MANAGING UNDERGROUND RISKS: GEOTECHNICAL BASELINE REPORTS

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Breakthroughs in Tunneling Short Course
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Topics

Historical Perspective
GBR Fundamentals
Risk Sharing Philosophy
Concept of Baselines
Lessons Learned
Future Developments
Historical Perspective

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

1974: **US National Committee on Tunneling Technology**
   1974: Better Contracting for Underground Construction
   “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
Disputes Review Board
**Historical Perspective (cont’d)**

- **1995:** Construction Disputes Review Board Manual
- **1997:** GBRs for Underground Construction (Yellow Book)
- **2007:** GBRs for Construction (2nd Edition – Gold Book)
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 means, methods, and construction cost
- Underground “surprises” = commercial risk
- Contractors do not accept risk, they price risk
- Owners want the lowest cost of construction for their projects
- It’s better to anticipate a risk event than be surprised
- Contracts that anticipate risks will result in lower cost and fewer claims
8 Underground “Facts of Life”

We prepare a Geotechnical Baseline Report to

- Describe the anticipated subsurface conditions and how they will influence the construction
- Describe how they influenced the design
- Identify the key subsurface risks on the project
- Describe how those risks are allocated between the contractor and the owner
- Describe how conditions beyond the baselines will be addressed

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A GBR Is

A Contract Document

A set of realistic contractual assumptions regarding the anticipated subsurface conditions

An aid to administering the Differing Site Conditions clause under the Contract

A guidance document for bidding the project

A means to help manage the construction
What is a GDR?

Geotechnical Data Report (GDR)

Is a compilation of data gathered during the site investigation(s)

Contains factual information, no interpretation

Is a Contract Document

Can be used to resolve a dispute if the GBR is silent on a matter or circumstance
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”

Risks and consequences are different
Risk Shed ding vs. Risk Shar ing

Risk Sharing:

Owner ultimately owns the ground

Risks allocated to contractor for:

Specified range of anticipated conditions
Means and methods consistent with the anticipated conditions
Workmanship
Cost / Schedule Performance
Risk Sharing Goals

Fairer basis for contracting

Help avoid and resolve disputes

Keep the lawyers out of our business
Concept of Baselines

Baseline Philosophy
Physical and Behavioral Baselines
Design-Build and PPP
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 baselines
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, $c/\Phi$, $K_a$
  - 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
Physical Baselines – Other Considerations

Baseline Representations

Characteristics of ground types across project
Percentage of ground types to be encountered
  At shaft locations
  By tunnel reach
Ground conditions
  Mixtures of different strata
  Interlayered systems
  Soil over rock
  Soil mixtures
  Rock mixtures
  Conditions beyond excavation limits
## Physical Baseline Representations

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Behavioral Baselines

How the ground will respond to the excavation process

- Open shield tunneling
- Close face / pressurized face
- SEM/NATM

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

Rock tunnels: blocky, cutterhead plucking, slaking, overstress-related spalling and slabbing
Pressurized Face Tunneling

Cohesive soils – Consistency Index

Function of LL, PL, and WC

Granular soils – response to different foam dosage rates
Cohesive Soils: Consistency Index (Stickiness, Clogging)


Granular Soils - Slump Tests

Different conditioners

- Foam Injection Ratios
- High Density Limestone Slurry
- Bentonite
- Polymer

Design-Build and PPP Delivery

Owner provides reference design only

Design-builder responsible for design and construction

PPP (and some DB) contracts have attempted to reverse history: All-risk “You bid it, you build it” demand

Recommendation:

- Same risk-sharing philosophy as DBB
- Owner owns the ground
- Subsurface risks are shared
- GBR: three-step development process
GBR Approach for D-B and PPP Contracts

**GBR-B**
By Owner

- Design Constraints
- Geologic Conditions
- Physical Baselines

**GBR-C**
By Contractor

- Design Bases
- Means/Methods
- Behavior Baselines

GBR to the Contract
Lessons Learned
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
Data vs Baselines

What if data is not representative?
- insufficient borings (number, location)
- insufficient testing
- non-representative data distribution
- uncertainty in between the borings

Previous experience is an excellent baseline
Baselines can / should consider more than just the data
“Fit” within the Contract

Page-Turning Consistency Check
“3 – C’s”
Clear
Concise
Consistent
Additional Reading

www.amazon.com
Future Developments
Future Developments

International Tunnelling Association

Working Group on Contractual Practices

Developing guidance documents for international applications

How to adapt GBRs to forms of contract around the world (FIDIC, NEC, French, Swiss, HK, Singapore)

Now used in New Zealand, Australia, Switzerland, Chile, Hong Kong, Singapore, the UK, France, and Japan

Gold Book - translated into Japanese

Will be translated into Spanish and Portuguese

Third Guidelines document in “planning”

Conclusion: GBRs can work, and are gaining acceptance around the world
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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