WATER RESOURCES & HYDROPOWER DEVELOPMENT IN ASIA

TRAINING COURSE ON CONTRACT MANAGEMENT

VIENTIANE, LAO PDR February 28 - 29, 2016

GUEST LECTURE

RISK MANAGEMENT

Principles in Hydropower Tunnelling

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CONTENT OUTLINE

1. Risk - Method Choice
2. Selected Excavation Methods
3. Challenges – Design, Construction, Contratring
4. Contracting – Principles & Efficiency
5. Risk Mitigation / Management Strategy
6. Contracting - Conventional & Advanced
7. Preconstruction
8. Risk – Performance
9. Construction – Trends
10. Conclusions

1. Risk Influencies & Method Choice

Governing Influencies

- geological and hydrological conditions,
- cross-section and length of continuous tunnel,
- local experience and time/cost considerations (what is the value of time in the project),
- limits of environmental impact plus others factors.

Excavation Methods

- Mechanical drilling/cutting
- Cut-and-cover
- Drill and blast
- Open & Shielded TBM's
- (Tunnel Boring Machines)
- New Austrian Tunnelling Method (NATM)
- Immersed Tunnels
- Special Methods (Tunnel jacking, etc.)

Bored Tunnel Procedure

- Probe Drilling (if necessary)
- Grouting (if necessary)
- Excavation (mechanical or blasting)
- Initial Support Installation
- Muck Transportation
- Lining or Coating/Sealing
- Draining/Cleaning
- Ventilation

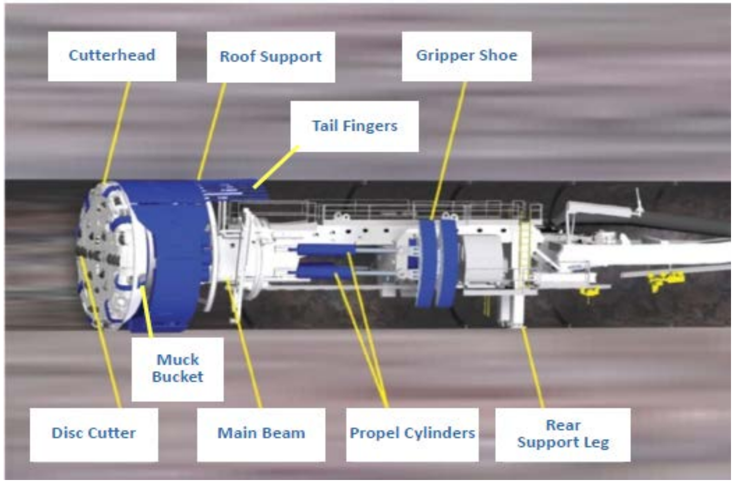
Contract & Risk – Combined Management

- Tunnelling - “Art of dealing with Geologic Uncertainties”.
- Hydro Tunnel Designer decide project future in early project stage.
- Designer manages Tunnel Construction.
- Choice of Design and Contract Type is governing success in construction.
- Contract & Risk Management for both Conventional and Mechanized Tunnelling shall follow “State of Art of Contracting”.

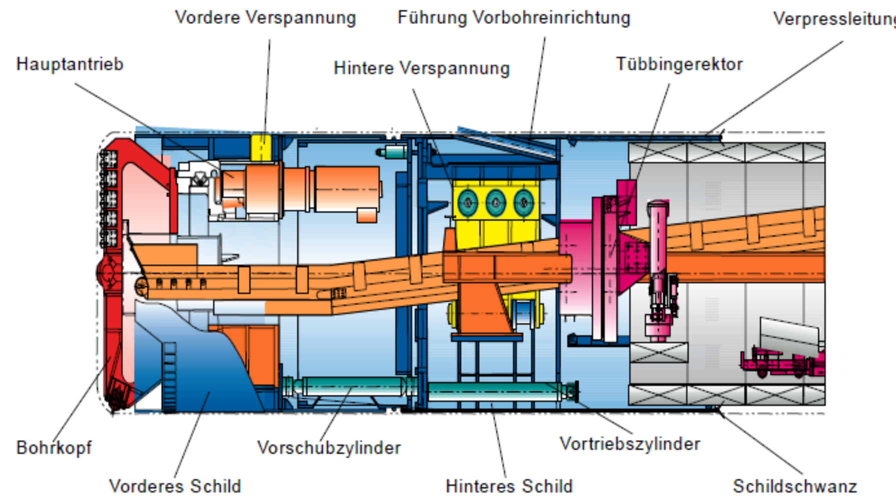
Elements in Design & Construction

- Evaluation/classification of ground conditions and particular project requirements
- Design subdivisions in stages, following the project and construction development
- Framework for a range of potential applications
- Construction Methods suitable for standard plant, equipment and material
- Risk Management Plan (RMP) in context with Geotechnical Baseline Report (GBR)
- Flexible Contract Models for fair remuneration.

