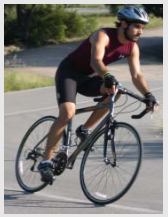
TEXAS DEPARTMENT OF TRANSPORTATION



COMMON PLAN ERRORS AND SELECTION OF TYPE OF RETAINING WALL AND RIPRAP

Dina Dewane, P.E.
TxDOT-BRG Division-Geotechnical Branch

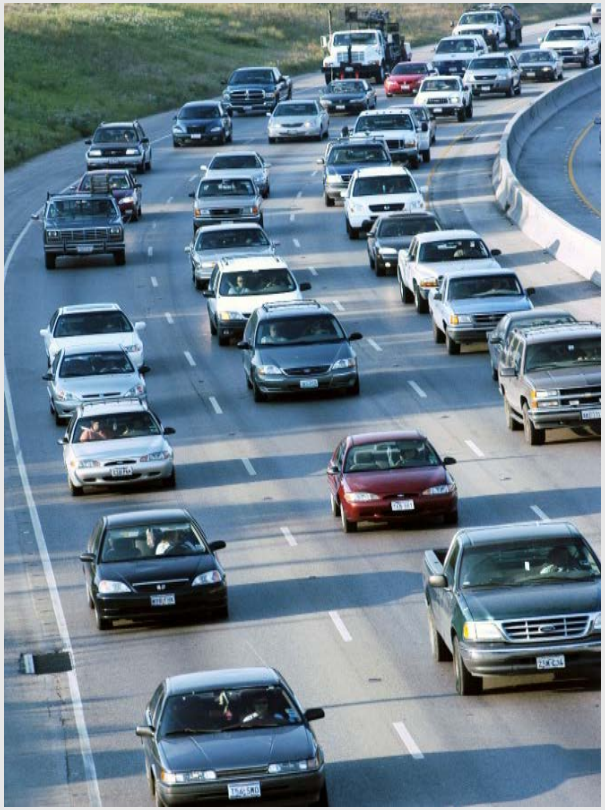


Table of contents

1	General Errors	3
2	Boreholes, General Notes	4-8
3	Typical Cross Sections, Temporary Special Shoring	9-11
4	Miscommunication/Misunderstanding of Information	12-14
5	TxDOT MSE Standard Sheets	15-17
6	Retaining Walls	18-24
7	Riprap	25-38

Common Plan Errors and Selection of RW and Riprap

General Errors

- *Missing sheets*
- *Some sheets are not signed*
- *Making reference to the wrong sheets*
- *Outdated information*
- *Location of boreholes are missing*
- *Project notes are confusing*
- *Typical cross sections are missing, misleading or misrepresenting*
- *Using the wrong standard sheet*
- *No indication of the modifications made to the standard sheets*
- *Sometimes temporary special shoring is not included in the plans when required. (therefore, its location, limits and estimated quantities are missing)*
- *Retaining wall layouts are missing key information (Top of wall el., bottom of wall el., location of inlets, culvert, utilities, etc.)*

Common Plan Errors and Selection of RW and Riprap

Boreholes

DRILLING LOG 2 of 3

Hole	B-2	District	
Structure	Bridge	Date	3/8/2018
Station		Grnd. Elev.	0.00 ft
Offset		GW Elev.	N/A

Strata Description	Triaxial Test		Properties				Additional Remarks
	Lateral Press. (psi)	Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	
stiff to hard, reddish d gray, shaley, with occasional ns (CL)							

- *Boreholes without station & offset information.*
- *Boreholes ground elevations are missing.*
- *Inconsistency of information between TCP values and soils density/consistency. (e.i. Clay with TCP=30 blows/12" is described as very stiff clay when in reality it is a stiff clay).*
- *The rock quality designation (RQD) and percent of recovery for rocks are missing.*
- *Existing As Built Plan boreholes used in the design are not included in the plans.*

Common Plan Errors and Selection of RW and Riprap

General Notes

8. REFER TO GEOTECHNICAL REPORT, SECTION 6.10, DRILLED SHAFT CONSTRUCTION RECOMMENDATIONS, RELATED TO CONSTRUCTION USING CASING, CLEANING OF DRILLED SHAFT HOLE PRIOR TO CONCRETE PLACEMENT, GROUND WATER, AND ALL OTHER ITEMS RELATED TO FOUNDATIONS CONSTRUCTION.

