

Concepts and Considerations for Category 5 Protection

George Filz



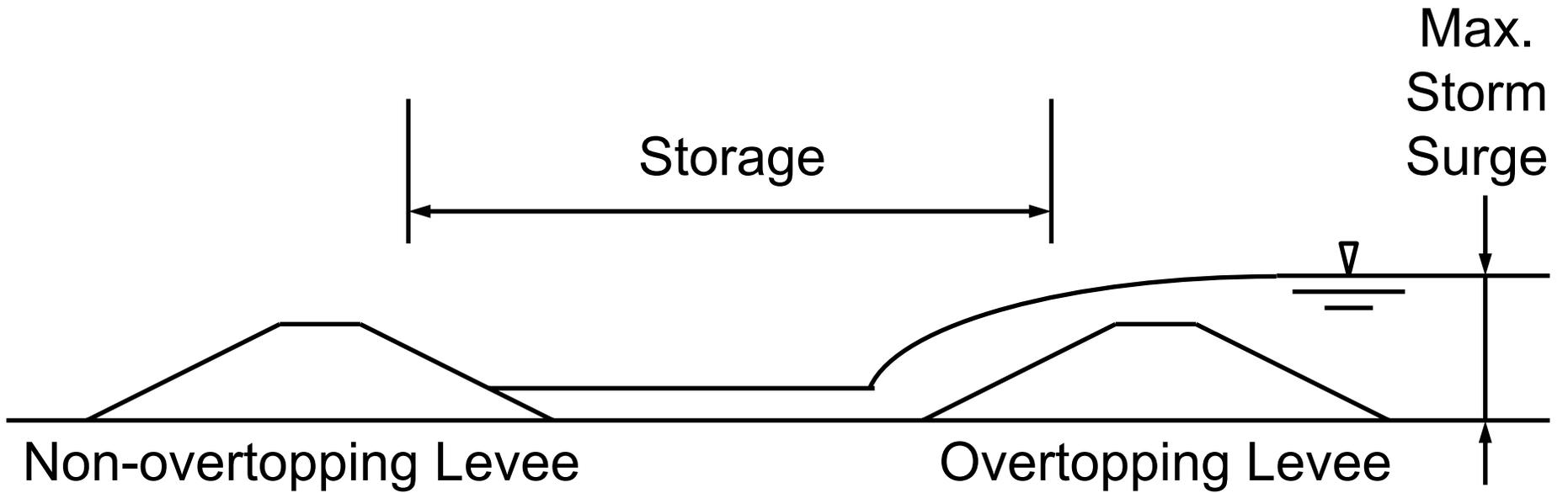
Two Approaches

- Reduce/redistribute the applied load
- Resist the applied load

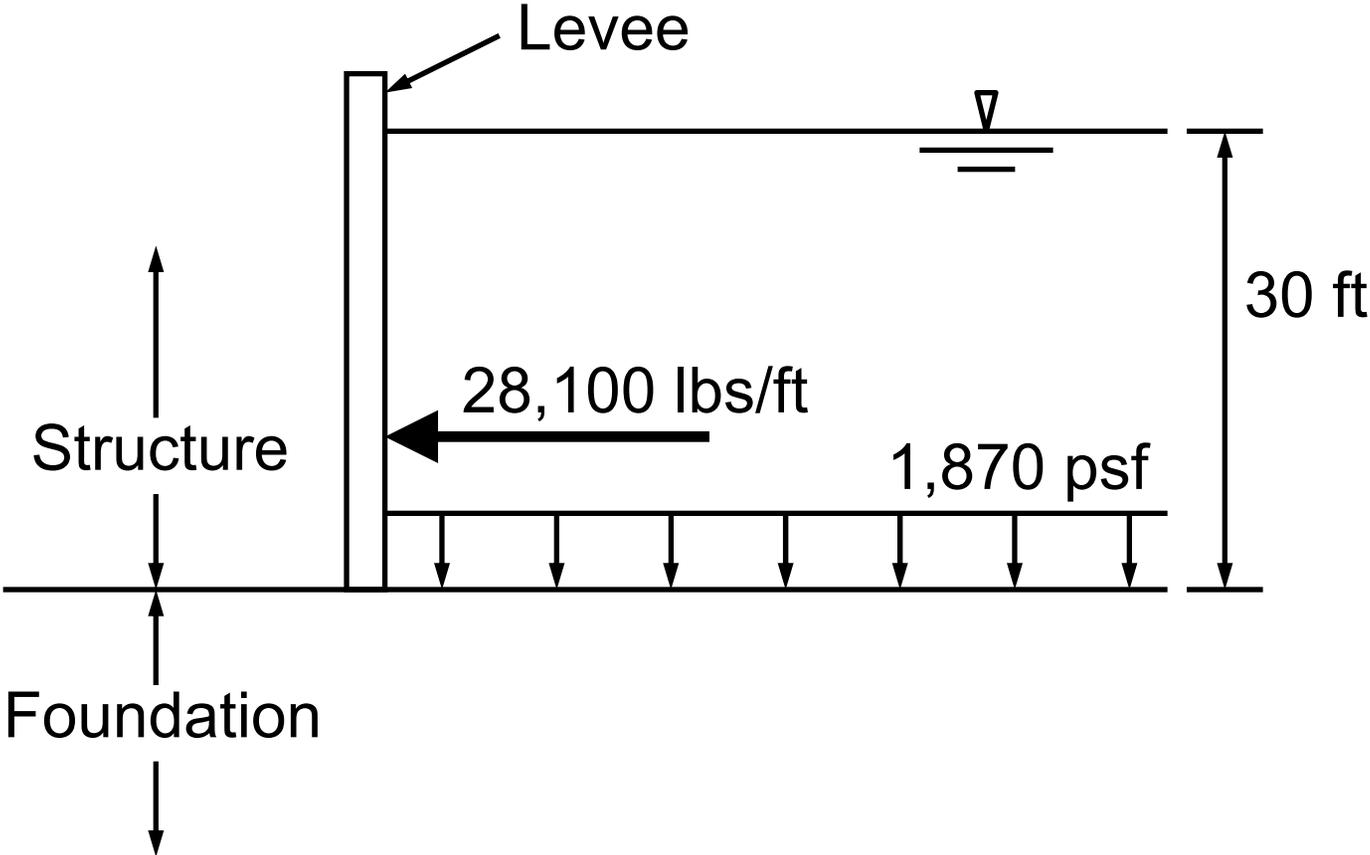
Reduce/Redistribute the Applied Load

- Restore and enhance the natural coastal environment
- Construct breakwaters
- Provide man-made storage

Man-Made Storage



Resist the Applied Load

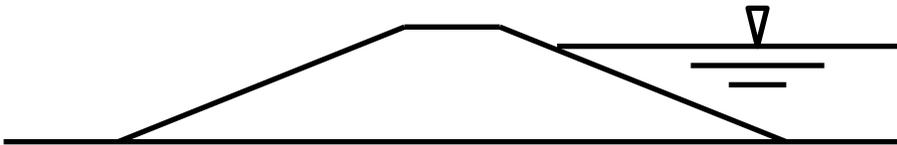


Structures

- Earthen levees
- Reinforced soil walls and slopes
- Concrete and steel structures
- Tubes
- Combinations

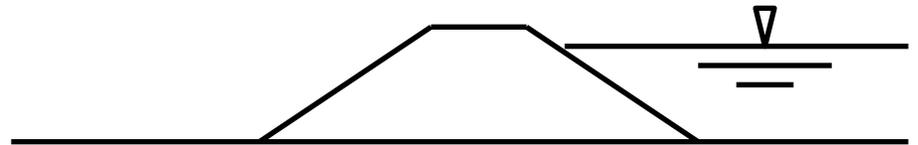
Earthen Levees

Homogenous, Unstabilized Soil:
Shallow Slopes



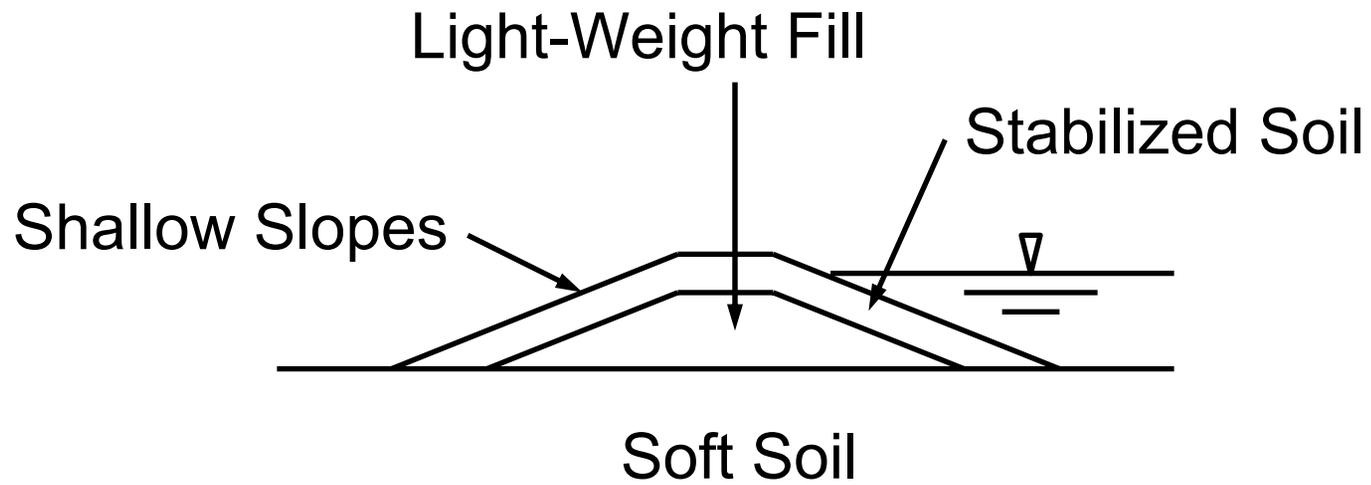
Can be used on soft foundations
Requires large borrow volume

