the past*	recognized	
	When the risk was recognized	***Project Phase:*** Construction	***Date:*** -
	Status of corresponding	additional cut-off wall for foundation improvement	
Project Phase	***History of correspond to risks***		
Plan			
Design	Using grouting for dam foundation improvement		
Construction	after grouting was conducted, the lugeon value doesn't meet requirement then the consultand porpose to add cut-off wall for foundation		

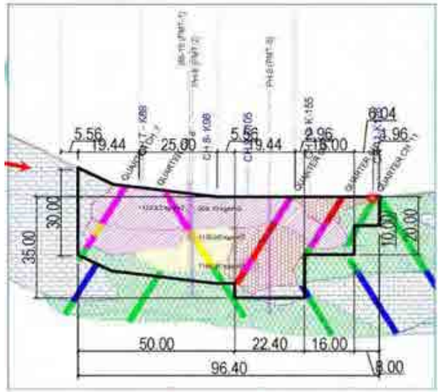


Figure-1 Design cross-section of foundation improvement with cut-off wall

Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		avoindance
	Measures	*How to deal with*	additional instalation of cut-off wall to improve permeability of foundation
		Basis for decision	Ground condition
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.)		
	the advantages and disadvantages of various alternative foundation improvement methods, the conclusions should be presented in a comparision matrix from the aspects of dam safety/success in achieving quality targets, effectiveness of foundation repair results, ease of implementation, time and cost, taking into account the geological conditions of the foundation		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Grouting, lugeon, permeability		
References	*Meeting Minutes:*	Risalah Diskusi Teknis Pembahasan Perubahan Perbaikan Fondasi, 2 Mei 2023	
	Meeting Materials:	Pembangunan BendungaN Jlantah, Feb 2023	
	Other:	-	

ID: 25 **Name:** Jlantah **Dam Type:** Gravel Pebble Random, Central Core **Dam Hight:** 70,0 **m**

Contents of Risk	1	***When the risk was identified (date)***	-
	2	***Project phase in which risks were recognized***	Construction
	3	***Location (Structure/Area)***	Dam foundation
	4	***Contents of risk***	Water seepage, uplift
	5	***Risk factors***	weak zone of cut-off wall conection
	6	***Events in which risks were recognized***	overlap of curtaion grouting and cut off wall is weak zone
	7	***Condition/Situation for risk realization***	Impounding
	8	***Impact if the risk realize***	Dam break
Perspectives on Risk Classification	9	***Where risk exists***	Geology, permeability, Desain
	10	***Character***	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	***Phase of Realization***	☑ Project Implementation
			☑ Operation
			☐ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	***Impact if the risk realize***	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	***Corresponding to risks***	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Foundation improvement ⇨ *Grouting was chosen for foundation improvement => grouting is insufcient for foundation improvement* ⇨ *Several part still has high lugeon value after gruting* ⇨ *Water seepage still can through foundation that may cause uplift* ⇨ *Dam break*

Additional cut-off wall for foundation improvement ⇨ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

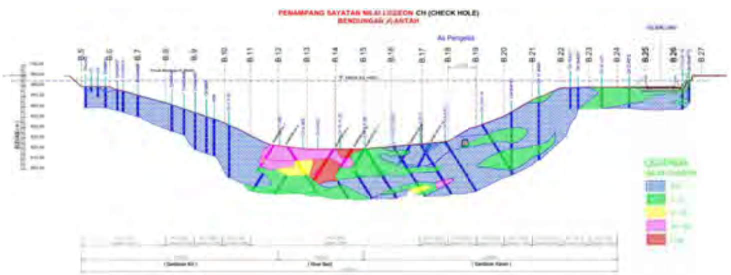


Figure-1 Lugeon profile of check hole / after grouting

ID: 25 **Name:** Jlantah **Dam Type:** Gravel Pebble Random, Central Core **Dam Hight:** 70,0 **m**