- *The geotechnical report is not a governing document and may not be available during construction.*

- *Report Recommendations*
  - *Are those recommendations consistent with TxDOT-Item 416?*
  - *What about the means and methods of Construction?*

- *Item 416 "Drilled Shaft Foundations" - Construction " Submit Drilled Shaft Installation plan for review no later than one month before drilled shaft construction" (experience, list of equipment, details of construction sequence, shaft excavation methods, method to clean the shaft excavation, details of reinforcement placement , etc.).*

Common Plan Errors and Selection of RW and Riprap

General Notes

(1) EMBANKMENT FOR THE RETAINING WALL REINFORCED ZONE IS TO BE TXDOT ITEM 423 TYPE "AS" WITH SOIL PARAMETERS AS SPECIFIED IN THE GEOTECHNICAL REPORT NO. 96155172 PROVIDED BY [redacted].

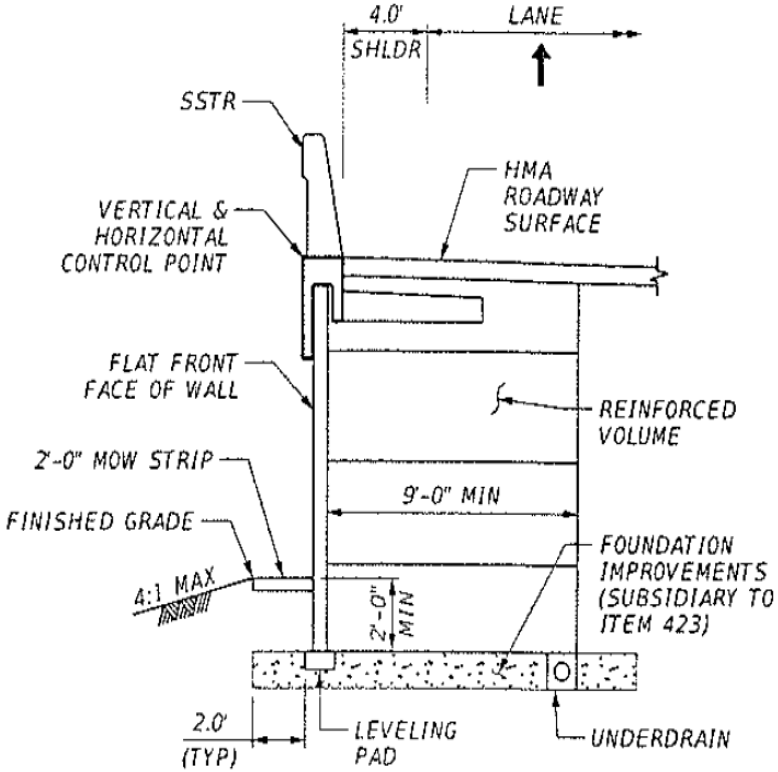
- *All the information has to be in the plans.*
- *The geotechnical report is not a governing document and may not be available during bidding and/or construction.*
- *Keep in mind that the contractual documents are the plans, Standard Specifications and Special Specifications (if any).*
- *In general key findings or conclusions are not included in the plans and may not be in agreement with TxDOT specifications. (i.e., foundation design, slope stability analysis, soil improvement, materials reports, etc.)*

Common Plan Errors and Selection of RW and Riprap

General Notes

3. SEE GEOTECHNICAL RECOMMENDATIONS AND DESIGN PARAMETERS INCLUDED IN THE GEOTECHNICAL ENGINEERING REPORT [redacted].

4. REFERENCE HORIZONTAL ALIGNMENT DATA SHEETS FOR CURVE INFORMATION



- *The design parameters for MSE walls should be included in the RW(MSE)DD sheet.*
- *The typical cross section indicates foundation improvements. The limits and specifications of the soil improvement were not included in the plans but they were referenced to the geotechnical report.*
- *Not all the information is included in the plans, which will cause confusion, delays, additional cost and change of orders.*

Common Plan Errors and Selection of RW and Riprap

General Notes

123 6001 RETAINING WALL (MSE).