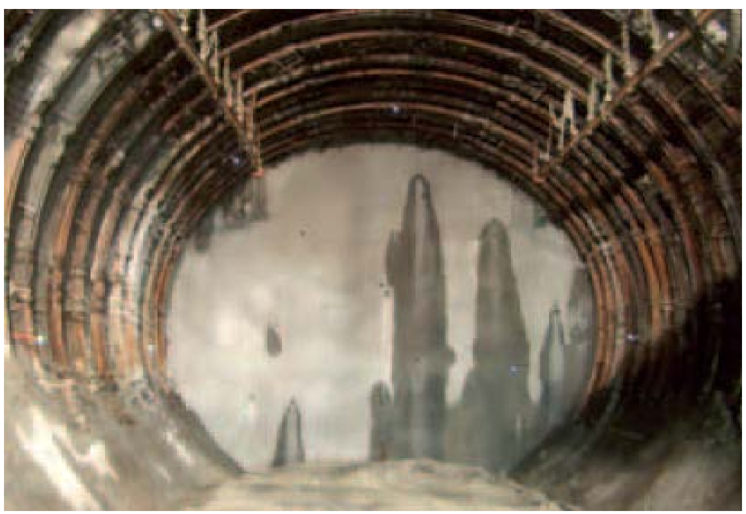
2. Selected Excavation Methods



Excavation using Open gripper TBM in hard rock

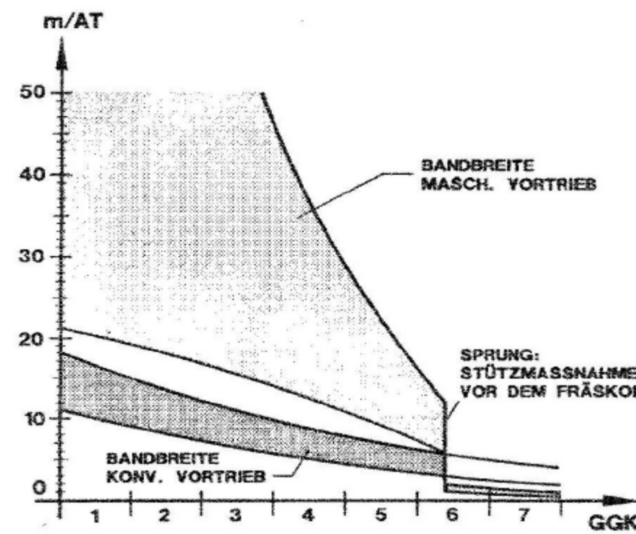


Excavation using Double Shield



Conventional Tunnelling Full face DBM Excavation

TBM vs. DBM Advance Rates & Rock Classes



CASE HISTORY – TBM ANIMATION

HK_gripper_e.wmv

Hard Rock TBM (Manufacturer - Herrenknecht)
5 min Movie

Construction Risk Impacts

MONITORING OF NOISE & VIBRATION

- Impacts due to Excavation
- Impacts due to Muck/Debris disposal
- Impacts due to Equipment
- Impacts of Indoor & Air Quality
- Impact on Water Quality
- Impact on Health & Safety

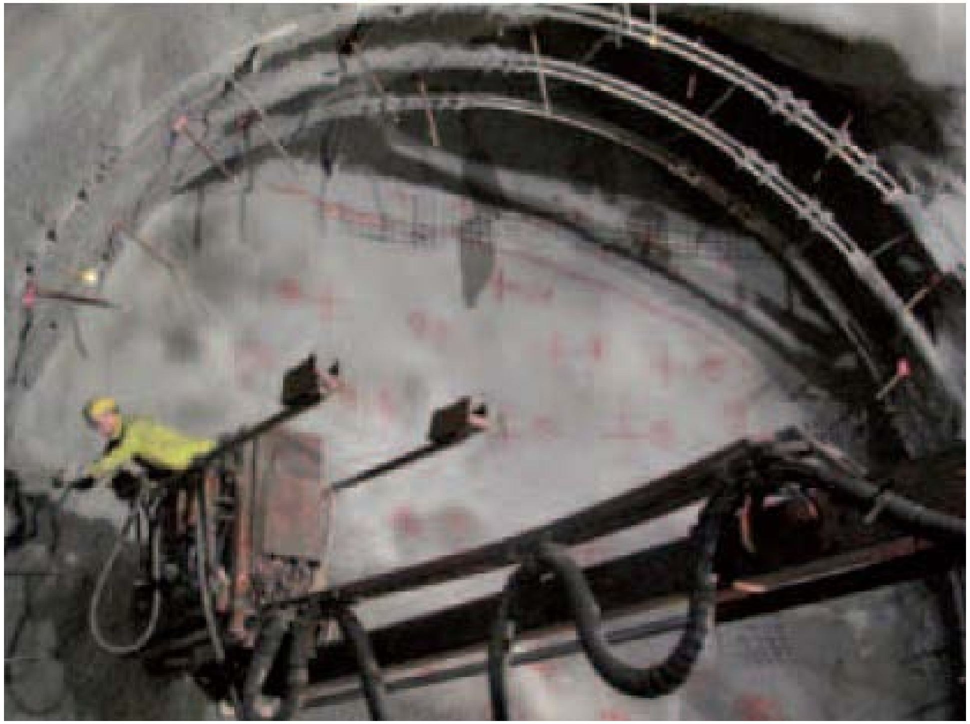
Perceptions

- Damage on structures
- Reduction in discharge of resources
- Reduction in productivity due to dust