Zoned, Stabilized, or
Reinforced Soil:
Steeper Slopes



Requires stronger foundation
Uses less borrow

Earthen Levees



Reinforced Soil Walls and Slopes



Requires stronger foundation
Uses less borrow

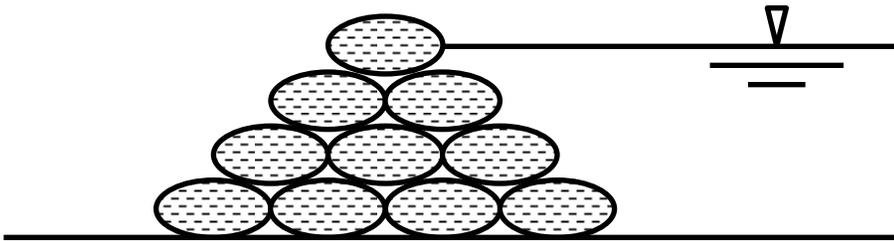
Concrete and Steel Structures



Requires foundation support

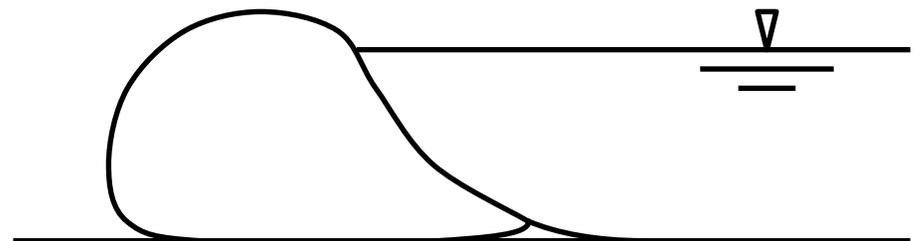
Tubes

Stacked, Surry-Filled
Geotextile Tubes



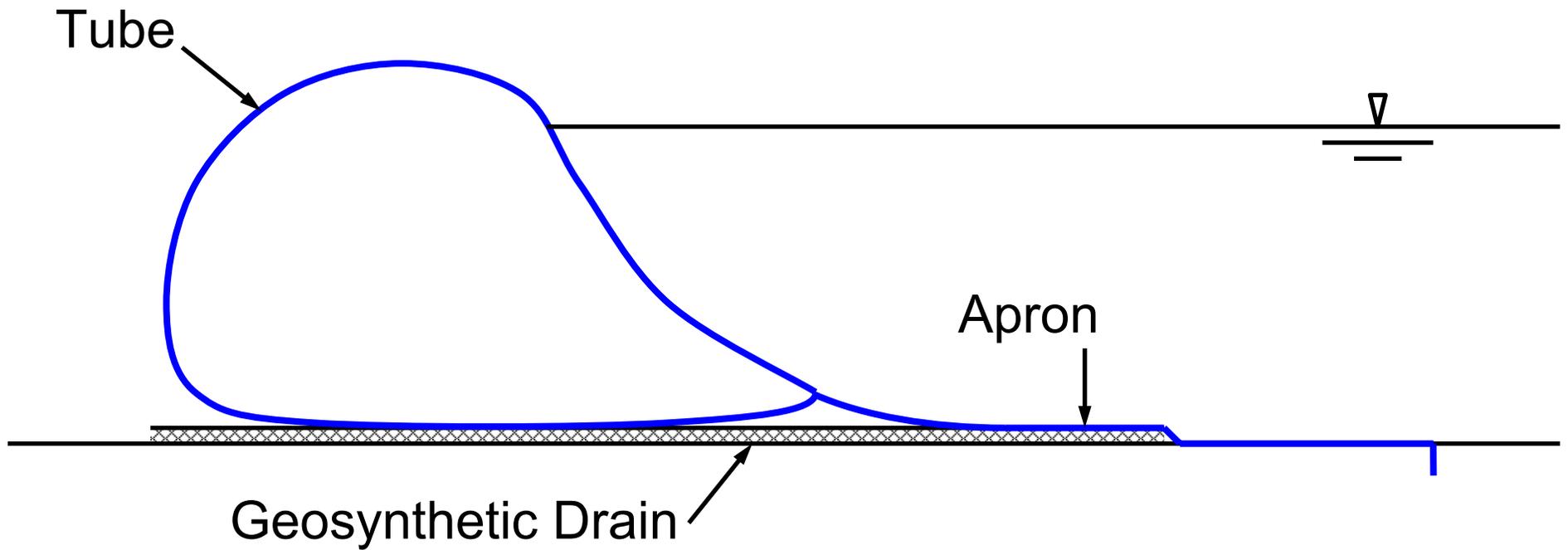
Can use dredge spoils

Air- or Water-Filled Tubes



Lighter load on foundation
Requires special details

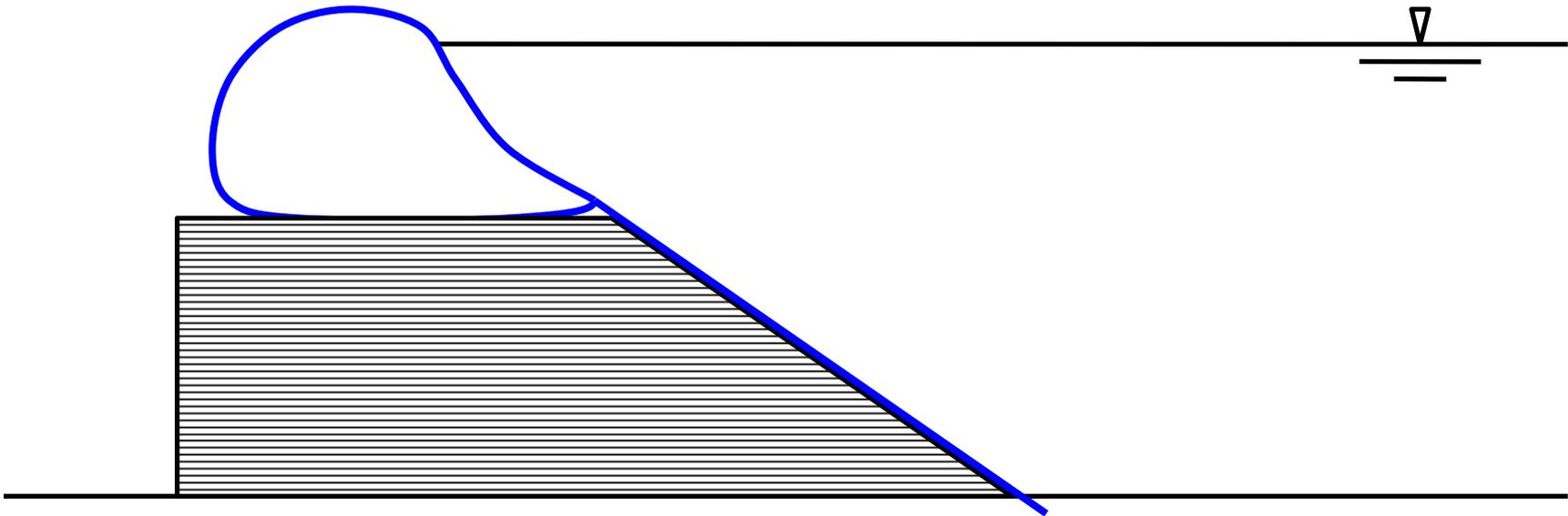
Air- or Water-Filled Tube with an Apron



Pilot-Scale Test of a Water-Filled Tube with Apron



Combinations



Other combinations are also possible

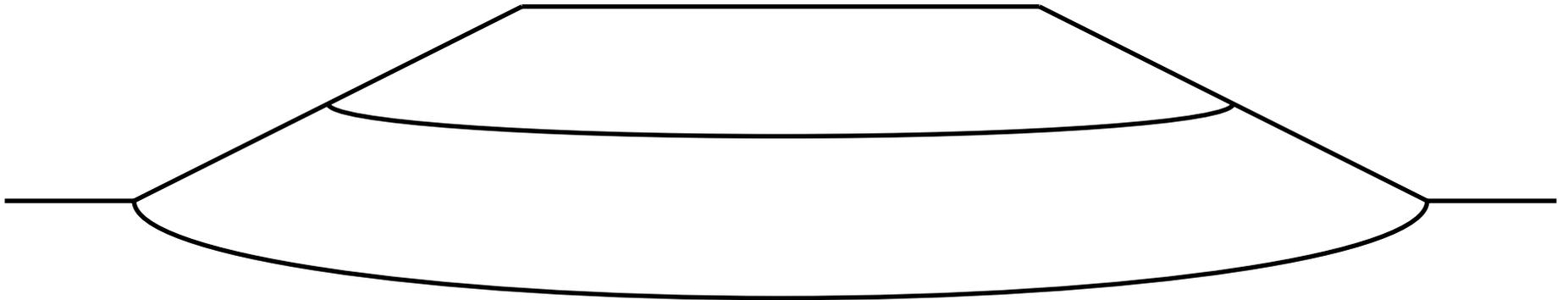
Foundations

- Foundation support
 - Staged construction
 - Driven piles
 - Deep mixing
- Seepage barriers
 - Sheet piles
 - Deep mixing
 - Jet grouting

