Slope Stability for New Construction, Phased Construction, and Rehabilitation

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Texas Department of Transportation

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New and Phased Construction

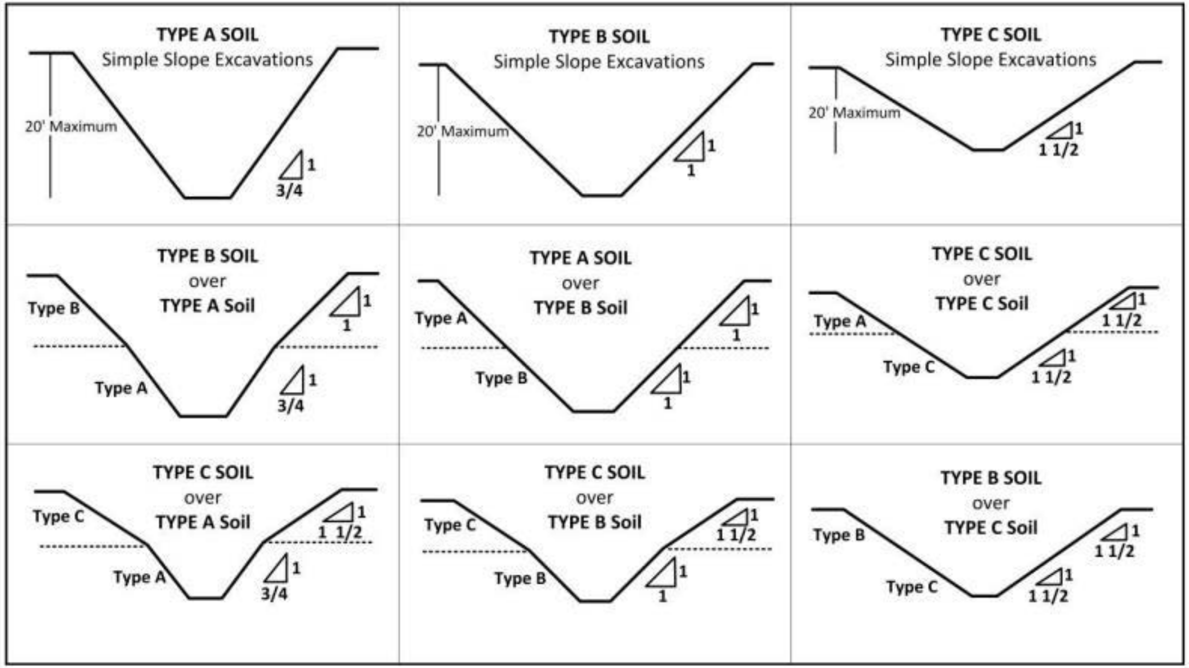
New and Phased Construction

- Item 403 "Temporary Special Shoring"
  - Shoring must comply with OSHA 29 CFR Part 1926, Subpart P – Excavations
  - Vertical or sloped cuts, benches, shields, support systems, or other systems to provide the necessary protection in accordance with the approved design
- Consider short term parameters

