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Management of Geotechnical Risks

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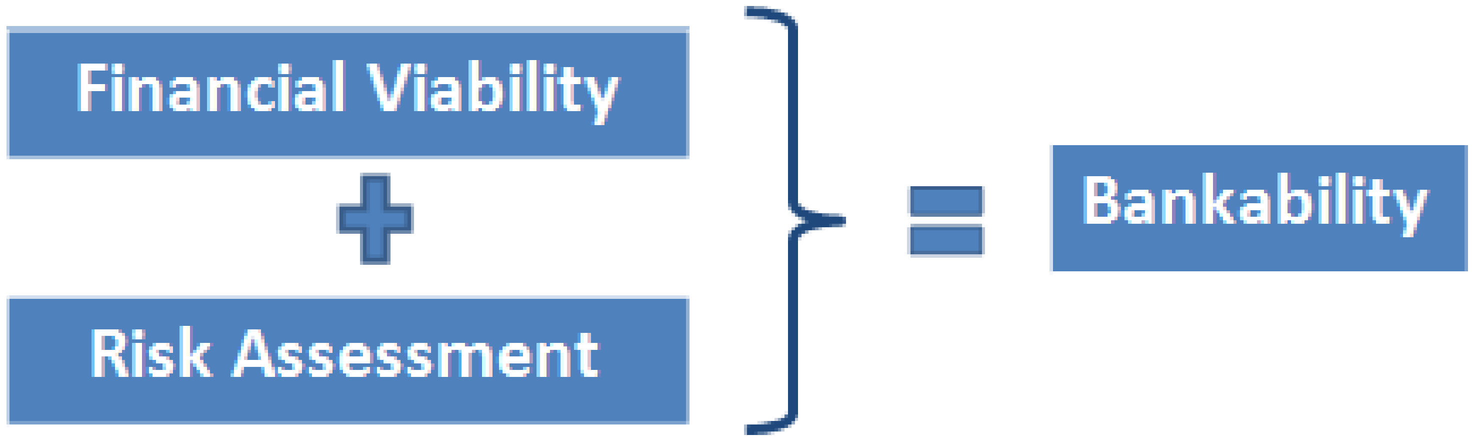
Outline

- Project’s Bankability

- Management of Project Risks

- Minimising “Unknown unknowns”

The concept of “bankability”



- Credit ratings that can extend from AAA (triple A) downwards
- BBB+ generally regarded as the threshold for an Investment Grade project
- Bankability determines also the interest rate and the tenor of the loan

Financial Viability

- Measure of the commercial strength of a project, judged typically over a period of 15 to 20 years.
- Determines whether the project is robust enough to repay loans at commercial rates of interest even under a downside scenario,
- and whether it is likely to provide a sufficiently high return on equity to attract private investors.

Risk Assessment

Type of Risk	Mitigation
Political (Country)	Guarantees
Commercial (Market, Defaulting Off-Taker)	Partially insurable
Project (site specific)	Usually not insurable

- Risk has a Cost
- Risk Cost depends on how risk is allocated

Project Risk Management
Geotechnical Risk

Key management tools:

- ❖Geotechnical Baseline Report (GBR), and
- ❖Project Risk Register (PRR)

Geotechnical Baseline Report

- Contractual understanding of the site conditions, referred to as the geotechnical / geological baseline.
- Contractor bears risk at or below baseline; Employer accepts risk above baseline.
- Baseline setting determines <u>risk allocation</u> and has a great influence on risk acceptance, <u>bid prices</u>, quantity of <u>change orders</u> and the <u>final cost</u> of the project

Re:"ASCE 2007, Geotechnical Baseline Report for Construction – *Suggested Guidelines*"

Project Risk Register (PRR)

- For each risk scenario the following elements are assessed:

Frequency or probability of occurrence
Preventive measures
Potential consequences, before remedial measures
Remedial measures
Resources and costs associated with remedial measures
Time influence after remedial measures
Cost consequences after remedial measures

