ITA Welcoming Remarks

2º Congresso Brasileiro de Túneis e Estruturas Subterrâneas

Seminário Internacional “South American Tunnelling” – 2008

by

Harvey W. Parker
Past President

International Tunnelling and Underground Space Association (ITA)

Sao Paulo

June 25, 2008
Congratulations & Thank You

• Organizers of the 2º Congresso Brasileiro de Túneis e Estruturas Subterrâneas
  – President CBT: Tarcísio Barreto Celestino
  – President Organizing Committee: Akira Koshima
  – Organizing Committee Members

• Authors & Presenters
• Sponsors & Exhibitors
• You, the participants in this Congress
International Tunnelling and Underground Space Association (ITA)

• Non-Profit NGO Founded in 1974
  – Headquarters in Lausanne, Switzerland

• ITA Recently Changed its Name to include Underground Space to recognize the significant contributions ITA made and is making in Underground Space

• Member Nations: 52 – Brazil Represented by CBT

• Network ~20,000 People

• Recognized by the United Nations as an NGO

WebSite & Electronic Newsletter (Business Card)
ITA-CBT Cooperation

• Very Strong Long-Term Relationship
• Annual ITA Congress in Sao Paulo – 1998
• Several Executive Council Meetings in Sao Paulo
• Dr. Andre Assis – President ITA 2001–2004
• Dr Tarcisio Celestino – Animateur – ITA Shotcrete Working Group
Megacities: 2001 = 19   2015 = 60
MegaCities Mean Huge Infrastructure Requirement

• Good News for our Industry but simply may not be enough planners, designers, and contractors to do the work.

• Enormous risks when too much work must be done too fast.
  - Enormous demand on training at all levels
    • Professional, Skilled, Unskilled
    • Safety, Technical, Managerial etc.

• 12 ITA Working Groups & 3 New ITA Committees:
  - ITA-COSUF ITA Committee on Underground Safety
  - ITA-CUS ITA Committee on Underground Space
  - ITA-CET ITA Committee on Education & Training
Best Wishes for Another Great Day for Your Congress

Obrigado
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Geotechnical Issues for Planning Tunnels & Underground Space

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Importance of Geology

- Geology is paramount in almost every tunnel decision
- Geology dictates
  - Feasibility
  - Alignment
  - Construction & Cost
  - Usefulness & maintenance of completed structure
Geotechnology & Planning

- Everyone in planning and design of tunnels must give geology serious consideration

- Therefore, Use Geology & Geotechnology as early as possible
  - Even the Conceptual stage
  - Even before Project Concept for Planning Underground
Geo-Challenges of the Underground
Strange & Unique Functions of the Ground in Tunnels

• The ground and groundwater = the load
  – They are also medium that transfers this load to the tunnel lining

• The ground is the structural material that actually carries most of the load
  – Tunnel linings only have to carry part of total load

We call it “Arching”
Selected Challenges of the Underground: Variability

- Geology can be Subtle and Illusive
- Variability is Often Abrupt
- Properties
  - Magnitude Varies Significantly
    - Time, Seasons, Sample Size, Rate of Loading
- Properties of Geologic Materials have an enormous range of values
Range of permeability

- Greater than any other engineering parameter
  - Roughly $10^{-7}$ to $10^{+3}$ cm/sec
  - Factor of 10,000,000,000
  - Units used in practice are factors of 10

- For Comparison: Strength
  - Smaller But Still Impressive Range
  - Soft Clay to Concrete ~ 1,000
  - Soft Clay to Steel/Rock ~ 100,000
Geotechnical Explorations
Comparative Sampling Frequency

• Concrete Structure
  – Every 20 to 50 m³
    • ~ 0.1%
  – See 100% off Truck

• Geotechnical Exploration
  – Borings: 6 to 8 cm
    Diameter core @ 90 m spacing =
    – ~ 0.0005%
Geotech sees only 0.0005% of Tunnel Volume (Thimble to ~50 Oil Drums)
Selected Important Geotechnical Issues

• Geology
• Groundwater
• Groundwater
• Groundwater
• Contaminated Soil & Groundwater
• Obstructions, Gas, & Other Safety Issues
• Ground and Groundwater Properties
Success in Spite of Vast Uncertainty

• Exploration sees only miniscule volume

• Never see ahead of the face
  – Major TBM issue

• Yet Fortunately – Owners, Designers & Contractors do a remarkable job
Special Challenges in Big Cities

• Very Few outcrops to actually see & touch soil

• Difficult to find safe location for borings
  – Because of Utilities or other obstructions
  – May not get all borings on alignment or where wanted
    • Borings may not be equally spaced or off line

• May encounter:
  – Obstructions or Archeologic Remains
  – Contaminated soil
Outcrops & Observation at Full Scale