3. Challenges of Design

during construction

- Approval of Design
- Appropriate Geomechanical Model
- Calculation & Simulation
- Definition of Threshold Values
- Interpretation of Monitoring Data

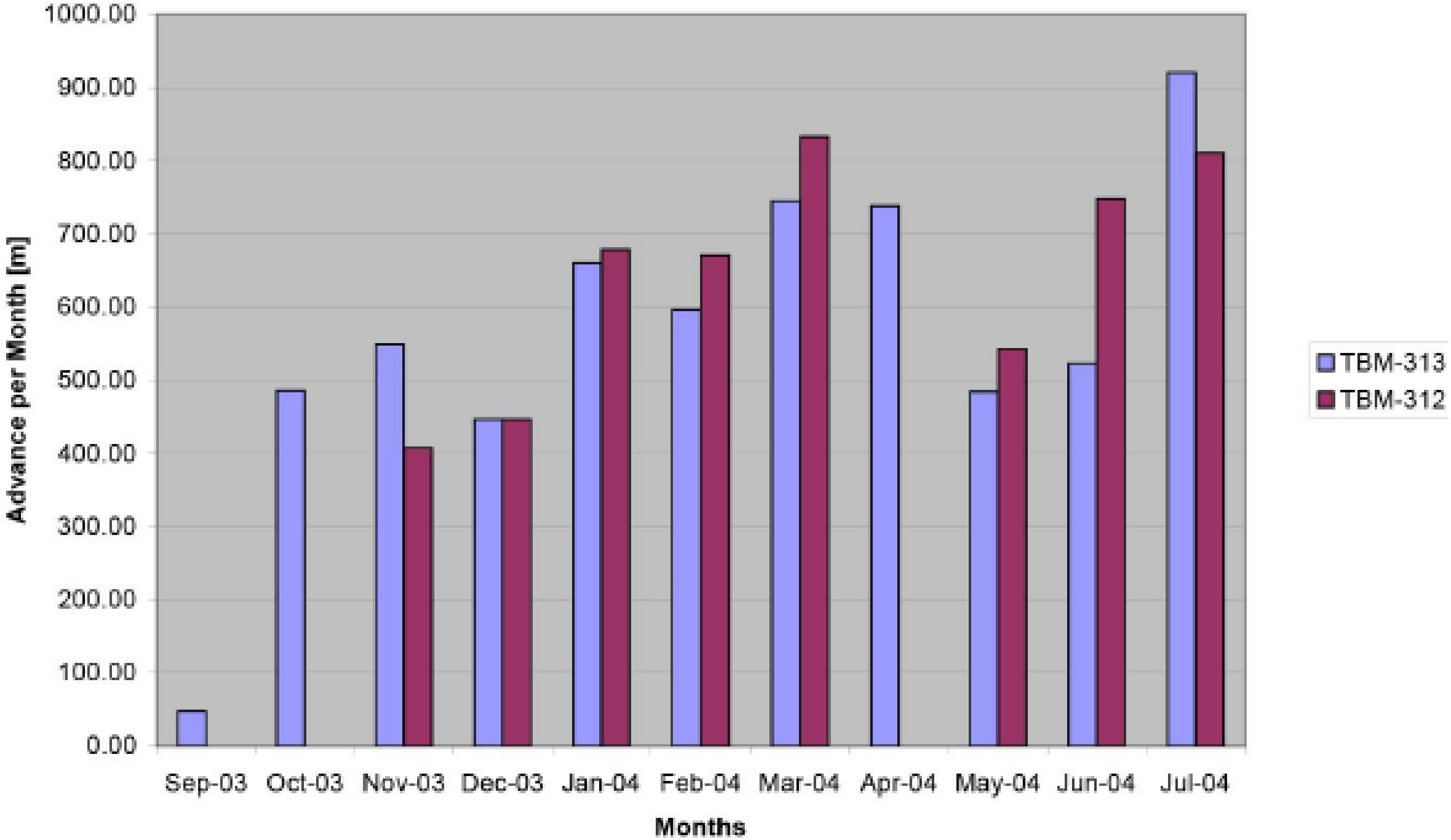


Design of Payment Lines and Geologic Overbreak

4. Challenges of Construction

- Construction approval regarding
  - Change of excavation direction
  - Increase of bench height
  - Increase of Progress Rate
  - Change of Blasting Scheme
- Construction Management
  - Quality Control
  - Decision making
  - Contingency Plans

