Construction of Structural Shoring and Retaining Walls

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Topics & Goals

- Discuss several wall construction projects that have or will impact wall design
- Wall types include
  - Unconventional Soil Nail – US-2 slide repair
  - Soldier Pile – Sahalee Way
  - Soldier Pile with tiebacks – Bear Canyon
- These issues are complex and are not intended as criticism of the original designs

US-2 Slide Repair

Overview

- Nov 06 sloped embankment failure led to loss of lanes on US-2 near Index, WA
- Emergency repair contract with federal funding
- Contract allowed conventional soil nail or hollow core self-augering steel reinforcing bars
- Soil nails required construction of a shelf, for the drill rig, on the unstable slope **or** 15 day full road closure

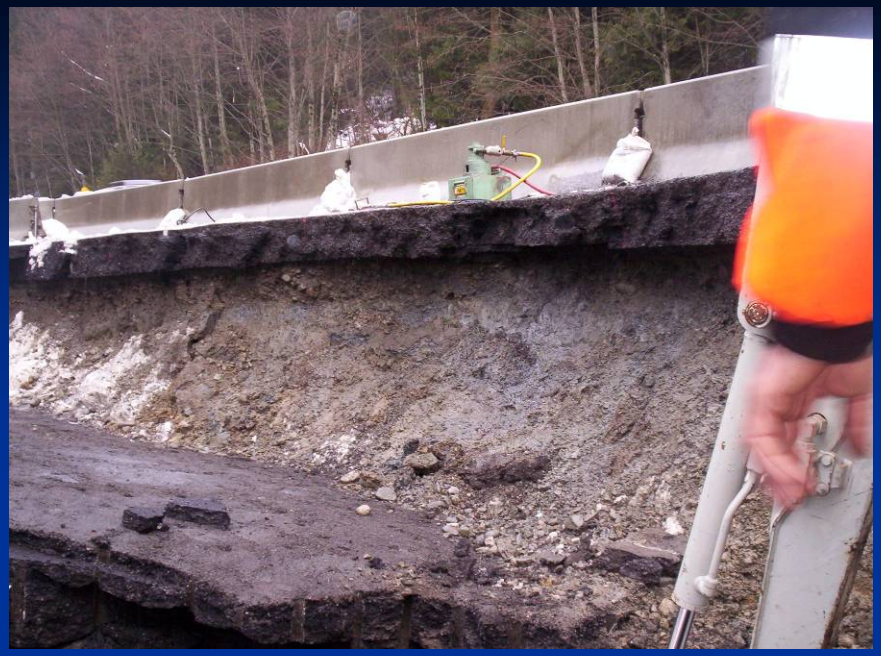

Approximate Fog
Line Location
(before slide)

Issues

- Contract included unrealistic solution using conventional soil nails - preferred solution of hollow-core nails did not meet "Buy America" requirements for federally funding
- Inadequate geotechnical investigation led to constructability difficulties and inferior result
- Work under emergency contract was hurried and not strictly in conformance with standard methods

Soil Nail Choice

- Bench was adequate for small drill rigs capable of installing hollow-core nails only
- Inadequate roadway width to work from above without closure
- We received waiver of "Buy America" to use hollow-core nails



Geotech Evaluation

- Soils were clayey sands
- Caused by culvert failure
- Nail grout ran
- Competency of some the nails is in question
- Walls designed to be 25ft tall, but only needed 7ft height

Construction Method

- Emergency contract = emergency methods
- Allowed installation of multiple rows of nails before shotcreting face
- Inadequate shoring used to expedite work

Lessons

- Contract requirements should be confirmed for unusual designs – Buy America
- Although an emergency contract, there was adequate time to evaluate the soils for the proposed nails; this repair will require replacement within several years; overdesign allowed us to accept deficient nails
- In the interest of speed, multiple rows of nails were installed without shotcrete facing; this led to instances of face sloughing and no consequent time-saving benefit; it also further jeopardized the roadway
- Standard process for shoring approval would have avoided project delay

Sahalee Way

Overview

- Widen SR-520 to Sahalee Way in Bellevue, WA
- Many walls with site data provided by WSDOT
- Work in congested urban locale with several municipal agencies and utilities