History	***Recognition or not in the past***	Unrecognized	
	When the risk was recognized	***Project Phase:*** Construction	***Date:*** -
	Status of corresponding	Considering cut off wall	
Project Phase	***History of correspond to risks***		
Plan			
Design	Grouting is used for dam improvement		
Construction	Grouting was conducted for dam improvement but several part still has high value of lugeon test. Additional Cut off wall for permeability improvement is considered		
Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	***Investigation/analysis to identify factors, etc.***		Lugeon value after grouting
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	***Contents of measures (avoidance, reduction, transfer) or retention***		Reduction
	Measures	***How to deal with***	Additional cut of wall
		Basis for decision	Ground condition, dam safety
	Retention (no measures)	***Reason***	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	***Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.***		
	Technical issue		
	The contact area between the curtain grouting structure and the diaphragm wall is a weak zone that can become a foundation seepage path. To assess the effectiveness of the cut off wall to be implemented, the pumping well test can be used.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Dam foundation, permeable zone, cut-off wall		
References	***Meeting Minutes:***	Risalah Diskusi Teknis Pembahasan Perubahan Perbaikan Fondasi, 2 Mei 2023	
	Meeting Materials:	Pembangunan BendungaN Jlantah, Feb 2023	
	Other:	-	

ID: 26 **Name:** Jragung **Dam Type:** Zonal with centre core **Dam Hight:** 59,5 m

	No.	Item	Content
Contents of Risk	1	*When the risk was identified (date)*	January 2022
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam / Foundation
	4	*Contents of risk*	Instability of the foundation
	5	*Risk factors*	Unequal settlement, groutcap demage causing crack
	6	*Events in which risks were recognized*	colluvium layer was observed during the foundation excavation
	7	*Condition/Situation for risk realization*	Foundation deterioration over time, groutcap cracking due to sattlement
	8	*Impact if the risk realize*	Dam breach causing flooding downstream
Perspectives on Risk Classification	9	*Where risk exists*	Geology / Strength, Permeability, Design / Foundation treatment
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Foundation excavation as designed ⇒ *Colluvium was observed during dam foundation excavation => identify distribution of colluvium* ⇒ *Foundation improvment for colluvium* ⇒ *Instability of the foundation* ⇒ *Dam breach, groutcap demage*

Dam foundation improvement using CTB (cement treated base). ⇒ *Risk Avoidance*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

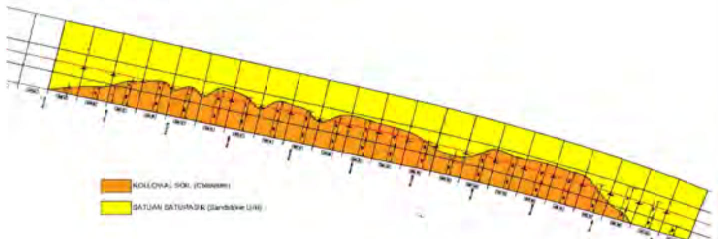


Figure-1 Distribution of Colluvium at Dam core foundation (main dam STA 1+150 s/d 1+350

Photo-1 Colluvium deposite at Jragung Dam foundation

ID: 26 **Name:** Jragung **Dam Type:** Zonal with centre core **Dam Hight:** 59,5 m

History	*Recognition or not in the past*	Unrecognized	
	When the risk was recognized	*Project Phase:* Construction	*Date:* January 2022
	Status of corresponding	Improvement using CTB (cement treated base).	
Project Phase	***History of correspond to risks***		
Plan			
Design	Using sandstone and claystone as dam foundation		
Construction	(see Figure-1)		
Impounding			
Operation/ maintenance			

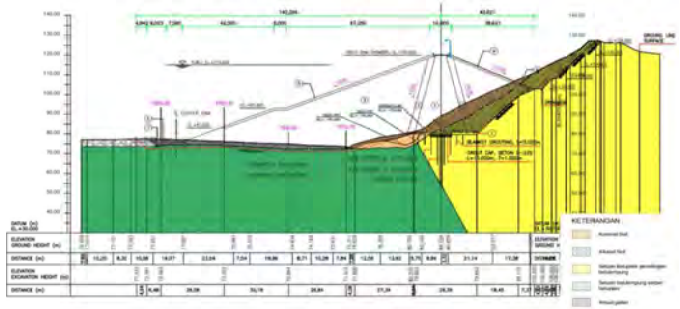


Figure-1 Gological profile of STA 1+150

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		
	Research/analysis, etc. to assess impact		
	Analysis, etc. to determine the need for and methods of response		
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Avoidance
	Measures	*How to deal with*	foundation improvement using Cement Treated Base
		Basis for decision	Cost, Groutcap instalation
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		
	Availability and method of information sharing		

Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*
	1) Technical issues, 2) Constraints in project implementation
	From the results of some consideration on colluvium location will be carried out using CTB (Cement Treated Base) with mixture: Cement: 118 kg, Aggregate: 252 kg and Water: 100. On age 28 will produce K100-k125 The CTB should compacted and the dental cement conducted on surface, because of there is a grout -cap , it is necessary to add contact grout then check holes should be carried out for grouting results.
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)
Keywords.	

