GBR Fundamentals
Past Practices and Lessons Learned

Seminar on Geotechnical Baseline Reports

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Association of Geotechnical and
Geoenvironmental Specialists

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Topics

- Historic Perspective
- GBR Fundamentals
- Risk Sharing Philosophy
- Physical vs Behavioral Baselines
- Lessons Learned
- Future Developments

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Historic Perspective

- The U.S. “enjoys” more lawyers per capita than anywhere else in the world
- 1970s – DC Subway
  - Claims were “litigated” in a Board of Contract Appeals process
- Solution: Improve US Contracting Practices to keep the lawyers out of our business

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Historic Perspective (cont'd)

- Underground Technology Research Council (ASCE) publication:
- "Avoiding and Resolving Disputes in Underground Construction" (1989)
  - Differing Site Conditions Clause
  - ***(Contractual) Geotechnical Interpretive Report***
  - Escrow Bid Documentation
  - Disputes Review Board

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Historic Perspective (cont'd)

- Contractual context is for North America
- Must adapt to accommodate different conditions of contract and legal norms

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GBR Fundamentals

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

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8 Underground “Facts of Life”

Tunnel projects are linear and can extend for kms

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

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8 Underground “Facts of Life”

We prepare a Geotechnical Baseline Report to

- Describe anticipated subsurface conditions during construction
- Describe how those conditions will influence construction
- Describe how those conditions have influenced the design
- Identify key risks on the project
- Describe who carries the risks for conditions within and beyond the baselines

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A GBR *Is*

- A Contract Document
- A set of 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 risk allocation document to help manage the construction

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A GBR is *Not*

- Based only on geotechnical data – also reflects local construction experience and data gaps
- A warranty that the baseline conditions will be encountered – Mother Nature is inherently variable and impossible to predict precisely
- A mechanism for pushing all risks to the Contractor

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Risk Sharing Philosophy

- Surface vs Subsurface Projects
- Risk Shedding vs Risk Sharing
- Goals:
  - Fairer basis for contracting
  - Help avoid and resolve disputes
  - *Keep the lawyers out of our business*

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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

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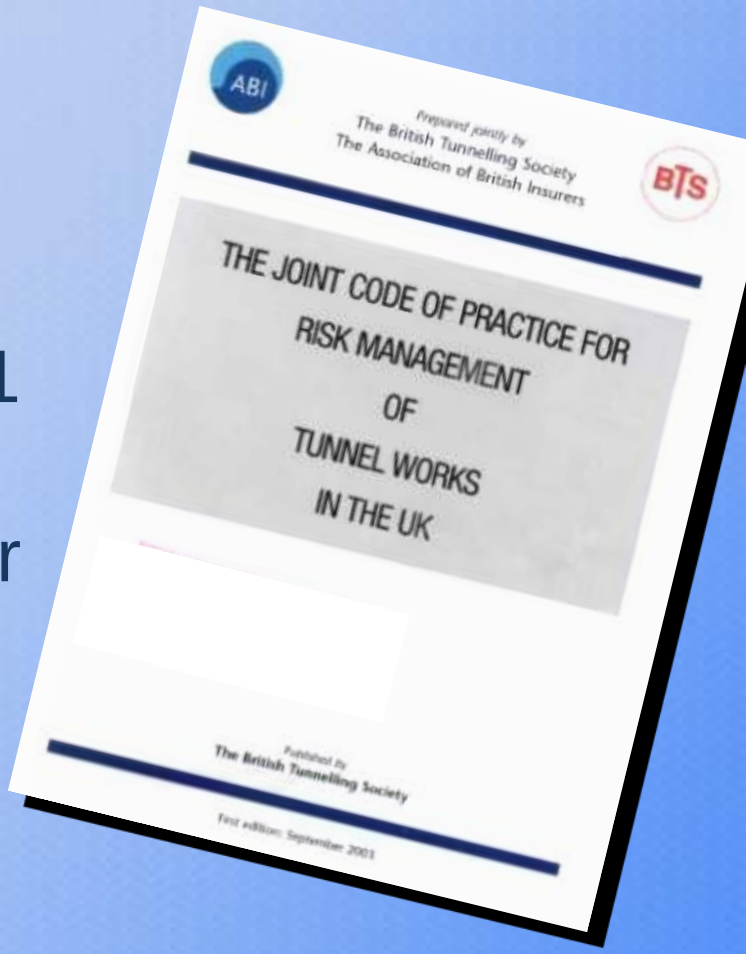
Joint Code of Practice for Risk Management of Tunnel Works in the UK (2003)

