


Managing Deep Excavations, Shoring, and Dewatering

A Guide for Municipal Designers and Construction Inspectors

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Learning Objectives

- *Identify conditions that make for high-risk excavations.*
- *Develop designs and specifications that limit and manage risk.*
- *Identify risks during submittals and construction.*




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Disclaimer and Ground Rules:

I am not a Lawyer.

- We will be talking a bit about specifications and a little bit about the potential for claims, but that is not the intent of the presentation.
- If we're talking about claims on a job, you've already lost.




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Disclaimer and Ground Rules:

You are not a contractor.

- We will not be talking about site safety
- We will not be talking about design the dozens of applicable shoring methods.




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Disclaimer and Ground Rules:

I don't know what your risk tolerance is.

- Risk is a continuum not a sharp line.
- There are no right answers. There are only considerations when determining how best to serve your community.
- Your risk tolerance will change based on your organization's budgets and the visibility of the project.




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Disclaimer and Ground Rules:

I've only been doing this for 18 years.

- I still have a lot to learn.
- I'd be very happy to hear your experiences and lessons learned.
- Please ask questions and let's have a discussion.



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Learning Objectives

Planning:

- Identify conditions that make for high-risk excavations.

Design:

- Develop designs and specifications that limit and manage risk.

Construction:

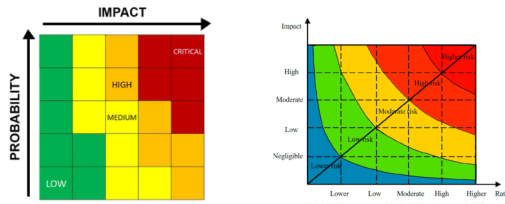
- Identify risks during submittals and construction.



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Planning: What conditions create a high-risk excavation?

Risk is the combination of Likelihood and Consequence.



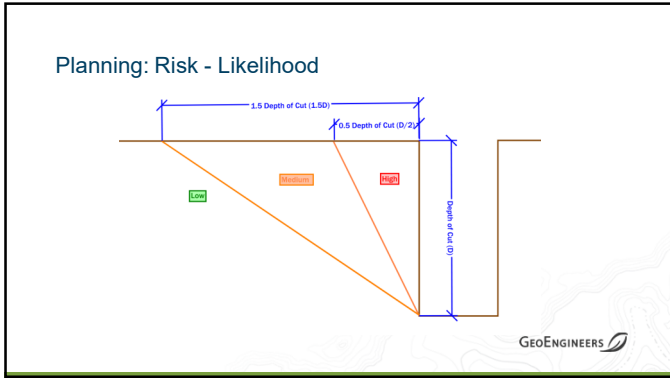
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Planning: What conditions create a high-risk excavation?

- Likelihood is likelihood of soil movement.
- Consequence is the damage that could occur, plus the fall out.



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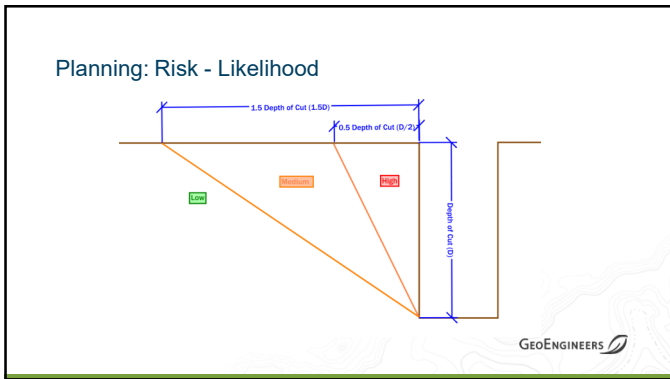


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Planning: Risk - Likelihood

The image shows an OSHA poster titled "PROTECT WORKERS IN TRENCHES". The poster text reads: "Prevent trench collapses and save lives: **SLOPE** or bench trench walls, **SHORE** trench walls with supports, or **SHIELD** trench walls with trench boxes". It includes an image of a trench with a worker and a logo for OSHA (Occupational Safety and Health Administration). The GEOENGINEERS logo is in the bottom right corner.

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Planning: Risk - Likelihood

$P_{ah} = 1/2 \gamma H^2 K_a \cos(\beta - \phi) \cos(\alpha - \beta)$
 $K_a = \frac{\sin^2(\alpha - \phi)}{\sin^2 \alpha \sin(\alpha + \phi)} \left[\frac{\cos \phi \cos(\alpha - \beta)}{\cos(\alpha - \phi) \cos \beta} \right]^2$
Coulomb Wedge Analysis

$P_{ah} = 1/2 \gamma H^2 K_a \cos \beta$
 $K_a = \cos \phi \left[\frac{\cos \beta - \sqrt{\cos^2 \beta - \cos^2 \phi}}{\cos \beta + \sqrt{\cos^2 \beta - \cos^2 \phi}} \right]^2$
 $\beta = 45 + \phi/2$
Rankine "state of stress" Analysis

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Planning: Risk - Likelihood

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Planning: What conditions create a high-risk excavation?