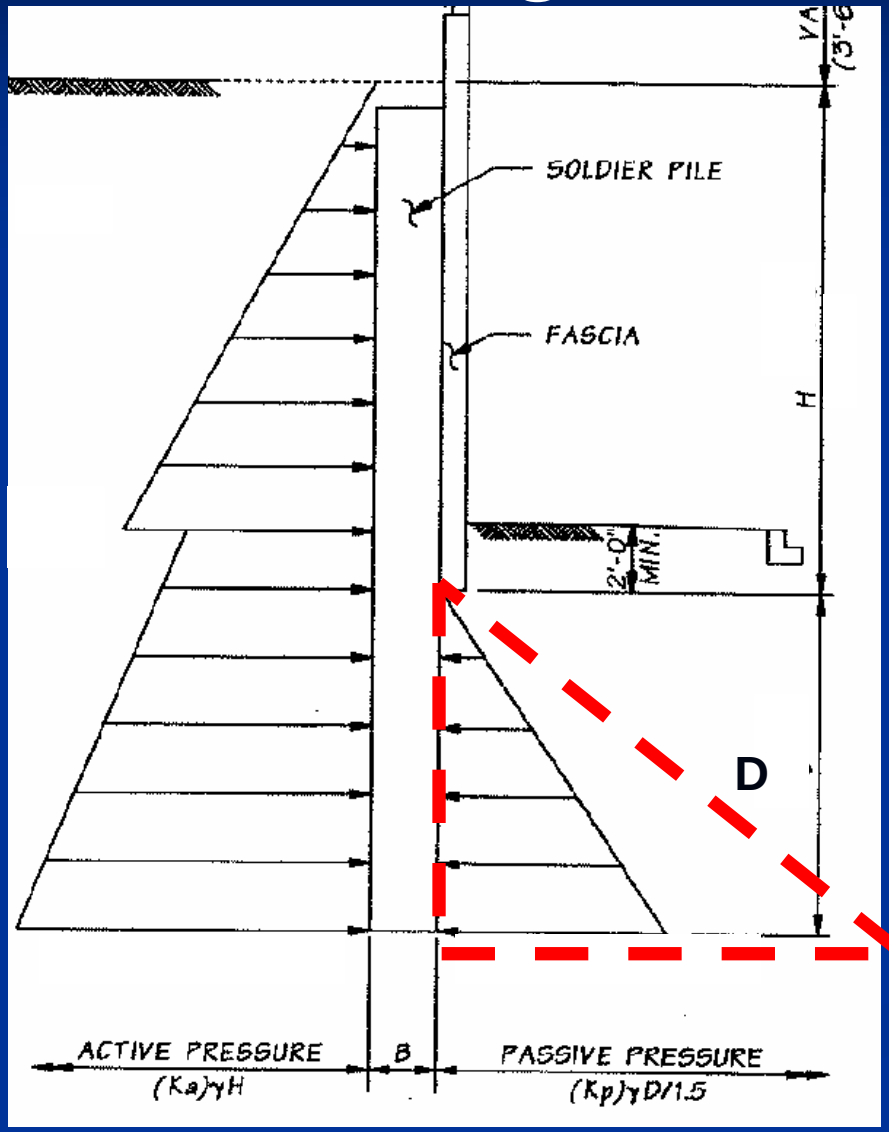
Issues

- Trenching in front of soldier pile walls for utility installation
- Incorrect site survey data