The 1990s – 2000s

- Several spectacular UK tunnel failures
- Insurance losses following 9/11 attack
- Insurers needed to reduce their risk exposure
- Two driving principles
  - Risk Registers
  - Reference Conditions (a.k.a. Baselines)



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Joint Code of Practice for Management of Tunnel Works in the UK (2003)

Section 7 - Project Development Design Studies

By the end of the *Project Development Stage*, the *Client* shall prepare (or have prepared on his behalf) ***ground reference conditions*** or ***geotechnical baseline conditions***[1]. Such "*Ground Reference Conditions*" or "*Geotechnical Baseline Conditions*" may not necessarily be those that have been assumed and adopted for the development of a preferred project option or options in terms of project outline designs or detailed designs as appropriate. They shall, however, be issued to tenderers as integral and formative information provided at time of tender on which tenders should be based (see Section 8). The *Client* shall take responsibility for the "*Ground Reference Conditions*" or "*Geotechnical Baseline Conditions*" so issued which shall form the basis for comparison with ground conditions encountered. The nature and form of the "*Ground Reference Conditions*" or "*Geotechnical Baseline Conditions*" shall be sufficiently detailed to obviate any argument as to matters of fact on which the tender was to be based and also provide the baseline against which encountered conditions can be reliably assessed.

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[1] *See "Geotechnical Baseline Reports for Underground Construction –Guidelines and Practices" published by the America Society of Civil Engineers, 1997*

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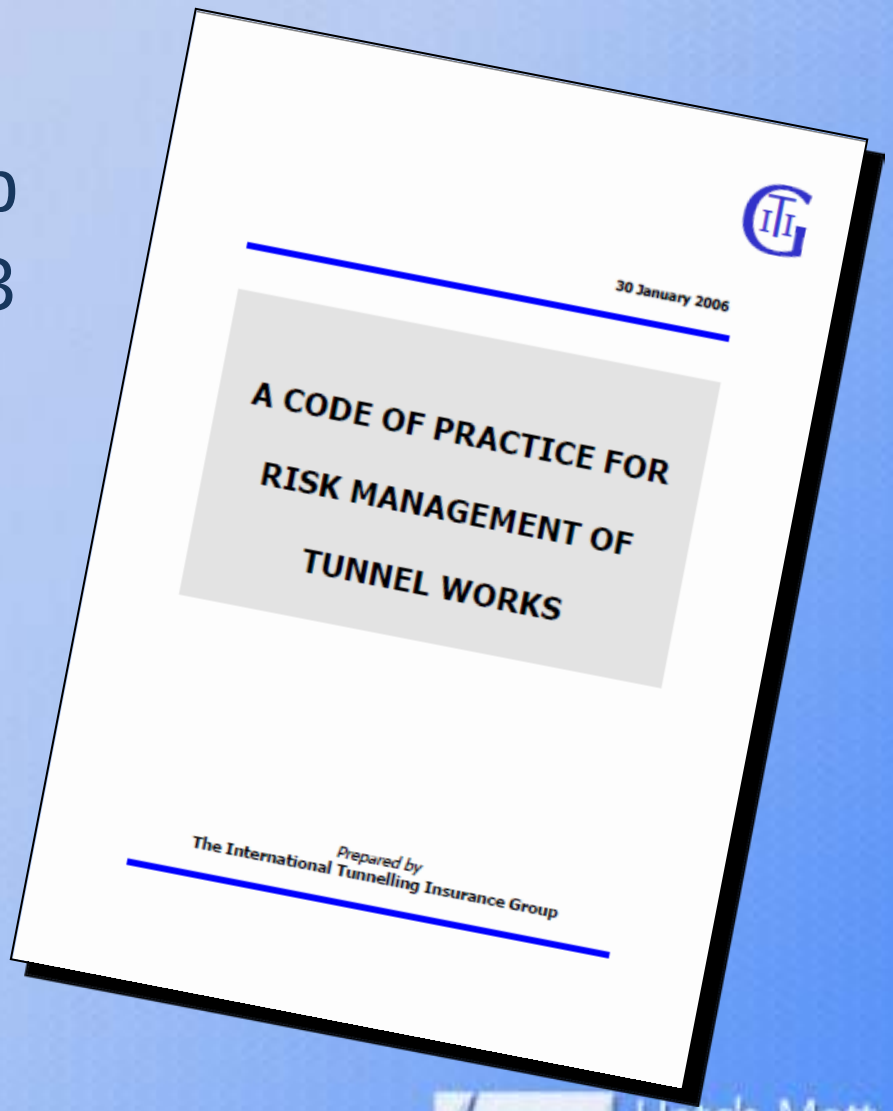
A Code of Practice for Risk Management of Tunnel Works (2006)