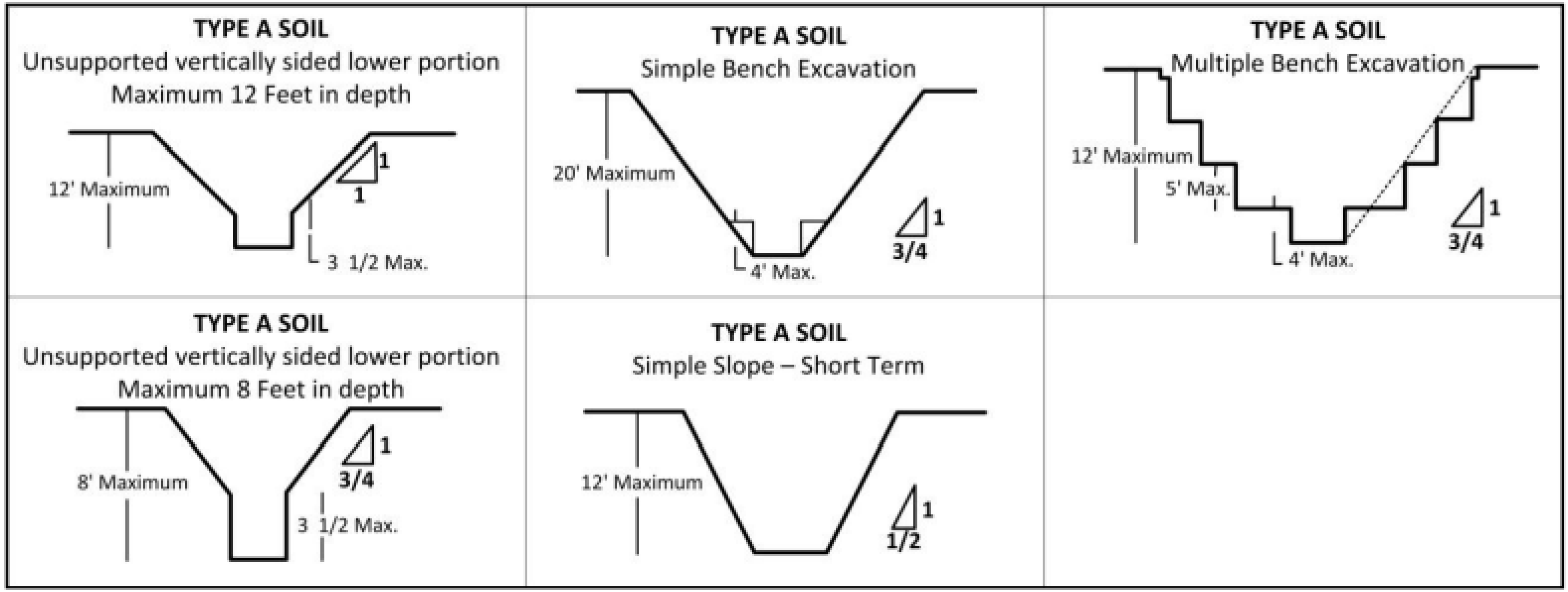
OSHA Subpart P - Excavations

Soil Type	Soil Examples	Unconfined Comp. Strength (TSF)	Max Allowable Slopes for Excavations Less Than 20 ft Deep
Stable Rock	Bedrock, Basalt, Limestone, Granite, Sandstone		Vertical (90°)
A	Clay, Silty Clay, Sandy Clay, Clay Loam, Caliche, Hardpan, Silty Clay Loam, Sandy Clay Loam	>1.5	¾:1 (53°)
B	Gravel, Silt, Silt Loam, Sandy Loam, Clay Silty Loam, Sandy Clay Loam	0.5 to 1.5	1:1 (45°)
C	Gravel, Sand, Loamy Sand, Submerged Soil or Soil From Which Water is Freely Seeping	<0.5	1½:1 (34°)