Risk Controlled Progress in Rock (TBM)

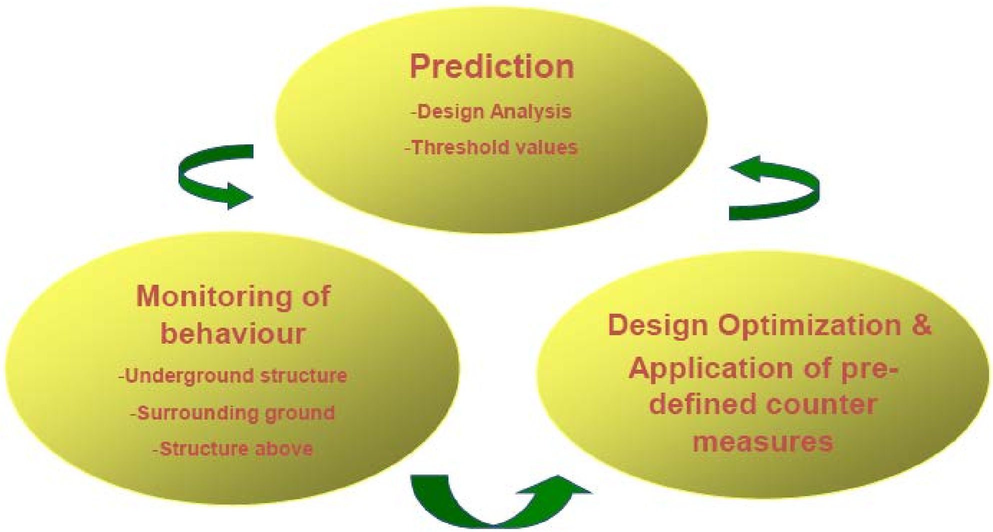


5. Challenges in Contracting

- Target on contractual **Fair Balance** between Quality, Schedule and Costs !
- Have full disclosed **Geotechnical Baselines** and independent Auditing of Control Parameters for Owners !
- Agree on **Risk Sharing** and **Risk Management** , implemented into contract before signing !
- Avoid **Shortcomings** in Engineering (Design and Construction) as this might lead to Collapses !
- **Main Challenge** - Spend Time on Contracting !

6. Contracting RMP Principles

RMP = OBSERVATIONAL METHOD + FLEXIBLE APPROACH + PAT



PAT = PREDICTION ANALYSIS & THRESHOLHD
RMP = RISK MANAGEMENT PLAN

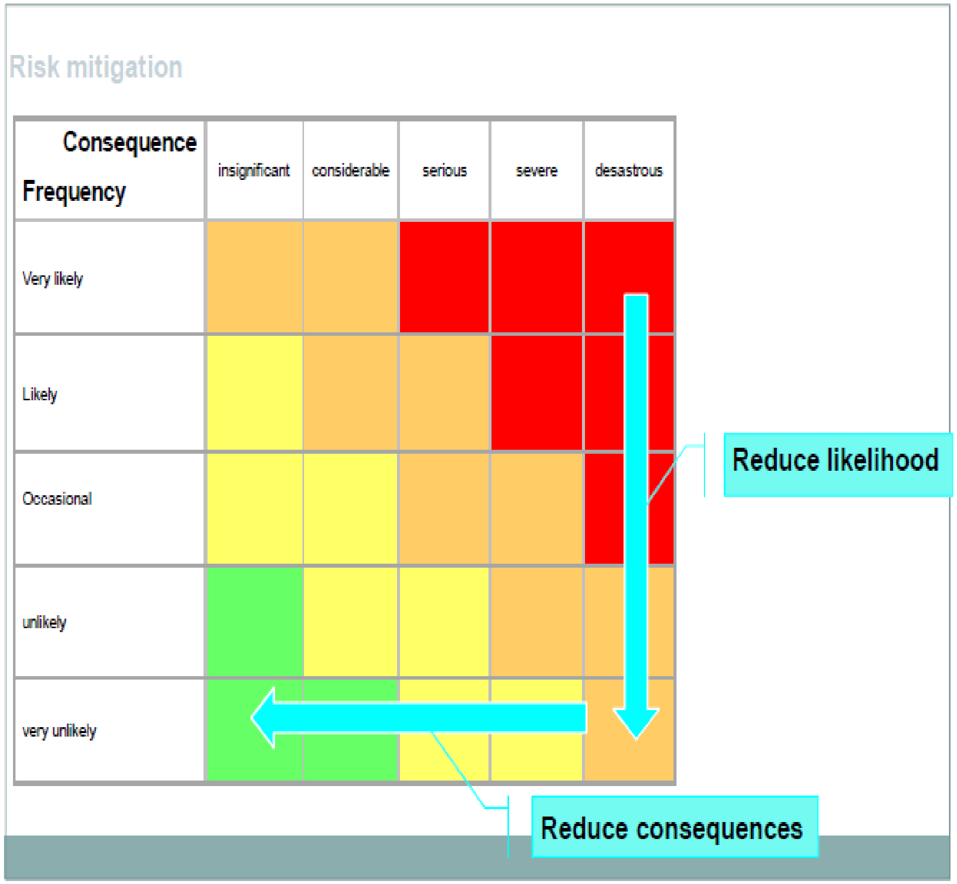
- Efficient Contracting
- EPC vs. Traditional Contracting
- Risk - Ownership and Management
- Approaches for Project Risks Alleviation
- Conventional Bidding vs. Strategic Partnering
- Eligibility and Prequalification
- Training and Capacity Building

