3. Presentation Materials in Seminar

<u>1st Seminar</u>

01 Towards Safety & Sustainability of Dam Construction in Indonesia

02 Seminar on Risk Management for Dam

03 Seminar on Risk Management for Dam_Geo

<u>2nd Seminar</u>

01 Seminar on Risk Management for Dam II

02 Seminar on Risk Management for Dam_Geo2

03 2024 INACOLD-- Risk Management of Ageing Dam

<u>INACOLD Webinar</u>

20240710 RCC Dam Basic Concept

1st Seminar

01 Towards Safety & Sustainability of Dam Construction in Indonesia

TOWARDS SAFETY and SUSTAINABILITY OF DAM CONSTRUCTION IN INDONESIA

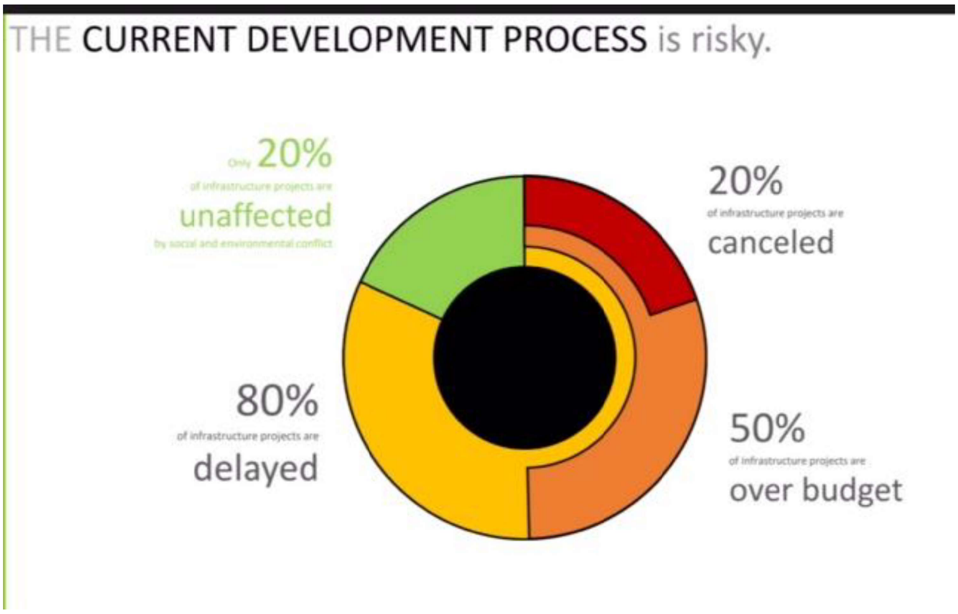
CONTENTS

- "Construction"
- Safety and Sustainability
- Design issues
- Implementation issues
- Moving forward

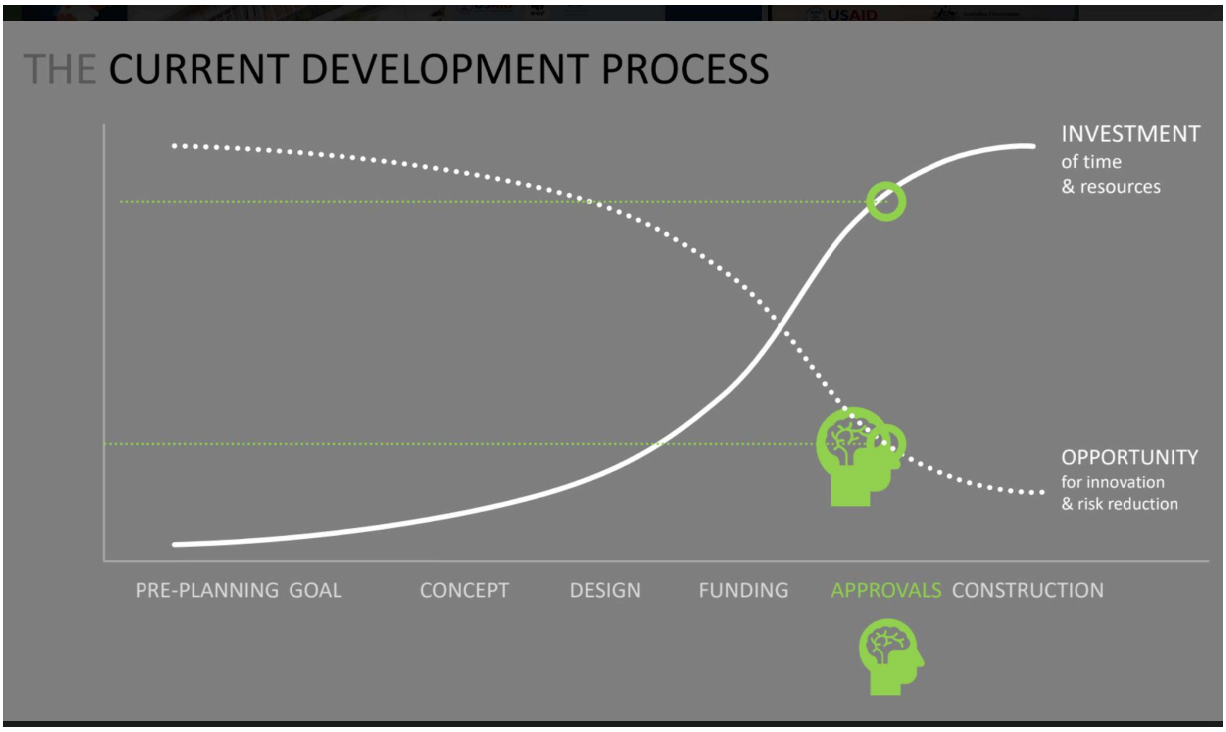
1. "CONSTRUCTION"

- Site activity focused?
- What about planning & design?
- Dams: multi disciplinary aspects

Construction / Infrastructure Projects



A review on dam development process



2. Safety in Dam Development

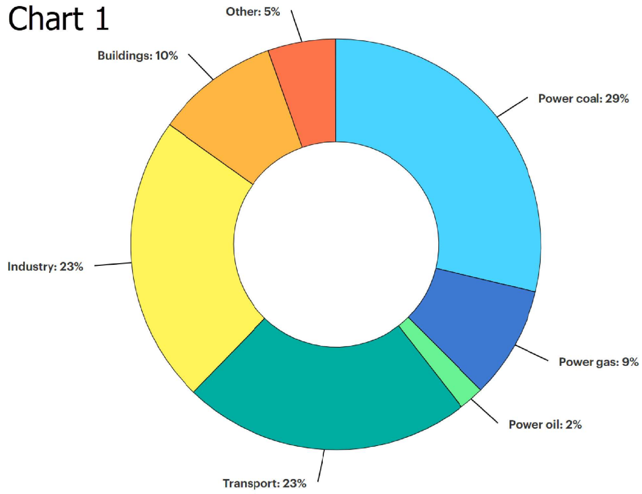
(Changing conditions: ICOLD's World Declaration)

> >> "Better Dams for a Better World"<<<

- Safety of Existing Dams – Same as New Dams
- Safety of Tailings Dams and Mining Dams – Same Criteria as Water Dams
- Lifecycle Dam Safety Assessments
- Safety of Specific Hazards (Floods, earthquakes, landslides, etc.)
- Safety of Systems – cascades, transboundary jurisdiction's, etc.
- Reservoir Sedimentation
- Climate Change Impacts
- Regular Operation and Maintenance

SUSTAINABILITY
in DAM CONSTRUCTION

Chart 1

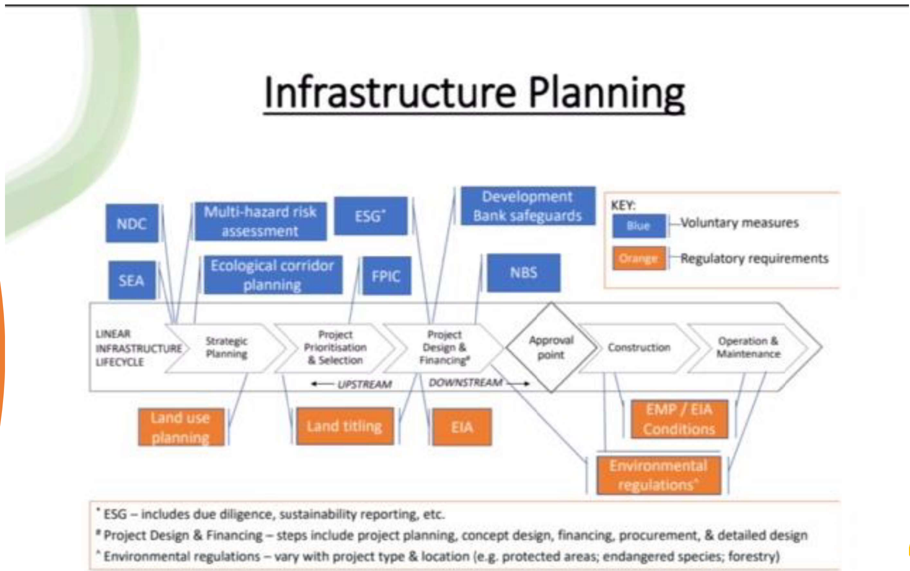


- **The heavy construction industry is accounting for almost 25% of global CO_2 emissions. For every 1 ton of cement produced there is a huge amount of CO_2 released in the atmosphere.**
- **The yearly production of cement is almost 4 billion tons. Hence this industry needs to expedite the current pace of decarbonisation by 300% compared to the previous 30 years in order to meet the COP26 goal by 2050.**
- **The chart 1 shows emissions by sectors (source: IEA).**

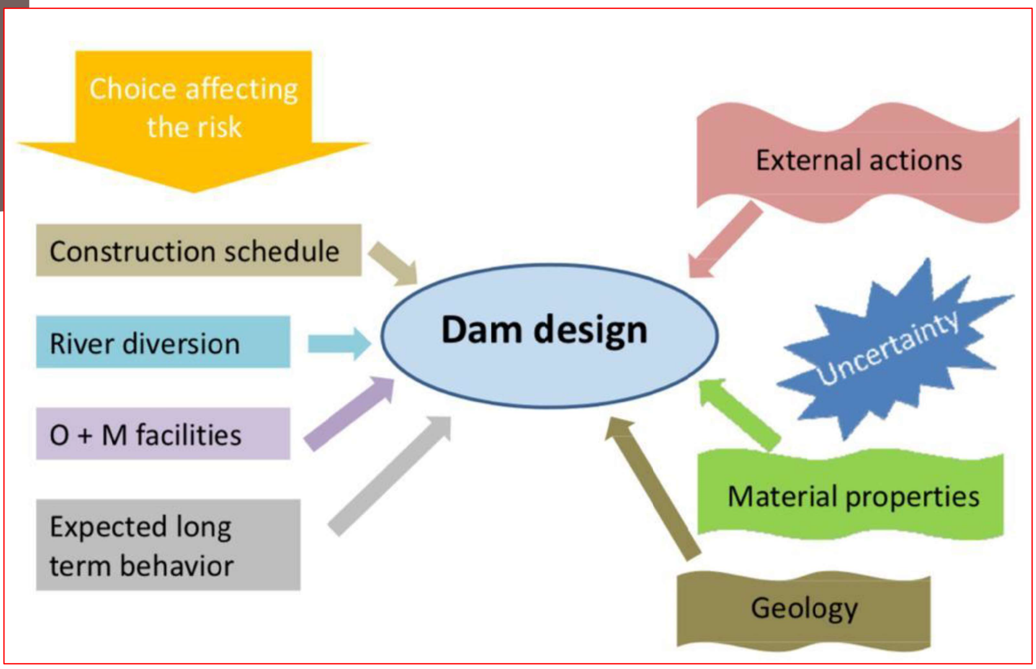
3. Design issues

- **A. Planning, Survey & Investigation**
- **B. Land acquisition**
- **C. Basic Design**
- **D. Detail Engineering Design**
- **E. Design approval process**

Planning stage of dam as part of infrastructures



Dam design: an Overview



Selection of dam types at Design stage

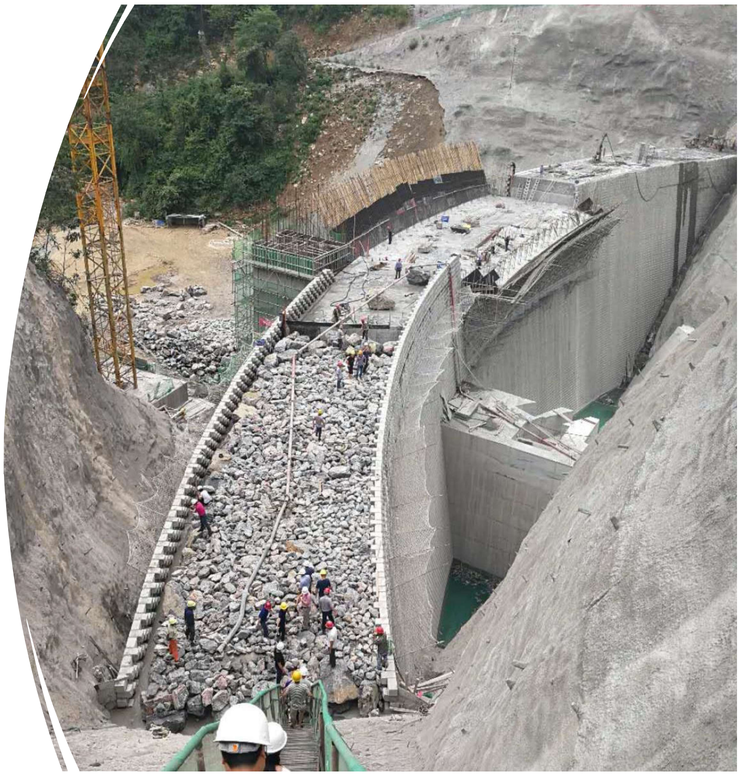
➢Embankment dams

- Clay core, asphalt core, CFRD etc.

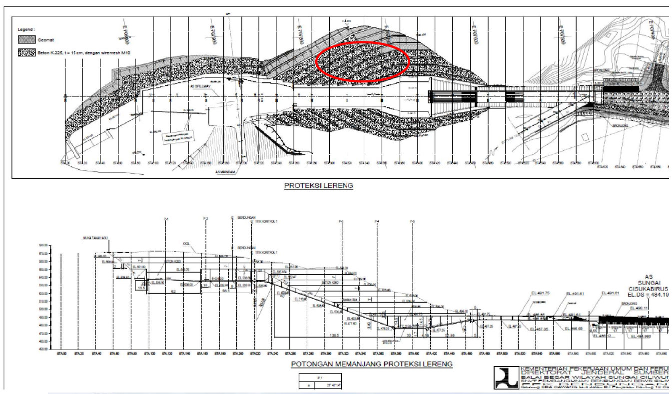
➢Concrete dams

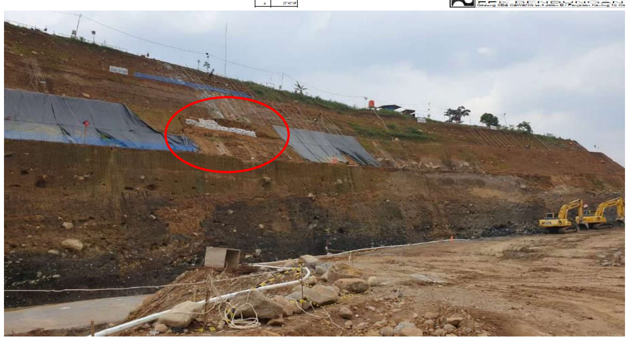
- Conventional, RCC, RFC etc.