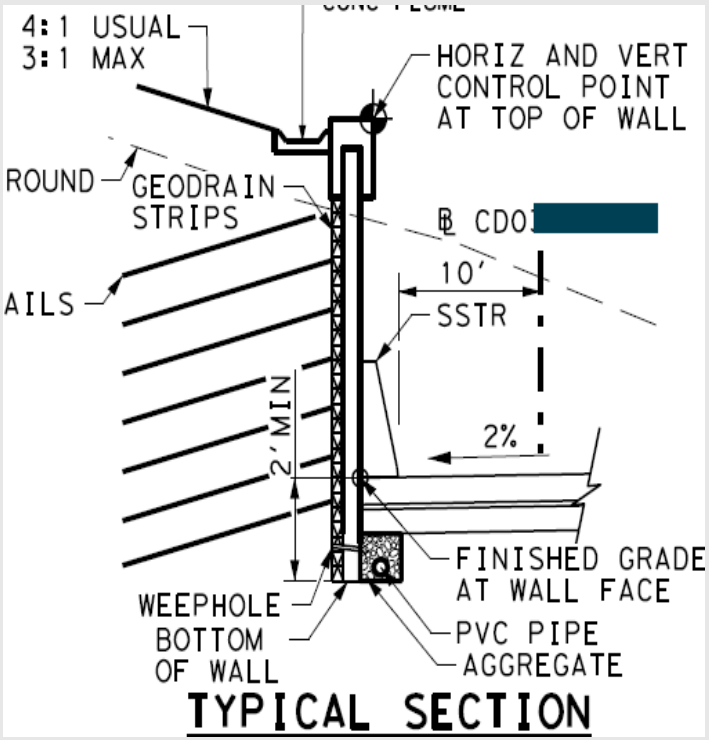
2. ON SITE INVESTIGATION OF SOILS TO CONFIRM PS&E SOIL DATA IS TO BE PERFORMED BEFORE ERECTION OF PERMANENT OR TEMPORARY WALLS.

- *The note is vague and very confusing.*
- *Site Investigations before construction to confirm soil data?*
- *What type of investigations?*
- *Who will pay for the investigations?*
- *Who will analyze the data?*
- *Who is responsible for the final design?*
- *Construction delays?*
- *Additional cost?*
- *Change of orders?*

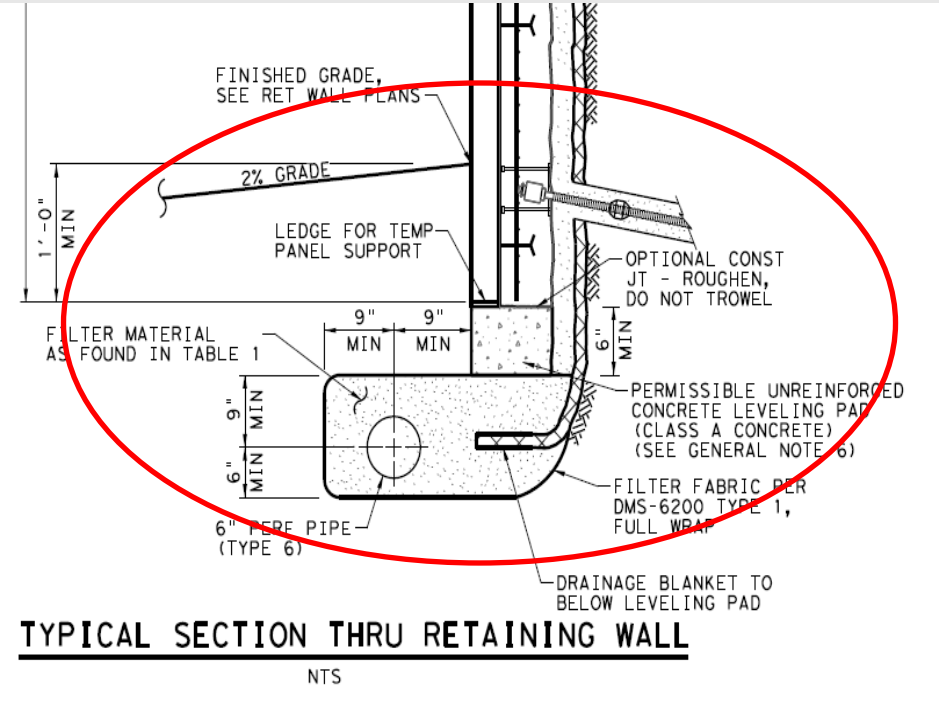
Common Plan Errors and Selection of RW and Riprap

Typical Cross sections

Drainage system: Drain strips, weepholes and underdrain. (RW Layout Sheet).