International Insurers Group

- 2006 Modification of 2003 document
- Same objectives



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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 anticipated conditions
  - Workmanship
  - Cost / Schedule Performance

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Baseline Philosophy

- *Physical* and *behavioral* baselines
- Baselines should be a reasonable extension 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 baseline

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Baseline Philosophy (cont'd)

- The GBR should be brief
  - 30-50 pages max
- The Owner should be involved with
  - the setting of the baselines
  - understanding the consequences of where the baselines are set

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Physical vs Behavioral Baselines

- Physical baselines
  - properties and strength characteristics - independent of construction means and methods
- Behavioral baselines
  - How the ground responds to excavation processes

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Physical Baselines - Soils

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

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Physical Baselines - 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)
- Rock Mass Defects - Joints, fractures, shears, weathering, alteration
- Permeability, Gas, Contamination

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Physical Baselines

- 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

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Physical Baseline Representations

Item	Poor	Better	Best
Geologic Profile	None	No stratum boundaries	Stratum boundaries
Profile Information	None	Stick logs	Soil logs with strength, plastic limits, water contents Rock logs with Recover, RQD, geophysics
Data	Tabulated results	Tabulated results with min, max, and average values	Histogram representation of data sets, showing min, max, baseline values, and data set “signature”

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Behavioral Baselines

- How the ground will respond to the excavation process
  - Open shield tunneling
  - Close face / pressurized face
  - NATM
- Tunnelman's classification (firm, raveling, running, flowing, squeezing)
  - Atmospheric behavior still useful for pressurized face assessments
- Pressurized face tunneling: responses of soil types to different soil conditioning agents and dosages

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Valuable Information for Pressurized Face Tunneling

- Cohesive soils – Consistency Index
  - Function of LL, PL, and W_C
- Granular soils – response to different foam dosage rates