➢Composite dams



Challenges at design stage





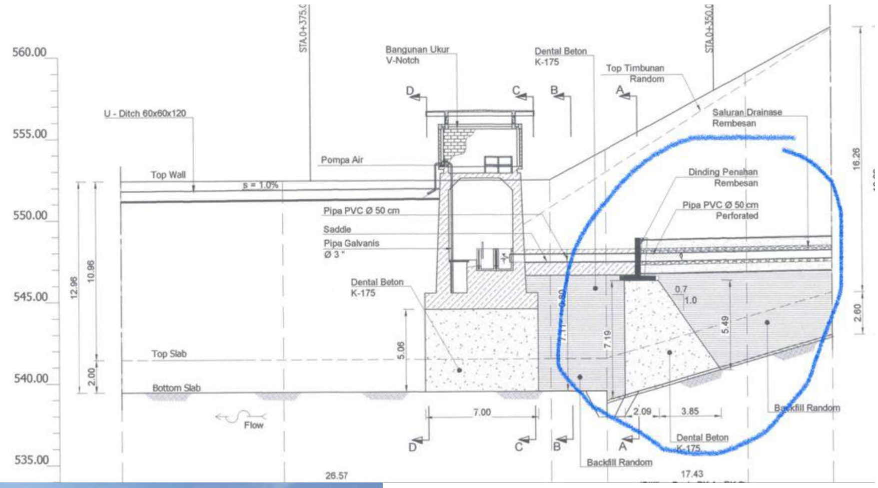
- Limited allocation of resources
- Innovation absolutely needed
- Not taking into account major issues in previous projects

4. Implementation issues

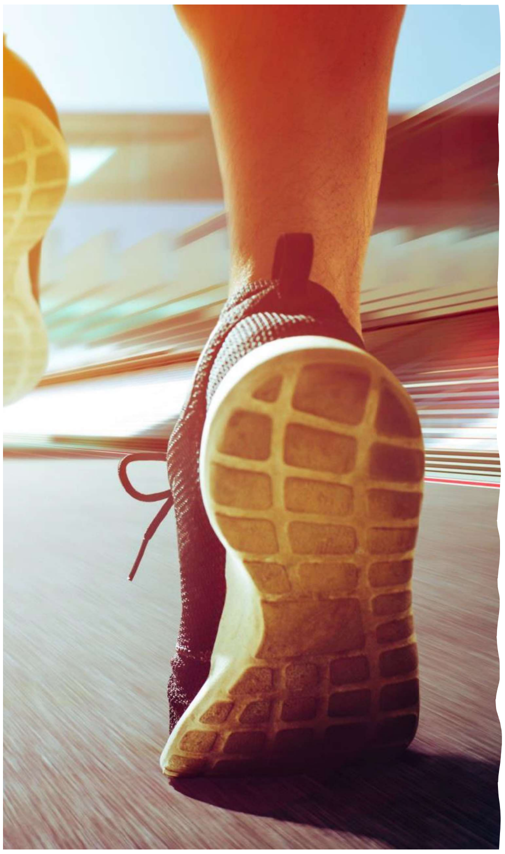
A. **Additional site investigation**
B. **Accessibility**
C. **Material availability**
D. **Method of statement**
E. **Unforeseeable conditions**

Additional site investigation

Method of statement



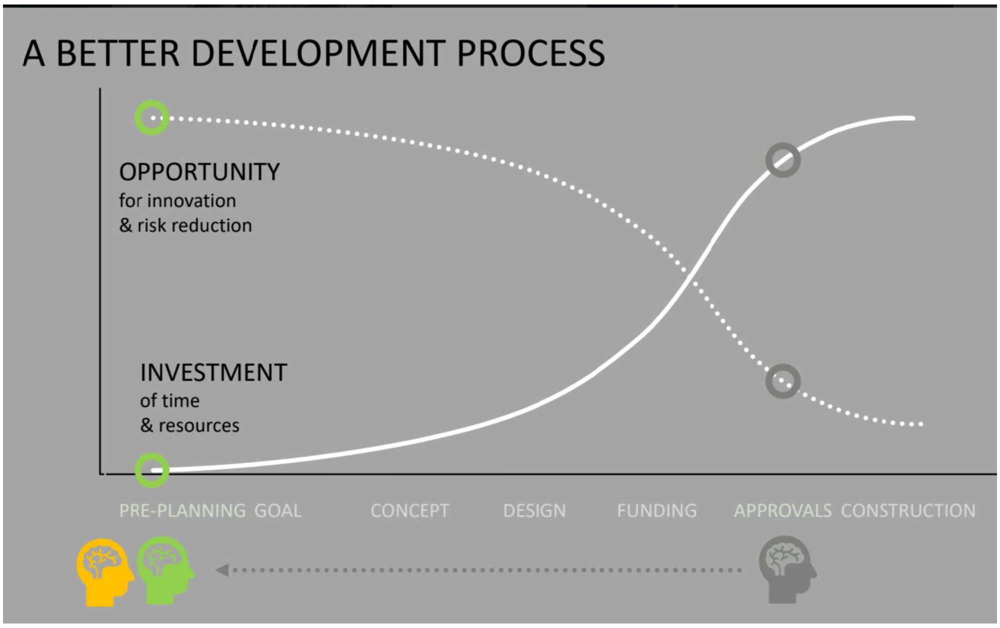
Embankment during wet season



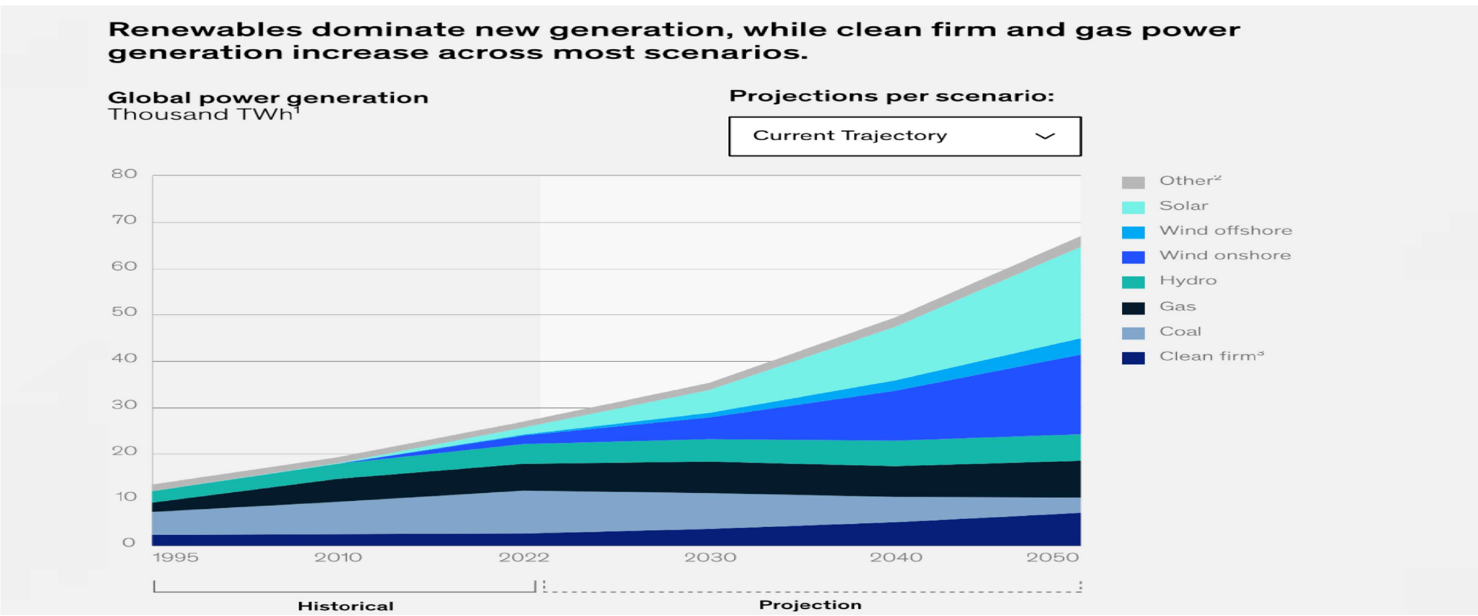
5. Moving forward

A. **Sustainable dam construction specialists**
B. **A full life cycle approach for resilient dams**
C. **Maintain dam & public safety during operation stage**

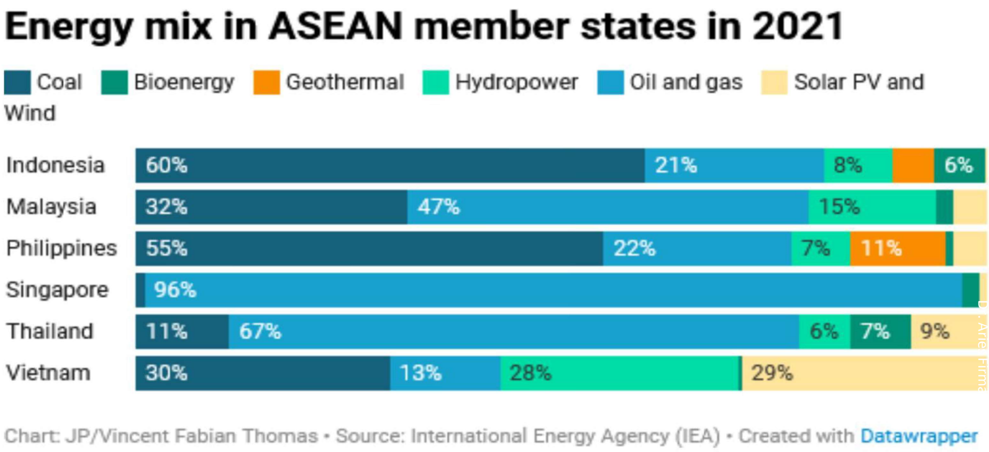
An improved dam development process



SUSTAINABILITY in Clean Energy Projects



Strengths & Weaknesses of R.E. in ASEAN



Recent dams related to hydropower (single purpose)

No	Name of Dam	Type, height & location	Owner	Status at DSC/KKB
1	Peusangan	Concrete gravity, H=16 m, North Sum'tra	PLN	Impoundment
2	Upper Cisokan	RCC, H= xx m, West Java	PLN	Revised DED
3	Karedok	Concrete gravity, H=17 m, West Java	PLN	Impoundment
4	Kumbih	Concrete gravity, H= xx m, Aceh	PLN	DED approval
5	Batang Toru	RCC with H= 74m, North Sumatera	NSHE	Construction of dam body
6	Mentarang	CFRD with H= 235 m, North Kalimantan	KHN	Diversion works in progress

Sustainable dam construction specialists

- Dam engineers with high qualification in design, construction & O/M
- Exposure to various type of dams and stages
- On site direct physical assignment

A full life cycle approach for resilient dams

- Continuous evaluation from design until O/M stages

Maintain dam & public safety during operation stage

- Prioritation on dam & public safety

Completely Installed: FPV - Hydropower Cirata 192MWp (West Java)

Expansion to other Water Bodies??? YES!!!

THANK YOU

1st Seminar

02 Seminar on Risk Management for Dam

Ministry of Public Works and National Housing
Directorate General of Water Resources
Japan International Cooperation Agency

Risk Management
in Dam Design & Construction

RISK RECOGNITION AND TREATMENT IN DAM PROJECTS

DECEMBER 8, 2023

NATIONAL SEMINAR, INDONESIA COMMITTEE ON LARGE DAM (INACOLD)

BY JICA, DAM CONSTRUCTION ADVISORS

Contents of Presentation on Risk Management

What is Risk Management

Risk Management:

- Risk Management is "Practice of Recognition, Evaluation, Investigation and Mitigation some menace/negative issues in the activities".
- Not only avoiding risks, but also minimizing damage in emergency.

Process for Risk Management

1. Risk Identification & Recognition,
2. Risk Analysis and Assessment,
3. Risk Treatment,
   - Dealing with each risk assessed by selecting one of the four types of risks: "Reduction," "Avoidance," "Transfer (sharing)," and "Acceptance".
4. Monitoring and Improvement

Necessity of Risk Management in Dam Project

Dam Design & Construction

- Constructed by the **Maximum Use of the Nature** such as regional geology, climate, and natural resources. *Nature is difficult to control,*
- Almost always many issues arise during construction stage.
- Many of such issues are originated in geology at site.

Face to Issues

1. **In Dam Design Stage**, predict risks to be arose during construction and operation in advance, and reflect them in design, as much as possible.
2. **In Dam Construction Stage**, establish a system that allows for quick and timely responses.

Risk Management System

- To promote recognition of these issues, one effective method may be "**Establishment of "Risk Management System**" and **Preparation of "Database of Issues"**.

Effects of Risk Management

1. To ensure Efficient and Safety of Dam Projects
   - **Adequate Response/Treatment** to the Risks. Because the uncertainty issues or geological issues has been handled depending on the experience of field engineers.
2. Additional Effects of Risk Management
   - **Appropriate Evaluation of Uncertain Risks** can be expected.
   - Supporting the **lack of experienced personnel** and **reducing human errors.**
   - **More Effects** by means of appropriate timing of risk management implementation. If risk management is conducted during survey and design stages, risks to be arose during construction stage can be significantly reduced.

Initiatives in Japan

on Risk Management
in Civil Engineering Projects

GUIDELINES FOR GEOLOGICAL AND FOUNDATION RISK MANAGEMENT IN CIVIL ENGINEERING PROJECTS

“TO RESPOND AGAINST RISKS AS ONE-TEAM”

Risk Management in Civil Engineering Project: Initiatives in Japan

In Japan, there are **Damages/Accidents caused by Geological Issues** in construction or after completion, same as in Indonesia.

Many **Geological Risks**, containing in dam projects, have been treated through so-called **"Tacit Knowledge"** of the well experienced engineers.

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) The guideline and supporting data are available in; https://www.pwri.go.jp/jpn/research/saisentan/tishitsu-jiban/iinkai-guide2020.html

Concept of Risk Management Guideline

1. **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.
2. **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.

Preparation of Guidelines Basic Policy

1. **Concepts and Basic Ideas** of geological and ground risk management in civil engineering projects
2. **Roles and Functions** that should be played by project conducting geological/ground risk management and the parties involved, as well as the ideal form of collaboration.
3. **Procedures and Methodologies** for introducing and implementing geological/ground risk management
4. **Notable Points** when operating geological/ground risk management
5. **ISO 31000 (Risk Management - Guidelines)**
   Refer to the concept and adapt it to civil engineering projects.

Preparation of Guidelines Focus Points

1. *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.

2. *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.

Preparation of Guidelines
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.

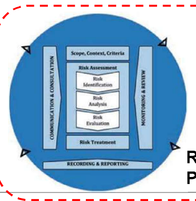
The goals of both are the same.

Composition

The Guideline of Geology/Ground Risk Management consists of the following 5 categories.

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

How to Proceed
Risk Management in projects

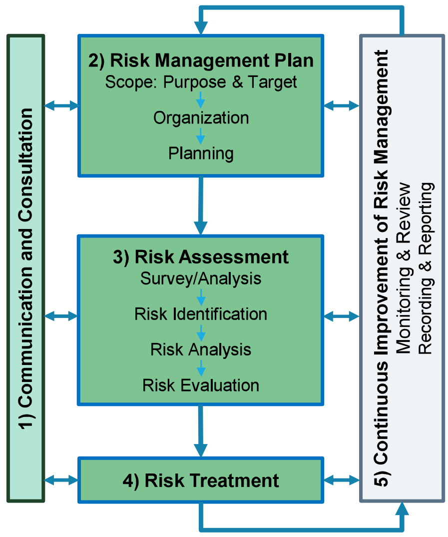


Risk Management Process in ISO-31000

Optimization of Processing System
- Applicable to various stages in the project
- Continuously implemented throughout the project

Implementation Procedures in Assessment & Treatment
- Communication and Consultation,
- Risk Management Plan,
- Risk Assessment
- Risk Treatment
- Continuous Improvement.