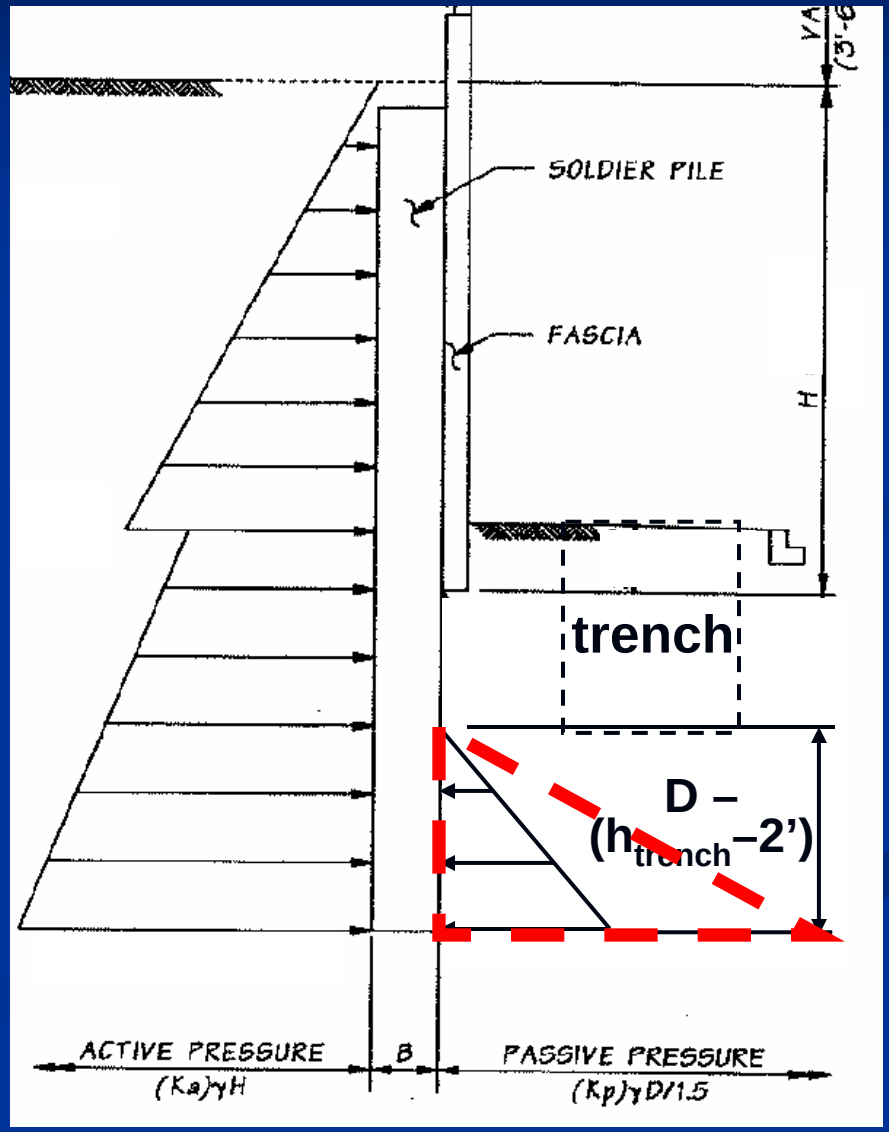

Emerald
Sanitary
Service
STOP

Wall Pressure Diagram

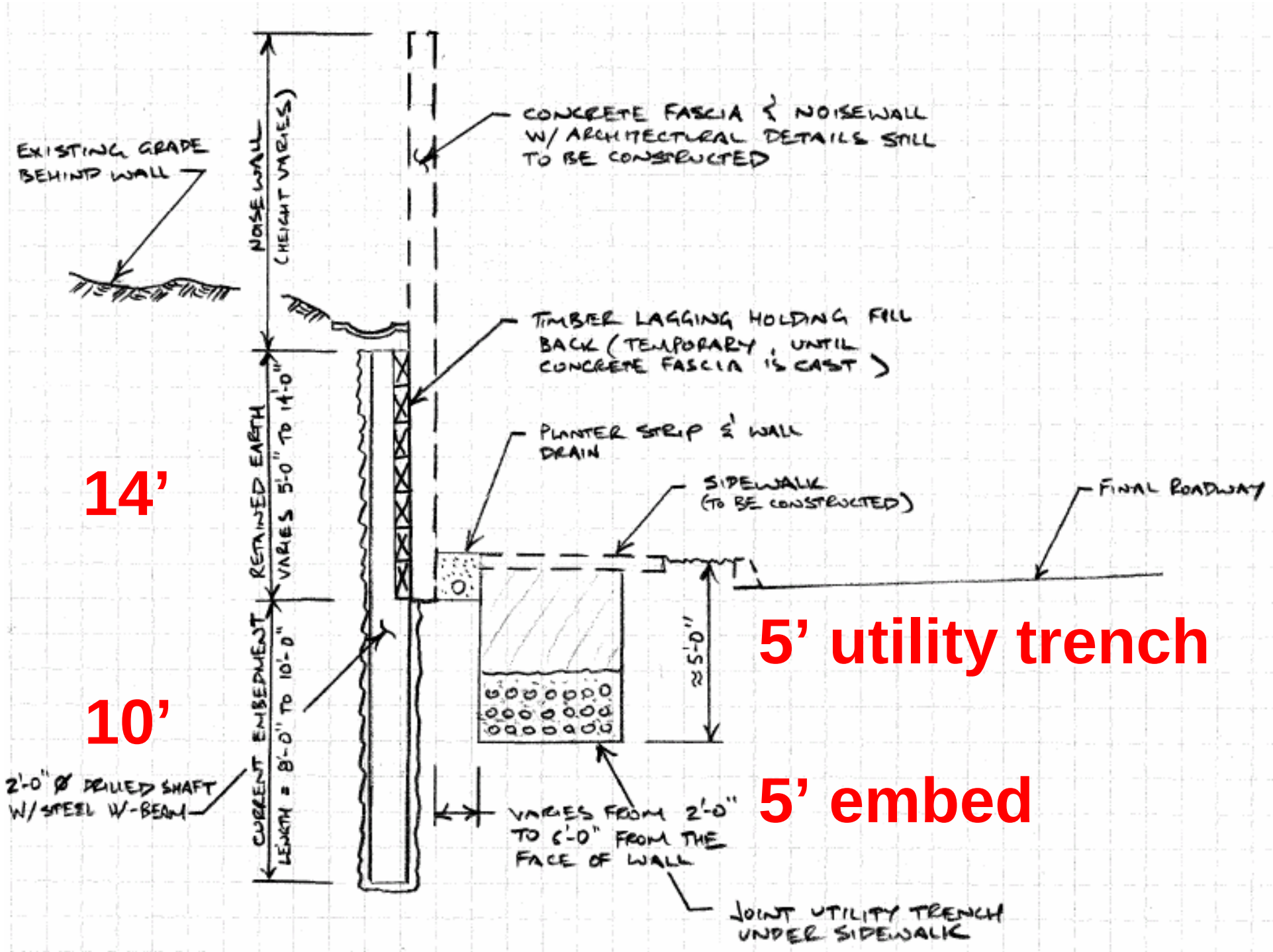
As Designed

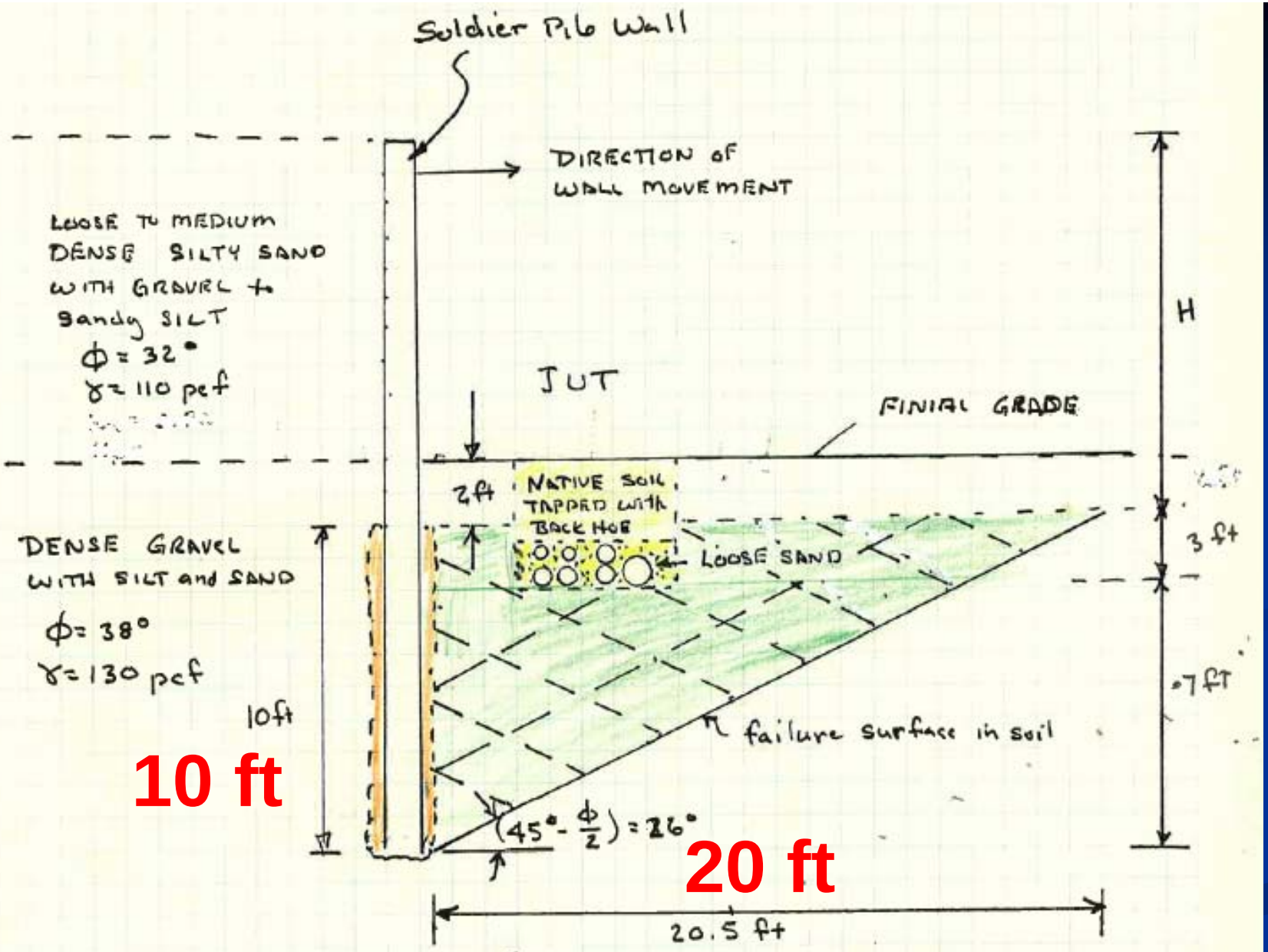


As Constructed




STOP
Emerald
CB
SEWER


EXISTING GRADE BEHIND WALL
NOISEWALL (HEIGHT VARIES)
CONCRETE FASCIA & NOISEWALL W/ ARCHITECTURAL DETAILS STILL TO BE CONSTRUCTED
TIMBER LAGGING HOLDING FILL BACK (TEMPORARY, UNTIL CONCRETE FASCIA IS CAST)
PLANTER STRIP & WALL DRAIN
SIDEWALK (TO BE CONSTRUCTED)
FINAL ROADWAY