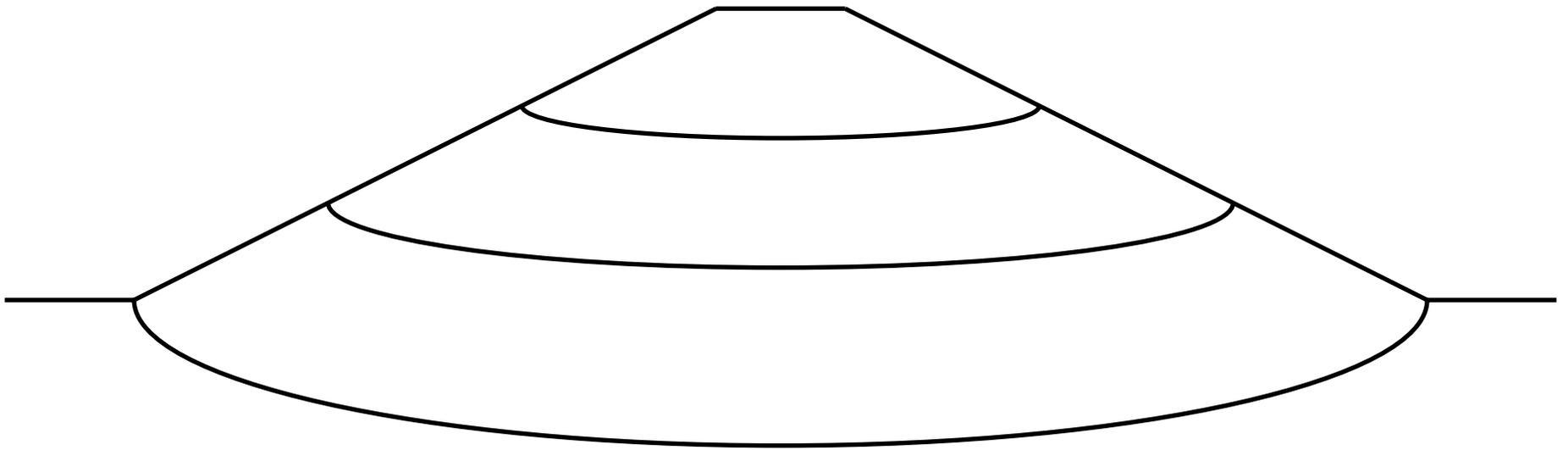
Staged Construction



Staged Construction

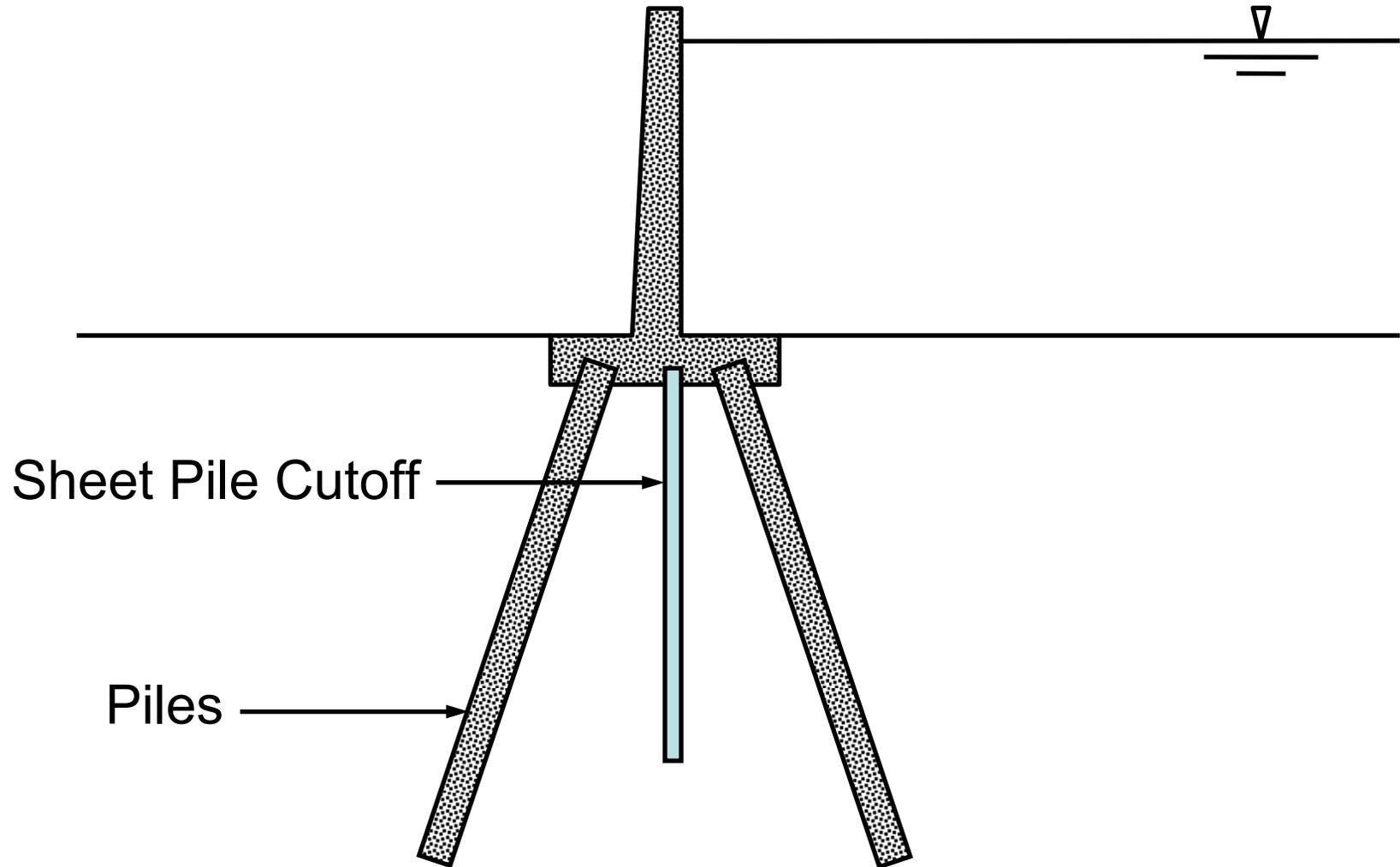


Staged Construction



Borrow volume, construction time,
long-term settlement, and maintenance

Pile Foundations



Deep Mixing

- Methods
 - Dry
 - Wet
- Configurations
 - Columns
 - Panels
 - Mass stabilization
- Design Issues
 - Mix design
 - Stability
 - Reliability

“Wet” and “Dry” Deep Mixing Methods

Wet Method:

Water-cement slurry
Larger & heavier equipment
Used in sands, silts, and clays
Significant spoils produced
2- to 12-ft diameter

Dry Method:

Dry lime and/or cement
Smaller & lighter equipment
Used in soft, wet ground
No significant spoils produced
1-ft to 3-ft diameter