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Planning: What conditions create a high-risk excavation?

- Likelihood is likelihood of soil movement.
- Consequence is the damage that could occur, plus the fall out.



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Planning: Risk - Consequence

Utilities	Structures
▪ Storm Drain – Low	▪ Park Bench – Low
▪ High Pressure Water – High	▪ City Hall – High
Surface Treatments	
▪ Grass – Low	
▪ Pavement - Medium	
▪ Architectural Concrete – High	



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Planning: Risk - Consequence

What is “fall out”?

- The impacts beyond just the physical structures.


What will be the impacts of repairing the damage?

- Offline utilities.
- Traffic.
- Project Schedule.

Who owns this?*

- Is it your infrastructure or someone else’s?


*More on this later.




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Planning: What conditions create a high-risk excavation?

Groundwater



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Planning: What conditions create a high-risk excavation?

- Groundwater increases risk on both the likelihood side and the consequence side.
- Impacts of mass dewatering can extend well beyond the excavation.
- Discharge of groundwater can be a major complication.



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Design: What options are available to control risk?

Avoidance


- Do you really need to put it there?

Alternatives Analysis

- Write down the assumptions.
- Write down the costs.

"If I had known it was going to be this expensive and take this much work, we would have just relocated it."

-- A City Engineer, possibly you...


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Design: What options are available to control risk?

Set your contractor up for success.

- Understand what you want.
- Communicate those expectations.
- Provide enough information for the contractor to meet those expectations.




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Design: Setting your Contractor up for Success

Do you need a shield system or a shoring system?

What's the difference?


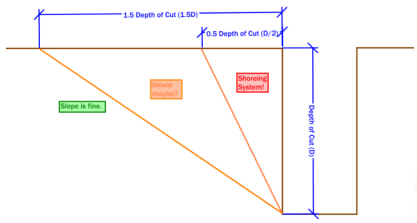
- A shield system prevents soil movement (cave-ins) from injuring workers.
- A shoring system prevents soil movement.
- Shield systems are placed in an open excavation before workers enter.
- Shield systems only "support" the excavation *after* a cave in.



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Design: Setting your Contractor up for Success

Do you need a shield system or a shoring system?



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Design: Setting your Contractor up for Success





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Design: Setting your Contractor up for Success

Communicate expectations through specifications by:

- Stating what is expected.
(e.g. Shoring vs. Shielding)
- Stating performance requirements.
(e.g. Maximum allowed deformations)
- Stating what type/level of design is required.



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Design: Setting your Contractor up for Success


- Communicate expectations through specifications by requiring a plan.
- WSDOT Standard Specifications 2-09.3(3)D Shoring and Cofferdams
- Any shoring submittal/plan should include:
 - Assumptions including baseline soil and groundwater conditions.
 - Construction sequencing.
 - Performance and monitoring requirements.
- Add your performance expectations as needed.



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Design: Setting your Contractor up for Success

- Examples:
 - "Contractor shall use a shoring system designed to limit lateral displacement of excavation to 1" or less."
 - "Dewatering shall occur prior to excavation and will lower groundwater levels to two feet below excavation depth."
 - "All excavations deeper than 4 feet shall be shored."




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Design: Setting your Contractor up for Success

Geotechnical Information, how much is required or appropriate?

Levels of information:

- None.
- Geotechnical Report or Geotechnical Data Report.
- Geotechnical Baseline Report.
- Shoring/Dewatering Conceptual Design.



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Design: Setting your Contractor up for Success

Geotechnical Information: None

What is it?


- Just drawings and specifications, no subsurface information.

When would you use this?

- Very basic, low risk projects.

How well does it work?

- No idea. I'm a Geotech...



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Design: Setting your Contractor up for Success


**Geotechnical Information:
Geotechnical Report and/or Geotechnical Data Report**

What is it?

- Geotechnical report includes recommendations for the design of the project and back up data.
- Geotechnical Data Report is just the back up data (borings, etc.)

When would you use this?

- Most projects



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Design: Setting your Contractor up for Success


**Geotechnical Information:
Geotechnical Report and/or Geotechnical Data Report**

Why would you use one or both?

- Geotech report can include a lot of extra design data related to the final structure or project that could be misused or misinterpreted by the contractor.
- Put the data report in the specifications/contract documents. Provide the full Geotech report separately as reference.
- Ask for both. We already wrote it; we can reformat fairly quickly.

How well does it work?

- Great! Standard information with standard specifications have a proven track record.