References	*Meeting Minutes:*	laporan inspeksi bendungan Jragung, 14 Juni 2023
	Meeting Materials:	Diskusi Teknis 31 Januari 2023 Kondisi Geologi Bendungan
	Other:	Final Report Geolistrik - Jragung Semarang - Abipraya Juni 2022

ID: 27 Name: Marangkayu Dam Type: Homogeneous Dam Dam Hight: 15,4 m

Contents of Risk	1	When the risk was identified (date)	2013
	2	Project phase in which risks were recognized	Impounding
	3	Location (Structure/Area)	Reservoir
	4	Contents of risk	External factor
	5	Risk factors	The reservoir impound gas well
	6	Events in which risks were recognized	Gas wells were observed will be drown by dam impounding
	7	Condition/Situation for risk realization	Diversion plugging
	8	Impact if the risk realize	External factor
Perspectives on Risk Classification	9	Where risk exists	Impounding, water level
	10	Character	☐ Mainly caused by external forces
			☐ Mainly due to technical factors
			☑ Factors other than the above
	11	Phase of Realization	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☐ Due to long-term use
			☐ Others
	12	Impact if the risk realize	☐ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	Corresponding to risks	☑ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships

Dam reservoir at NWL as +110 m ⇒ before impounding at reservoir there were several gas well will be drown => identify elevation of gas well ⇒ Impounding, diversion plugging ⇒ gas well will be drown ⇒ external factor (gas well operatation)

Impound below the gas well elevation ⇒ Risk avoidance

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Figure-1 Situation of drown well (red mark) at dam NWL (elv. +110 m)

ID: 27 Name: Marangkayu Dam Type: Homogeneous Dam Dam Hight: 15,4 m

History	Recognition or not in the past	Unricognized	
	When the risk was recognized	Project Phase: Impounding	Date: 2013
	Status of corresponding	Considering lowering reservoir water level	
Project Phase	History of correspond to risks		
Plan			
Design	The reservoir was planned at elvation of +110 m for normal water level		
Construction	Dam was constructed at elvation of +110 m for normal water level		
Impounding	the initial impounding will be targeted at elevation of +107.23 m by using emergency spillway		

Figure-1 Initial impunding target (elv. 107.23 m)

Operation/ maintenance			
Investigation /analysis	Investigation/analysis to identify factors, etc.		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	Contents of measures (avoidance, reduction, transfer) or retention		avoidance
	Measures	How to deal with	Reducing reservoir water level
		Basis for decision	External factor of gas well
	Retention (no measures)	Reason	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.		
	1) Technical issue		
	Consider cutting or lowering some of the main spillway building crests. To obtain a large enough reservoir volume, consider the overflow building in combination with installing several doors.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.			
References	Meeting Minutes:	Risalah Persiapan Pengisian Awal Waduk, 28 Desember 2021	
	Meeting Materials:	Kajian Geoteknik Sertifikasi Ponding Review Ulang Hidrologi , 2021	
	Other:	Laporan DED Bendungan Marangkayu, PT. Teknika Cipta Konsula, Maret 2007	

ID: 28 Name: Sepaku Semoi Dam Type: Homogeneous Dam Dam Hight: 22,0 m

	No.	Item	Content
Contents of Risk	1	*When the risk was identified (date)*	-
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam foundation
	4	*Contents of risk*	Differential settlement
	5	*Risk factors*	High difference modulus value of rock foundation and concrete for tretment
	6	*Events in which risks were recognized*	During excavation cavity was observed
	7	*Condition/Situation for risk realization*	Embankment load
	8	*Impact if the risk realize*	Cracking at core material, water leakage, dam breach
Perspectives on Risk Classification	9	*Where risk exists*	Geology / strengh, construction material, treatment
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Foundation improvement ⇒ *During excavation cavity was observed => foundation treatment by dental concrete k225* ⇒ *loading of embankment* ⇒ *Differential settlement* ⇒ *Cracking at core material, water leakage, dam breach*

using concrete which has same modulus of rock foundation ⇒ *Risk reduction*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Photo-1 Rock foundation condition of Sepaku Semoi Dam