View of the South Beach Bluffs, Fort Lawton, Seattle

Photo from Seattle Geologic Mapping Project. Univ. of WA
Locating Safe Places to Drill Borings

Photo Courtesy of ConEd, 1916

Parker, 2005
Geotechnical Issues with Hazardous Waste
Geotechnical Issues with Archeology
Geotechnical Database for Cities

• Summarizes all available Geotechnical data
  – All cities should create, maintain, & update such a database
    • Note the quality of the data entries; some are better than others

• Should Include:
  – Geotechnical Records
    • Borings, Test Pits, Basement Excavations
    • Existing Foundations including Pile Driving Records
  – Water, Oil, and Geothermal Well Logs
  – Groundwater Information
  – Information on Contamination
  – Archeological Information
  – Man-made Subsurface Features
    – Obstructions such as Utilities, Old Sea Walls, Piers, Piles, Wells
Groundwater Information for Cities

• Document all information on groundwater
  - Water Levels and Pressure Trends
    • Current (Include Artesian Conditions)
    • Future (Consider Global Warming)
  - Groundwater Flow Directions
    • For environmental purposes
    • To evaluate flow of contaminated plumes
    • To evaluate salt water intrusion, if applicable

• Document Permeability of Ground
  - Part of Geotechnical Database
  - Identify strata or features of High or Low Permeability
    • Impermeable layers
    • Highly permeable zones
    • Obstructions to water flow
The Seattle Area Geologic Mapping Project is developing a comprehensive geologic database and set of geologic maps to support hazard assessments and land use applications. Our focus, the Puget Lowland, is in a unique geologic setting near a subducting tectonic plate. The area has been glaciated at least 6 times in the last 2 million years and is young and complex. It is also a region of high population density. Because of this, it is subject to abundant geologic hazards, such as earthquakes, slumping, landslides, and debris flow failures. Because of the cost of mitigating for geologic hazards, many agencies work to mitigate for geologic hazards.

Web-based, public access to database
Asset Management Program

• Database of Existing Utilities and Other Subsurface Features
• Documents Location and Condition
• Very useful for managing potential replacement and upgrading costs during your project or in future
• Valuable Input to Overall Planning of Underground Space for your City
Geotechnical Role in Underground Planning

• It is urgent to plan your underground space immediately and to follow up

• Why
  – Allows synergistic & energy-efficient use of space

• Document what exists and its condition

• Asset Management

• Characterize Ground & Groundwater Conditions

• Plan Underground Future
  – Same emphasis and level of effort as surface planning
Plan Underground to Same Creative and Intensive Level as Surface Planning
Future Trend=BIM=3D

- Building Information Modeling
  - 3D Virtual Model
  - Recent development:

- Ideal trend for Underground Planning
  - And for Geotechnical Engineers

- Detailed 3D Drawings of above and underground
Geotechnical Survey Explorations

Methods & Principles
NO LONGER SUFFICIENT TO DESCRIBE
STRATIGRAPHY & GROUNDWATER TABLE

MUST PREDICT BEHAVIOR

MUST ESTABLISH A BASELINE

So "changed condition" (if encountered) can be administered fairly
Geotechnical Investment

• No easy formula
  – Range is 1 to 8 or 10% depending on complexity

• Budget at least 3% of Construction Cost

• Geotechnical investigation
  – For properly done additional exploration, bid prices usually are lower because it reduces contractor’s uncertainty
  – Generally save $10 to $15 for every $1 spent wisely
Guidelines for Level of Geotechnical Effort
All Tunnel Projects

- Emphasize Geology
- Conduct at least two exploration phases
- Fund the initial phase well
  - confidently select the alignment
  - estimate of the likely construction methods, lining and cost
- Pre-approve contingency fund
  - Answer technical questions resulting from initial boring program
- Use Contingency only if needed
Recommendations on Site Investigation

- Make GBR a Contract Document (Now Required by ITIG)
  - No Disclaimers
  - Establish a Baseline
  - This evolved into the Geotechnical Baseline Report (GBR) also called Geotechnical Reference Conditions Report

- Compile As-Built Report
Guidelines for Level of Geotechnical Effort
All Tunnel Projects

- Don't do any exploration unless it specifically fills a genuine need
  - Often, reduction of uncertainty is a genuine need

- Good Exploration reduces BID COST by:
  - 10 to 15 Times Exploration cost
Guidelines for Level of Geotechnical Effort
All Tunnel Projects

- Conduct a “Supplementary Cost Exploration Phase”
  - After alignment is fixed & after designed
  - To Confirm the design concept
  - Get information contractor needs to estimate
    - Productivity (rate of advance)
  - Estimate the costs and to bid the job
Muck Disposal- Significant Geo - Issue (Often Neglected)