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Design: Setting your Contractor up for Success

**Geotechnical Information:
Geotechnical Report and/or Geotechnical Data Report**

What data should be included?

- Subsurface data (borings) sufficient for designing shoring.
 - At least 5' below
 - Up to 3 times the excavation depth (cantilever wall).
- Groundwater Wells
 - Soil Gradation (Sieves)
 - Long Term Groundwater Data
 - Slug Tests



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Design: Setting your Contractor up for Success

Geotechnical Information: Geotechnical Baseline Report

What is it?

- A Geotechnical Baseline Report is like a Data Report but with specific interpretations incorporated into the contract.

When would you use this?

- High risk projects where the CONTRACTOR is at risk and the risk is driven by subsurface conditions.
- Tunneling projects.
- Highly variable and different soil conditions that require different construction techniques (i.e. remobilization) rather than just different quantities.

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Design: Setting your Contractor up for Success

Geotechnical Information: Geotechnical Baseline Report

Examples:

- Data Report:
"We observed bedrock underlying the alluvium at Elevation 123 feet."
- Baseline Report:
"Contractor shall assume bedrock is located between Elevation 120 and 125 feet within the project alignment. No change of condition will be granted for geologic contacts within this range."

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Design: Setting your Contractor up for Success

Geotechnical Information: Geotechnical Baseline Report

Examples:

- Data Report:
"Glacial deposits can contain cobbles and boulders."
- Baseline Report:
"Contractor shall be prepared to manage and remove, as required, boulders up to 30-inches in diameter."



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Design: Setting your Contractor up for Success


Geotechnical Information: Geotechnical Baseline Report

Why would you use this?

- Communicates that the owner is sharing subsurface risk.
- Reduces conflict should differing conditions occur.
- Reduces the need for the contractor to add cost for certain risks.
- Rewards efficient contractors not recklessness contractors.

How well does it work?

- Doesn't eliminate conflicts but sets the ground rules.



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Design: Setting your Contractor up for Success


Geotechnical Information: Shoring/Dewatering Conceptual Design

What is it?

- Plan of where shoring will go with explicit performance requirements.
- Includes design soil pressures and surcharge loads.
- Can include dewatering estimates.

When would you use this?

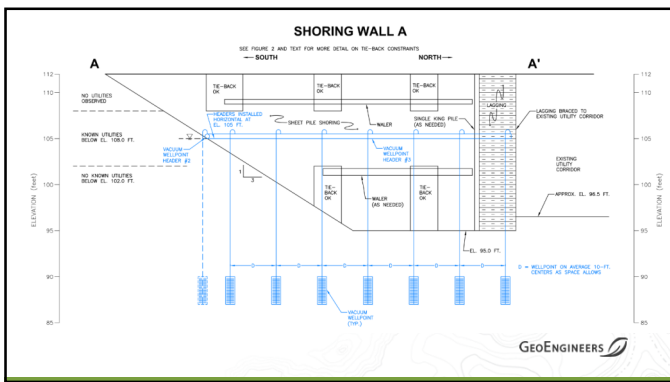
- High risk projects where the risk is driven by consequences to surrounding infrastructure.



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Design: Setting your Contractor up for Success

Geotechnical Information:
Shoring/Dewatering Conceptual Design

How does it work?

- Highly specialized, limited experience.

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***Step 2.5: Pre-Construction Survey**



Critical when at-risk infrastructure (consequence) isn't yours.

Pre-Construction Conditions Survey.

- Video Survey > Photo Survey
- Crack monitors.
- Physical Survey.

Vibration Monitoring

- Newer guidelines (5 years).
- Do a background survey!





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Construction: Get what you paid for!

Reviewing Submittals

- Should you review shoring submittals?
 - "I just make sure they did it. I don't want the responsibility or liability of 'approving' a shoring plan." – A Construction Inspector, maybe you.




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Construction: Get what you paid for!

Reviewing Submittals

- Example:
 - "We will meet the 2-week paving schedule required in the contract by working weekends. We plan to work both weekends (i.e. Sat, Sun, Mon-Fri, Sat, Sun) for 9 total days. Nine days per week over two weeks is a total of 18 working days."
 - Hypothetical Contractor
 - "We have assumed that ground water will be lowered to below the proposed mudline prior to excavation."
 - Real Shoring Submittal
 - "Dewatering will be achieved by placing well points within the excavation and only the interior of the excavation will be dewatered."
 - Real Dewatering Submittal




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Construction: Get what you paid for!

During Construction

- You paid for shoring, make sure you get it.
- You paid for a shoring design, make sure you use it.
- Track changes in sequencing and ask for revisions or confirmations from contractor's engineer.
- If something isn't looking right on-site, request that their engineer come out and confirm.



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Questions?



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