Dry DMM

Mixing Tool



Finished Column



Dry Mixing – Mass Stabilization, U.S. Hwy 1, FL



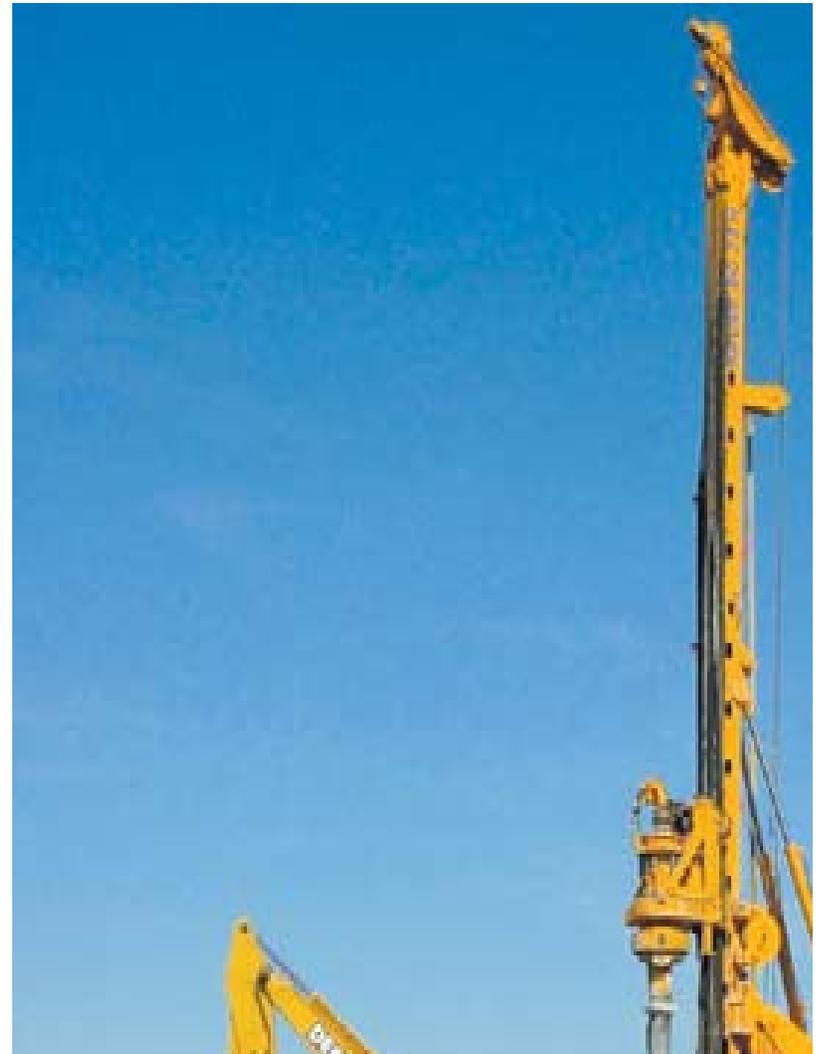
Dry Mixing – Mass Stabilization, U.S. Hwy 1, FL



Dry Mixing – Mass Stabilization, U.S. Hwy 1, FL



Single-Axis Wet DMM



310-ft Dia. Oil Storage Tanks at Galliano, Louisiana



Multiple-Axis Wet DMM



TRD Method of Wet Mixing



A Possible Deep-Mixing Configuration for Levees

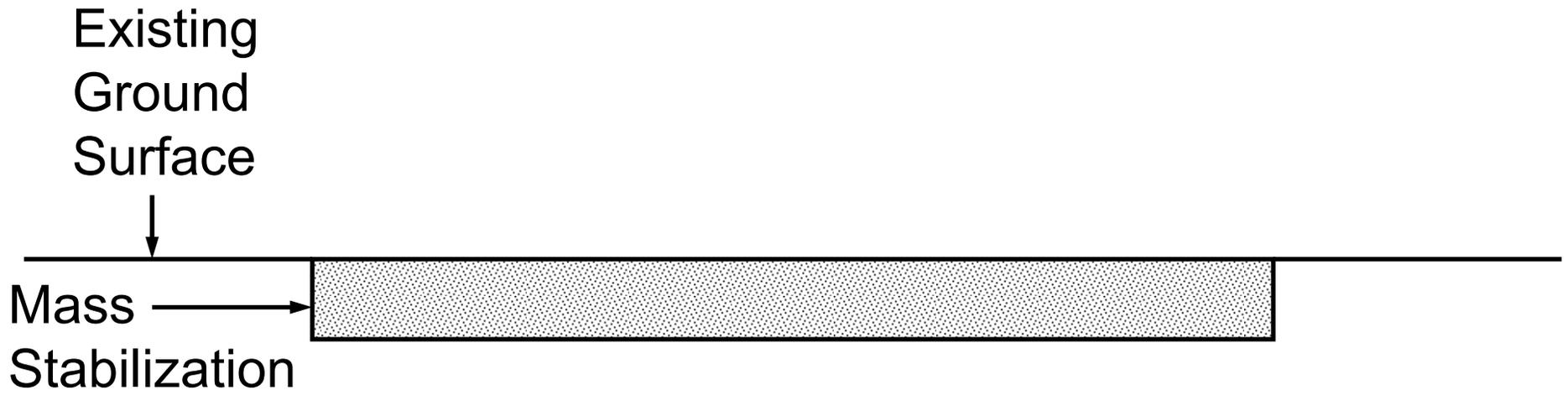
A Possible Deep-Mixing Configuration for Levees

Cross-Section View

Existing
Ground
Surface



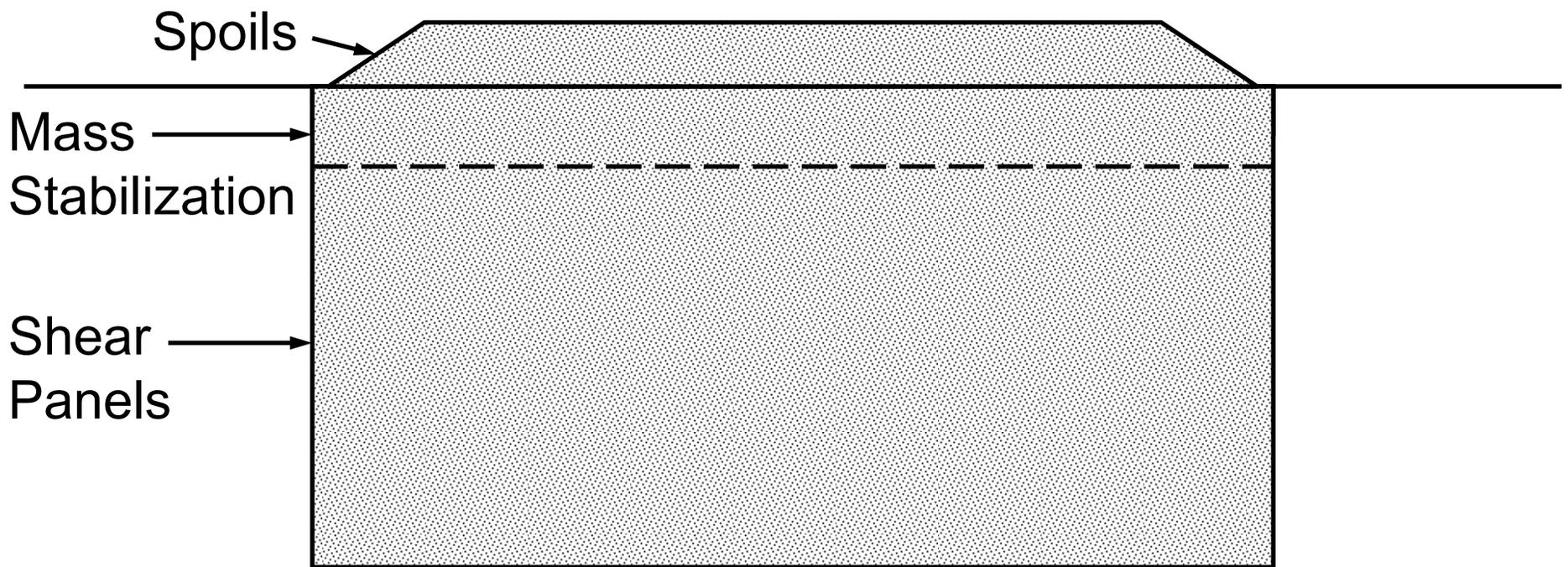
A Possible Deep-Mixing Configuration for Levees