RETAINED EARTH VARIES 5'-0" TO 14'-0"
14'
CURRENT EMBEDMENT LENGTH = 8'-0" TO 10'-0"
10'
2'-0" Ø DRILLED SHAFT W/ STEEL W-BEAM
≈5'-0"
5' utility trench
5' embed
VARIES FROM 2'-0" TO 6'-0" FROM THE FACE OF WALL
JOINT UTILITY TRENCH UNDER SIDEWALK


Soldier Pile Wall
DIRECTION OF WALL MOVEMENT
LOOSE TO MEDIUM DENSE SILTY SAND WITH GRAVEL to Sandy SILT
$\phi = 32°$
$\gamma = 110$ pcf
JUT
FINIAL GRADE
H
2ft
NATIVE SOIL TAPPED WITH BACK HOE
LOOSE SAND
3 ft
DENSE GRAVEL WITH SILT and SAND
$\phi = 38°$
$\gamma = 130$ pcf
10ft
10 ft
7 ft
failure surface in soil
$(45° - \frac{\phi}{2}) = 26°$
20 ft
20.5 ft
RANKINE PASSIVE WEDGE
Principles of Foundation Engineering
FOURTH EDITION BRAJA M. DAS

- Site survey errors

Lessons

- To prevent undermining of structural walls, require structural designers review final utility plans before contract is advertised
- If site survey data is provided by owner and is extensive part of contract, create checking system; extra surveying is far less expensive than significant construction contract changes & repairs