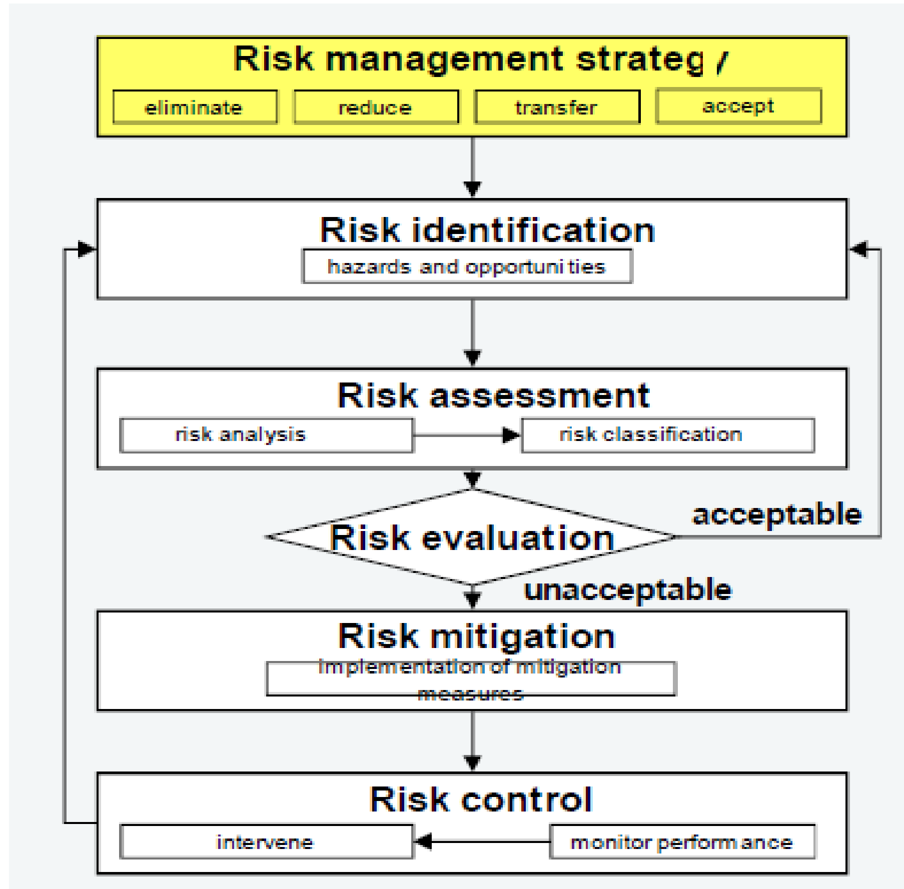
7. Contracting with Efficiency

Concepts shall reflect **Views of Stakeholders**, including government, developers, consultants, contractors, manufacturers, financial institutions and NGOs.