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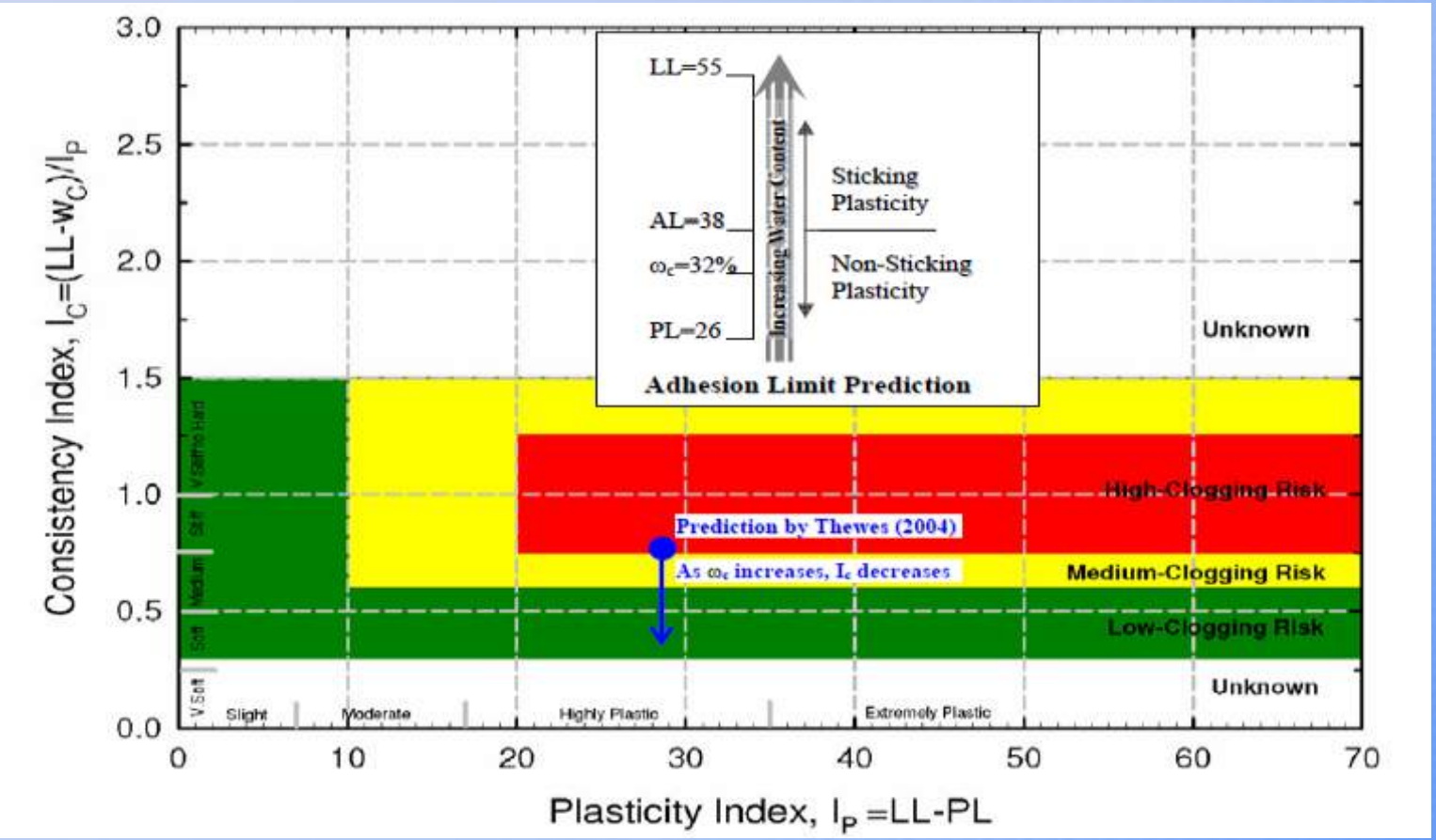
Cohesive Soils: Consistency Index (Stickiness, Clogging)



Ball, Young, Isaacson, Champa, Gause (2009). *Research in Soil Conditioning for EPB Tunneling through Difficult Soils.* Rapid Excavation and Tunneling Conference

Thewes and Burger (2004) *Clogging risks for TBM drives in clay. Tunnels &* Tunnelling International, pp.28-31. June.

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Granular Soils – Slump Tests