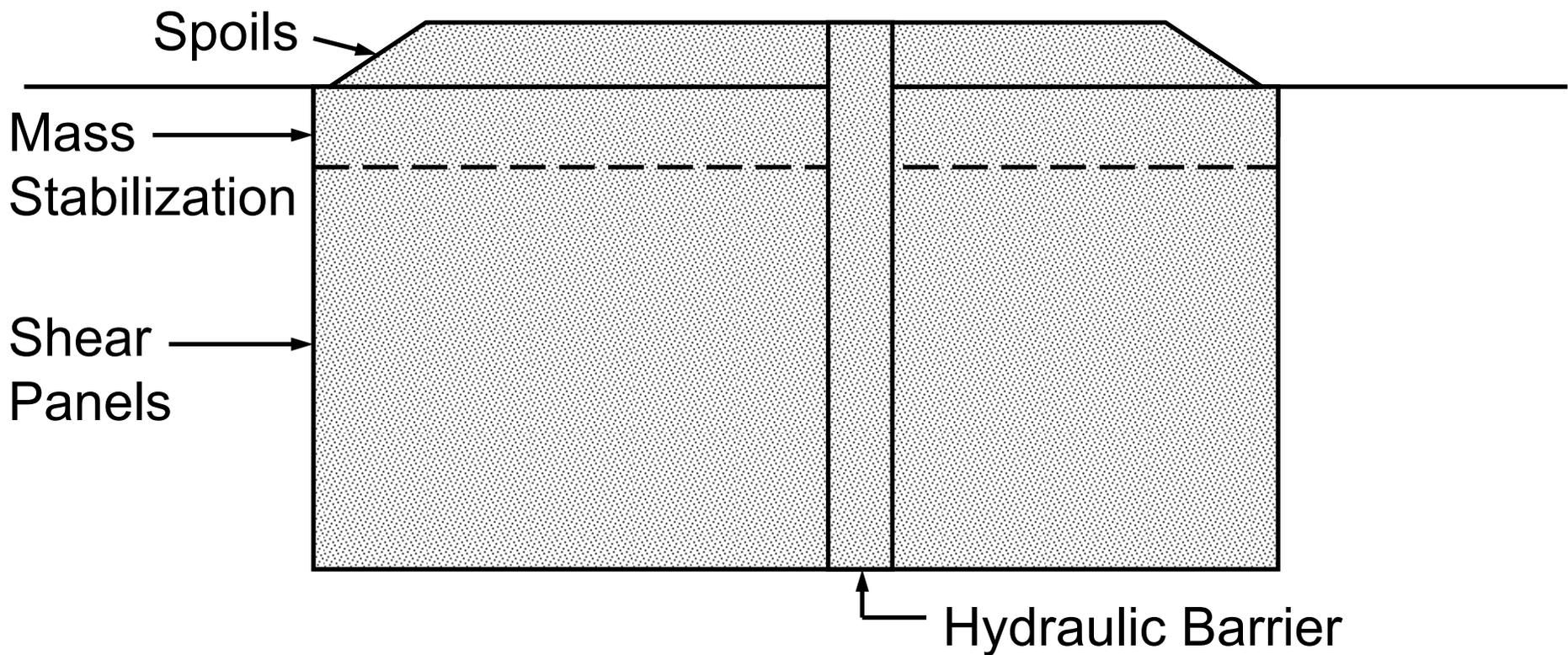
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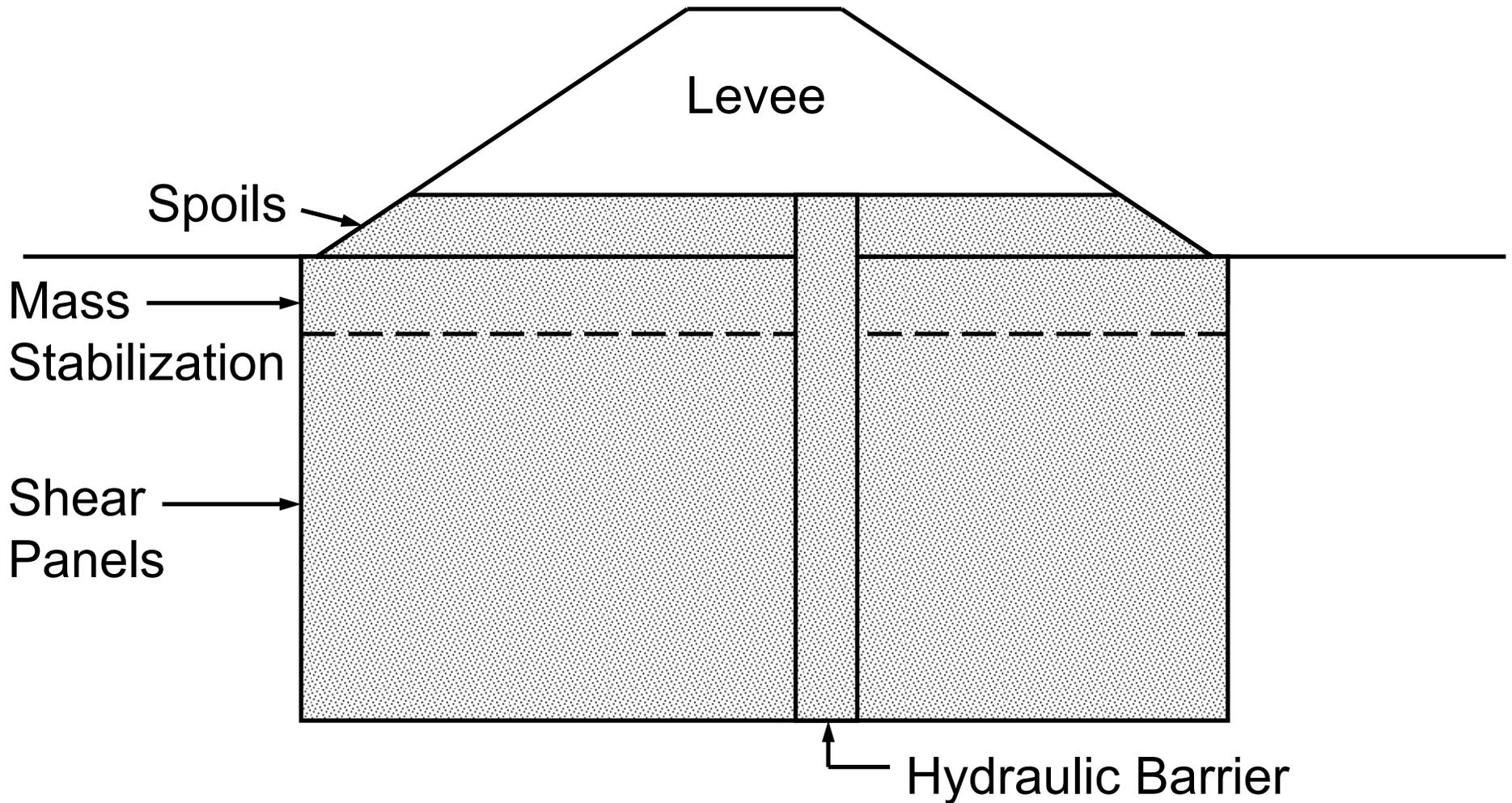
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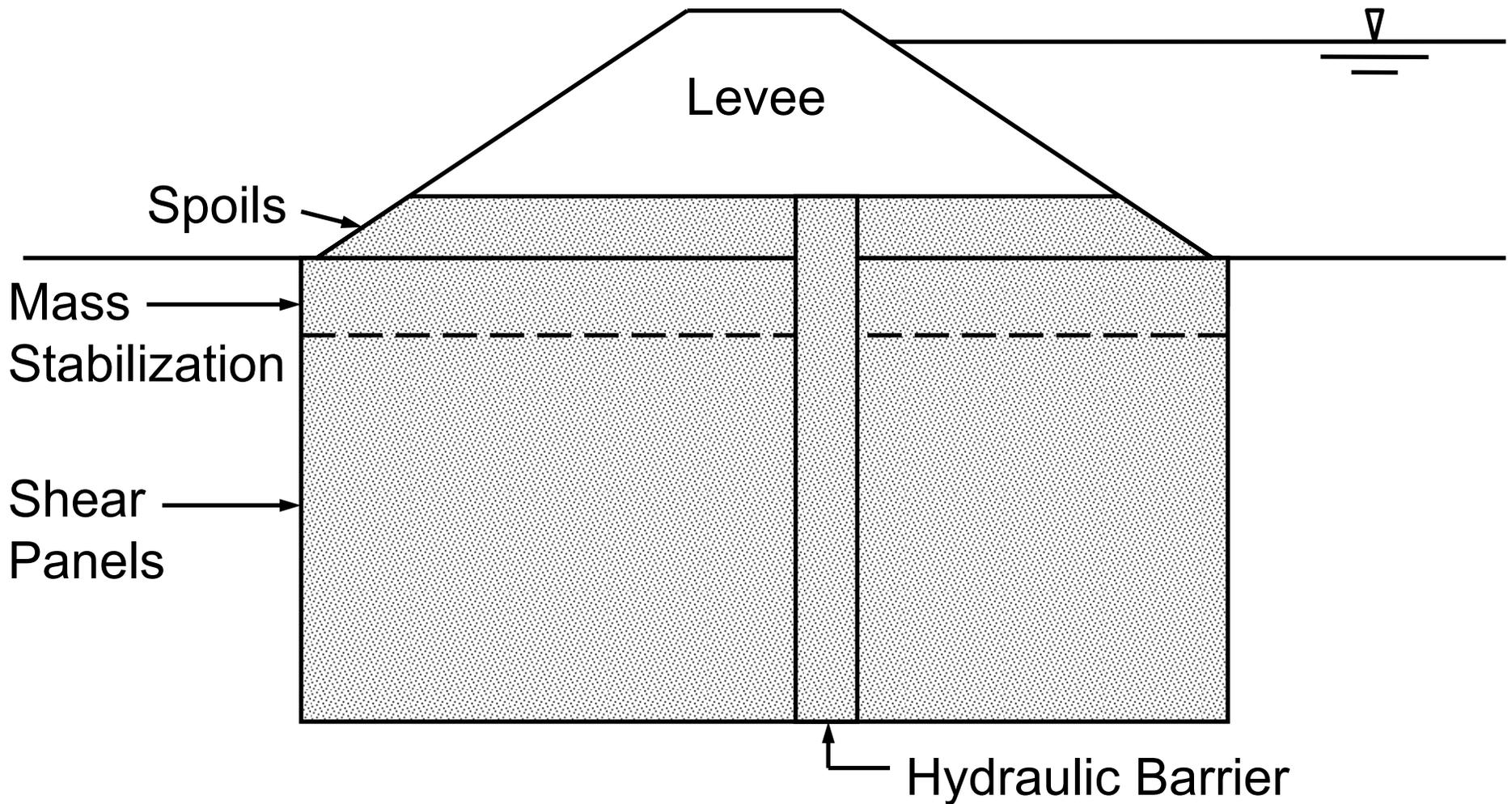
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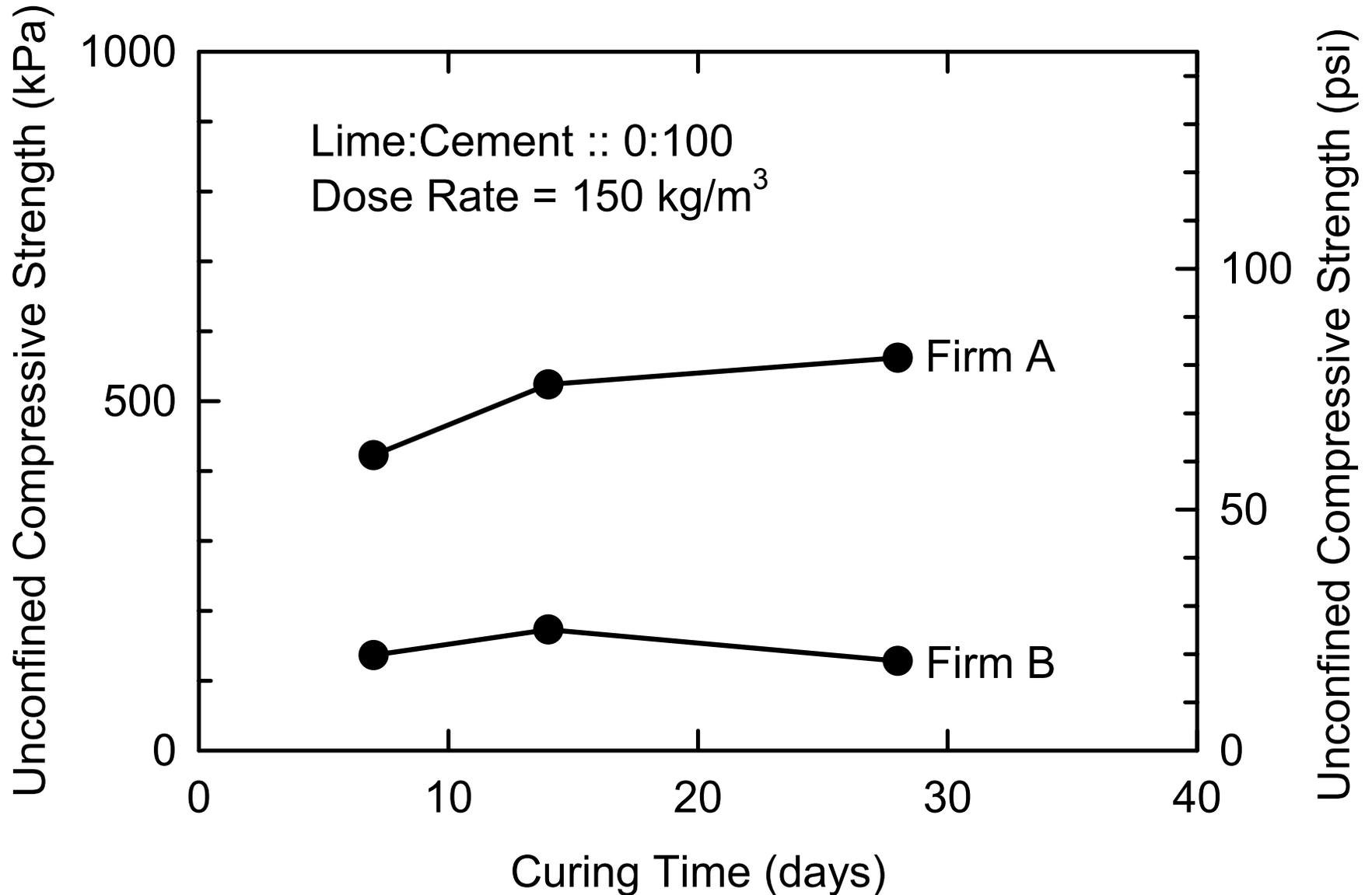
Deep Mixing Design Issues