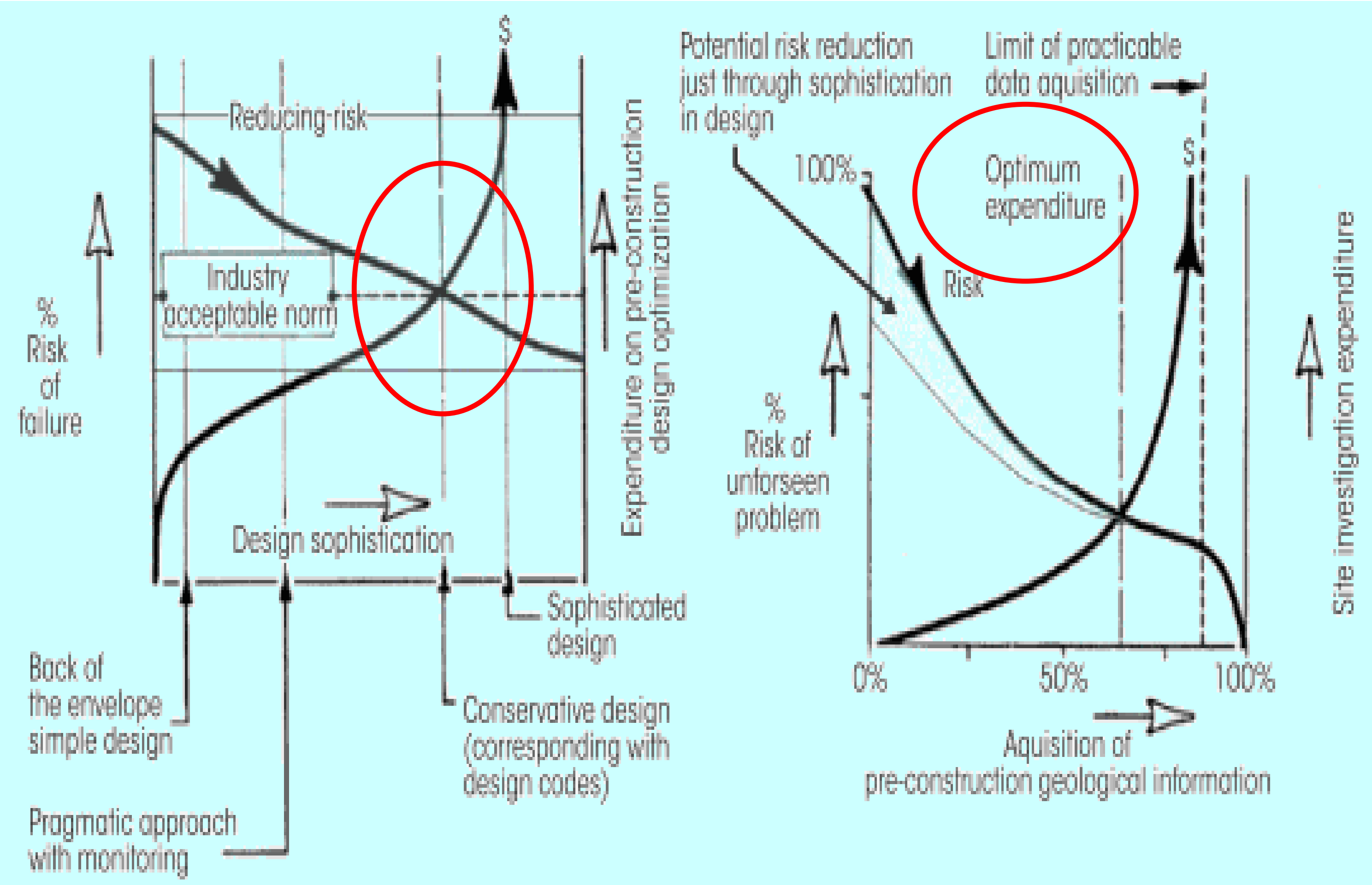
Best Practices are sharing issues including use of standard bidding documents. EPC vs. Traditional Contracting, Capacity Building, Flexibility of Standard Procurement Rules for efficient Contracting and **Risk Sharing Mechanisms**.

8. Risk Mitigation / Management Strategy





Optimized Risk Reduction



9. Conventional vs. Advanced Contracting

- EPC contracts require more **Geotechnical Information** at the time of bidding than is normally available. This puts pressure on **Qualified** Designers to get **Concept Design** as accurate as possible at bid stage.
- Design based on **Insufficient** site investigations may result in delays because more site investigations will be requested.
- **Underground uncertainties** are the most significant risks on hydropower tunnel contracts. Within an EPC Contract, such uncertainties could be controlled and managed by price reopeners and extensions of time based on the **Geotechnical Baseline Report.**

10. Preconstruction Risk Sharing

- For designers and manufacturers, **EPC** can mean taking **Joint Risks** (excluding geological risk) with contractor.
- Contractors and suppliers do not like carrying **Design Risk** that they cannot control.
- Designers and E&M suppliers are unwilling to share risk having only a small share of contract value.

11. Risk Responsibility

- The party who "owns" a Risk, will pay for it if it materializes. **Risks** should be owned by the party with the best ability to control the outcome.
- A **Responsibility Matrix** should be included in the contract to clarify which parties are responsible for which risks.
- The **"Austrian System"** involves a clear risk sharing / risk allocation model. The geologic and hydrologic risk is with the client. The geotechnical behaviour risk is with the contractor.

Assessing continuous Vulnerability and Risk

Level	Likelihood
A	Remote
B	Unlikely
C	Likely
D	Highly Likely
E	Near Certainty

ASSESSMENT GUIDE

Likelihood	a	b	c	d	e
E	M	M	H	H	H
D	L	M	M	H	H
C	L	L	M	M	H
B	L	L	L	M	M
A	L	L	L	L	M

Consequence

Level	Schedule	and/or	Cost
a	Minimal or no impact		Minimal or no impact
b	Additional resources required; able to meet		<5%
c	Minor slip in key milestones; not able to meet need date		5-7%
d	Major slip in key milestone or critical path impacted		7-10%
e	Can't achieve key team or major program milestone		>10%

RISK ASSESSMENT

High (Red)
Unacceptable. Major disruption likely. Different approach required. Priority management attention required

Moderate (Yellow)
Some disruption. Different approach may be required. Additional management attention may be needed

Low (Green)
Minimum impact. Minimum oversight needed to ensure risk remains low

Innovations - Contract Elements

- **Technological Reasons** for performance and risk of TBM's and CTM's ,
- **Reasons** justifying sole use of TBM's or combined use of TBM/CTM,
- **RMP** with Mitigation Measures for improving of TBM's and/or CTM's,
- **Contractual Provisions** to support actual TBM & DBM Tunnelling,
- **Technological Provisions** to support future TBM/CTM Tunnelling.