Bear Canyon

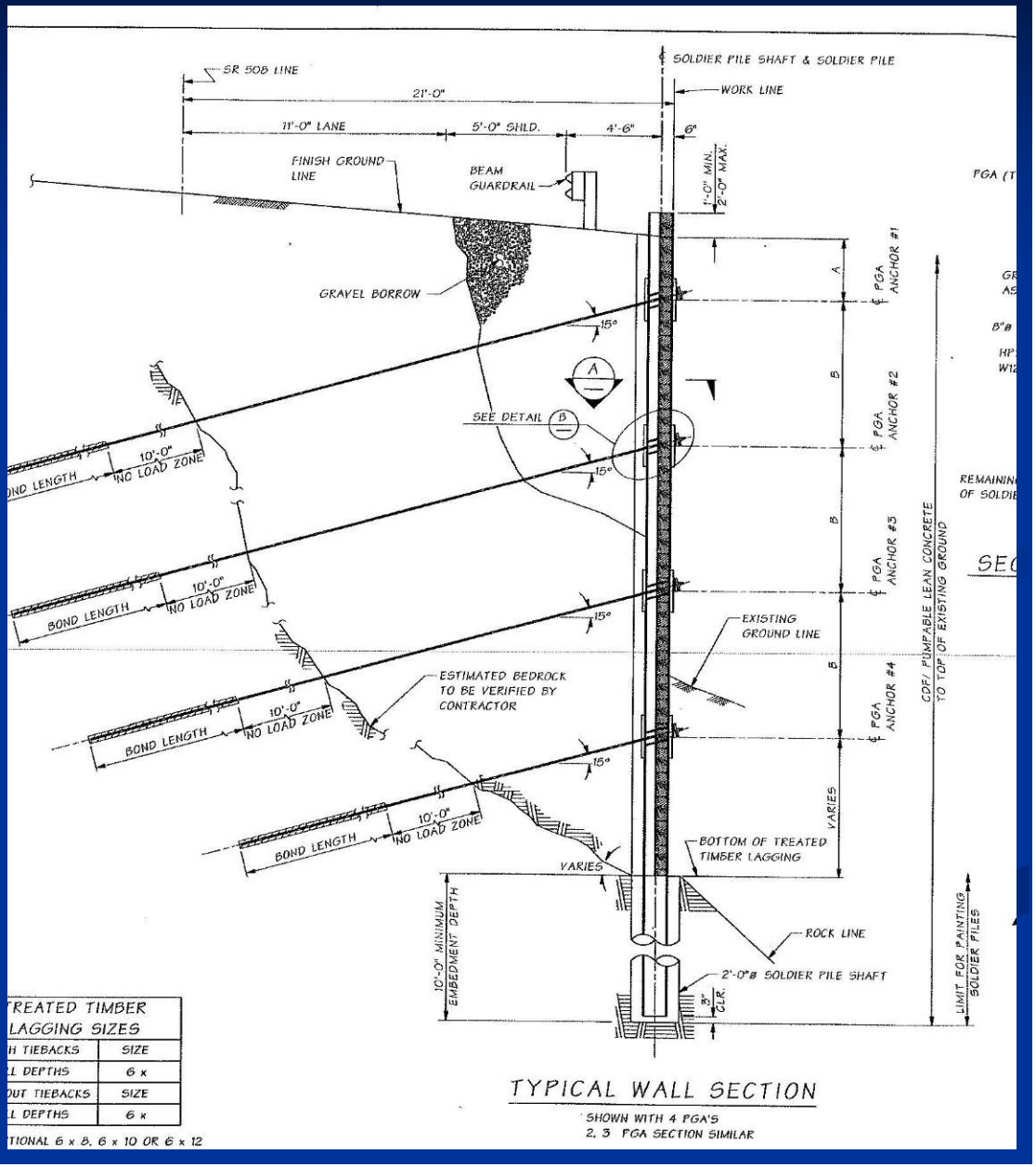
Overview

- Slope failure led to loss of lanes on SR-508 near Morton, WA
- Contract design chose soldier pile tieback versus structural earth wall due to extreme slope of slide and proposed installation method
- Construction included stabilization of remaining soils and re-build of lost slope and roadway


Roadway Location
(before slide)

Construction Method

- Stabilize slope be removing sliding material and creating road access
- Install pile 10ft embed in rock, typ 15-20ft in ground
- Pile lengths 50-60ft
- Excavate slope at wall toe and lag down to rock
- Backfill to original road and lag up
- Install PGAs whenever soldier pile supports ~>11ft fill; partial tention