Implementation method (right diagram)
- following ISO-31000 methodology.



Proposed Process
Geological Risk Management

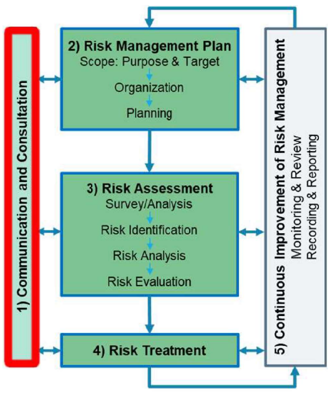
(1) Communication and Consultation

The most important elements in the risk management framework and process.

It is important to **continuously carry out** risk management: "Communication and Consultation" in the risk management process, to constantly update about Risk Recognition and Treatment.

"Communication and Consultation" is consisted of;
1. **Internal** communication and discussions
2. Communication and Consultation with **external** parties

Notable Points for Communication and Consultation;
- Carry out 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.



Proposed Process
Geological Risk Management

(2) Risk Management Plan

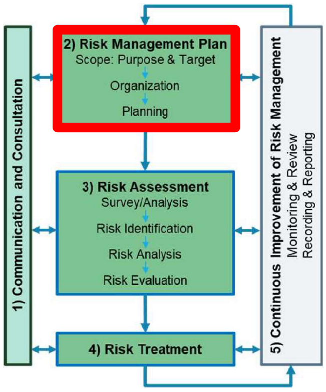
Establishment of a **Management Policies and Processes** in advance applicable to all stages.

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

Notable Points:

when risk management at each stage is planned, followings shall be considered;

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



Proposed Process
Geological Risk Management

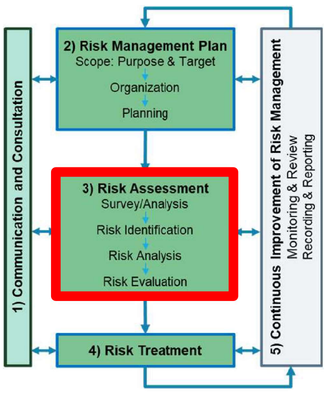
(3) Risk Assessment (1/2)

Role of Risk Assessment:

- To **Provide Materials** for determining risk Treatments and their priorities.
- To **Evaluate what kind of Results** will occur due to the combination of
  - geological/ground properties,
  - geological structure,
  - external forces, etc.,
- How it will **affect to the project**.

Contents In the Risk Assessment:

- **Analyzing the Expected Performance** of the geology and ground based on the information available at that time, and
- Checking whether:
  - the information on the performance required for the **Design Parameters have already been obtained**,
  - **how uncertain** it is.



Proposed Process
Geological Risk Management

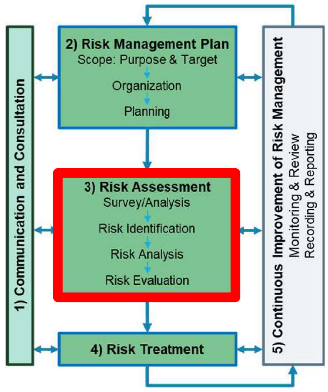
(3) Risk Assessment (2/2) Key Points for Implementation

To Avoid Overlooking Risks expecting Large Impact

- it is necessary to conduct geological and geotechnical surveys even at an early stage of the project.

In the Implementation of Risk Management

- To **Clarify the Premises** in information such as surveys and analyzes to be utilized for decision making.
- Geological survey are not always carried out prior to risk identification and risk analysis so **Additional Survey** may be required as risk treatment option.



Proposed Process
Geological Risk Management

(4) Risk Treatment

Risk Treatment is **Process** for;

- **Modifying Risks** by avoiding, reducing, relocating, holding, etc.
- **Decision-Making** to selecting an optimal treatment option, based on the characteristics and magnitude of risk impact evaluated through risk assessment.

Output of Risk Treatment Process

- Select countermeasures,
- Present the status of risk treatment and concept of risk monitoring,
- including cases of holding decision.

Content and scale of risks might be changed, because the latest information is obtained in design and construction progress.

Proposed Process
Geological Risk Management

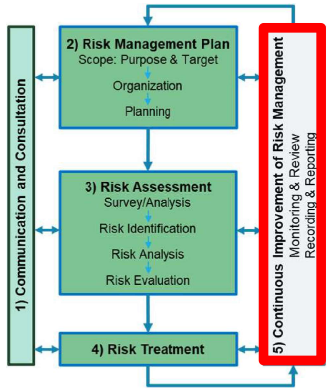
(5) Continuous Improvement of Risk Management

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;

1. **Monitoring** project progress, changes in external conditions, changes in risk information, and the current status of systems and organizations
2. 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.



Proposed Process
Geological Risk Management

Organizing of Risk Management Team

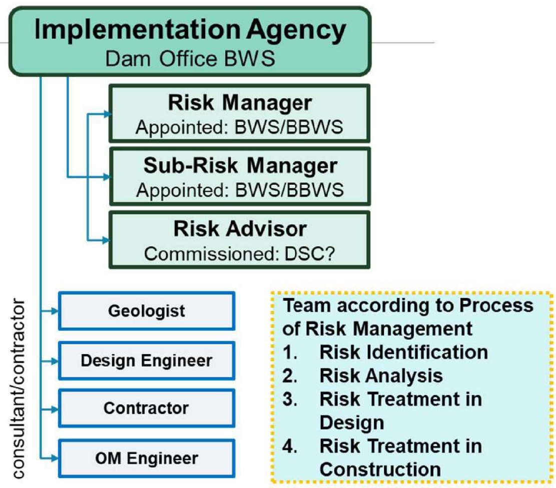
Team for Risk management shall be;

- Consists of internal and external parties with the necessary abilities and knowledge, and
- Possible to ensure a collaborative system among these parties, acting as "One-Team".

The Main Team Members
(refer to right diagram)

- Project Implementation Agency, Risk Managers, Risk Sub-manager, Geotechnical engineer, Design Engineer, Construction Engineer and OM Engineer.

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.



The team shall be composed of members with necessary skills and knowledge.

Image of Risk Management Team Organization

Timing of Risk Management

The risk management is a concept **applicable at any stage** of the project but early conducting can be expected more benefits.

Benefits of Starting Early

- **More Options** for dealing with the uncertainties and risks.
- To achieve **Better Results** (even if the start is in the middle of project).

These were confirmed by analyzing the collected data for organizing the guideline in Japan.

Timing of Risk Management
Early Implementation of Risk Management

Early Start of RM can be expected more benefits.

Example of Benefit

- ✓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.
- ✓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.

Configuring the 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)	✓							

Configuring the System in Other Countries
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.

The Japanese guideline, therefore, 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.

Application to Indonesia

PRELIMINARY SURVEY FOR RISK MANAGEMENT

1. INDIVIDUAL EVENT SUMMARY REPORT
2. PREPARATION OF DATABASE
3. RISK ASSESSMENT

ESTABLISHMENT OF RISK MANAGEMENT SYSTEM IN INDONESIA

UTILIZATION OF THE SYSTEM

Preliminary Survey for Risk Management

INDIVIDUAL EVENT SUMMARY REPORT
PREPARATION OF DATABASE
RISK ASSESSMENT

Preliminary Survey for Preparation of System
Individual Event Summary Report

Currently, more than 60 dam construction projects are underway in Indonesia, and many problems are arising on site, due to misinterpretation of the geology, lack of understanding of design concepts, and lack of experience in construction technology.

For preparation of Risk Management System in Indonesia, firstly, it is essential to collect and to analyze the issues that are currently arising/occurring at dam construction sites.

Creation of an Event Summary Report of individual cases and issues that occurred during construction of the 61 dams in the Strategic Plan

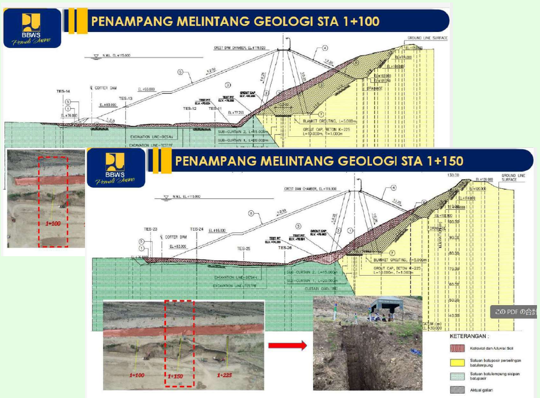
1. Basic information on dams: construction site, dam type, dam specifications, geology, etc.
2. Details of accidents/issues
3. Cause of risk occurrence
4. Risks that have occurred or are expected in the future
5. Actions and consequences: Was the risk avoided or reduced? on hold?

Example of Event Summary Report for Risk Recognition

MISESTIMATION OF COLLUVIAL ZONE THICKNESS OF DAM FOUNDATION

Event Summary

It was veryfied that the thickness of Clluvial Zone on Dam Foundation and it was found that the required safety factor can not be obtained.



Examples of risk recognition

Risk Recognization by Checklists

Check item	Check column: check result	Check column
	yes / no / unknown / Not applicable	If "Yes" → Enter the name of the document referenced for confirmation If "No" or "Unknown" → Describe Treatment plan In the case of "not applicable" → state the reason
Is the geological survey during design is enough? Has the caractor of the colluvial zone was tested and confirmed?	yes	Existance of colluvial was confirmed but the thickness and distrivution was just assumed. Plate Loading test was conducted and analized the stability.

Checklist

Result of investigation

It was clarified that the colluvial zone on the dam foundation must be removed and replaced with concrete to secure the

Utilizing Technical Materials (Checklist)

to show the one of the method when week zone found on dam foundation.

Preparation of Database
Actual Risks at Construction Site

In order **to understand trends in risks** associated with dam construction in Indonesia, the results of individual event summary reports will be classified into the following categories and collect statistics.

Category of Risk Type (Japanese example)

- Type A: Cases where impacts related to geology and ground risks were avoided;
- Type B: Cases where impacts related to geology/ground risk occurred;
- Type C: Examples of detecting signs of geological and ground risks and reducing impacts

Classification Factor

- Natural factors: Geology that is difficult to predict and understand
- Human factors: errors in interpretation/judgment, lack of knowledge, insufficient survey quantity, problems in project implementation (construction period/cost)

others

- Topography and geology to be cause of risk
- Timing of risk treatment

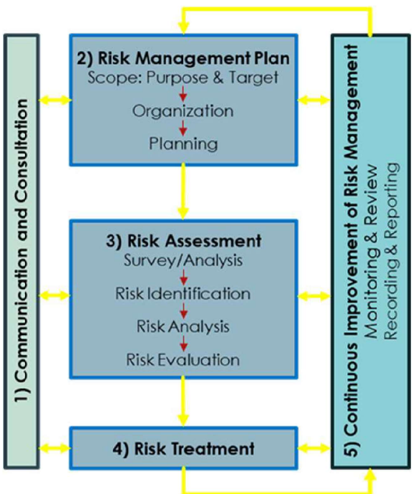
Establishment of
Risk Management System in Indonesia

Risk Management Plan

- It is not necessary to built up a fixed system, but rather it is implemented using the most appropriate system available at the time, depending on the purpose and characteristics of the project.
- 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.

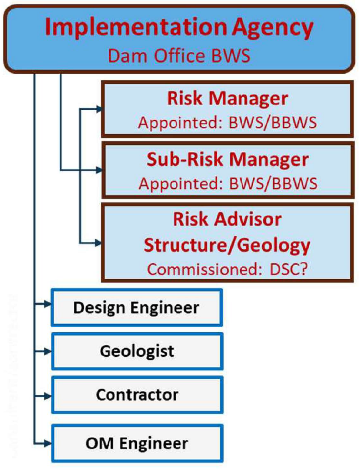
Risk Assessment

- The risk manager sets up the methods of data compiling and display of risk level, based on the policy of risk assessment.
- For setting them up, it is necessary to consider to be applicable in the risk assessment and risk treatment and a "communication and consultation" within the team shall be held, and select applicable methods based on the purpose of the project and target structures.



Organizing of Management System in Each Stages of Project

Member	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 Dngineer (the Consultant/dam engineer)	A person who designs dam/structures, etc.
Geotechnical Engineer (the Consultant/geologist)	A person who conducts geological survey and analysis, etc.
Construction Engineer (the Contractor)	A person who constructs structures, etc. based on the design.
OM Engineer (if necessary) (the Consultant)	A person who conducts inspections in the maintenance and management of structures.



Utilization of the 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.

1. The timings of checking are mainly set based on the technical session by dam safety commission (but the session maybe need more frequently).
2. 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."
3. 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.)
4. Applying this process, all dam implementing agencies can carry out the Individual Event Summary Report at the necessary stage.

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.
- ✓ It is supposed that adaptation of "Risk Management System" introduced here 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.
- ✓ From now on, we, dam technical advisors would like to have discussion with PUPR (DSC, DSU and BTB) regarding improvement of dam construction status in Indonesia.

Thank you for your kind attention

Dam Engineer must Innovative but Conservative for dam safety

IF YOU HAVE INQUIRY, PLEASE CONTACT:
Email: shimizu@ctii.co.jp
WhatsApp: +62 8124286509

Next Topics

Geological Study for Risk Management

THE CHALLENGES WE HAVE SEEN AT DAM CONSTRUCTION SITES, ARE ORIGINATED IN GEOLOGICAL SURVEYS, ANALYSIS, AND THE APPLICATION OF THE RESULTS IN DESIGN. REGARDING THIS, MR. MIZUNO, WHO IS IN CHARGE OF GEOTECHNICAL ADVISOR, WOULD LIKE TO PRESENT OUR IMPRESSIONS AND IMPROVEMENT POINTS AS DAM CONSTRUCTION ADVISORS.

1st Seminar

03 Seminar on Risk Management for Dam_Geo

Ministry of Public Works and National Housing
Directorate General of Water Resources
Japan International Cooperation Agency

Geological Study for Risk Management

December 8, 2023

National Seminar, Indonesia Committee on Large Dam (INACOLD)

By JICA, Dam Geological Advisors
Naoya Mizuno

Table of Contents

1. Importance of Geological Study

- Many of the issues at dam construction sites where we have conducted site inspections are due to the site geology. The causes may include the following.

1. ***Insufficient of geological survey***
2. ***Insufficient of geological analysis (Analysis and Interpretation of survey results)***
3. ***Insufficient of consideration of geological risks (georisks) in design***
4. ***Uncertainty of geology difficult to avoid***

- Of these, No. 1 to No. 3 can be improved, and the improvement is very important because it is expected to avoid delays in the construction schedule and a significant increase in construction costs.
- Therefore, I would like to propose some ideas regarding No. 1 to No. 3.
- In my presentation, the drilling and testing is called "Geological Survey", and the analysis of the results is called "Geological Analysis", and together they are called "Geological Study", and geological risk is called "Georisk".

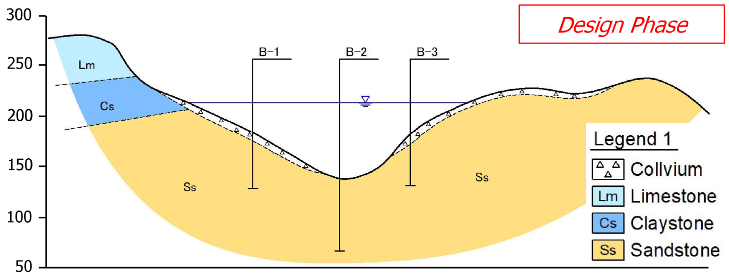
2. Geological Survey
2.1 Boring Survey by Grid

- Appropriate estimation of the geological stratigraphy and geological structure of a dam site is necessary for the identification of georisks and proper design.
- However, inadequate survey quantities (geological information) will reduce the accuracy of the estimation.
- As a result, there will be large differences in the geological map between the geological study and design phase and the construction phase, which will have a significant impact on the cost and schedule due to reconsideration of the design and an increased construction work.
- Compared to the loss due to the impact, the cost of the geological study is quite small.
- Therefore, I would like to propose increasing the amount of geological survey at the FS (Feasibility Study) phase. Otherwise, feasibility may become unfeasible.