• Muck is generated 24 hours/day
  – Potential Public Disturbance

• Muck disposal sites are often far away
  – Cost and Disturbance Issue

• Re-Use is Sometimes but not Always Practical

• Muck is sometimes contaminated
  – Can go only to certain very expensive disposal sites

• EPB and Slurry Muck needs special treatment
Methane, Hydrogen Sulfide & Ground Contamination

- More Prevalent in Tunnels & Mines than Previously Thought
- Must Investigate for these Hazards
- Important Decision Regarding Safety Measures and Cost
RISK & CHOICES ARE PLENTIFUL
Geotechnical Risk Management

- Conduct Geotechnical Surveys Specifically to Reduce Uncertainty of High-risk Issues

- Identify Issues using Risk Management Techniques
  - Workshop sessions by technical staff
Guidelines for tunnelling risk management: International Tunnelling Association, Working Group No. 2

Søren Degn Eskesen, Per Tengborg, Jørgen Kampmann, Trine Holst Veicherts

ITA Working Group 2, Research, ITA-AITES, c/o EPFL, Bat GC, CH 1015 Lausanne, Switzerland
ITIG International Risk Code

- Requires Risk Registers and RMP from project conception through construction
- Re-Insurance Industry is demanding compliance with Code
- Revised following ITA intervention. Use 30 January 2006 version
Risk Worksessions

- Risk worksessions force the project team to consider potential problems
- Not complicated
- Process:
  1. Identify & characterize potential threats
  2. Develop risk reduction strategies
  3. Determine cost/benefits for these strategies
  4. Decide a prudent course of action

Source: Reilly
### RMP: Risk Identification

#### Probability/Impact classification - example

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<th>IMPACT</th>
<th>Negligible</th>
<th>Unlikely</th>
<th>Likely</th>
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<tr>
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<td>6</td>
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<td>4</td>
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<td>8</td>
<td>10</td>
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<td>Very low</td>
<td>1</td>
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<td>3</td>
<td>4</td>
<td>5</td>
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<table>
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<th>R=P × I</th>
<th>RESPONSE</th>
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<td>Unacceptable</td>
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<tr>
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<td>13-16</td>
<td>Unacceptable</td>
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<td>9-12</td>
<td>Early attention</td>
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<td>5-8</td>
<td>Regular attention</td>
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<tr>
<td>Insignificant</td>
<td>1-4</td>
<td>Monitor</td>
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</table>

The detailed process of risk identification is project-specific.

*Source: Grasso*
Geotechnical Aspects of Contracting Practices

- No Disclaimers for ground conditions
  - Include a Fair Changed Condition Clause

- Share Risk and Share Fairly

- Adapt ITIG Requirements to your Country

- Prepare Geotechnical Baseline Report (GBR)
  - GBR also called Ground Reference Conditions
  - Cross-checked with plans & specifications
  - Make GBR part of contract documents

- Provide for Disputes Review Board (DRB)
References


• ITA Working Group 2 Task Underway

Geotechnical Surveys: Conclusions

- Geology Dominates Every Major Decision
- Allow Geo-Issues their Proper Role in Planning
  - Challenges and Potential Benefits of the Underground are Enormous
  - Exploration programs “see” only a very small % of volume to be tunnelled. (0.0005%)
- The Ground is the Load and it also provides Support for Most of the Load
Geotechnical Surveys: Conclusions

- Incorporate Formal Systematic Risk Studies
  - As soon as project identified
  - Use risk management to direct geotechnical studies
- Follow Guidelines: Adapt to ITIG Code
- Start Geotechnical Work in Conceptual Stage & Continue Geotechnical Observations
  - During Construction
  - Prepare As-Built Report
  - While in Service
Geotechnical Surveys: Conclusions

• Many Challenges Exist in Big Cities

• Recommended Practices
  – Develop & Disseminate a Geotechnical Database
    • Groundwater Trends
  – Asset Management Program
  – Take an Active Role in Formal Planning of Underground Space

• BIM may be in future
Geotechnical Surveys: Conclusions

• Prepare a Geotechnical Baseline Report (GBR) (also known as Geotechnical Reference Conditions Report)
  – Distinguish between Fact and Interpretation

• Prepare As-Built Report
Geotechnical Surveys: Conclusions

- Budget 3% for Geotechnical Investigation

- Don't do any exploration unless it specifically fills a genuine need
  - However, often, reduction of uncertainty is a genuine need

- Good Exploration reduces BID COST by:
  - 10 to 15 Times the Cost of Exploration
Overall Conclusion

Geology & Geotechnology are Essential to Planning, Design & Construction
Obrigado

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