MANAGING UNDERGROUND RISKS: GEOTECHNICAL BASELINE REPORTS

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Breakthroughs in Tunneling Short Course
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Topics

Historical Perspective
Geotechnical Data Report
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
Dispute Review Board
Historical Perspective

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- Differing Site Conditions Clause
- Geotechnical Baseline Report
- Escrow Bid Documentation
- Dispute Review Board
Historical Perspective (cont’d)


1997: GBRs for Underground Construction (Yellow Book)


20XX: GBRs for Construction (3rd Edition)
Geotechnical Data Report
Geotechnical Data Report

Geologic setting of the project site
Geomorphic
Hydrologic
Tectonic

Site exploration program
Aerial mapping, geophysics, drilling methods
Geotech and environmental
Boring location plan
Sampling procedures
Sample preparation
Sample storage

Field and laboratory testing programs
Tests performed
Test procedures

Results of the exploration and testing programs
Boring logs
Tabulated field and laboratory test results

Results from past programs

*The GDR is included in the Contract*
GBR Fundamentals

Tunneling “Facts of Life”
What is a GBR?
How is it used?
Subsurface conditions influence construction methods and cost. Subsurface conditions can vary significantly across the site. Owners seek the lowest cost of construction and contractors do not accept risk, they price risk. Contracts that anticipate risks result in fewer claims and lower costs. It's cheaper to anticipate risks than be surprised. Underground "surprises" = commercial risk. Tunnel projects are linear and can extend for miles.
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

It’s cheaper to anticipate risks than be surprised

Contracts that anticipate risks result in fewer claims and lower costs

Owners seek the lowest cost of construction

Contractors do not accept risk, they price risk
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

The only set of binding interpretations in the Contract – GBR takes precedence over the GDR
The GDR is

- A compilation of data gathered during the site investigation(s)
- Contains factual information, no interpretation
- Is a Contract Document
- May 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 impacts are different*
Risk Shedding vs. Risk Sharing

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 address conditions beyond the baselines with provisional payment terms
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/non-pressurized shields
- Pressurized shields
- 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

GBR-C
By Contractor

GBR to the Contract

- Design Constraints
- Geologic Conditions
- Physical Baselines
- Means/Methods
- Behavior Baselines
Lessons Learned
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
Clarify how the Baselines Apply

Are the strength parameters intended for design or for excavation planning?

To what a real extent do the baselines apply – if baselines are shown anticipating a 30 ft diam shaft, but the Contractor excavates a 50 ft shaft, do the baselines apply?

Boulder UCS – how is UCS intended to be used within the project?

Clogging potential of claystones vs sticky clays
“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
   Currently re-writing FIDIC to incorporate GBRs
   How to adapt GBRs to other forms of contract around the world (NEC, French, Swiss, HK, Singapore)

Now used in US, Canada, New Zealand, Australia, Switzerland, Chile, Hong Kong, Singapore, UK, India, Abu Dhabi, South Africa

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
Future Challenges - PPP

Some PPP advisors believe that they can shed all risk to the developer/concessionaire/contractor

- Single price, single completion date
- All risks to single party, no risk sharing

Underground industry needs to educate PPP advisors as we have owners over the last 40 years

Risk Management Conference, DC, November 28-29, 2017 will address these and other topics
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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