2. Geological Survey
2.1 Boring Survey by Grid

- For example, Insufficiency of geological study can make a big difference between the design and construction phases, as shown in the figure.

(a) Design Phase



(b) Construction Phase

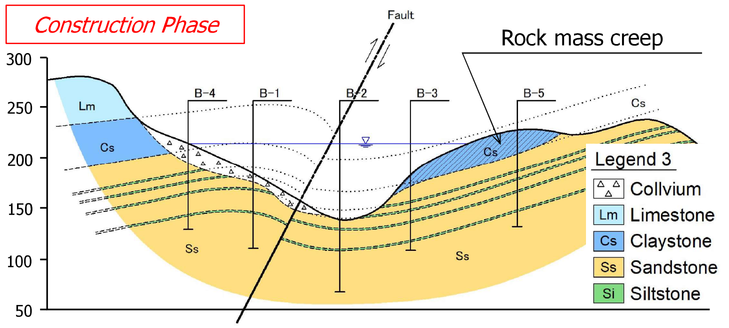


Figure-1 Differences in Geological Profiles

2. Geological Survey
2.1 Boring Survey by Grid

- To accurately estimate the geological stratigraphy and structure of a dam site, it is necessary to view it in three dimensions.
- The step-by-step survey using the grid method is very effective for this purpose.
- In this method, a grid is set over the dam site and survey boreholes are basically placed at the intersections of the grid.
- For reference, ***PANDUAN PERENCANAAN BENDUGAN Vol.1 (1999)*** recommends 20 to 30m as the spacing between boreholes.
- The figure shows an example of borehole layout in initial stage I recommend.

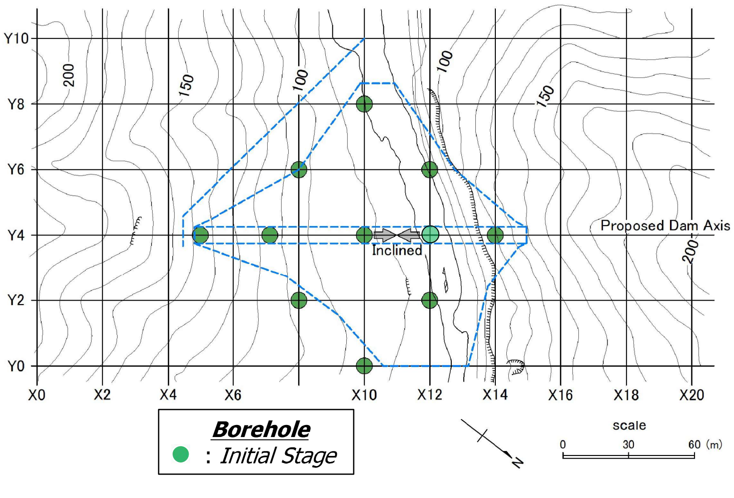


Figure-2 Initial Stage (for Feasibility Study)

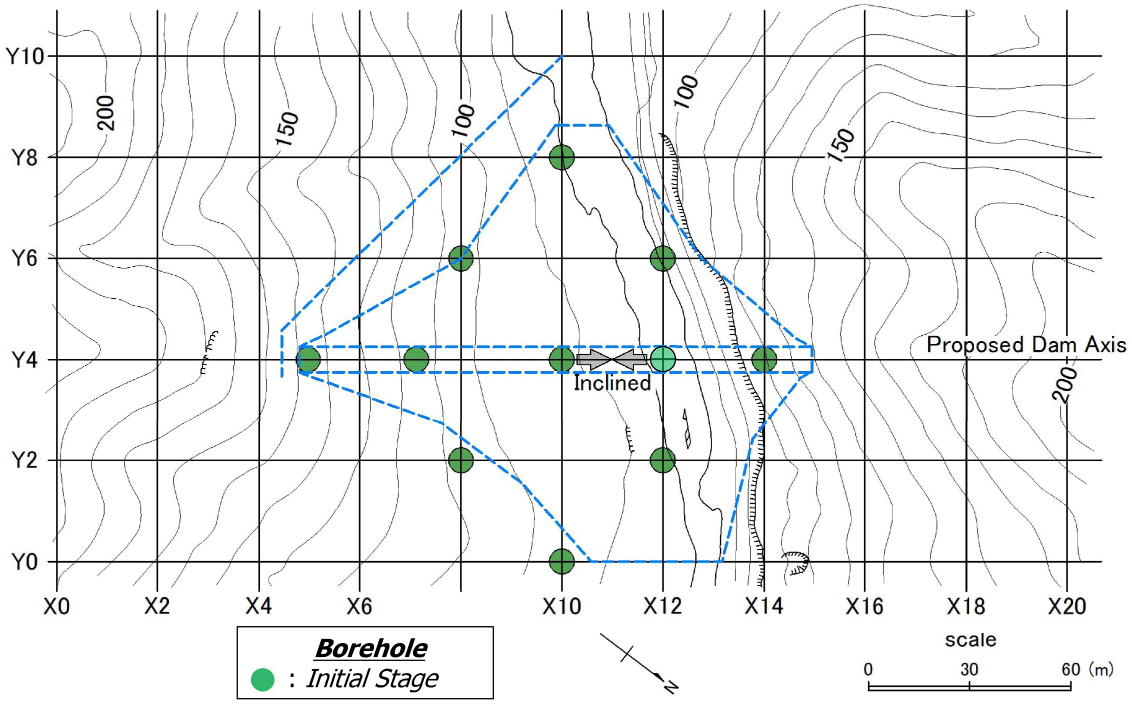


Figure-2 Initial Stage (for Basic Design)

2. Geological Survey
2.1 Boring Survey by Grid

- Based on the results of the initial stage survey, the layout of the dam body is set in consultation with the design engineer, and a survey plan for the next stage is developed.
- The second stage is to place survey boreholes along the proposed dam axis and spillway centerline, in and around the foundation area.
- To study the appropriate curtain grouting area, survey boreholes will also be placed along the extension of the dam axis outside of the foundation area.
- To prevent or reduce the occurrence of sliding, survey boreholes will be placed on the planned large cutting slopes.

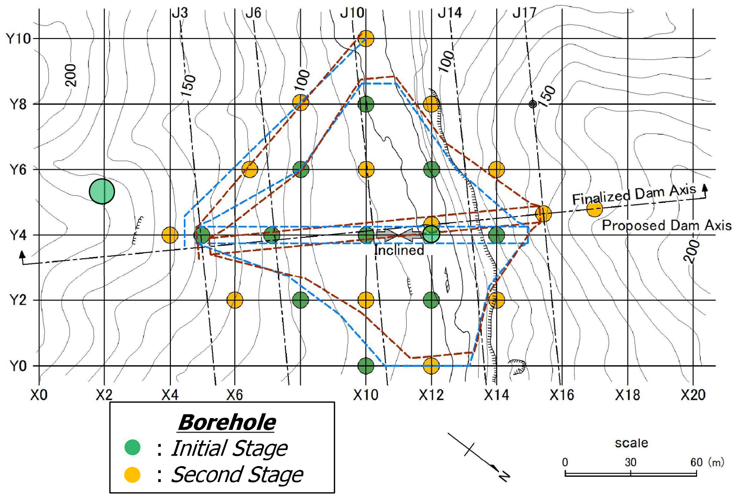


Figure-3 Second Stage (for Basic Design)

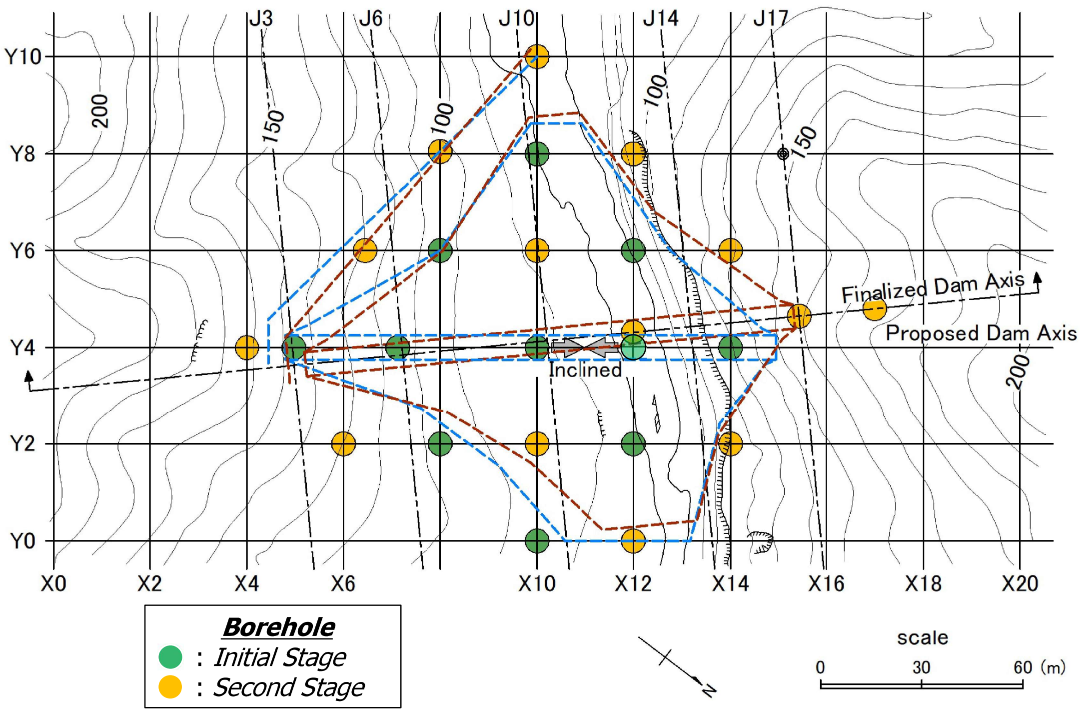


Figure-3 Second Stage (for Detailed Design)

2. Geological Survey

2.1 Boring Survey by Grid

- The dam axis layout will be finalized based on the results of the second stage.
- Based on the finalized layout, survey boreholes will be placed at locations where more detailed geological information is needed for detailed design follow-up and where there may be potential georisks.
- The figure shows an example of the arrangement of additional (special-purpose) survey boreholes as the third stage.

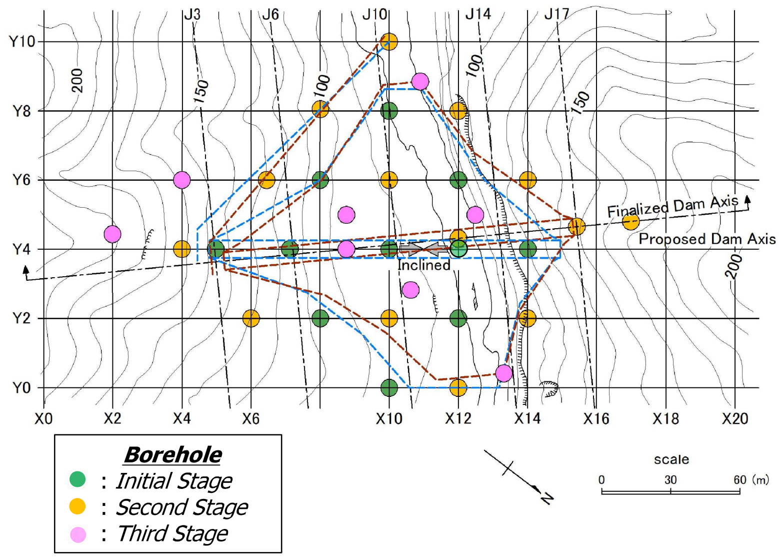


Figure-4 Third Stage (Before Construction)

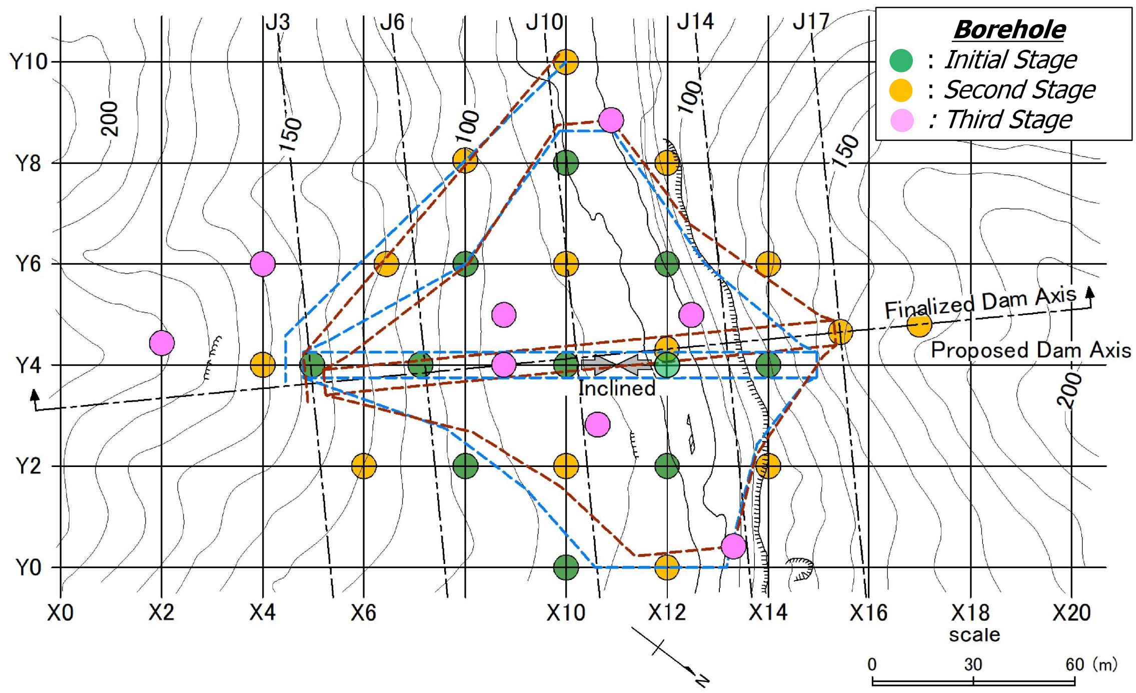
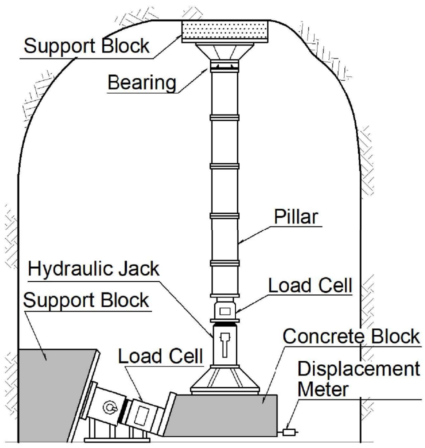


Figure-4 Third Stage (Before Construction)



Schematic Diagram of Shear Test Equipment

Audit (Small Tunnel) Excavation and Shear Test

2. Geological Survey
-Quality of Drilling Core Sample-

- To avoid misinterpretation of site geology, it is important to increase the quantity of surveys as well as develop the quality of drilling core samples.
- In Japan, drilling cores are collected using high-level techniques as needed to minimize disturbance to the subsurface conditions for colluvium and fault fracture zones, etc.
- For example, to accurately determine the sliding boundaries of landslides to design rational countermeasures in areas where fault fracture zones develop.