12. Performance Factors

Rock
Rock type
Mineral composition
Rock strength (comp., tension, splitting tensile, and shear)
Anisotropy

→

- Penetration
- Abrasion
- Muck composition

Rock mass
Bedding and cleavage to boring axis
Joints
Presence of pore water

→

- Penetration
- Time requirement for support
- Abrasion
- Muck grading

TBM
Diameter
Thrust and torque
Disc type
Spacing between discs
Buckets
Support installation equipment

→

- Penetration
- Tunnel face stability
- Chip size
- Time requirement for support

Swiss Underground Engineering Standard (1998)

13. Construction Qualifying

- In Construction Practice, **Pre-qualification Process** ensures the field is restricted to a limited number of well-qualified competitors.
- In deciding whether to invest in the cost of bidding, a contractor / supplier will consider **Probability of Success** and likely revenue.
- Pre-qualification shall take place in stages, with Shortlisted Companies, competitive **Dialogue during Negotiation**, evaluation criteria, and possibly reimbursement of expenses to unselected firms.

Prequalification & Risk Management

Hydropower Tunnels are specific to challenging sites. This shall be reflected in both design and pre-qualification criteria.

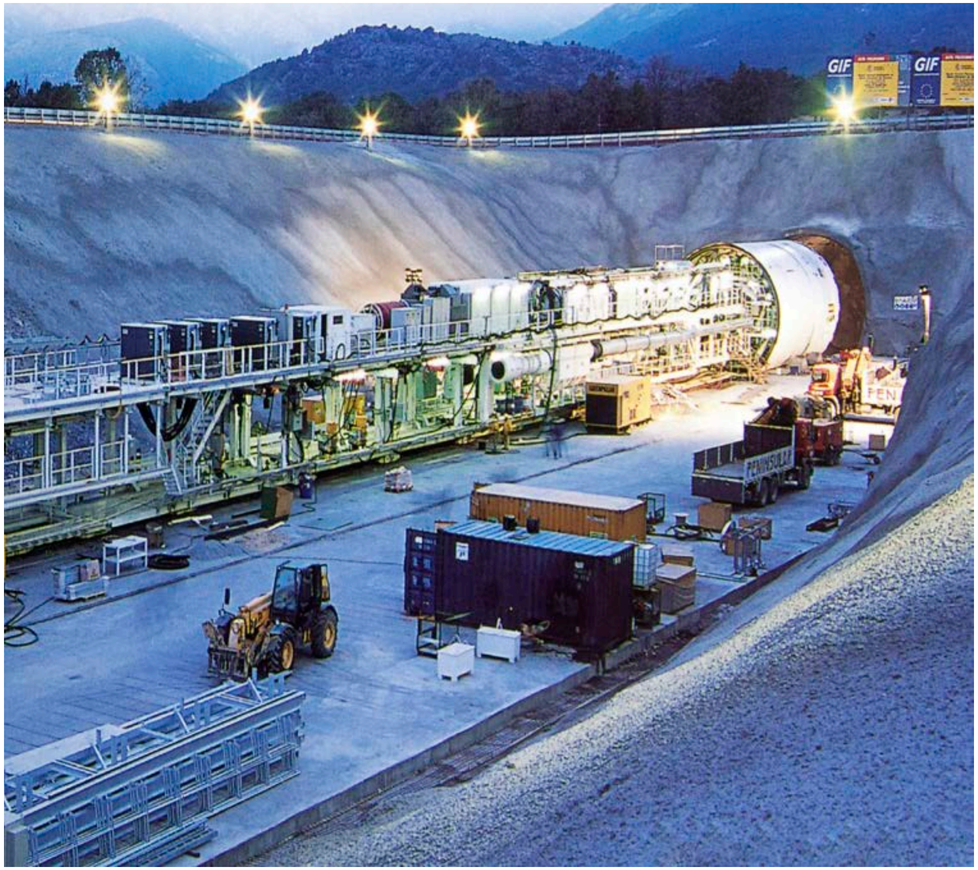
There should be international competitive bidding for **Advisors, Independent Checking Engineers** and **Consultants.**

ToR should include Risk Management experience, Team compatibility and intellectual quality.

14. Contracting Trends

Lessons learned in design and in construction show, **Geotechnical Baseline Report (GBR)** and **Risk Management Plan (RMP)** shall be part of any contract.

Contracting trends show that project owners tend to shift the **Geotechnical Risk** of adverse geology to the contractor.