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

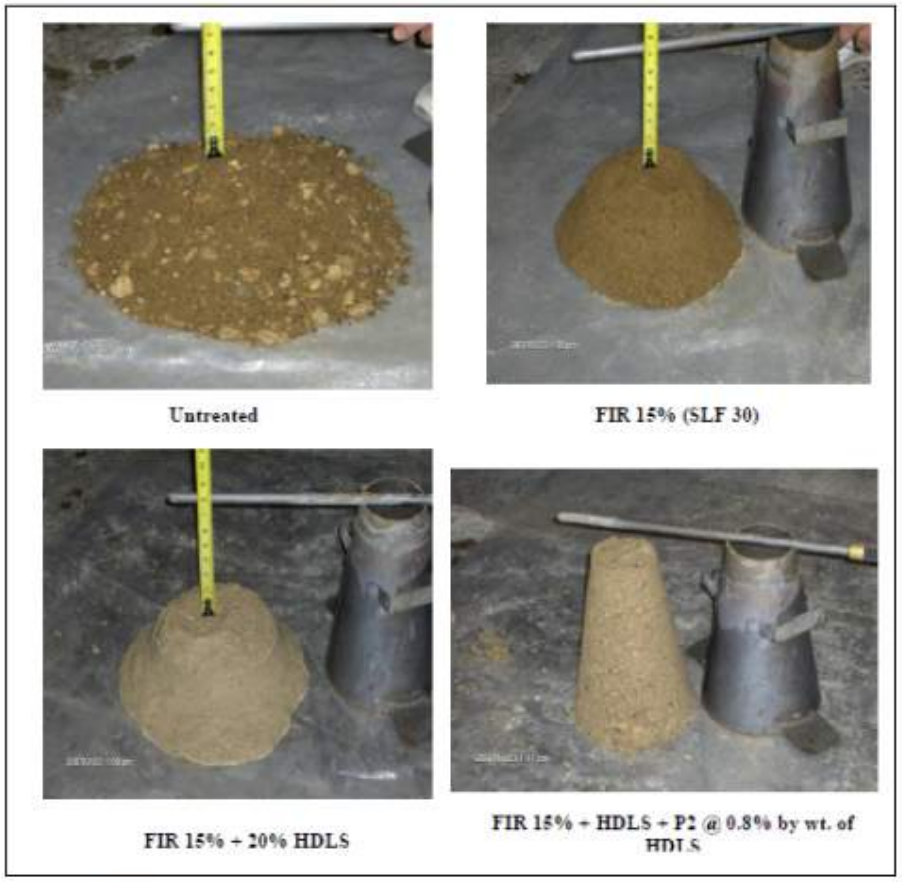

Figure 7 – Photos of soils conditioning on BASF mixture of sand and gravel with low fines

Ball, Young, Isaacson, Champa, Gause (2009). *Research in Soil Conditioning for EPB Tunneling through Difficult Soils.* Rapid Excavation and Tunneling Conference

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Approach for D-B Contracts

- Same philosophy
  - Owner owns the ground
  - Risks should/can be shared
- Three-step development process
- Step 1 - GBR for Bidding (GBR-B)
  - Addresses relevant physical conditions
  - Specify/preclude certain means/methods
  - Provides gaps for DB teams to explain
    - Design approaches and bases
    - Construction approaches and bases
    - Anticipated ground behavior consistent with approaches

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Approach for D-B Contracts (cont'd)

- Step 2 – GBR for Construction (GBR-C)
  - Blanks filled in
  - States behavioral issues key to design and construction means / methods
- Step 3 - Owner review
  - Review baseline statements for reasonableness
  - Resolve baseline terms and bid items
  - Discussions with more than one bidder
- Accepted GBR is basis for Contract

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Lessons Learned: Terms

- Avoid use of ambiguous words, such as “could”, “may”, or “might”
  - if it “might” be encountered, Contractor can assume that it won’t
- Avoid qualitative words
  - “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*

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Lessons Learned: Data vs Baselines

- Baselines should be consistent with the data, if representative
- What if data is not representative
  - insufficient borings
  - insufficient testing
  - non-representative database
  - uncertainty in between the borings
- Previous experience
- In this case, baselines can over-ride the data

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Lessons Learned: “Fit” within Contract

- GBR must fit with other Contract Documents
- Best to finalize following design completion
- Key link: measurement and payment provisions
- Reference, do not repeat or paraphrase, other Contract Documents
- GBR can serve as a roadmap to the Project
- Identify constraints and latitudes