PRR in a Tunneling Context

Hazard	Risk
Presence of faults not recognized or anticipated	Inappropriate excavation technique or support, leading to collapse.
Sudden changes in ground conditions due to major or secondary faults	Unprepared for changes in ground conditions, appropriate support not available leading to delays and possible collapse.
Highly jointed/ sheared rock mass	Ravelling ground, roof falls and sidewall instability requiring high level of support
Fault gouges	Soft ground or mixed face conditions with potential roof falls and sidewall instability requiring high level of support
Squeezing ground conditions (weak rock at high stress levels)	High deformation of tunnel perimeter requiring re-excavation, uncontrolled collapse, overstressing or failure of support.
Poor quality rock mass conditions	Reduced progress rate, high level of support; difficulty in applying primary support; advance lengths reduced.

PRR in a Tunneling Context (cont.)

Hazard	Risk
Water ingress, possibly under high pressure	Water entering face and causing instability of face and as excavation proceeds. Problems with drilling and charging blast holes. Difficulties with shotcrete application. Reduced progress, problems evacuating water from tunnel.
Tunnel running parallel to fault alignment	Extensive length of poor ground conditions; <u>mixed face conditions</u>; overstressing of rock pillar between tunnel and fault.
Hydrothermal water/ gases (seismically active regions)	Inadequate ventilation available. Difficult/ hazardous working conditions for personnel and machinery. Explosive/ toxic gases.
Low stress conditions (low cover or running parallel to fault zone)	Unraveling due to small interlocking blocks and wedges, collapse can propagate a long way into the rock mass if not controlled.
Adverse geological structures, i.e. folding, perpendicular to faults.	Rock mass quality decrease, reduced progress, increase in primary support required.

Sample Mitigation Measures

Typical Risk	Mitigation Measures
Poor quality rock mass conditions	1. Reduce length of advance; face support/ buttressing/ partial face. 2. Reduce powder factor to lessen blast damage 3. Increase rock support; use rock-bolts and steel fiber shotcrete; use lattice girders with shotcrete, possibly with invert strut or concrete invert. 4. Provision of instrumentation to monitor movement to optimize support. 5. Stockpiling of support materials and equipment close to face; use hydration control additives to store wet-mix shotcrete (to be available “on demand”) 6. Install spilling bars or canopy tubes without; closely spaced pipe spiles in severe conditions to form “umbrella” support in advance of excavation

Project Risk Management

Jointly, GBR and PRR allow to:

- inform decision making on the most appropriate project technology and procurement strategy;
- inform contract documents preparation, and allocation of contingency funds;
- prepare an Health & Safety Management Plan to be implemented during construction;
- manage design variations and associated claims during construction.

Minimizing the "unknown unknowns”

- In a paper on hydro plant rehabilitation, Gummer and Obermoser [1], introduce the concept of “unknown unknowns”

- The concept is equally suitable in tunneling projects

[1] J.H. Gummer, and H. Obermoser (2008) “A new approach to defining risk in rehabilitation works” Int. Journal on Hydropower & Dams, Issue Five, 2008

Dealing with "Unknown" in a Tunneling Context

Unknown Type	Tunneling context	What to do
"Known knowns"	General geology, overburden, expected rock types, groundwater.	The problems lie in the detail, i.e. adequate site investigations at planning stage.
"Known unknowns"	Actual distribution of rock masses along tunnel alignment, extent of fault areas, sudden water inflows, etc.	Availability of adequate resources, and designed contractual flexibility.
"Unknown unknowns"	Un-anticipated extensive fault area, large karst cavity with water and debris filling, mud-like soil within hard rock	The importance of investigation during construction (probe drilling, gas detection, etc.)

How to do it

- “*Known knowns*” can be dealt with at design with adequate investigations
- “*Known unknowns*” should be mitigated by appropriate contractual architecture
- “*Unknown unknowns*” can be minimised if investigations is embedded in the construction phase.
- Residual uncertainties should be incorporated in the Operation & Maintenance Plan