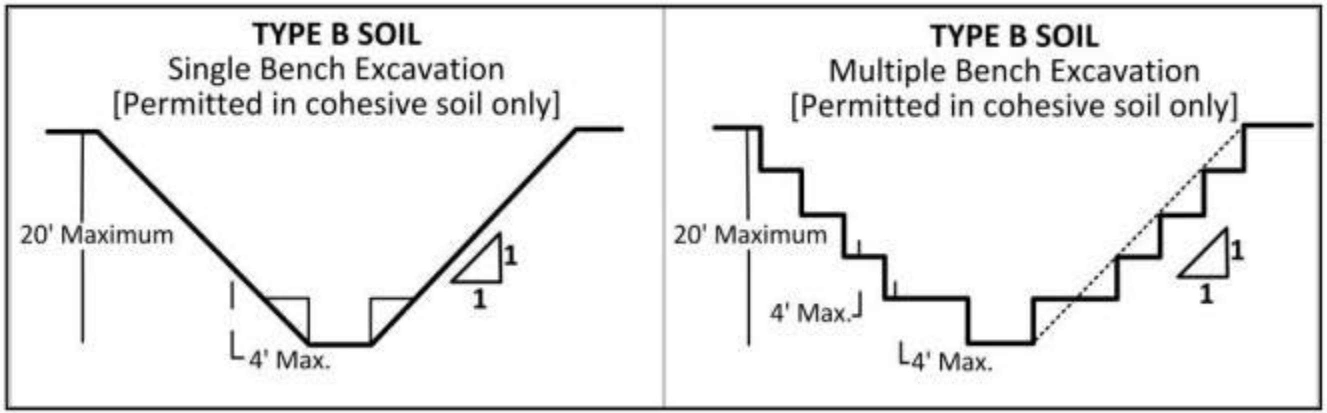
Layered Soils



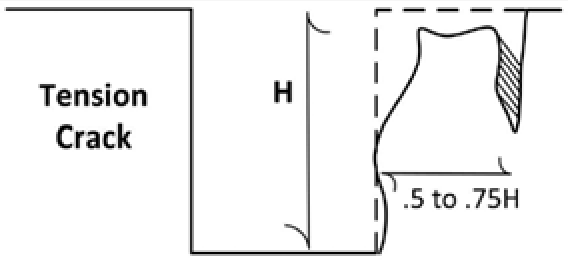
Excavations in Type A Soils

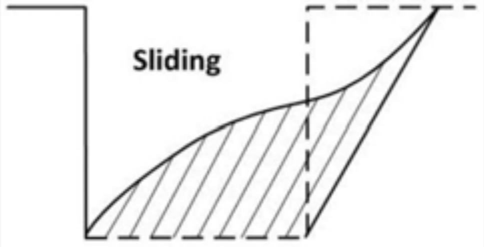


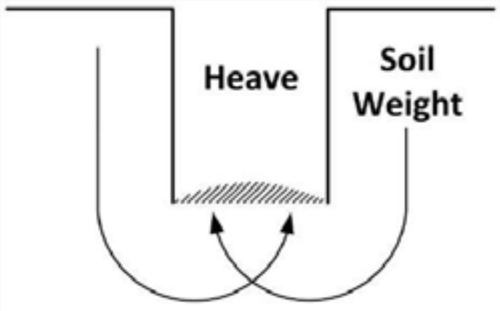
Excavations in Type B Soils

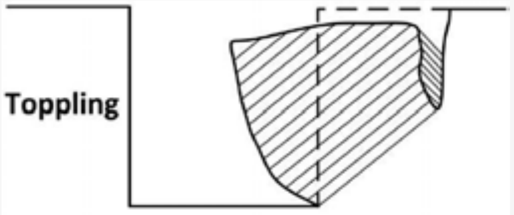


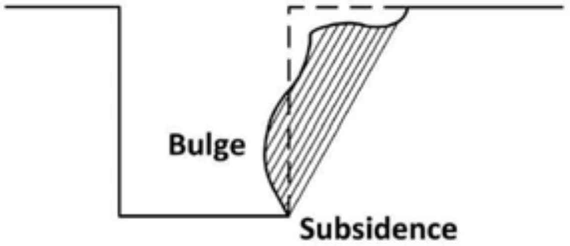
Trench Failures

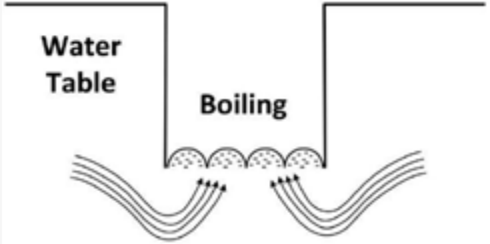




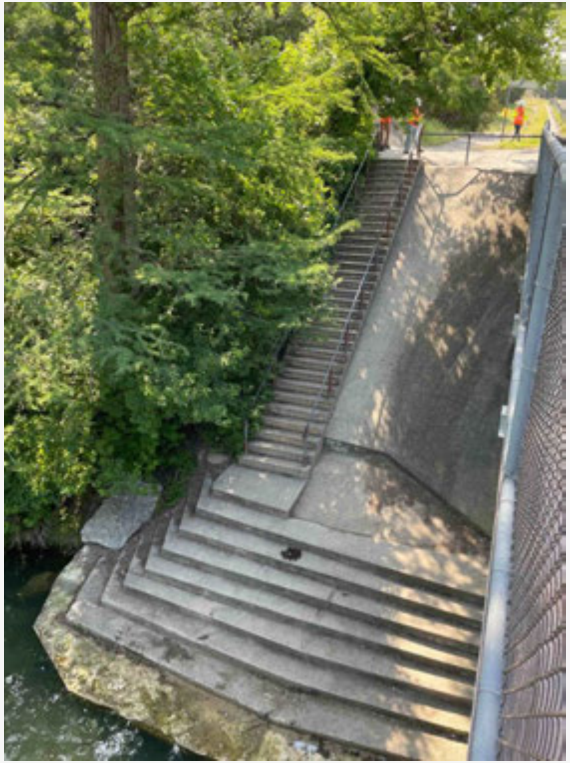






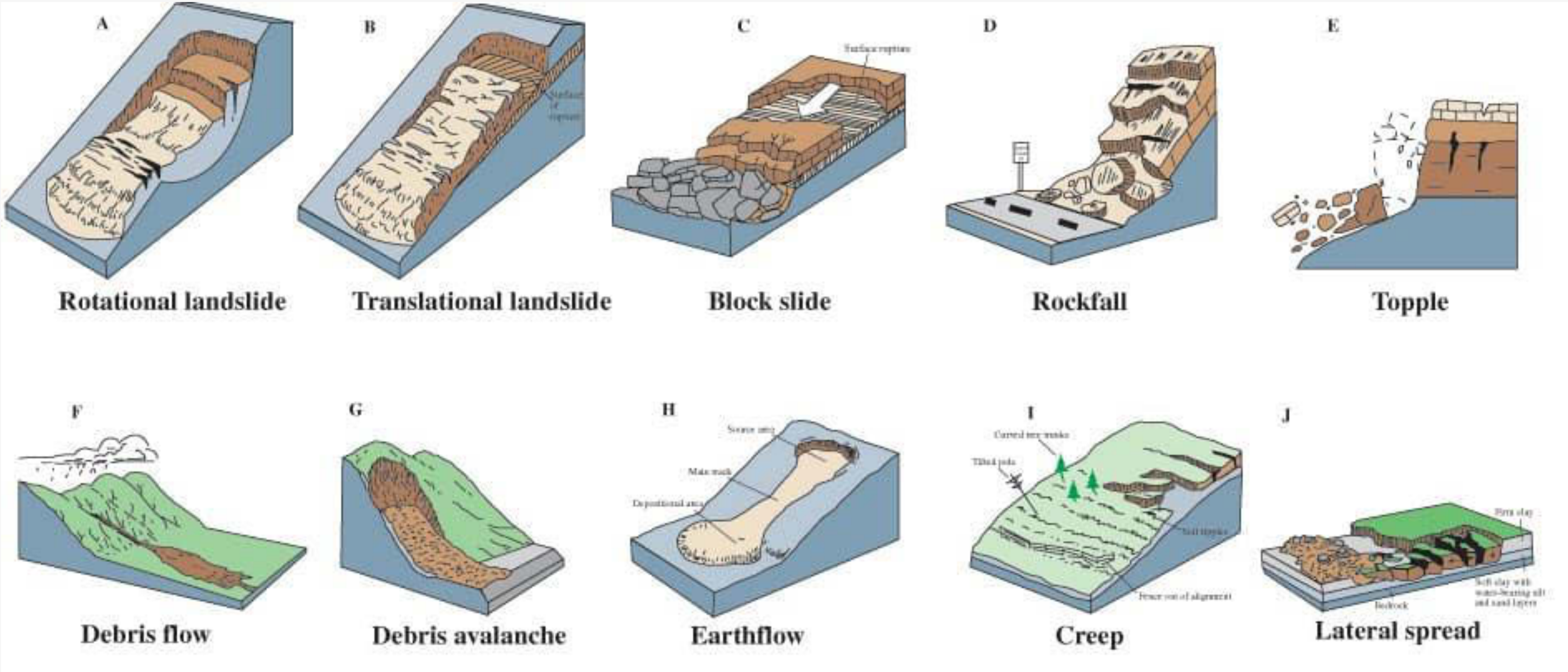


Quick Case Study



Rehabilitation

Types of Slope Failures



Common Causes of Slope Failures

- Water infiltration
- Increase load at the top of the slope
- Removal of material along the toe
- Seismic activity
- Rapid drawdown
- Vegetation loss

Rotational Failure

Excessive load at top of slope

Topple Failure

High Plasticity Clays

- Absorbs large amounts of water (when available)
- Swells and softens when wet
- Shrinks and cracks when dry
- Simple lab test to determine Plasticity Index (PI)
- PI > 30 is troublesome

High Plasticity Clays

- As constructed, material is dry and well compacted
- Surface immediately begins to absorb water, swell and soften
- During dry periods, material shrinks and cracks
  - Shrink/swell contributing to global failure
- During next wet cycle, rain penetrates more **deeply**, clay material swells and softens further
- Finally, material can no longer hold its own weight, and flows down the slope

Plasticity Index Recommendations

TxDOT Geotechnical Manual – LRFD
Table 7-1: Plasticity Index Range for Exposed Side Slopes Required for FS=1.3 for Long Term Drained Condition

Slope (H:V)	Plasticity Index (PI) (%)
2.5:1	<5
3.0:1	<20
3.5:1	<35
4.0:1	<55
4.5:1	<85

General Guide for Plasticity Index Range for Various Slopes Required for FS = 1.3 (global) in the Long-Term (Drained) Condition using infinite slope analysis accounting for seepage of water parallel to face of slope. We recommend analysis and checking global stability in all slopes.