ID: 28 Name: Sepaku Semoi Dam Type: Homogeneous Dam Dam Hight: 22,0 m

History	*Recognition or not in the past*	Unrecognized	
	When the risk was recognized	*Project Phase:* Construction	*Date:* -
	Status of corresponding	Foundation improvement using dental concrete K225	
Project Phase	***History of correspond to risks***		
Plan			
Design	No cavity information during the investigation at design stage		
Construction	Foundation improvement by dental concret K225 at cavity but the the modulus of concrete and rock foundation has high modulus differece		
Impounding	-		
Operation/ maintenance	-		
Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Reduction
	Measures	*How to deal with*	conducting dental congcrete
		Basis for decision	Rock foundation condition
	Retention (no measures)	*Reason*	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	Technical issues		
	Anything that needs to be considered is the potential for differential settlement if the dental modulus value of the concrete is significantly different from the modulus value of the surrounding rock		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.	Satlement, limestone		
References	*Meeting Minutes:*	Risalah Sidang Pengisian Awal Waduk, 26 Juni 2023	
	Meeting Materials:	Diskusi Persiapan Impounding	
	Other:	Executive Report, November 2019, PT. Teknika CiPTa Konsultan	

ID: 29 Name: Karralloe Dam Type: Concrete face rock-filled Dam (CRFD) Dam Hight: 85,0 m

Contents of Risk	1	*When the risk was identified (date)*	July 2023
	2	*Project phase in which risks were recognized*	After impounding
	3	*Location (Structure/Area)*	Intake tunnel
	4	*Contents of risk*	Water flow, material dissolution
	5	*Risk factors*	tunnel collapse
	6	*Events in which risks were recognized*	during inspection seepage was observed at the intake tunnel
	7	*Condition/Situation for risk realization*	Water pressure, water flow
	8	*Impact if the risk realize*	Unstable wall tunnel
Perspectives on Risk Classification	9	*Where risk exists*	Geology, permeability, concrete material
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Seepage at intake tunnel ⇒ *during inspection seepage was observed at the intake tunnel = Debit monitoring* ⇒ *Water come out through tunnel wall due to Water pressure,* ⇒ *material dissolution => Decrising material quality* ⇒ *Unstable wall tunnel, Tunnel collpse*

water discharge and condition monitoring ⇒ *Risk retention*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

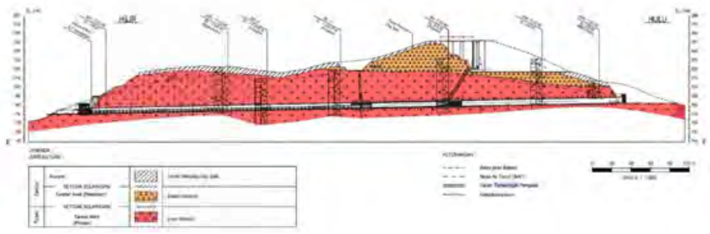


Figure-1 Geological profile along the tunnel of Karalloe Dam

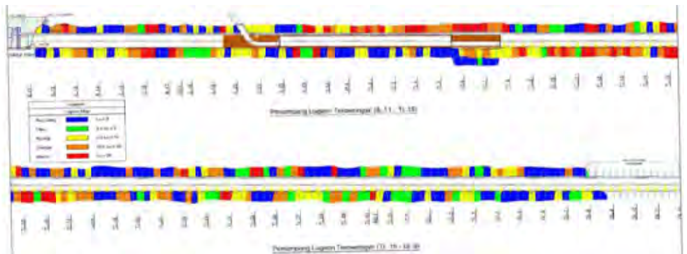


Figure-2 Lugeon profile along the tunnel of Karalloe Dam

ID: 29 Name: Karralloe Dam Type: Concrete face rock-filled Dam (CRFD) Dam Hight: 85,0 m

History	*Recognition or not in the past*	Unrecognized
	When the risk was recognized	*Project Phase:* Impouding — *Date:* July 2023
	Status of corresponding	Risk retention and monitoring

Project Phase	History of correspond to risks
Plan	-
Design	-
Construction	-
Impounding	The water that comes out is tolerated because the discharge is relatively constant and is not affected by the ups and downs of the reservoir water so it is considered to come from groundwater.
Operation/ maintenance	-

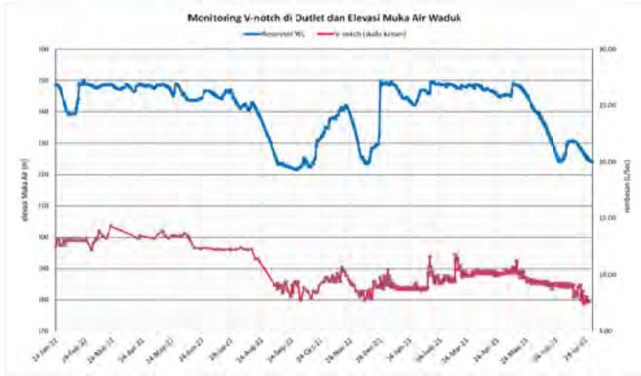


Figure-1 Graph of v-note monitoring at the outlet of tunnel (red)

