Geotechnical Risk Management Using Geotechnical Baseline Reports

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Risk Management in Underground Construction Course

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Topics

Historical Perspective
Assessing Geotechnical Risk
Risk Sharing Philosophy
GBR Fundamentals
Lessons Learned
Future Developments
Historical perspective

1970s: Construction claims spiraled, industry got a black eye

1974: US National Committee on Tunneling Technology
   “Better Contracting for Underground Construction”

1984: US National Committee on Tunneling Technology
   “Geotechnical Site Investigations for Underground Projects”
   “Should spend at least 1% and up to 3% of the construction value on exploration”

   • Differing Site Conditions Clause
   • Geotechnical Baseline Report
   • Escrow Bid Documentation
   • Dispute Review Board
Historical perspective

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Historical perspective (cont’d)


1997: GBRs for Underground Construction (Yellow Book)


201X: GBRs for Construction (3rd Edition)
Types of risk for an underground project

- Regulatory/Permitting
- Design/Operational
- Financial/Commercial/Contractual
- Site Access/Logistics
- Construction
- Environmental
- Health/Safety/Security

Geotechnical conditions can affect every risk category
Risk assessment process

- Events
- Probability
- Consequences
- Cost to Mitigate
- Base Cost Assumptions
- Risk Identification
- Mitigation Strategies

A GBR is a mitigation strategy
Risk sharing philosophy

Surface vs subsurface construction
Risk sharing vs risk shedding
Surface vs. subsurface construction

Surface Works
- Complicated construction
- Simple constraints
- Can “work-around” delays

Underground
- Repetitive construction
- Complicated constraints
- Linear = Limited Critical Path
- No “work-arounds”
- “Beware the velocity of the loss***
  *George Fox – Grow Tunneling

Risks and consequences are different
Risk sharing vs. risk shedding

Risk Sharing:
- Owner ultimately owns the ground but
- Contractor is responsible for anticipated conditions

Contractor still carries the risk for:
- Appropriate means and methods
- Safety / Workmanship
- Cost / Schedule Performance
Risk sharing goals

Provide common basis for all bidders

Avoid disputes / resolve quickly

*Keep the lawyers out of our business*
GBR fundamentals

Tunneling “Facts of Life”
What is a GBR
How is it used?
8 Underground “Facts of Life”

- Tunnel projects are linear and can extend for miles
- Subsurface conditions can vary significantly across the site
- Subsurface conditions influence construction methods and cost
- Underground “surprises” = commercial risk
- Contractors do not accept risk, they price risk
- Owners seek the lowest cost of construction
- It’s cheaper to anticipate risks than be surprised
- Contracts that anticipate risks result in fewer claims and lower costs
We prepare a Geotechnical Baseline Report to

<table>
<thead>
<tr>
<th>Describe the anticipated subsurface conditions and how they will influence the construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe how they influenced the design</td>
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<tr>
<td>Identify the key subsurface risks on the project</td>
</tr>
<tr>
<td>Describe how those risks are allocated between the contractor and the owner</td>
</tr>
<tr>
<td>Describe how conditions beyond the baselines will be addressed</td>
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</tbody>
</table>

Underground “surprises” = commercial risk

Subsurface conditions significantly vary across the site

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Baseline philosophy

Baselines describe anticipated conditions

Baselines should be a realistic reflection of the available information

Assume the baseline is a “line in the sand”

Within the baselines

Contractor’s Risk

Beyond the baselines

Owner’s Risk

Can set provisional sums for potential conditions outside the baseline
Physical and behavioral baselines

Physical baselines

  Properties and strength characteristics - independent of construction means and methods

Behavioral baselines

  How the ground responds to excavation processes
Physical baselines

**Soils**
- Clays, silts, sands and gravels
  - Strength, c/Φ, K_A
  - Unit weight, water content, grain size, Atterberg limits
  - Abrasivity, stickiness potential
  - Permeability (horizontal and vertical)
- Cobbles, boulders, obstructions
- Groundwater levels, artesian conditions
- Contaminated ground / groundwater

**Rocks**
- Rock types - Sedimentary, Igneous, Metamorphic
- Strength - UCS, BTS, Point load, Punch penetration
- Mineralogy - Grain size, shape, interlock
- Boreability: DRI, CLI, Cerchar Abrasivity
- Stickiness potential (claystones – beware of current vs future water contents)
- Rock Mass Defects - Joints, fractures, faults, shears, weathering, alteration
- Permeability, Gas, Contamination
Behavioral baselines

How the ground will respond to the excavation process

Soil tunnels: Tunnelman’s classification (firm, raveling, running, flowing, squeezing)

Rock tunnels: blocky, cutterhead plucking, slaking, swelling, stress-related spalling and slabbing
GBRs were developed for traditional DBB delivery
What about DB and P3 delivery?

The approach to managing subsurface construction risks should not change

- Follow the same risk sharing philosophy
- Develop and apply a GBR (modified approach)
- Employ a DRB or other alternative dispute resolution method
- Include provisions to address conditions beyond the baselines
GBRs for DB and P3 delivery

The Owner carries out site exploration and develops a reference design.

The DB or Concessionaire Team is responsible for the final design and the construction approach. Means, and methods.

Owner initiates the GBR but describes the physical baselines only.

DB or Concessionaire adds describes the design and construction approaches, and the anticipated ground behavior.
GBRs for DB and P3 delivery

GBR-B
By Owner

GBR-C
By Contractor

GBR to the Contract

Design Constraints

Geologic Conditions

Physical Baselines

Means/Methods

Behavioral Baselines

Ratified by Owner
Lessons learned

Terminology
Ground Behavior
Contractual “Fit”
Terms

Avoid ambiguous words, such as “could”, “may”, or “might”

if it “might” be encountered, Contractor can assume that it won’t

Avoid qualitative descriptors

“high” groundwater table
“frequent” occurrence of boulders
“occasional” joints
“short” stand-up time

Use quantitative terms where possible that can be measured and verified in the field
Ground Behavior – What you see is what you get (?)

Cohesive Soils: Consistency Index (Stickiness, Clogging)


“Fit” within the Contract

Page-turning consistency check
“3 – C’s”
Clear
Concise
Consistent
Future developments
Future developments

**International Tunnelling Association**

- Working Group on Contractual Practices
- Currently writing FIDIC “Emerald Book” to incorporate GBRs and DRBs
- How to adapt GBRs to other international forms of contract (NEC, French, Swiss, HK, Singapore)

**UCA of SME**

- Pamphlet – Alternative contracting approaches for underground construction
Additional reading

www.amazon.com
Summary

Underground construction is unique
Different contracting strategies are warranted
GBR approach not perfect, but it works
Write reasonable baselines and enforce them

*Benefit from the many lessons learned*...
Thank You!

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