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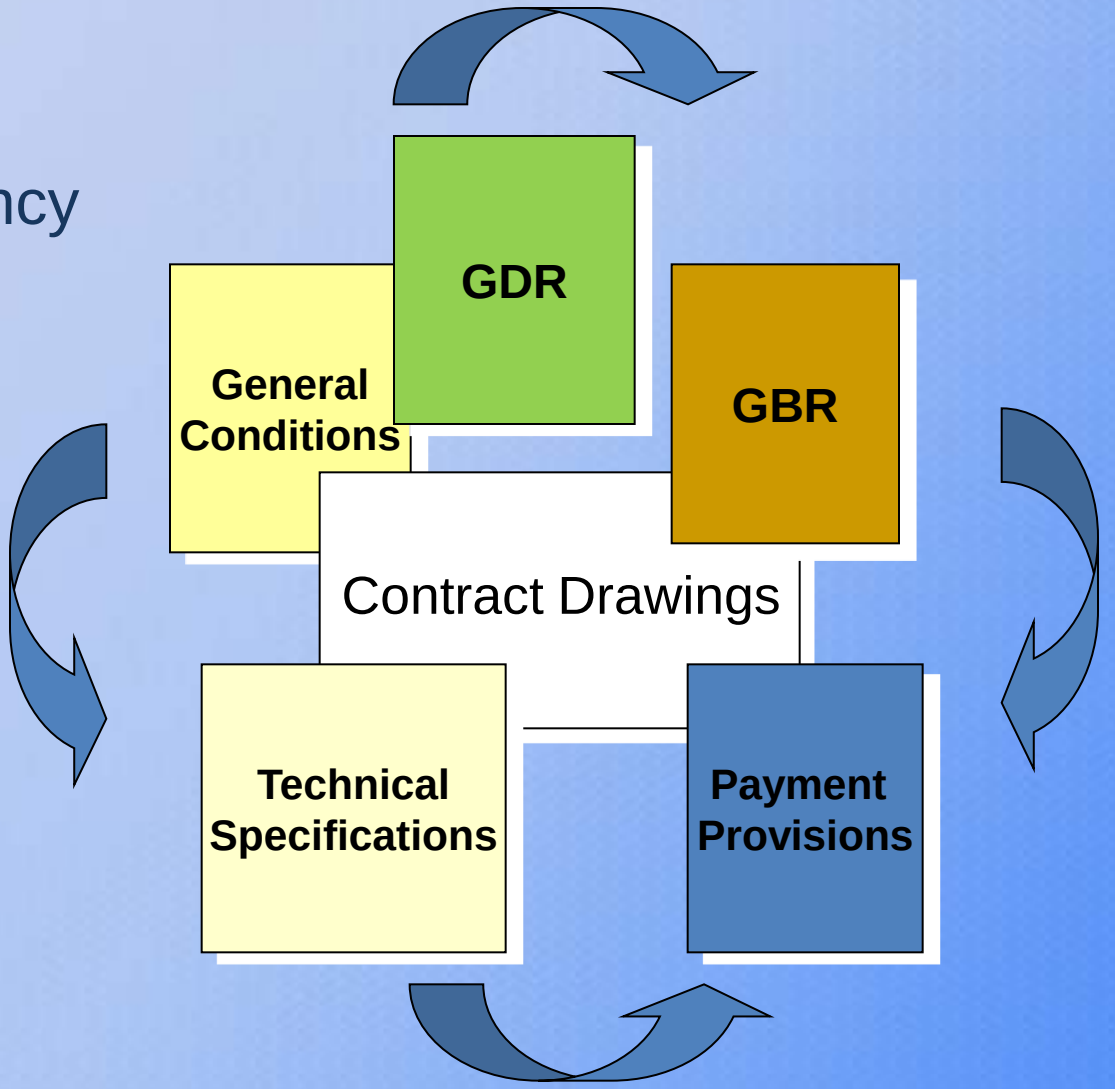
Compatibility Check