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Retention
	Measures	*How to deal with*	-
		Basis for decision	-
	Retention (no measures)	*Reason*	Resevoir water level is not effect to dischage at tunnel seepage
		Expected impact	Decresing quality of concrete material of tunnel
	Availability and method of monitoring		Instalation v-notch
	Availability and method of information sharing		-

Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*
	technical issue
	even the seepage has no relation to reservoir, the control of water should be conducted. The water at the tunnel can increase the air moisturation that effect to concrete inside the tunnel
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)
Keywords	Seepage, tunnel

References	*Meeting Minutes:*	-
	Meeting Materials:	Diskusi Teknis Karalloe, Pemantauan Setelah Impounding Bendungan Karalloe, 7 Januari 2022 Pendahuluan-Sertifikasi Izin Operasi, 4 Juni 2023
	Other:	Laporan Akhir (PT. Mettana, 2014): Desain Bendungan Karalloe (Sertifikasi Karalloe,2014)

ID: 29 **Name:** Karralloe **Dam Type:** Concrete face rock-filled Dam (CRFD) **Dam Hight:** 85,0 **m**

Contents of Risk	1	*When the risk was identified (date)*	-
	2	*Project phase in which risks were recognized*	Construction
	3	*Location (Structure/Area)*	Dam faundation
	4	*Contents of risk*	material leaching, water leakage
	5	*Risk factors*	water seepage
	6	*Events in which risks were recognized*	several springs were observed in dam foundation
	7	*Condition/Situation for risk realization*	increasing ground water level, impounding
	8	*Impact if the risk realize*	piping, dam stability
Perspectives on Risk Classification	9	*Where risk exists*	
	10	*Character*	☐ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	*Phase of Realization*	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	*Impact if the risk realize*	☑ Affects dam safety
			☐ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	*Corresponding to risks*	☐ Basically risk avoidance
			☐ Consider mitigation measures as risk avoidance is difficult.
			☑ Risk retention under certain conditions

Overview of Causal Relationships

Spring on dam foundation ⇒ *during foundation excavation, spring observed that come out through water fracture* ⇒ *increasing ground water level may increasing the spring discharge* ⇒ *material leaching, water leakage* ⇒ *piping, dam stability*

Monitoring ⇒ *Risk Retention*

Explanatory Diagram (Schematic Diagram/ Photos, etc.)

Photo-1Seepage of water at downstream of right bank above the river basin

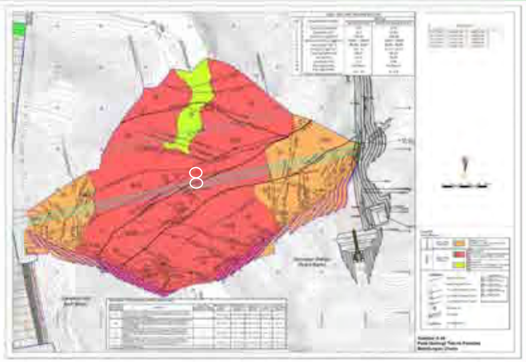


Figure -1 Location of seepage under geological map of dam foundation (white ciecle)

ID: 29 **Name:** Karralloe **Dam Type:** Concrete face rock-filled Dam (CRFD) **Dam Hight:** 85,0 **m**

History	*Recognition or not in the past*	Unrecognized	
	When the risk was recognized	*Project Phase:* Construction	*Date:* -
	Status of corresponding	Retention	

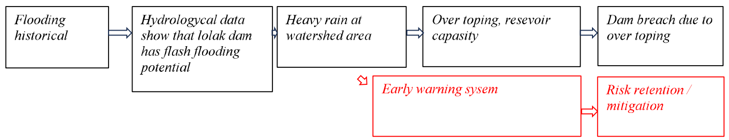
Project Phase	***History of correspond to risks***
Plan	
Design	
Construction	Based on consultant information that water seepage found downstream to the right of the dam above the river trough has a discharge of about 1 l/s and did not increase during construction, so that after being buried by zone 3c embankment material during construction until post impounding.
Impounding	The seepage also flows on the surface and merges with the water whose volume is recorded at the V-notch. The volume recorded at the v-notch in the dry season is about 7.5 l/s and in the rain season 40-50 l/s.
Operation/ maintenance	-