- Mix design, material property values, and durability
- Load transfer and element capacities
- Settlement
- Stability
- Reliability
- Cost
- Constructability
- Quality Assurance

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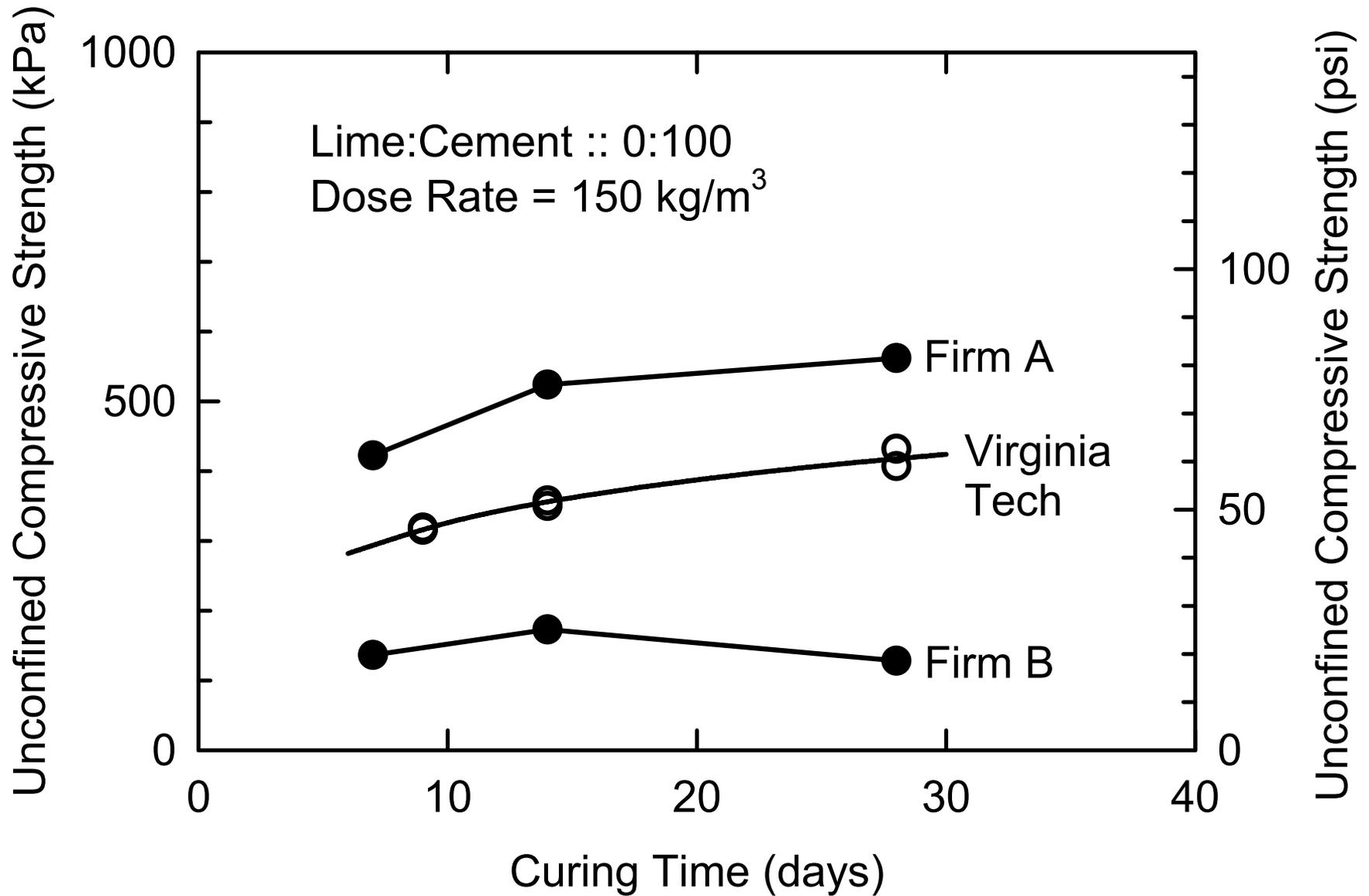
Design-Phase Testing for Embankments, Alexandria, VA