Photo-1 Colluvium

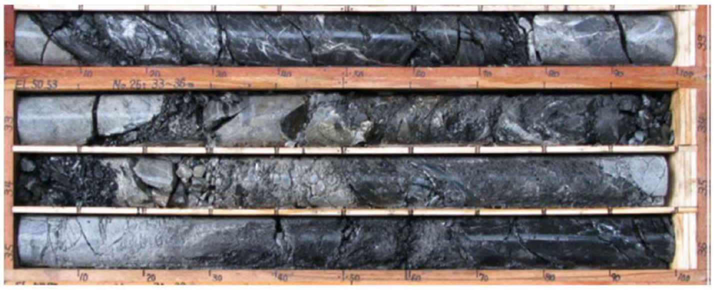


Photo-2 Fault Fracture Zone

2. Geological Survey
2.2 Utilization of Seismic Exploration

- P-wave refraction seismic surveys are effective for geological study of dam sites for the following purposes

a. To estimate the bedrock conditions (thickness of weathering zones, distribution of faults, etc.) based on P-wave velocities.

b. To complement the stratigraphic distribution between survey boreholes.

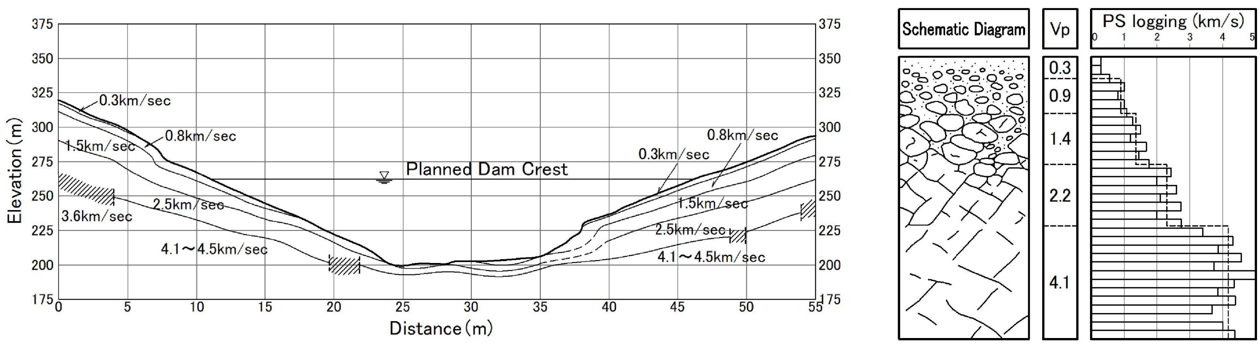


Figure-5 Example for Analysis Result of P-wave Refraction Seismic Survey

2. Geological Survey
2.2 Utilization of Seismic Exploration

Crack Coefficient

- Expressing the P-wave velocity of the rock mass as Vp_1 and that of the intact rock as Vp_0, the crack coefficient ***Cr*** calculated by the following equation is used as an index to evaluate the rock mass condition.

$$Cr = 1 - (Vp_1/Vp_0)^2$$

Table-1 Rock Evaluation Using Cr Index

Source: (One of the standards in Japan)

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

2. Geological Survey
2.2 Utilization of Seismic Exploration

Concept of Competence Factor

- In the surroundings of an excavated circular tunnel under isotropic ground pressure, if the ground is assumed to be an elastic body, radial stress σr = 0 and circumferential stress σθ = 2P on the tunnel wall.
- Here, P is the load due to overburden. If qu'/P, which is the ratio between the unconfined compressive strength of the rock mass qu' and overburden P, is less than 2, the risk of destabilizing the tunnel ground is high.

Competence Factor = qu'/P

< 2 : High Risk

- Here, qu' is calculated using the crack coefficient ***Cr*** according to the following equation.

$$q_u' = (1 - Cr) \times p_u$$

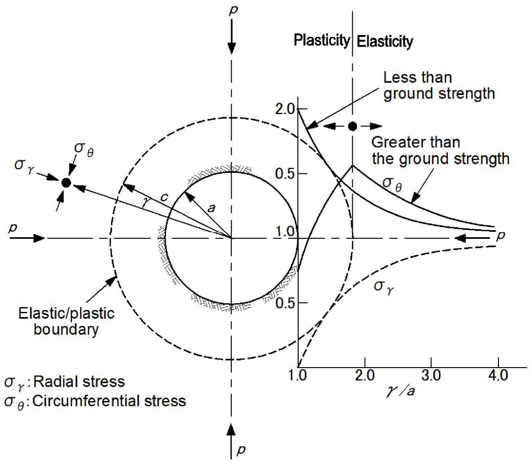


Figure-6 Concept of Competence Factor

3. Geological Analysis
3.1 Purpose

- Geological analysis is the process of organizing and analyzing geological information (e.g., results of previous borehole surveys, laboratory tests, in-situ tests, etc.) to make a geotechnical model for design.
- The geotechnical model consists of several kinds of classification maps where the foundation is zoned into areas with the same geotechnical characteristics.
- Geological analysis should be performed at each stage of the geological survey and should not only analyze newly acquired geological information but also integrate geological information acquired in the past.

3. Geological Analysis
3.2 Role in Risk Management

From a risk management perspective, geological analysis should contribute to ensuring dam safety and project performance in the following ways;

- Estimating (extracting) georisks of a project site in the early phase.
- Continuously studying and updating the georisks identified at each phase of geological study, design and construction.
- Discuss with geological and design engineers the consideration of georisks in the design.

Geological engineers can imagine or estimate various georisks through geological study. However, it is very important to share these imagined or estimated georisks with design engineers and others involved in the project.

For reference, Japan has qualifications for engineers related to georisk, such as "***Geotechnical Interpreter of Topography***" and "***Geological Risk Engineer (GRE)***".

3. Geological Analysis
3.3 Procedure

The basic procedure for geological analysis considering risk management is shown in the figure.

- An initial overview is very important.
- To perform an appropriate geotechnical evaluation, it is necessary to consider the geological stratigraphy/geological structure that is the background of the physical properties and appropriate geological classification.
- During the geological analysis, communication with the design engineer is also important to determine the need for additional geological study.

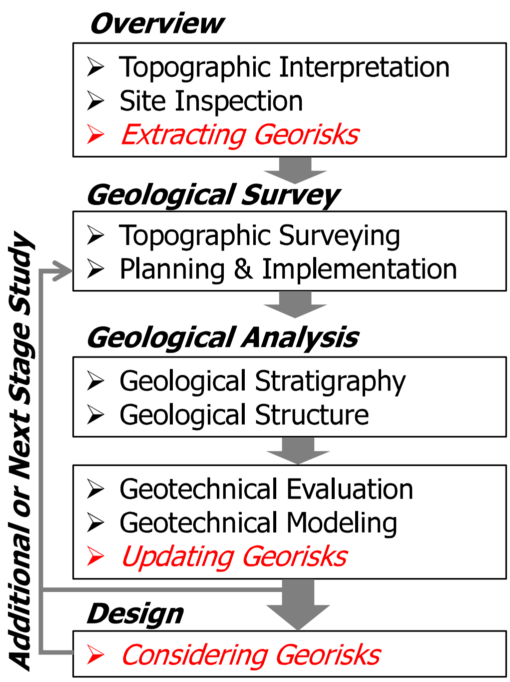


Figure-8 Flowchart

3.3 Procedure
(1) Topographic Interpretation

- Since the topography reflects the geology, the following geological conditions can be estimated based on the landform.

a. ***Foundation rock***: Sedimentary rock, Volcanic rock, etc.

b. ***Geological structure***: Strike/dip trends, Distribution of folds, faults, etc.

c. ***Rock condition:*** Distribution of thick weathered layer, rock mass creep, etc.

d. ***Covering layer***: Distribution of pyroclastic flow, landslide, colluvium, etc.

- For example, based on this topographic map, you can find areas of thick colluvium and distribution of a fault fracture zone.

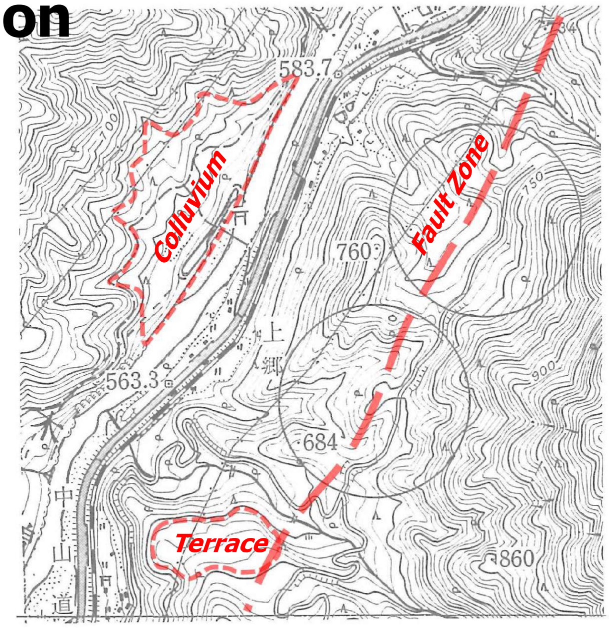


Figure-10 Example of Topographic Interpretation

3.3 Procedure
(1) Topographic Interpretation

- Currently, satellite images and topographic maps of various regions of the world are easily available on the Internet.
- In Japan, many landslides and floods occur every year. For this reason, geomorphological classification maps along major rivers and distribution maps of potential landslides have been developed nationwide.
- This figure shows the distribution of potential landslides. This map is drawn at a scale of 1:50,000.

Source: https://www.jshis.bosai.go.jp/landslidemap

Figure-12 Distribution Map of Potential Landslides

3.3 Procedure
(1) Topographic Interpretation

- In addition, airborne and drone laser scanning (LiDAR) can be used to create high-resolution topographic maps of the project site.
- Based on such high-resolution maps, it is possible to interpret the distribution of cover layers, landslides, and geological structures.

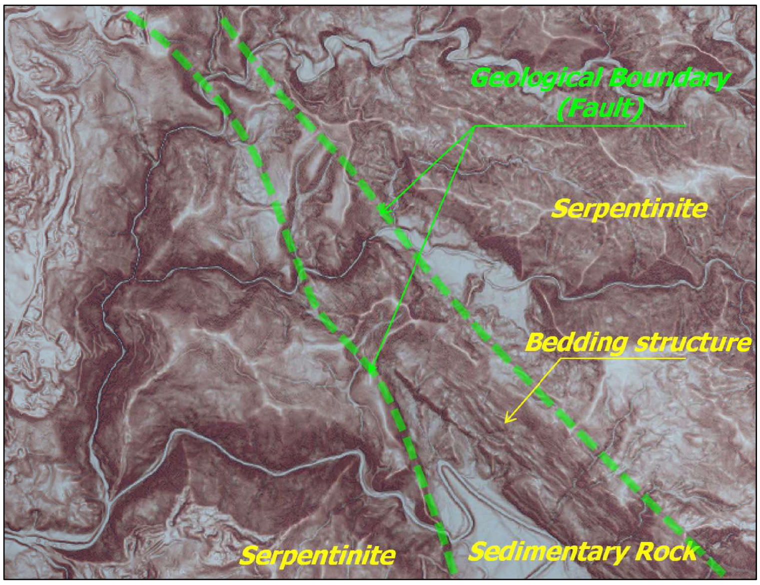


Figure-13 Topographic Map by Lidar Survey

3.3 Procedure
(1) Topographic Interpretation

◆ During the FS (Feasibility Study) phase, three survey boreholes (B-1 to B-3) are often placed on the proposed dam axis.

◆ However, if georisks are a concern due to the topography, as shown in the figure, it is necessary to place survey boreholes outside of the proposed dam abutment as well.

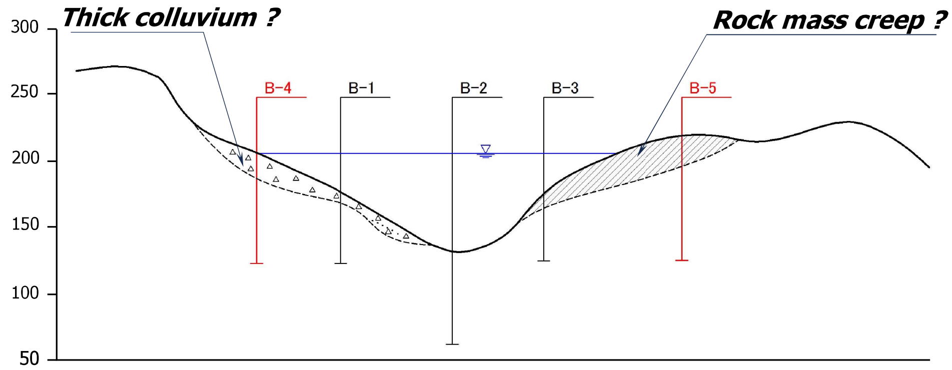


Figure-14 Geological Surveys for Georisk

3.3 Procedure
(2) Geological Stratigraphy/Geological Structure

◆ To avoid overlooking georisks, it is important to consider the geological structure of the entire dam site. For example, as shown in the figure, the continuity of strata on the left and right banks should be considered to avoid overlooking faults that exist near the riverbed.

◆ In geological analysis, it is necessary to focus on intercalated mudstone layers that could be used as key layers and express them on the geological cross section map to consider the geological structure.

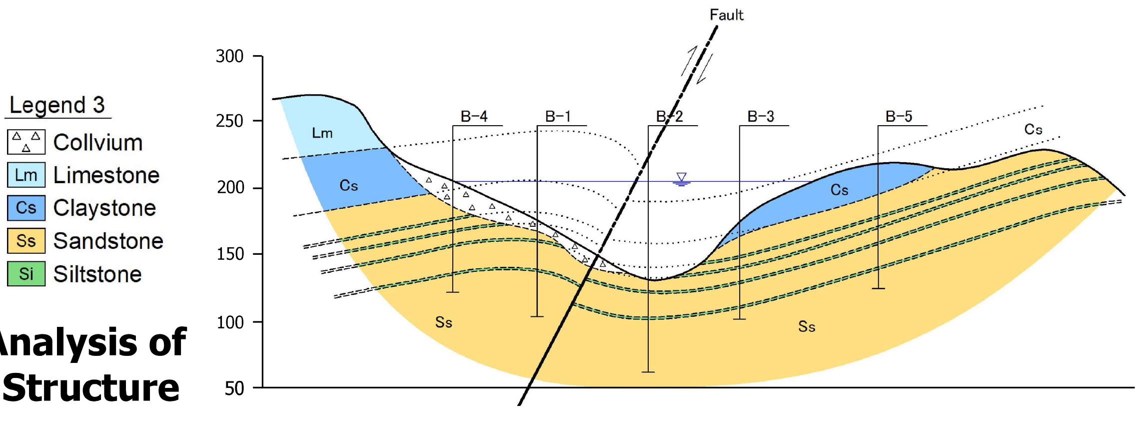


Figure-15 Analysis of Geological Structure

3.3 Procedure
(2) Geological Stratigraphy/Geological Structure

- It is necessary to define classifications and classification names that design engineers can easily understand the geotechnical characteristics of the site geology.
- For example, if a formation described as “Sandstone dominant" on the regional geological map is a formation with a relatively high proportion of mudstone at the project site, it is necessary to be described as a mudstone-dominant alternation or a mudstone, and so on. This is because mudstone has higher georisks than sandstone, such as slaking and swelling.