Investigation /analysis	*Investigation/analysis to identify factors, etc.*		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	*Contents of measures (avoidance, reduction, transfer) or retention*		Retention
	Measures	*How to deal with*	-
		Basis for decision	-
	Retention (no measures)	*Reason*	Cannot be monitoring after burried by embankment
		Expected impact	Material leaching
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	*Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.*		
	Technical issue		
	A comparison of the discharge from construction to post impounding should be presented at this time.		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.			
References	*Meeting Minutes:*	-	
	Meeting Materials:	Diskusi Teknis Karalloe, Pemantauan Setelah Impounding Bendungan Karalloe, 7 Januari 2022 Pendahuluan-Sertifikasi Izin Operasi, 4 Juni 2023	
	Other:	Laporan Akhir (PT. Mettana, 2014): Desain Bendungan Karalloe (Sertifikasi Karalloe,2014)	

ID: 30 **Name:** Lolak **Dam Type:** Zonal with central core **Dam Hight:** 58,0 **m**

Contents of Risk	1	**When the risk was identified (date)**	-
	2	**Project phase in which risks were recognized**	Construction
	3	**Location (Structure/Area)**	Dam body
	4	**Contents of risk**	Over toping, resevoir capasity
	5	**Risk factors**	Flash Flooding, sedimentation
	6	**Events in which risks were recognized**	Historical of flash flooding is convey when technical discussion
	7	**Condition/Situation for risk realization**	Heavy rain at watershed area
	8	**Impact if the risk realize**	Dam breach due to over toping
Perspectives on Risk Classification	9	**Where risk exists**	Design, morphology
	10	**Character**	☑ Mainly caused by external forces
			☑ Mainly due to technical factors
			☐ Factors other than the above
	11	**Phase of Realization**	☐ Project Implementation
			☑ Operation
			☑ Due to large-scale external force action
			☑ Due to long-term use
			☐ Others
	12	**Impact if the risk realize**	☑ Affects dam safety
			☑ Affects dam function
			☐ Affect the schedule and costs of the projects
	13	**Corresponding to risks**	☐ Basically risk avoidance
			☑ Consider mitigation measures as risk avoidance is difficult.
			☐ Risk retention under certain conditions

Overview of Causal Relationships



Explanatory Diagram (Schematic Diagram/ Photos, etc.)

ID: 30 **Name:** Lolak **Dam Type:** Zonal with central core **Dam Hight:** 58,0 **m**

History	**Recognition or not in the past**	-	
	When the risk was recognized	**Project Phase:**	**Date:** -
	Status of corresponding		
Project Phase	**History of correspond to risks**		
Plan			
Design	No information about flashflooding potential		
Construction	no data		
Impounding	no data		
Operation/ maintenance	-		

Investigation /analysis	**Investigation/analysis to identify factors, etc.**		-
	Research/analysis, etc. to assess impact		-
	Analysis, etc. to determine the need for and methods of response		-
How to respond to risk	**Contents of measures (avoidance, reduction, transfer) or retention**		Retention
	Measures	**How to deal with**	Eartly warning system
		Basis for decision	Climate condition
	Retention (no measures)	**Reason**	-
		Expected impact	-
	Availability and method of monitoring		-
	Availability and method of information sharing		-
Special Notes	**Challenges: 1) Technical issues, 2) Constraints in project implementation requirements (Construction time, costs, etc.), 3) Constraints in dam operation, 4) Issues due to human and organisational factors, results of risk response - 5) Impact on processes, costs, etc., 6) Reflection points (room for improvement of risk management methods), etc.**		
	Technical issue		
	1. Should be able to use an early warning system as was done in previous studies to minimize the impact of flash floods. 2. Response to flooding if using the model will take time. The guidline should be able to provide that the Dam Manaement Unit can hold to respond to future floods		
Applicable standards	(Describe standards related to geological study, dam design, and countermeasure design.)		
Keywords.			
References	**Meeting Minutes:**	Risalah Diskusi Teknis Pembahasan Kesiapan Pengisian Awal Bendunga Lolak, 11 Agustus 2023	
	Meeting Materials:	Pembahasan Kesiapan Pengisian Awal, 11 Agustus 2023	
	Other:	Laporan Akhir, Perencanaan DD Bendungan Lolak, 2007 Laporan Akhir, Sertifikasi Bendungan Lolak, PT. Indrakarya, Desember 2014	