Page-Turning Consistency Check

- “3 – C’s”
- Clear
- Concise
- Consistent



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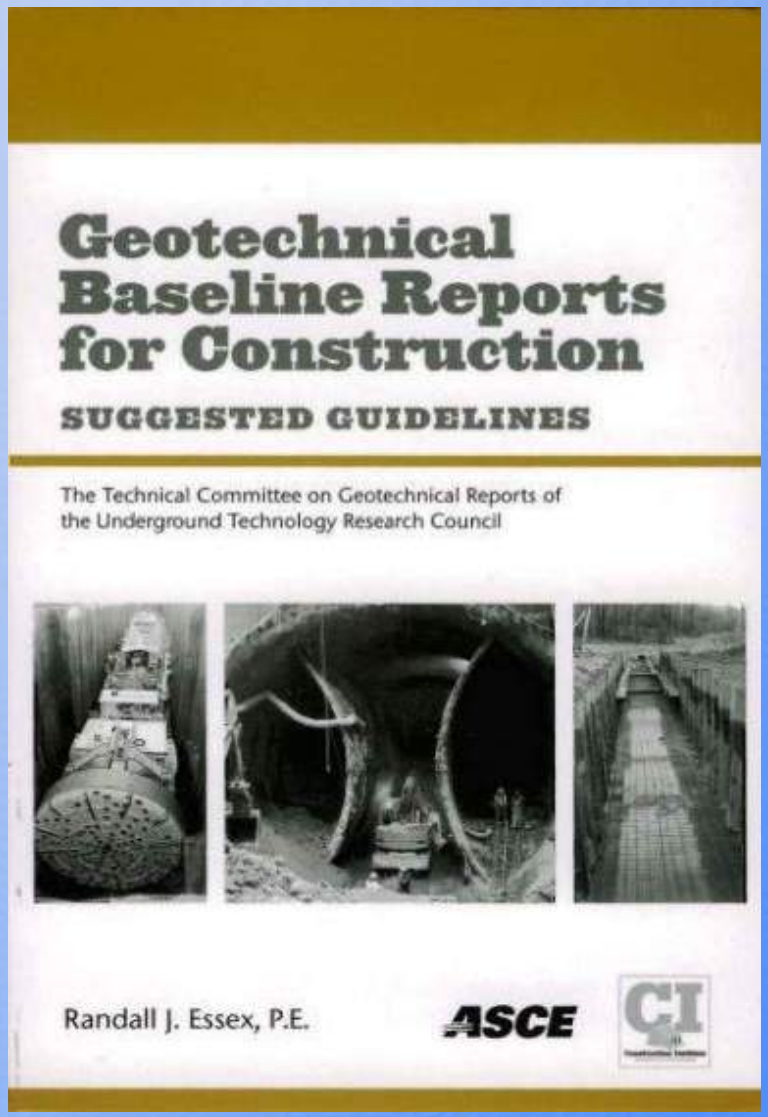
Additional Reading

- ASCE Guidelines Publication
- Reflects
  - 30 years of practice
  - Several industry feedback forums
  - North America's views on GBR preparation and use
- ASCE Book Dept.,ISBN 13: 978-0-7844-0930-5
- Amazon.com



PPP – A Growing Challenge

- From ground risk perspective, PPP is no different than design-build
- But PPP schemes are forcing us back to the “You bid it, you build it” ways of the 1970s
- We need to educate the financiers and concessionaires

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Future Developments

- 2010 ITA World Tunnel Congress in Vancouver
  - Dedicated 4 hours to Ground Reference Condition Reports
- ITA Contracting Practices Working Group will issue a GBRs guidance document for international use
- Conclusion: GRRs (or GBRs) serve a critical role, and are being used with increasing frequency around the world

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Future Developments (cont'd)

- GBRs are being used in Switzerland, New Zealand, Chile, Hong Kong, Singapore, Australia, the UK, and Japan
- Are they well written? Yes and No.
- ASCE Gold Book was recently translated into Japanese for application in Japan
- ASCE Gold Book will be translated into German
- Increased focus on understanding influence of different soil conditioning agents on tunnel spoil behavior – how to baseline / should we baseline?

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Future Developments (cont'd)

- Abrasion-related wear is becoming the Achilles heal of pressurized face tunneling projects
- How to baseline or allocate risks associated with planned and unplanned interventions?
- Most critical for large diameter TBM projects

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Summary

- Underground construction is unique
- Tunneling projects are becoming increasingly risky – dependent upon successful application of sophisticated tunneling equipment
- Different contracting strategies are warranted
- GBR approach works
- Consistent with UK and Int'l Joint Code Recommendations re "Ground Reference Conditions"
- Write *reasonable* baselines and enforce them
- *Better to benefit from others' lessons learned than your own…*

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Past Practices and Lessons Learned

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Thank You!

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