FS = 1.5 or greater required for slopes (and walls) supporting buildings and critical infrastructure.

Common Mistake

Regrading the slope

April 2017

January 2018

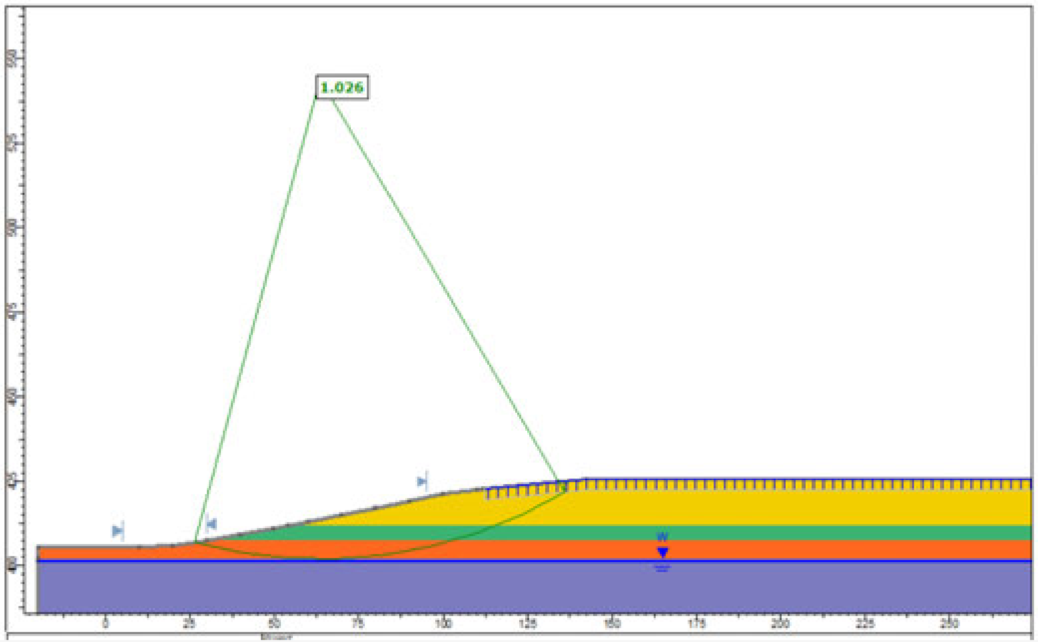
January 2022

Repair – Step 1: Site Investigation

Survey the Area

Drill Borings

Repair – Step 2: Modeling



Estimate Failure Depth

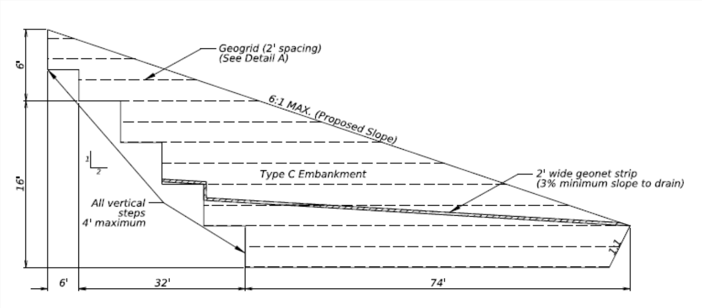
Repair – Step 3: Evaluation

Ask yourself these questions:

- What is the primary cause and mode of failure?
  - Establish preliminary repair options
- Are there ROW constraints?
  - Shoring may be needed
- Is the failure near a major roadway or critical facility?
  - Establish timeline for design and repair
- Budget?

Repair – Step 4: Long-term Fix

- Add drainage
- Flatten slope
- Remove and replace all problem material
  - Replacement possibly to include reinforcement (RSS)
- Install retaining wall
- Maintain vegetation on slopes.
  - Mulching, Seeding, Soil Retention Blankets



Take Aways

- Natural and engineered fill slopes **should not be overlooked** in design or construction phase of infrastructure projects
- Failures are often due to a **combination of factors**, and most efficient fix is usually a **combination of methods**
- Identify **early** and **fix the source** of the problem.
  - If potential failure is identified early, time and costs for maintenance and potential retrofit and rebuilding is significantly better
  - Drainage, geometry, and soil/fill properties are key factors in stability
- Effectiveness should come first, but long-term cost depends on thorough initial design, quality construction and routine monitoring to catch potential problems

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Questions?

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