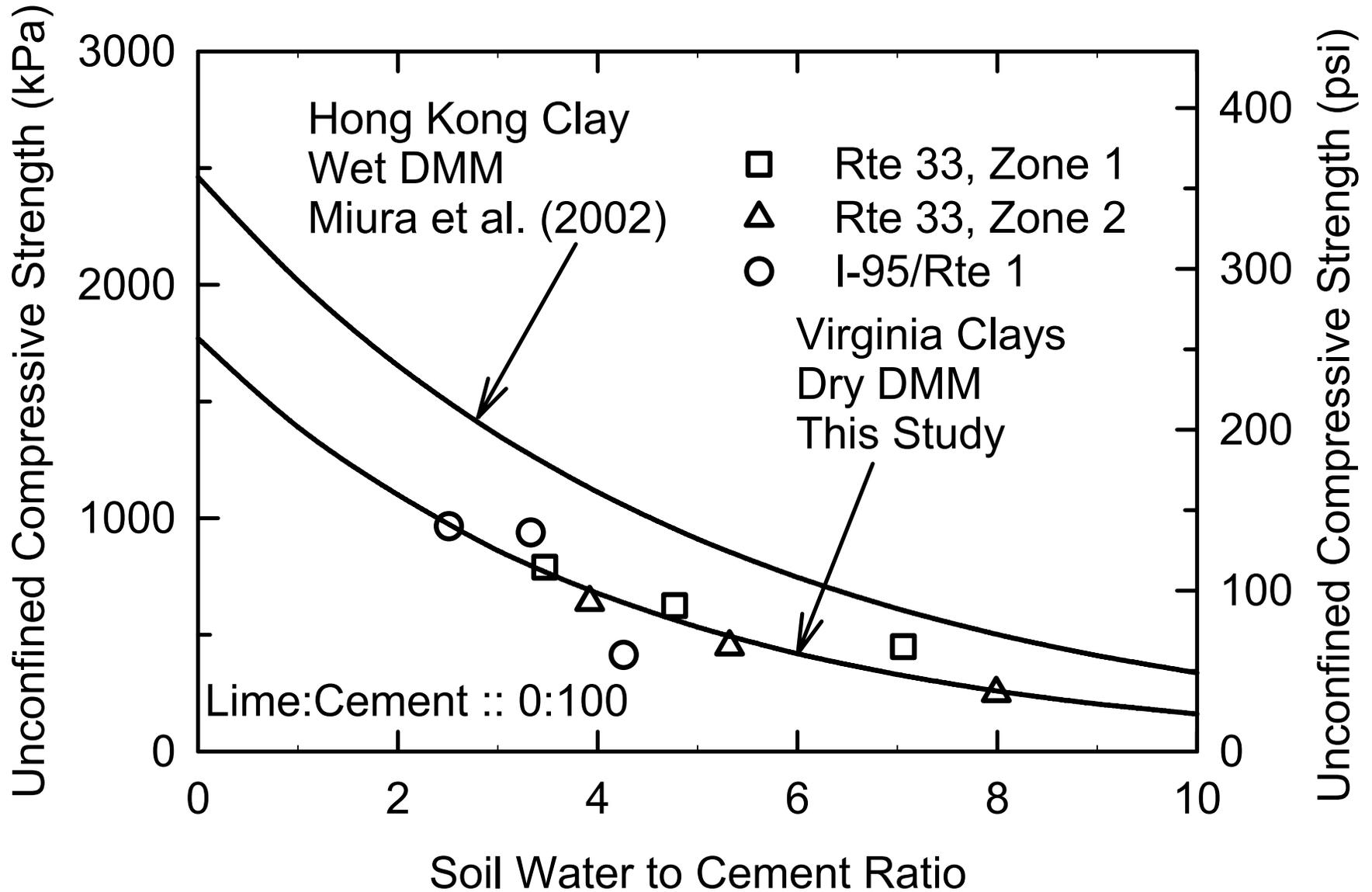
Reasons for the Difference

- Firm B dried and then re-hydrated its samples
- Firm B cured its specimens at a lower temperature than Firm A
- Firm A used a definition of dose rate that put more cement in its specimens

Standardized Test Procedure



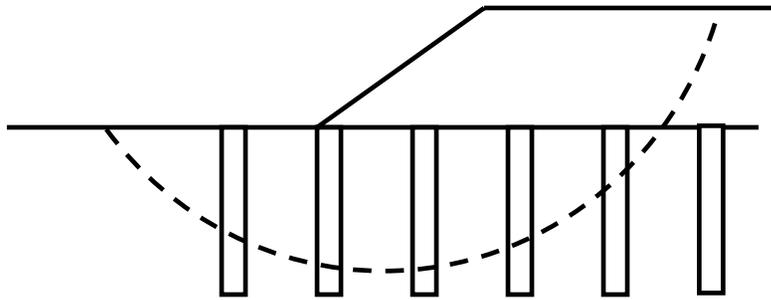
Strength vs Water-to-Cement Ratio



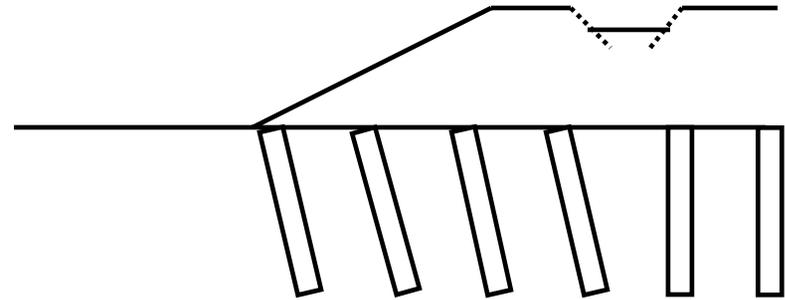
Variability of DMM Field Strengths

- Ten sites in the U.S.
- 7000 strength measurements
- Coefficient of variation ranged from 0.4 to 0.7
- Spatial correlation
 - Enough data at three sites
 - Autocorrelation distance ≈ 12 m

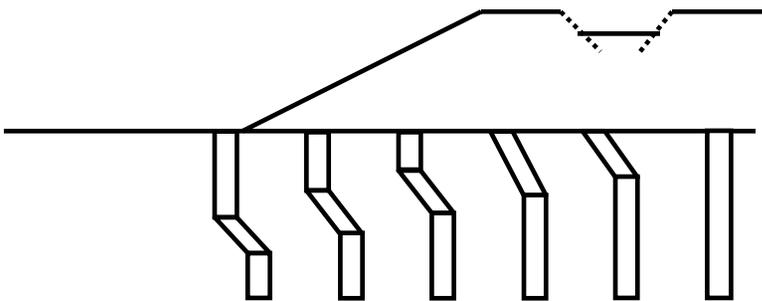
Stability Failure Modes for DMM Column-Supported Embankments