Table-2 Geological Classification of the Dam Site

Regional Geology		*Dam Site*	
Formation	*Stratum*	*Layer*	*Geotechnical*
A	Limestone dominant	Marl	Mudstone
		Calcarenite	Sandstone
		Calcirudite	Conglomerate
	Sandstone dominant	Claystone	Mudstone
		Siltstone	
		Sandstone	Sandstone
B	Volcanic breccia dominant	Marl	Mudstone
		Tuff	Tuff
		Lapilli tuff	Volcanic conglomerate
		Tuff breccia	
		Volcanic breccia	

3.3 Procedure
(2) Geological Stratigraphy/Geological Structure

- Even if a layer is classified as colluvium, the geology of its source is different, and its geotechnical properties may be very different.
- In this case, it is necessary to divide the colluvium layer into “Colluvium 1” and “Colluvium 2” and set geotechnical parameters for each layer for the design.

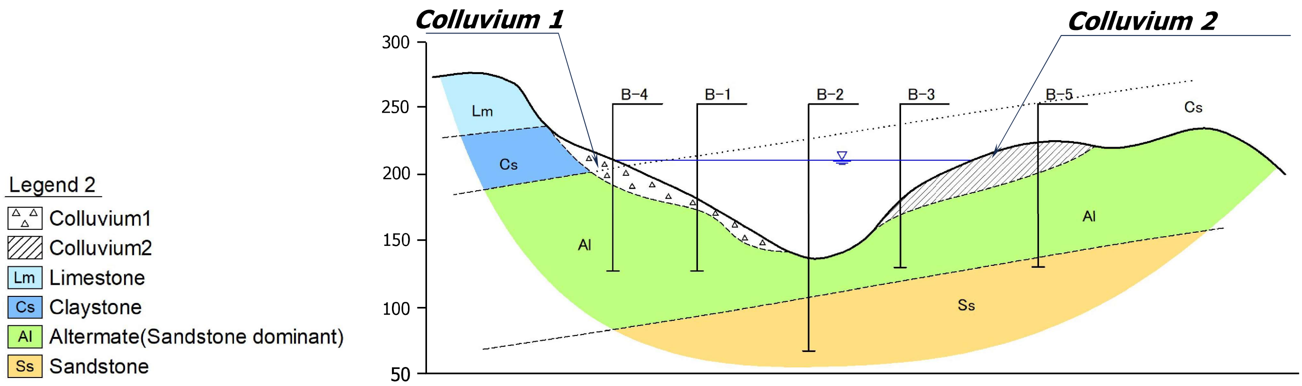


Figure-16 Differences in Properties of Colluviums

3.3 Procedure
(3) Geotechnical Evaluation

- The design requires strength, deformability and permeability for the dam foundation. Therefore, the geotechnical maps required for the design are mainly rock mass classification or ground classification maps and permeability classification or Lugeon maps.
- Geotechnical classification maps mainly depend on geological characteristics and weathering effects. Therefore, there is a correspondence between each classification map.

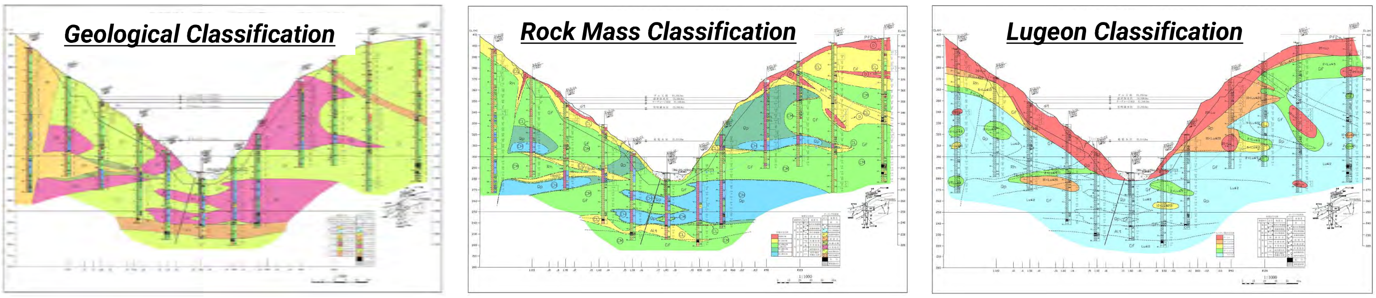


Figure-17 Geotechnical Classification Map

3.3 Procedure
(3) Geotechnical Evaluation

- These are the geological classification and rock mass classification map of the concrete dam. In this case, the dam foundation consists of tuff and intrusive rocks and different shear strengths were set for the CM class tuff and the CM class intrusive rock. In the rock mass classification map, they are represented by different colors (green and dark green).
- For appropriate design, good geological engineers are aware of the correspondence between geology and geotechnical parameter.

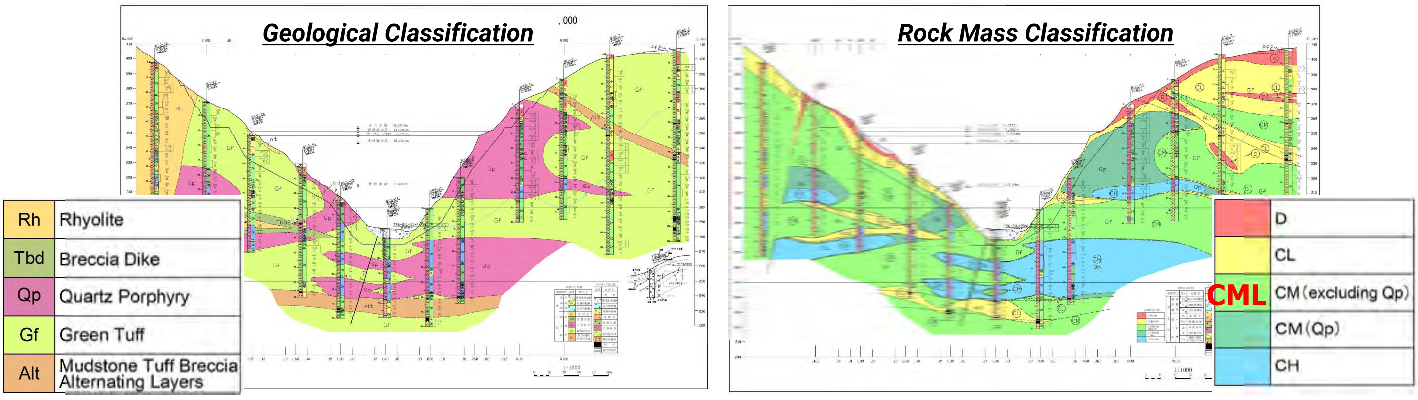


Figure-18 Geological Classification and Rock Mass Classification

3.3 Procedure
(3) Geotechnical Evaluation

- The permeability of the rock mass depends on the characteristics of the layers, especially the frequency of joints and cracks due to the weathering. In this case, the high permeability zone corresponds to the D class and CL class near the ground surface.
- However, please be noted that geotechnical boundaries do not always match between each classification map.

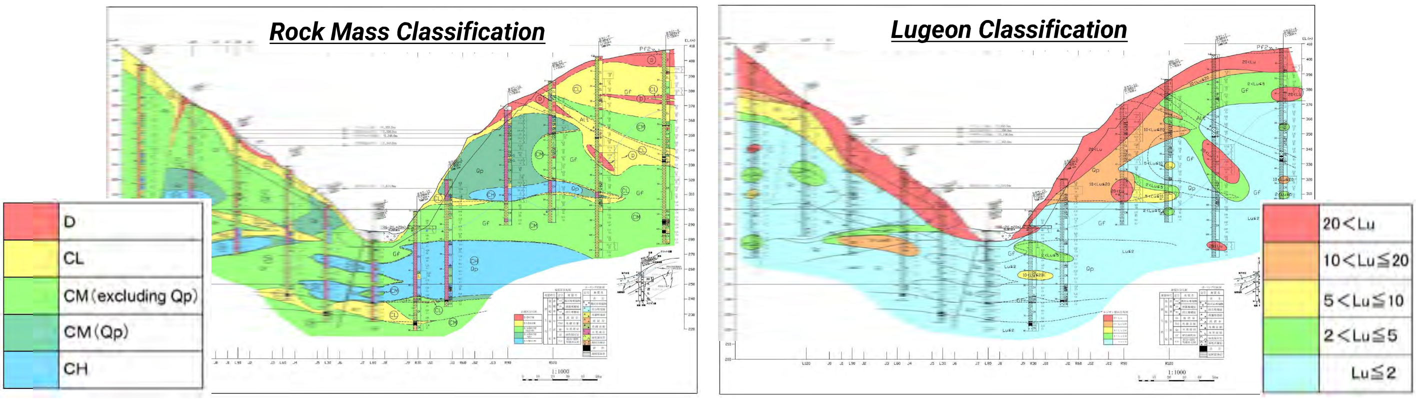


Figure-19 Rock Mass Classification and Permeability Classification Map

4. Consideration of Georisks in Design
4.1 Georisk Category

- As one idea, the georisks that should be considered in design can be broadly classified into the following four categories.

  1. **Discontinuity**
  2. **Volcanic Activity**
  3. **Weathering**
  4. **Swelling/Slaking**

- During our site inspections, I was impressed by sites where deformation of the cutting slope and tunnel occurs due to discontinuities and swelling/slaking. Therefore, I would like to offer some ideas on how to better address these issues.

4.1 Georisk Categories
(1) Discontinuity

- Typical discontinuities are fault fracture zones and joints. Joints are also formed not only by crustal stress but also by stress release due to weathering, erosion, and excavation.
- These affect the strength of the rock mass. Open joints formed by stress release and lava cooling greatly affect not only the strength but also the permeability of the rock mass.

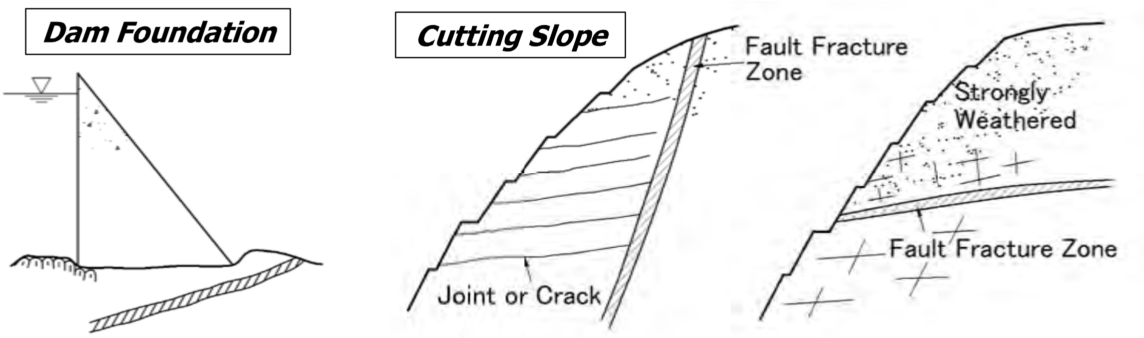


Figure-20 Discontinuity

4.1 Georisk Categories
(2) Volcanic Activity

- Georisks in volcanic areas include the following:

a. Volcanic deposits cover old landforms.

b. A soft tuff layer is intercalated at the boundary of the unit, which can be a weak layer as a foundation.

c. The soft tuff layer has low permeability and regulates the hydraulic structure of the bedrock.

- For reference, Japan has many volcanic hot springs, so deterioration of the bedrock due to hydrothermal alteration is also issues.

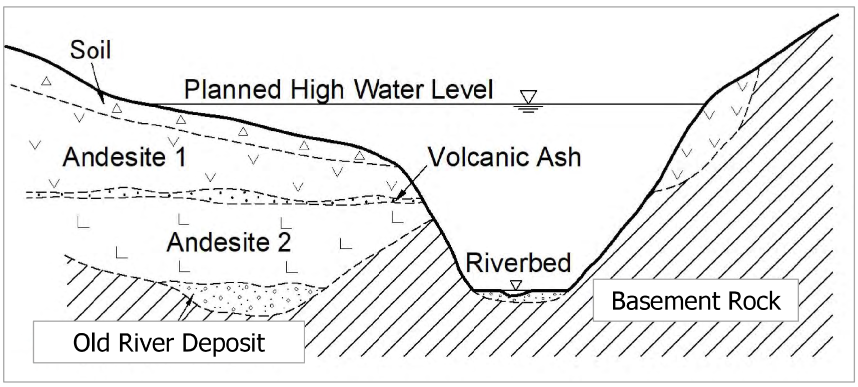


Figure-21 Volcanic Activity

4.1 Georisk Categories
(3) Weathering

- Georisks due to weathering include the following:

a. Deep weathering along discontinuities

b. Formation of thick weathered residual soil

c. Rock mass creep

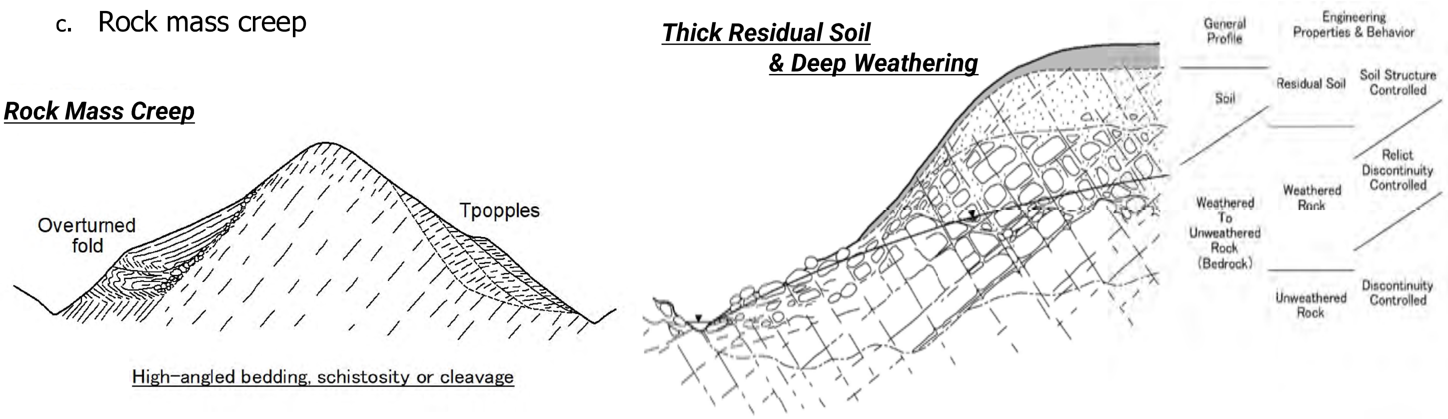


Figure-22 Weathering

4.1 Georisk Categories
(4) Swelling/Slaking

- The georisks due to swelling/slaking is a significant reduction in the strength of the rock after construction (mainly excavation).
- Swelling is a phenomenon in which certain clay minerals become wet and expand, increasing the volume of the rock. During this process, tensile microcracks are generated inside the rock, increasing the porosity. As a result, the strength of the rock decreases.
- Slaking is a phenomenon in which rocks deteriorate due to repeated swelling by wetting and shrinkage by drying.