Risk Coverage

- **EPC** (Engineering Procurement) Tunnel Contracts require more geotechnical investigations and related expenses than conventional contracts

- **GBR & RMP** are helpful tools for owners and contractors during project development in Hydropower Tunnelling at challenging sites.

- Contracting, in particular choices for contract modelling as well as for tunnelling technology, should be decided upon viewing the best **Risk Coverage**.

CASE HISTORY - MALAYSIAN WATER TUNNEL

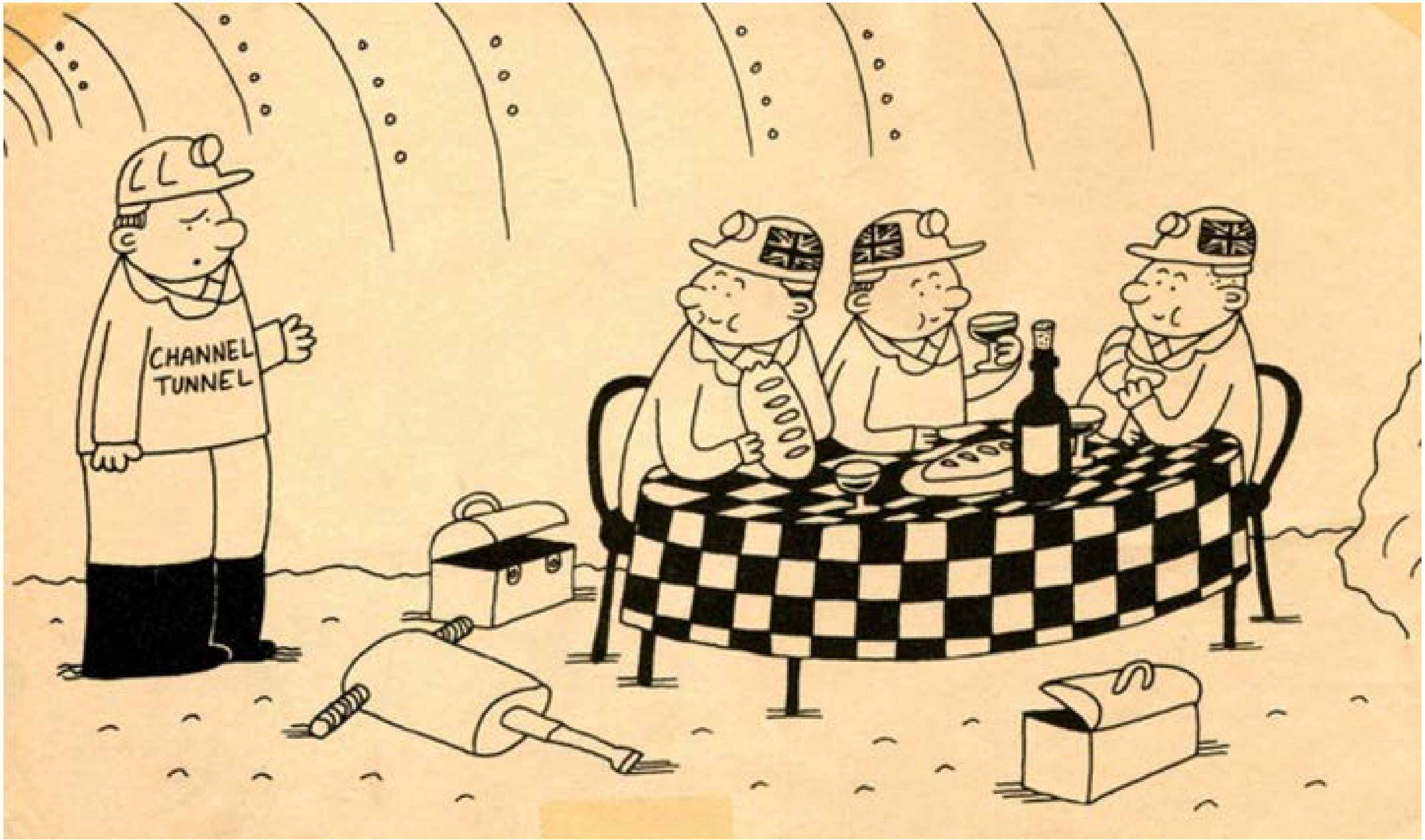
Malaysia Water Tunnel.wmv

Hard Rock TBM (Manufacturer - ROBBINS)
5 min Movie

15. Conclusions

- **Tunnelling** needs **Technology & Contract** Planning
- Reliable Information is needed to achieve efficient **Tunnel Construction**
  - Geological & Geotechnical Baselines,
  - Risk Assessment
  - Construction Options. e.g. TBM, Drill & Blast, etc.
- **Safety** in planning & during implementation includes
  - Capacity Building, and
  - Real-time Monitoring Programs

Tunnels – Symbols of Civilization like Churches, Temples .



Your Attention is appreciated !