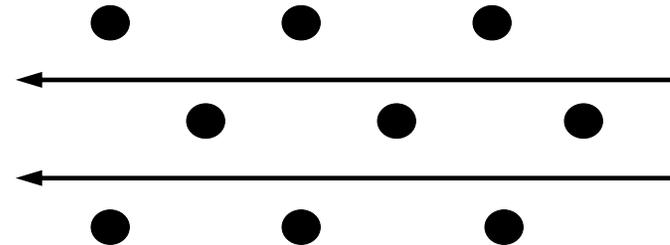
Shearing Mode



Tilting Mode

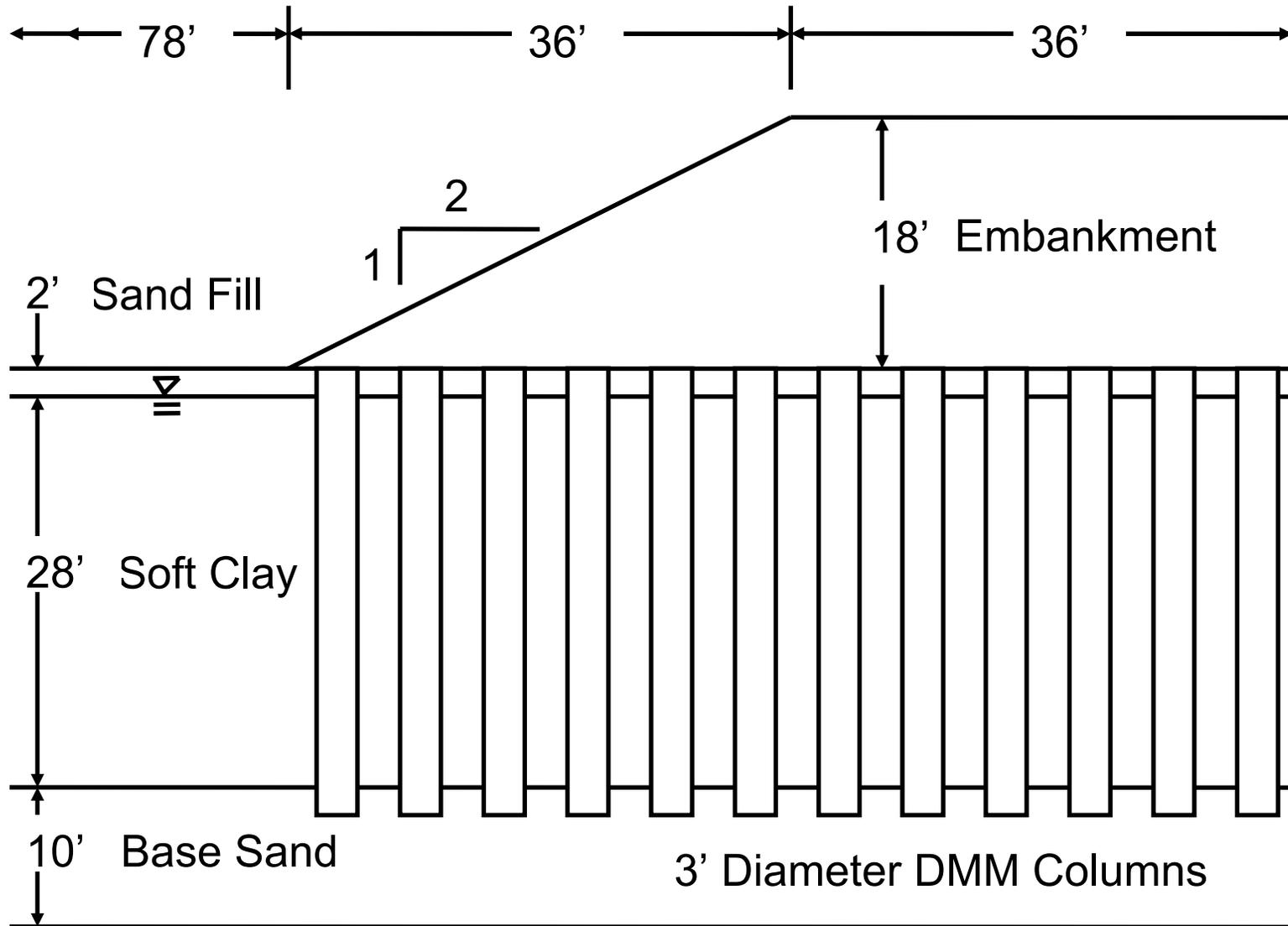


Bending Mode

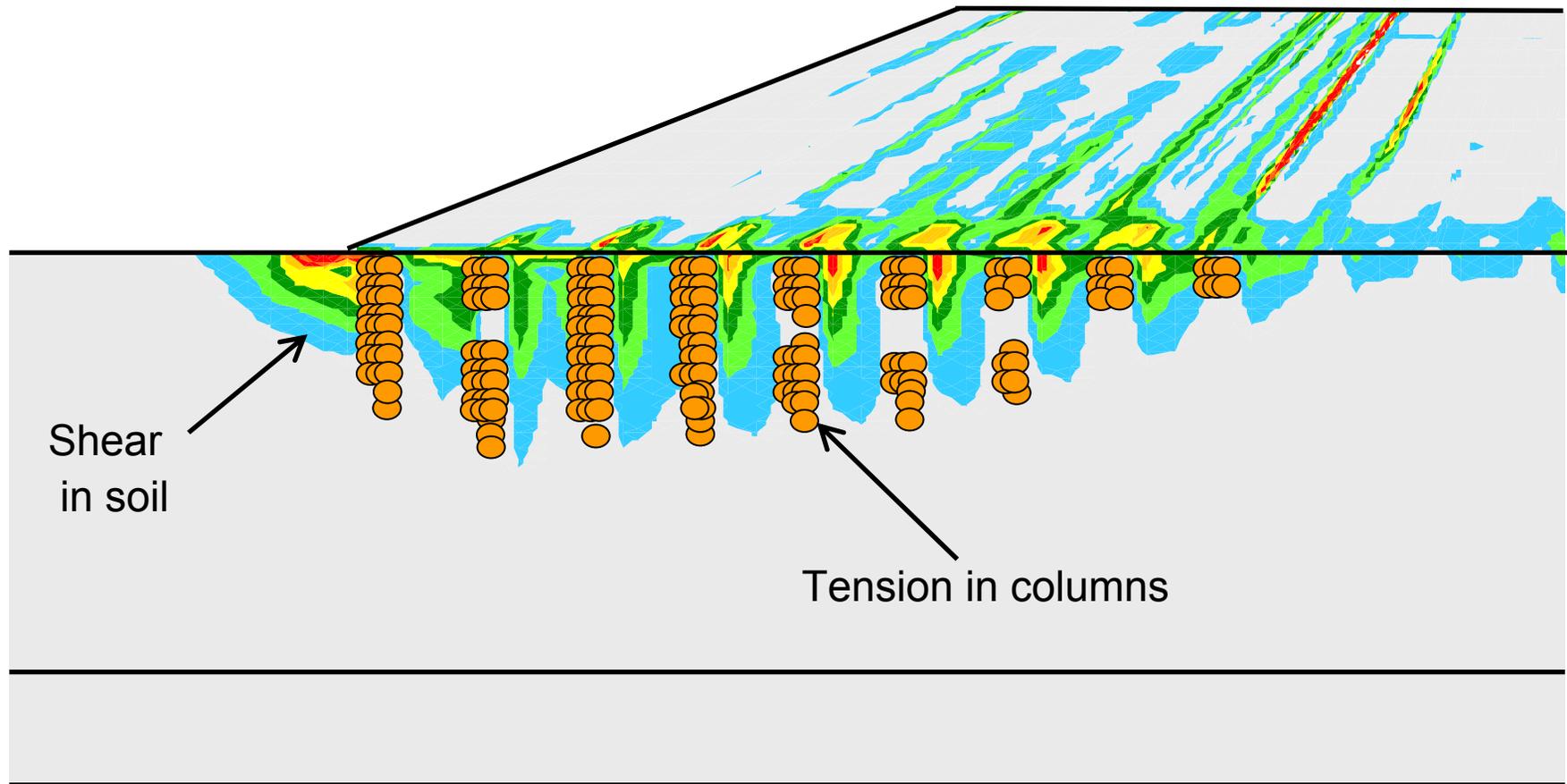


Extrusion Mode

Example for Reliability Analyses with Isolated Columns under the Slope



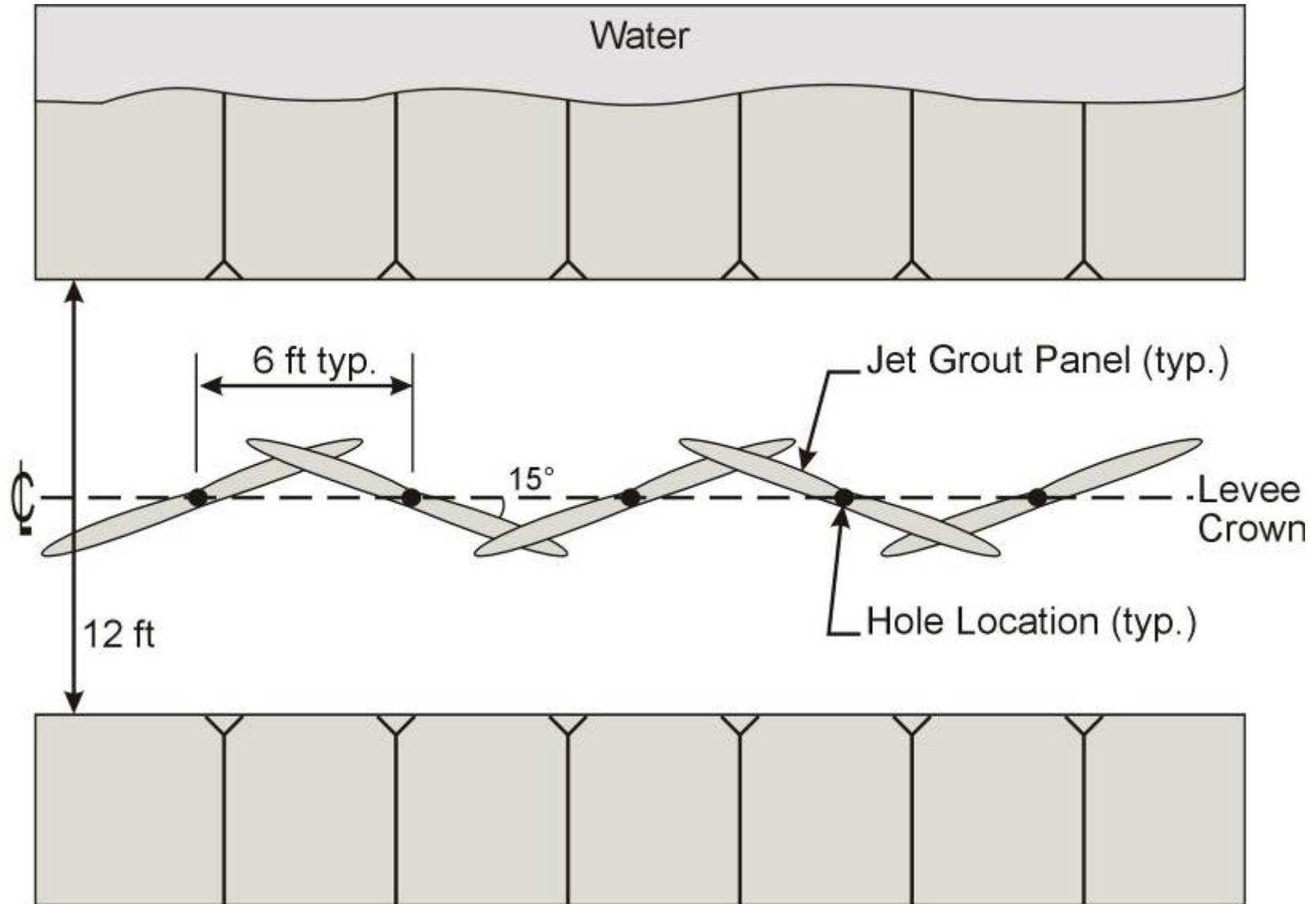
Numerical Analyses Model Bending Failure of Columns



Results of Reliability Analyses

	Limit Equilibrium	Stress-Strain
Factor of Safety	4.3	1.4
Prob. of Failure	0.06%	5.2%

Jet Grouting to Construct a Hydraulic Barrier



Summary: Reduce/Redistribute the Applied Load

- Restore and enhance the natural coastal environment
- Construct breakwaters
- Provide man-made storage

Summary: Resist the Applied Load

- Structures
 - Earthen levees
 - Reinforced soil
 - Concrete and steel structures
 - Tubes
 - Combinations
- Foundations
 - Staged loading
 - Piles
 - Deep mixing
 - Sheet piles
 - Jet grouting