RISK Considerations for Geotechnical Construction

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Advice from Dr. Elio D’Appolonia (1995)

- Risk Categories
  - Knowns
  - Known-Unknowns
  - Unknowns

- Knowns can be identified clearly
- Known-Unknowns can be identified from experience and intuition
- Unknowns will always be there

Sharing experiences permits newer project managers to identify the Known-Unknowns
Experience enables us to implicitly manage risks.

Sharing experience is much more difficult than you might think.
Understanding and Containing Geotechnical Risk (Trenter, 2003)

- Earliest on the job
- Methods are faster than ever before
- Methods require fewer people to perform

Less time to react to hazards that are revealed, and fewer people to identify and mitigate them

And the impact extends to all of the follow-on work
Managing Geotechnical Risk: Time for Change (Clayton, 2001)

- Properties and distribution of the ground and groundwater beneath a construction site are pre-existing (and out of our control)

- Ground and groundwater conditions
  - Highly variable
  - From place to place
  - And with depth

- Construction in the ground is carried out at the start of a project...so delays will affect latter stages of construction
So what do we do?

- Geotechnical risk exists
- We know little about it
- But we must design with what we know

So MANAGE IT!
Kinds of Construction Risks

- Weather
- Insurance and bonding
- Safety
- Soil and Rock
- Groundwater
- Design
- Performance
- Verification

- Schedule
- Materials
- Resources
- Contract
- Subcontract
- Access
- Experience
- Proximity to sensitive structures or utilities
1. Do I have a good enough understanding of the subsurface conditions?

- **Site History**
  - Structures, utilities, old foundations
  - Old fills and/or surcharge loads
  - Old stream beds, lakes, beaches
  - Previous quarries or mine activity
1. Do I have a good enough understanding of the subsurface conditions?

- Sampling and insitu testing
  - SPTs
  - CPTs
  - Other insitu tests
  - Site reconnaissance observations

"You can observe a lot just by watching."
(Yogi Berra)
1. Do I have a good enough understanding of the subsurface conditions?

- Laboratory testing
  - Does the testing provide:
    - Direct parameters for design?
    - Of the strata desired?
    - To the depth of influence appropriate?
  - Or must you interpret the parameters used by indirect means?
1. Do I have a good enough understanding of the subsurface conditions?

- **Interpretations**
  - Rely on local knowledge
    - Investigated sites nearby
    - Seen lab testing from similar materials
    - Observed performance from previous construction
  - Evaluate what you have
    - Do you have enough of what you need?
    - Is there genuine historic awareness?
1. Do I have a good enough understanding of the subsurface conditions?

- Recommendations
  - Do they result from variable data?
  - Do they consider the construction risks?
  - If unsatisfactory, is there time to get what you need?
  - Have they identified the hazards?
2. Are the objectives of the construction clearly understood?

- There can be several objectives of the construction:
  - Identify them
  - In priority

- Don’t be ambiguous, it only leads to disagreements.

Offering a bid proposal to do the work, exclusive of exceptions to the terms and conditions of a contract, is considered acceptance of the constructability of the work in accordance with the plans and specifications.
3. Can the requirements of the specification be met?

- Expectation must be consistent with the technology
  - Understand the method
  - Understand the product
  - Understand the verification method

- How do you do this?
  - Seek out experts
  - Question all important aspects
  - Understand variability and how to design for it
  - Question the process to know what is controllable and what is not
4. Does the schedule impact achieving the specification requirement?

From a technical perspective:

Evaluate if the verification can be completed and accepted prior to the next phase of construction.

- Issues include:
  - Curing of samples
  - Time rate of consolidation
  - Performance testing
5. Are the materials available to support my project needs?

- Just-in-time inventory is affecting all construction.
- Specialized materials require further investigation.
- Proximity to the suppliers can impact the construction.
6. Is there another way to achieve the objectives?

- The value of specialized construction is difficult to assess.
- Some specialist contractors are better at some technologies than others.
- Performance-based contracts can offer value:
  - Be certain the objective can be met with proposed system(s).
  - Be certain the performance can be verified.
  - Be certain the contractor is qualified and has the necessary resources.
7. Are there operational or contractual issues that could impact construction?

- Can the project logistics be worked out
- Fair allocation of subsurface risk
- Bureaucratic impacts that could restrict communications
3 Biggest Challenges

(Greatest Risks)

- Stopping Groundwater
- Resisting Large Forces
- Large Area Loads
Large area loads

- Dams, embankments, tanks

What is the stress at each of these points?
Tank Farm in South Louisiana

310 ft diameter
Cross-section
Very soft to soft clay

w/ shell sand pockets

Med. Dense sand

Soft to med. Stiff clay and sandy clay w/ sand layers, lenses and pockets

Med. Dense to very dense sand w/shell and clay pockets

Med. Stiff to stiff clay & sandy clay w/silt and sand layers, lenses and pockets

Wicks to here
**Undrained F.S. against Edge Shear** *(without preconsolidation)*

<table>
<thead>
<tr>
<th>Case</th>
<th>$F_e$</th>
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<tbody>
<tr>
<td>Pad and empty tank</td>
<td>4.03</td>
</tr>
<tr>
<td>10 feet of water</td>
<td>2.12</td>
</tr>
<tr>
<td>20 feet of water</td>
<td>1.44</td>
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<tr>
<td>30 feet of water</td>
<td>1.09</td>
</tr>
<tr>
<td>40 feet of water</td>
<td>0.88</td>
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Issues

- Need instrumentation to show strengthening during hydro testing
- Watch subsurface delections
- Watch settlements
- 1st 2 tanks used the hydro test to preconsolidate the ground
- Last 10 tanks used a soil surcharge to preconsolidate the ground
- Next 3 tanks took treatment to 75 ft deep to save time of consolidation
Resisting large forces

- Landslides (especially those that are moving)
- Deep excavations
  - *Groundwater usually plays a major role*
Blue Trail Slide

Work Area
Aerial View of Work Site
Finished Cap – Upper Wall
Drilling
Finished Project
10 years later
Stopping Groundwater

- Requires perfection (windowless)
Risk Example

SHEET PILE TOP
EL 14

W24 WALE
(TYP)

24” DIA
PIPE STRUT

36.75’

36.75’

Q STRUT
EL 9.50

BOTTOM OF
EXCAVATION
EL -5.58

TOP OF JET
GROUT PLUG
EL -25

PIPE PILES

5’

JET GROUT PLUG

SHEET PILE
TYPE AZ-18
(TYP)
Risks identified

Before Construction
- Schedule…LDs in the prime contractors contract
- GW pumping tolerance limited to 130 gpm
- Best resources needed

Post project scrutiny
- QC was good
- Best sequence used,
  - Ground disturbance from pile installation?
  - Reflection of energy?
- Fill included jetting obstructions
- Unforeseen government intervention
Summary

- Geotechnical construction is risky!
- Subsurface conditions cannot be perfectly represented
- Identify as many known-unknowns as possible
- Contractors/consultants/owners alike do not possess x-ray glasses
- Do you homework, use this checklist
Thank You!

Questions are welcomed!