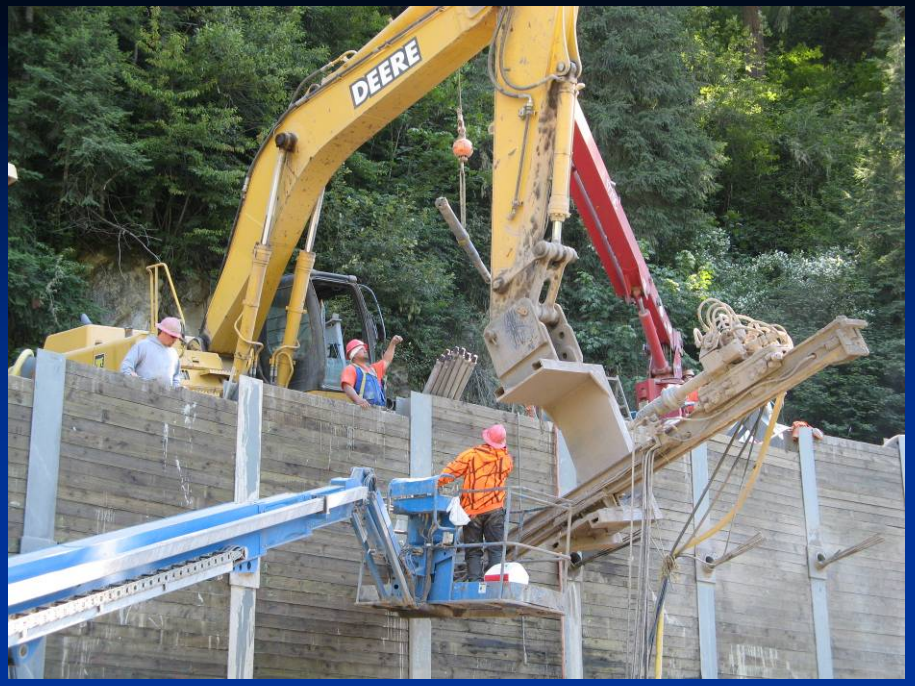


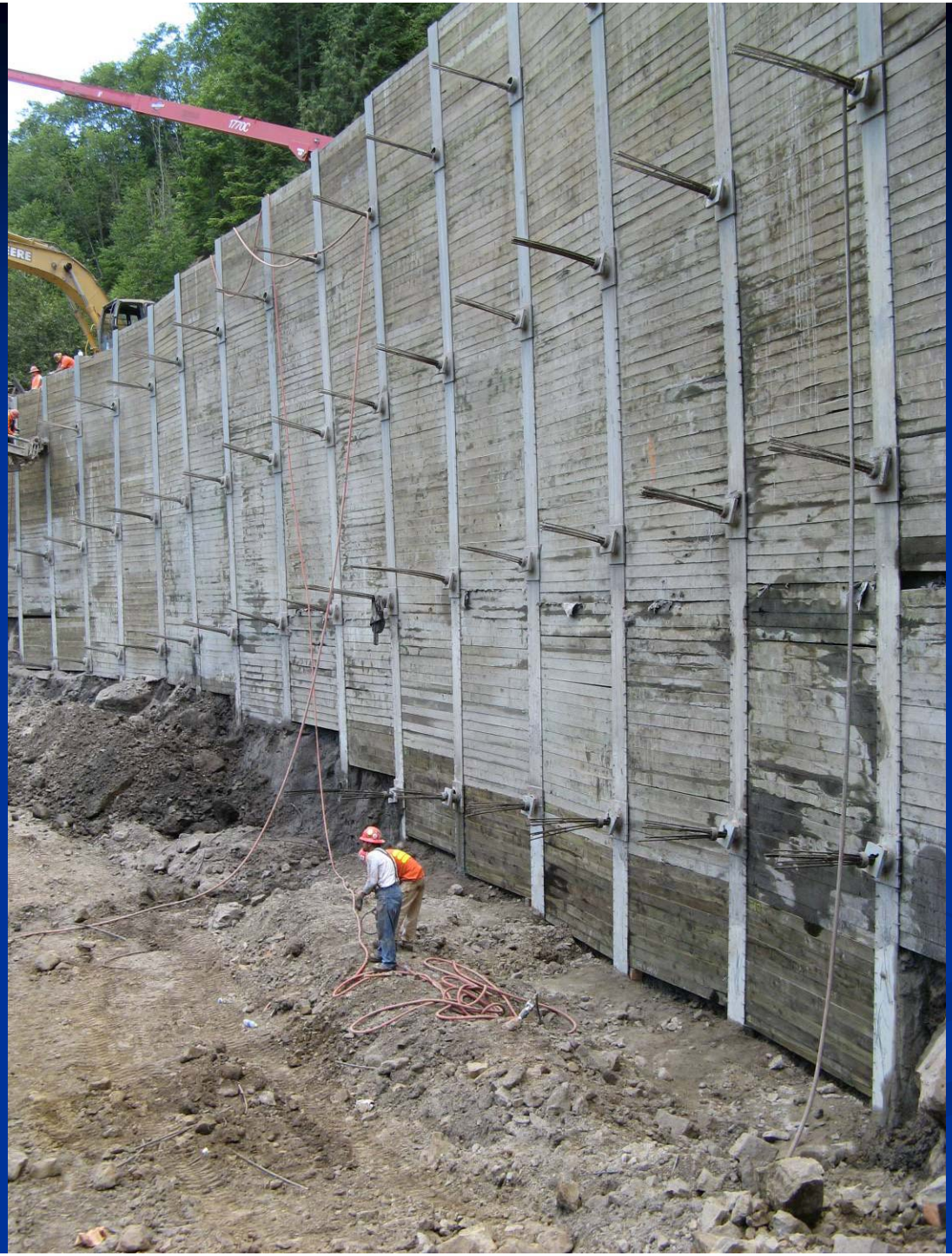

LODRIL


HITACHI


CAT


PAPE
MACHINERY
ZAXIS
35U
D18


DEERE



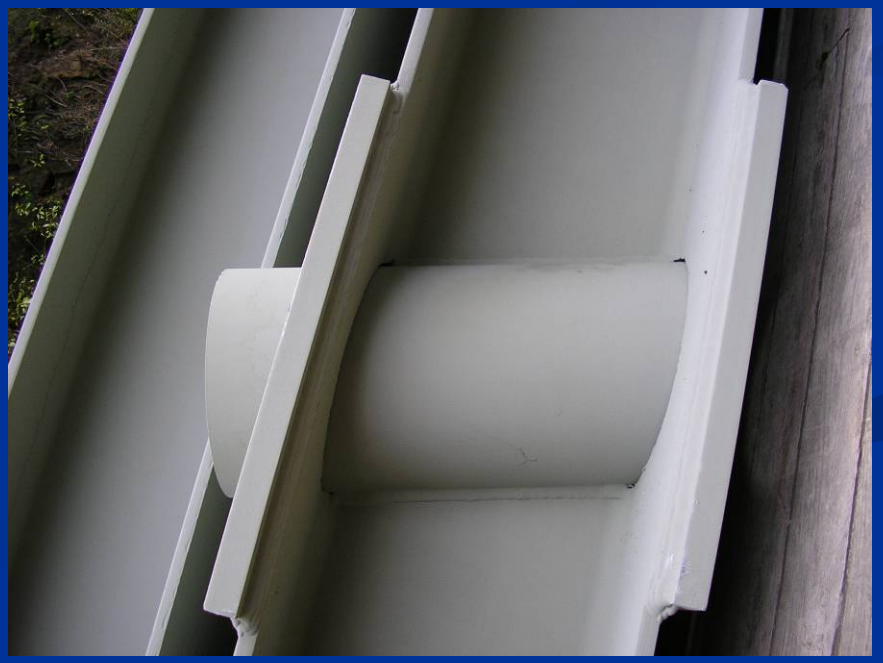

DEERE

Issues

- Soldier piles were supplied by WSDOT
- Construction method was incompatible with tolerances:
  - pile top location (15ft embed, 35ft cantilever)
  - wall alignment when lagging down and then back up; does Contractor meet PGA forces or wall alignment
  - outward deflection from backfill compaction process
- PGA performance testing was undesirable
- Voids behind lagging

Owner Supplied

- Fabrication process is on critical path – highly undesirable
- We had to accept deviations from standard fabrication quality to maintain contract timeline



Tolerances

- Pile top location tolerance changed to 6”
- Goal – construct backfill per plan and maintain wall alignment with expanded tolerance
  - PGA tensioned to less than design
  - PGAs tensioned 2+ times
  - Eliminate performance testing which unloads PGAs

Voids

- Overexcavation during removal of lean concrete around piles to install lagging
- Softer materials such as CDF, lean concrete reduces the removal effort and voids
- Tremie placed gravel at base of voids that chimneyed to surface

Lessons

- Avoid owner procurement of materials
- Revise tolerances and construction method for bottom-up soldier pile tieback walls
- Estimate outward deflection from fill compaction in bottom-up construction
- Prohibit overexcavation during lagging installation

Other Wall Issues

Open Excavation vs Shoring

- Require Geotechnical Engineer design for shoring – Geologist is not acceptable
- Design is critical case for temporary installations that may change – heavy rains…

Wall Deflection

- Rotation of wall alignment vertically can result in significant increase in concrete volume to get required thickness and wall face alignment
- This has added cost to several projects
- Include actual geometry of wall in design

Construction Loads

- Design for overburden loads at top of walls – temporary and permanent
- This requirement is included in WSDOT designs as a result of repeated requests and practical consideration of unknown conditions

Lagging Selection

- Allow Contractor selection of lagging
- Steel plates may be preferable where sloughing materials are present
- Recommend research to design alternate laging materials

Thank you