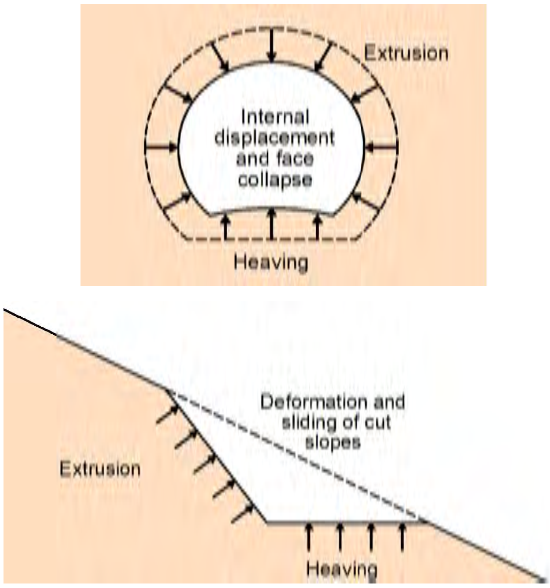


Figure-23 Swelling/Slaking

4.2 Cutting Slope
(1) Stress Release Ratio

- As the overburden load is removed by excavation, the larger the slope, the more the slope surface layer loosens due to stress release, its strength decreases.
- It is believed that the sliding depth is closely correlated with the stress release ratio SRR, except in cases where sliding depth is controlled by the geological structure.
- The above on the graph shows the SRR of each part in actual sliding in Japan. This horizontal axis corresponds to the sliding position in the below figure.
- Empirically, SRR=2 has been obtained as the average value for the middle part of the sliding. ***This means that the sliding risk is high up to a depth of about SRR=2***.

Source: Kimura et.al (2015)

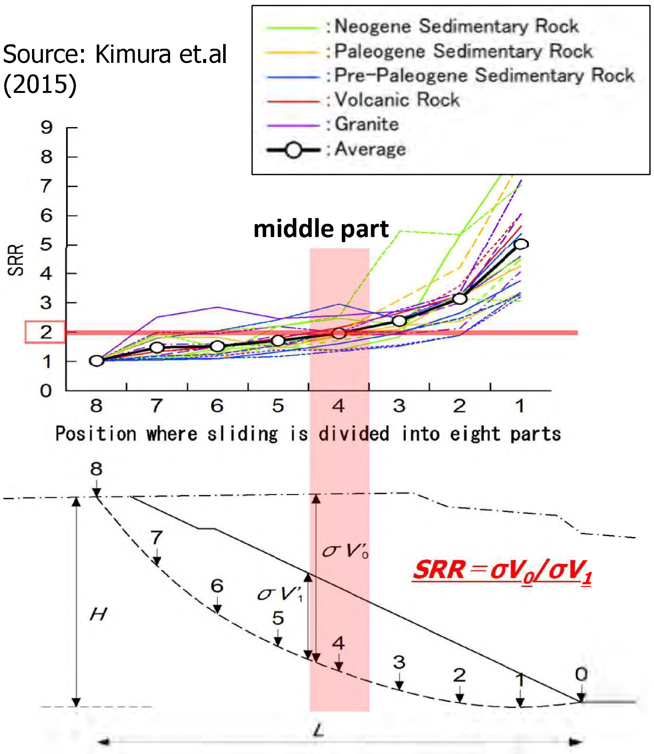


Figure-24 Concept of SRR (Stress Release Ratio)

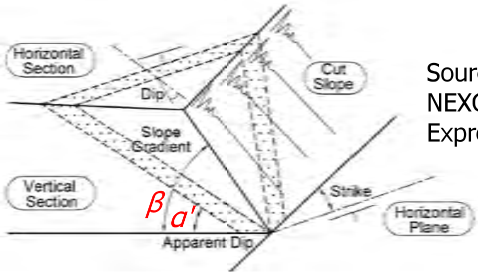
4.2 Cutting Slope
(2) Excavation Gradient

- The basic principle of cutting slope design is to set the excavation gradient as much as possible so that the slope does not become unstable.
- In Japan, which has many mountainous regions, many cutting slopes have been constructed due to road construction.
- Based on the experience, a guideline of excavation gradient according to geological conditions and slope height has been proposed to avoid destabilization of the cutting slope.
- Among them, I would like to introduce those related to discontinuity and swelling/slaking.

4.2 Cutting Slope
(2) Excavation Gradient

Discontinuity

- In the case of discontinuities, the relationship between the direction of the discontinuity and that of the slope determines the risk of sliding, since the strength loss of the rock mass occurs along the discontinuity due to the stress release.
- The figure shows that sliding is likely to occur when the gradient β of the cutting slope is larger than the apparent dip α′ of the discontinuities.
- Therefore, if β is set to be larger than α' due to certain constraints, it is necessary to consider measures such as rock bolts depending on the rock mass condition.



Source: Standard of NEXCO (Nippon Expressway Company)

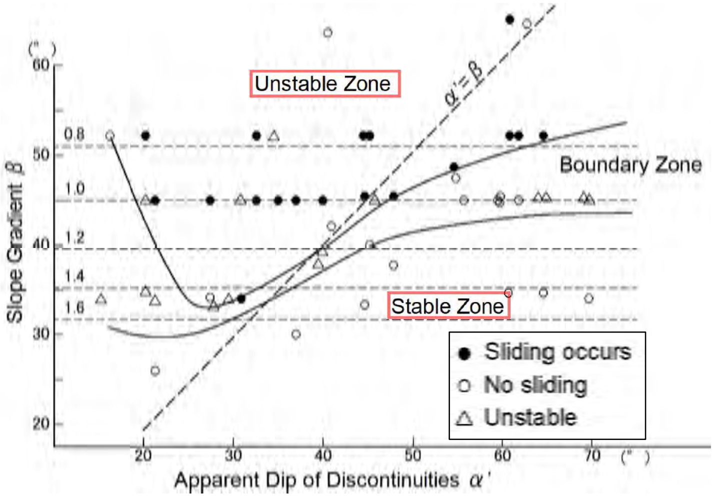


Figure-25 Angle of Discontinuity and Cut slope

4.2 Cutting Slope
(2) Excavation Gradient

Source: Standard of NEXCO (Nippon Expressway Company)

Swelling/ Slaking (Mudstone/Tuff)

- In the case of swelling/slaking, the excavation gradient and the surrounding environment determine the risk of sliding, since the reduction in rock strength occurs within the rock.
- The figure shows the presence or absence of sliding due to excavation gradient for each rock type with swelling and slaking properties.

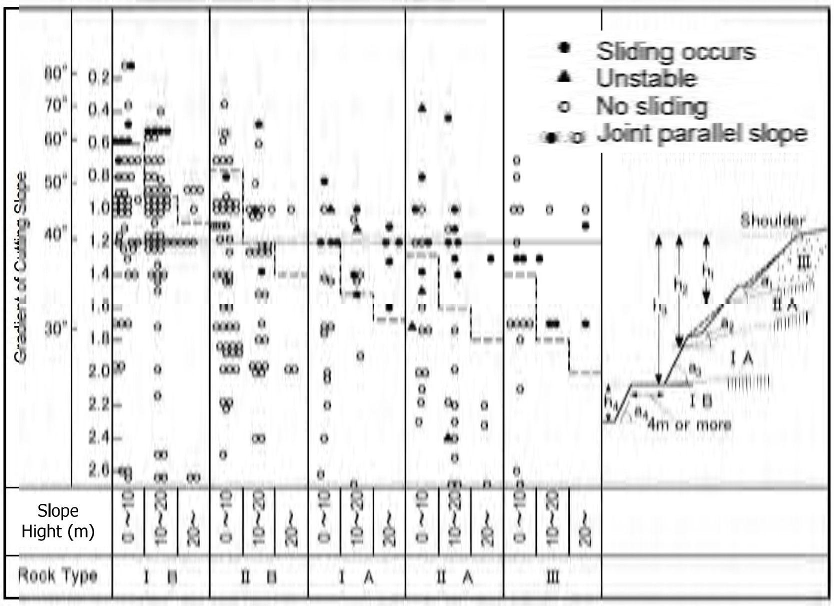


Figure-26 Rock Type and Cut slope Gradient

- Here the rock types are set in combination with the rock density and characteristic.
- For IA, IIA, and III rock types, It is recommended to set a slope gentler than 1:1.2.

Table-3 Rock Type

Properties underground

Rock Type	P wave Velocity (m/s)	Description
I	≥1,600	Fresh and hard
II	<1,600	Poorly consolidated or Weathered rock
III	-	Unconsolidated, Strongly weathered/altered rock

Swelling/slaking property

Rock Type	Water Absorption Expansion Rate (%)	Description
A	≥1.5	High strength loss after excavation.
B	<1.5	Low strength loss after excavation.

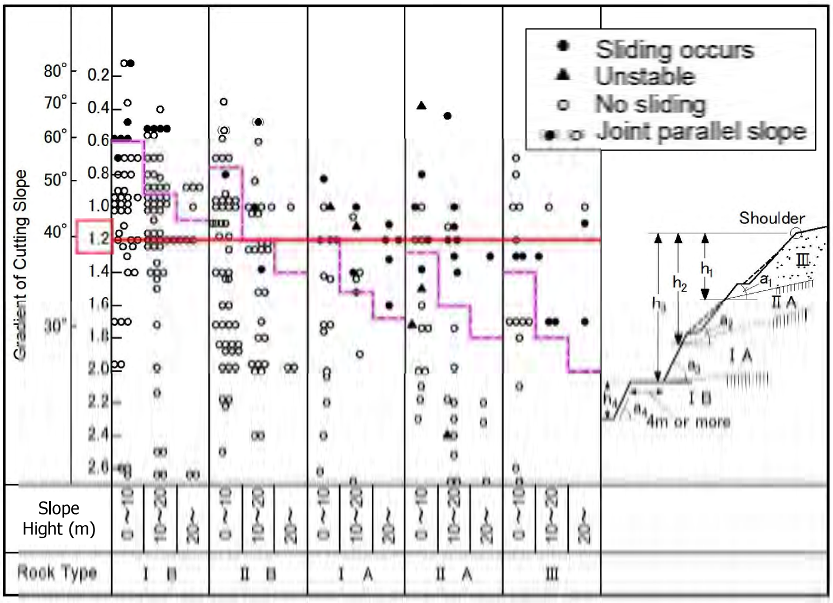


Figure-26 Rock Type and Cut slope Gradient

4.2 Cutting Slope
(3) Characteristic Geological Structures

Caprock Structure

- A structure in which strata with very different physical properties overlie lower strata is called a caprock structure.
- Caprock include limestone layers above mudstone layers and volcanic rocks above tuff layers.
- In this case, seepage flow may reduce the strength of the lower layer at the boundary with the caprock.
- For this reason, it is not possible to prevent sliding simply by setting the excavation gradient of the caprock gently, so rock bolts or anchors are required.

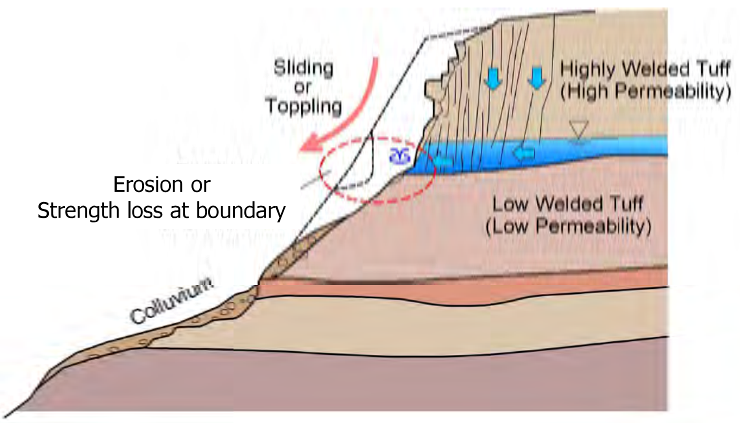


Figure-27 Sliding by Caprock Structure

4.2 Cutting Slope
(4) Protection of Cut Slope

- Slope protection is important as a measure to prevent slope deterioration. Typical protection methods include shotcrete and framework.
- To prevent erosion, bottle units (like a gabion, but flexible) are used as a protection method with good drainage and good flexibility in Japan.

Photo-5 Bottle Units
https://www.maedakosen.jp/case/4034/

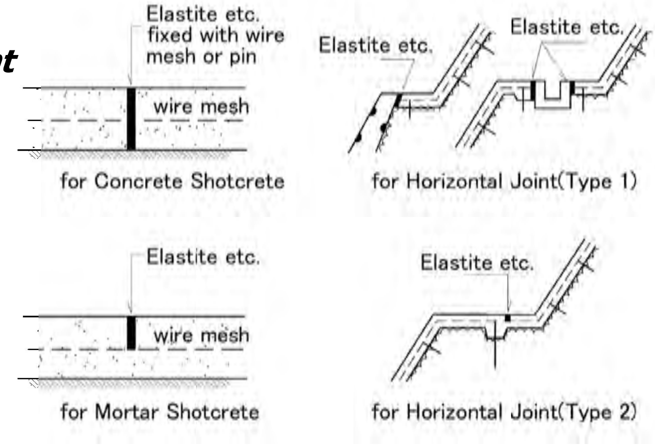
Photo-3 Shotcrete
http://green-eng.com/projects/hukitsuke.php

Photo-4 Framework
http://www.chikenbousai.com/work/index.html

4.2 Cutting Slope
(4) Protection of Cut Slope

- When using shotcrete for slopes with swelling/slaking characteristics, it is very important to prevent rainwater and surface water from entering the slope as much as possible, and to drain surface water from the slope as quickly as possible.
- To prevent water from entering the slope surface, expansion joints will be installed to prevent cracks and shoulders will be treated.

★Install Expansion Joint



★Treatment of Cut Slope Shoulder

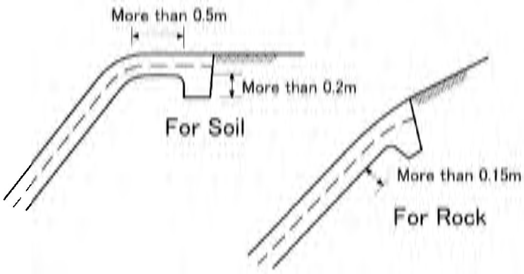


Figure-28 Design Considerations for Shotcrete

4.3 Tunnel
(1) Discontinuity

- Tunnel excavation creates a space underground, which loosens the ground around the tunnel due to stress release.
- If discontinuities develop, the tunnel roof is likely to collapse. In particular, if soft intercalated layers such as mudstone are distributed at a low angle near the tunnel roof, the risk of the roof collapse is high.
- Such geological conditions can be identified during the geological study and design phase, and auxiliary methods such as forepoling can be designed prior to construction. Active communication between geological engineers and design engineers is required to consider the georisk in design.

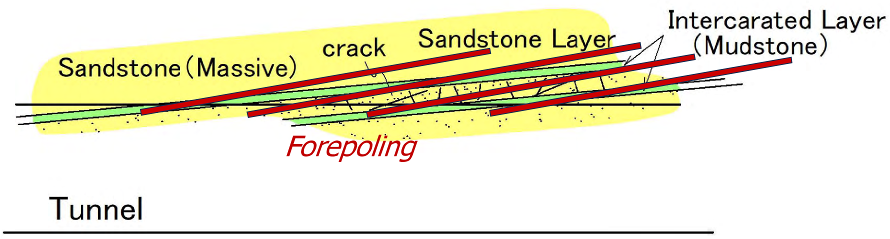


Figure-29 Geological Risk of Tunnel Roof Collapse

4.3 Tunnel
(2) Swelling

- As a geological condition of a tunnel, swelling characteristics can be identified during the geological study phase. Therefore, the swelling of the ground can be considered in the design.
- NATM (New Austrian Tunneling Method) is recommended as the tunnel construction method because it is effective to reinforce the ground around the tunnel to inhibit internal displacement of the tunnel.
- In addition, early closure by invert is effective for ground where relatively large displacements are estimated.
- The construction procedure for NATM is shown next slied.

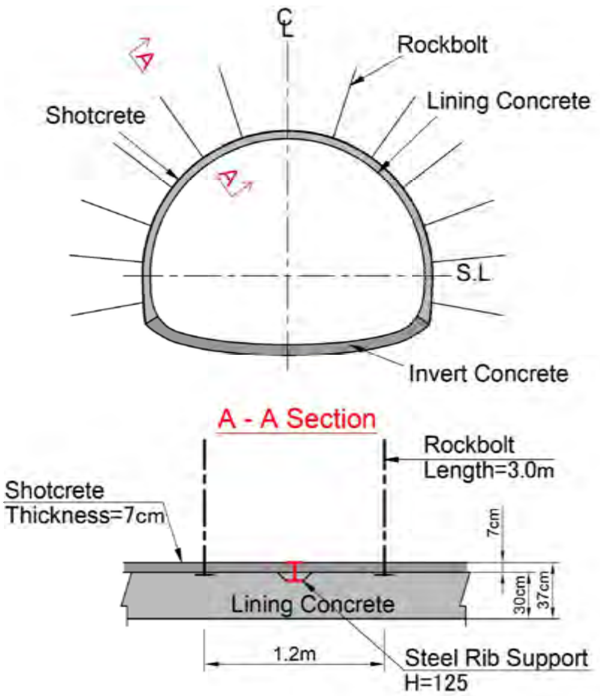


Figure-30 Example for Tunnel Structure by NATM Method

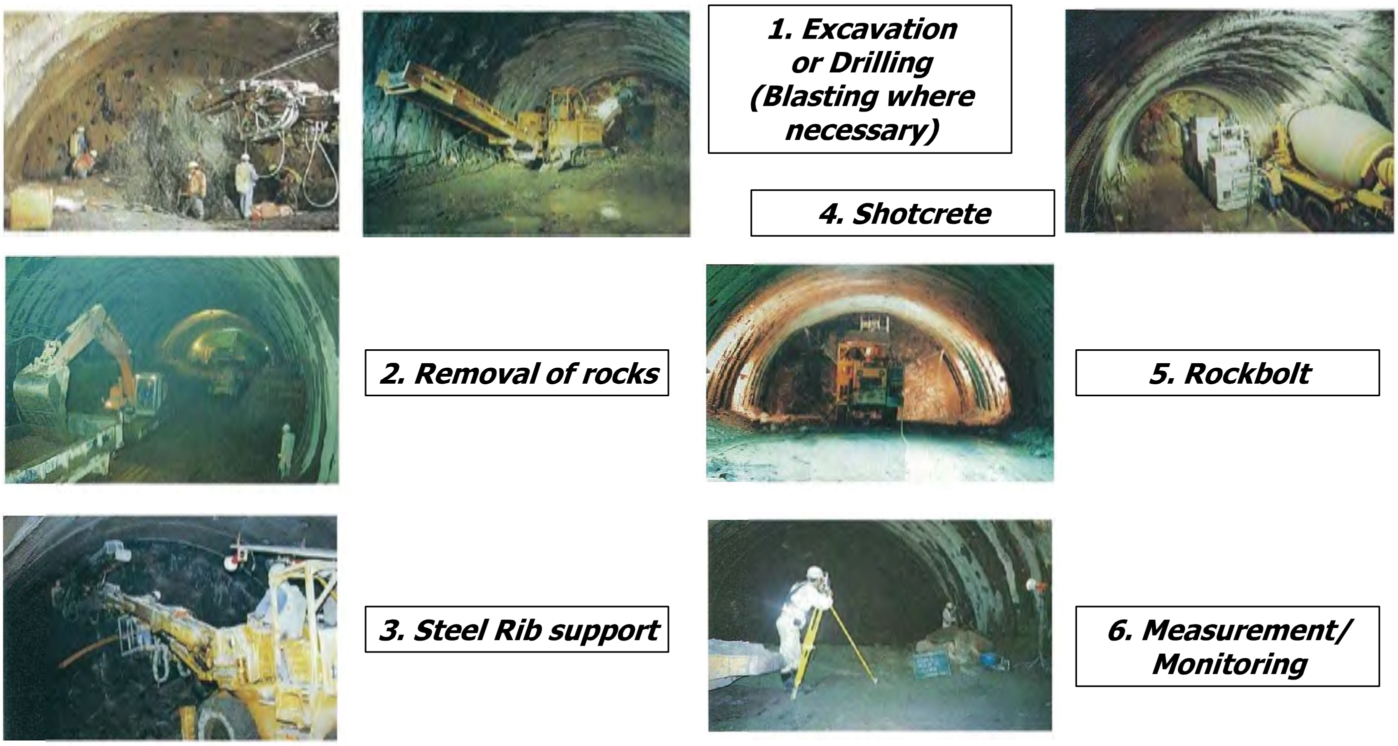


Figure-32 Construction Procedure http://tunnel-ceth.jp/

4.3 Tunnel
(2) Swelling

- However, the swelling pressure during construction may exceed the estimate in the design.
- Therefore, it is important to consider countermeasures before construction and to monitor during tunnel excavation.
- These photos show the deformation that occurred in a tunnel constructed by NATM.

Photo-5 Damaged Shotcrete

Photo-6 Buckling of Steel Ribs

Photo-7 Rupture of Invert Strut

4.3 Tunnel
(2) Swelling

- There are several successes in Japan where steel rib supports were used in multiplex to control high swelling pressure.

Source: https://www.obayashi.co.jp/tunnelworld/system/mountain/case/

Specification

Item			High strength pattern
Primary support	Upper/Lower	Steel rib support	H-200 (SS540)
			t=25cm
			Contains reinforcing fiber
			36N/mm^2
		Rockbolt	4.0m x 10
			4.5m x 16
	Invert	Steel struts	H-200 (SS540)
		Shotcrete	t=25cm
			36N/mm^2
Secondary support	Upper/ Lower	Steel rib support	H-150 (SS400)
		Shotcrete	t=15cm
			18N/mm^2
	Invert	Steel struts	H-150 (SS400)
		Shotcrete	t=15cm
			18N/mm^2

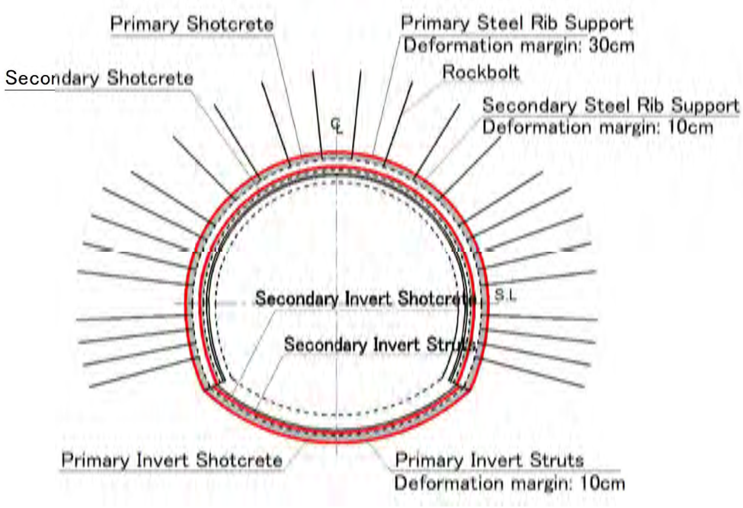


Figure-37 Multiple Steel Rib Support

4.3 Tunnel
(2) Swelling

- For reference, construction methods that allow for deformation can be applied to the ground where there is concern about long-term and large deformation after excavation due to swelling or squeezing.
- There are basically two technical options for accommodating deformation without damage to the lining.

a. Arranging a compressible layer between the extrados of a stiff lining and the excavation boundary

b. Installation of a yielding lining in contact with the rock face. However, the inner cross section of the tunnel becomes smaller in the long term.

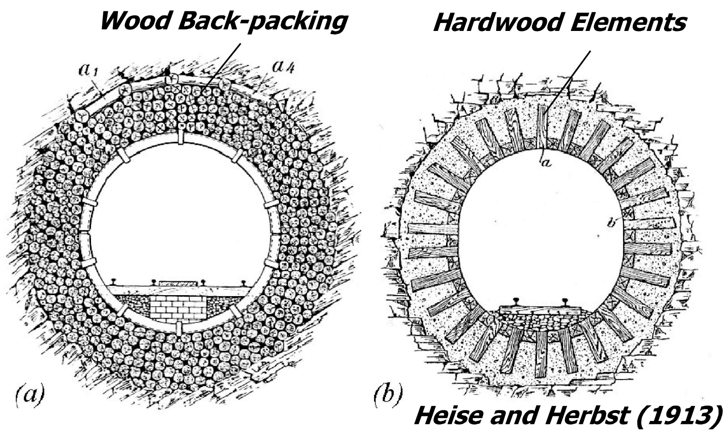


Figure-33 Yielding Support (Old Type)

Source: Kalman Kovári (2009)

Design Methods With Yielding Support in Squeezing and Swelling Rocks

4.3 Tunnel
(2) Swelling

- In recent years, compressible materials such as cement with high porosity are used instead of wood for option a. Additionally, a steel rib support with flexible joints is used as the support for option b.
- Yielding support has a lot of experience in use in Europe, so if you are interested, please refer to it.
- Engineers need to look broadly at the world's technologies. The technology includes not only new technology but also old technology.

Source: G. Anagnostou & L. Cantieni (2007) Design and analysis of yielding support in squeezing ground

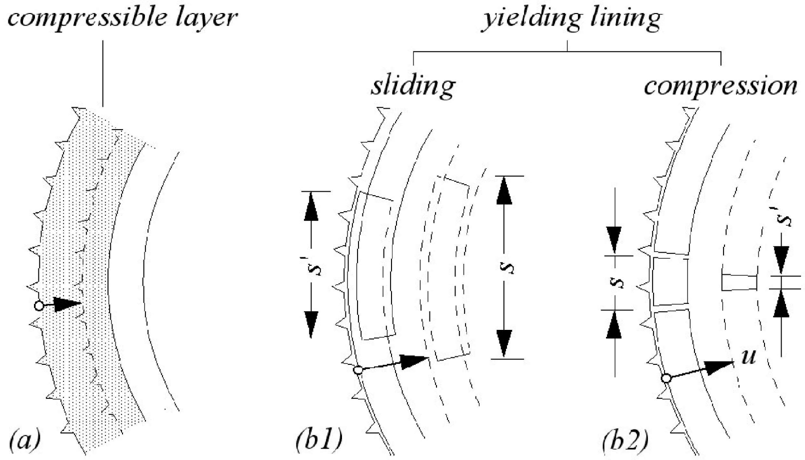


Figure-34 Yielding Support (Recent Type)

Lastly, I would like to say some closing words;

- Currently, many dams are being planned, designed, and constructed in Indonesia, and I believe that by accumulating experience, Indonesia's dam technology and civil engineering technology will develop.
- I believe that by increasing the opportunities for one engineer's experience and knowledge to be shared with other engineers, we can accelerate the development of technology. To that end, interaction between engineers is important, and I think the role of INACOLD and BTB will become even more important in the future.

Terima kasih atas perhatian Anda !

If you have any questions, please contact:

<may be omitted>

- In addition, to address heaving in existing tunnels, it is possible to improve the invert as shown in the figure. In the case, anchors and steel supports using yield material are installed in the invert.
- Yielding support has a lot of experience in use in Europe, so if you are interested, please refer to it.
- Engineers need to look broadly at the world's technologies. The technology includes not only new technology but also old technology.

Source: Kalman Kovári (2009) Design Methods With Yielding Support in Squeezing and Swelling Rocks

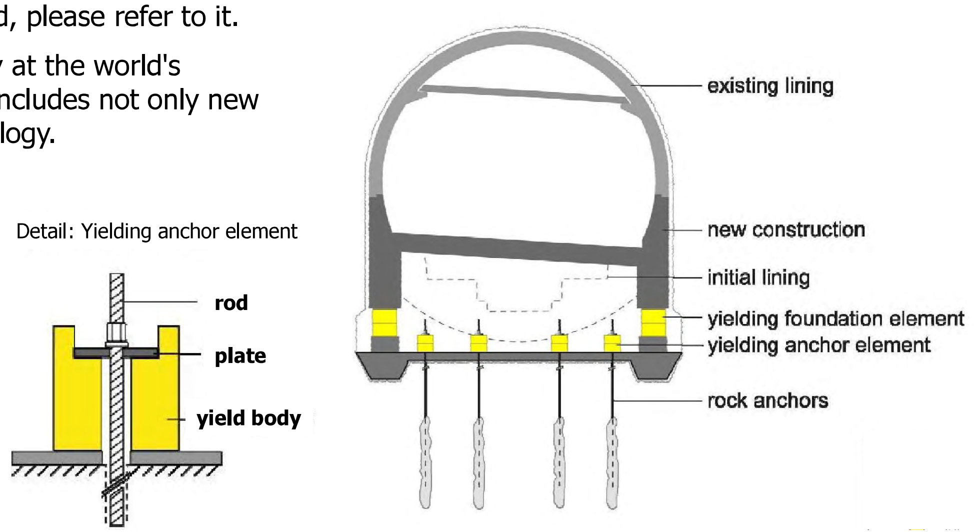


Figure-35 Yielding Support (Recent Type)

<may be omitted>

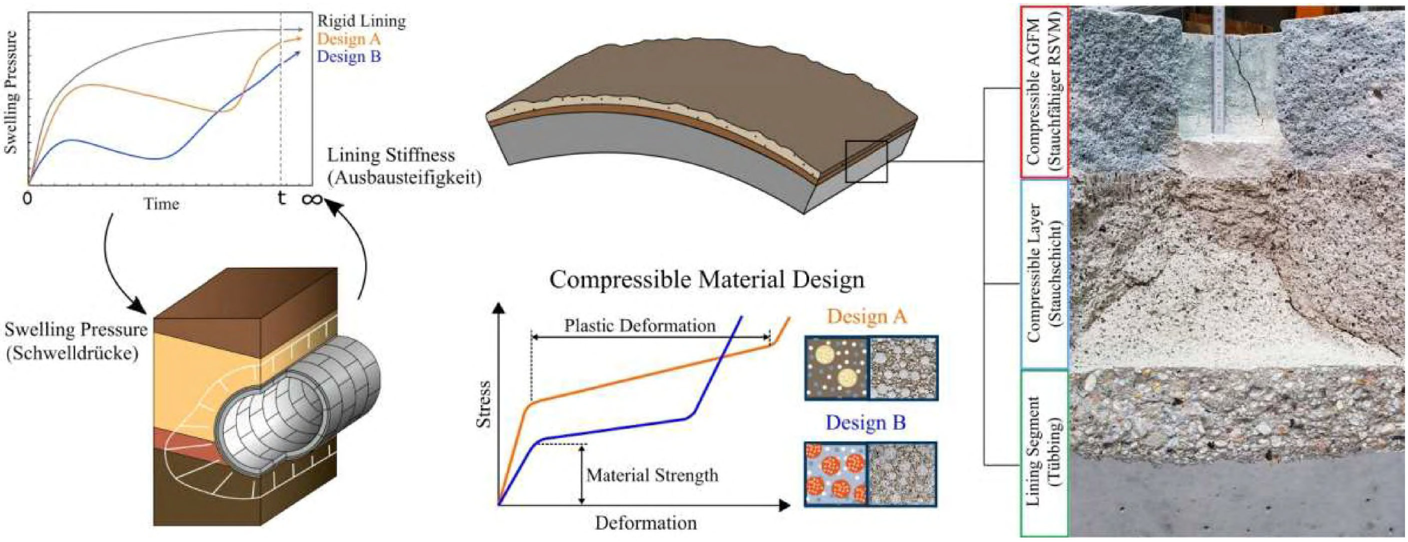


Figure-36 Compressible Cementitious Layer

Source: https://www.tunnel-online.info/en/artikel/tunnel_Deformation-Tolerant_Tunnel_Linings_in_Swelling_Soils-3675510.html