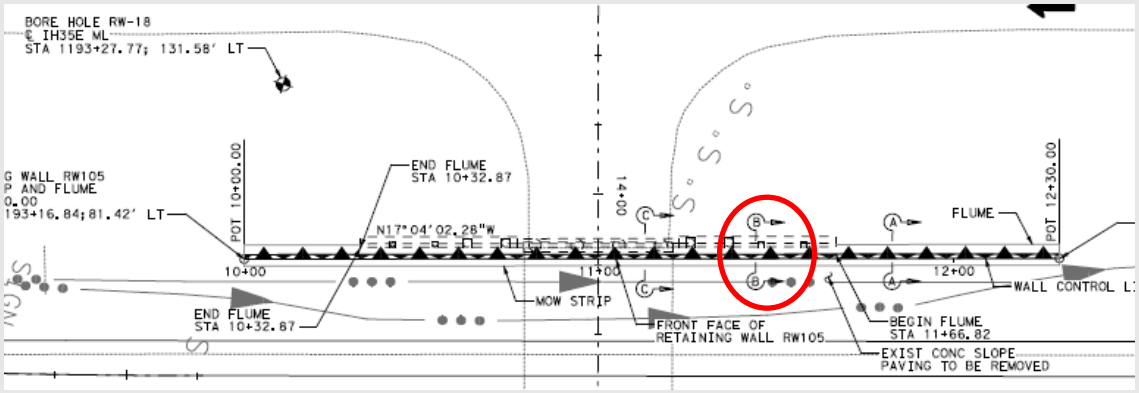


Drainage system: Drain strip and underdrain (RW-Detail Sheet) .

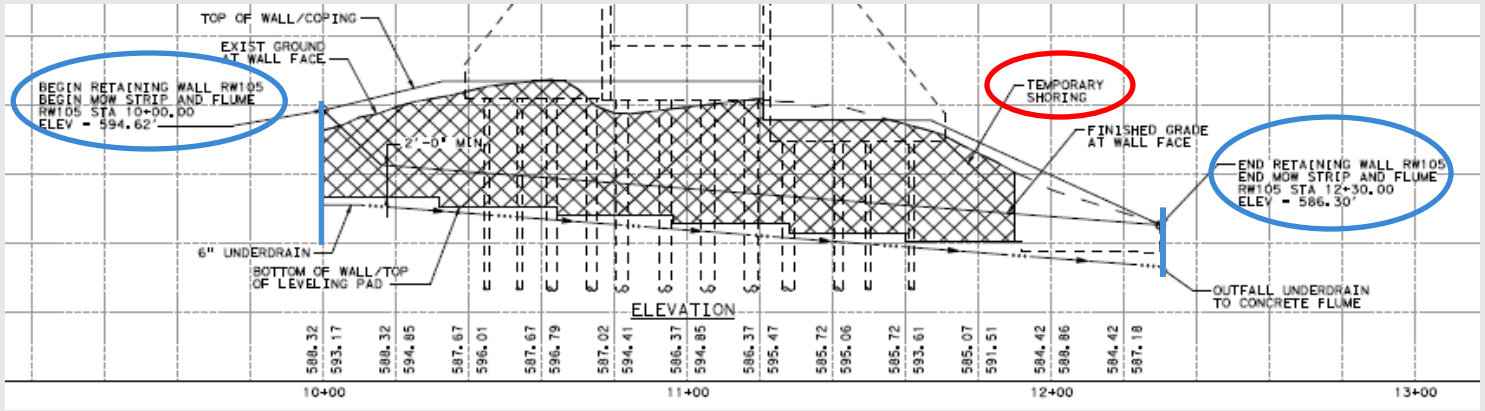


Common Plan Errors and Selection of RW and Riprap

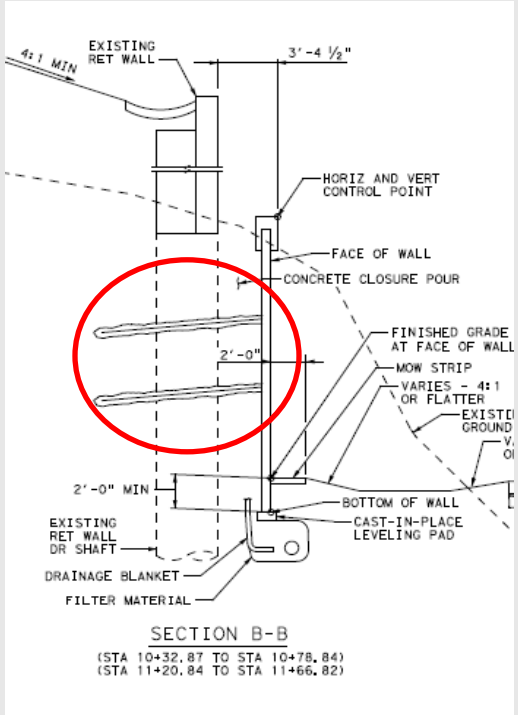
Temporary Special Shoring?



95% SUBMITTAL
PRELIMINARY: NOT INTENDED FOR PERMIT, BIDDING OR CONSTRUCTION.



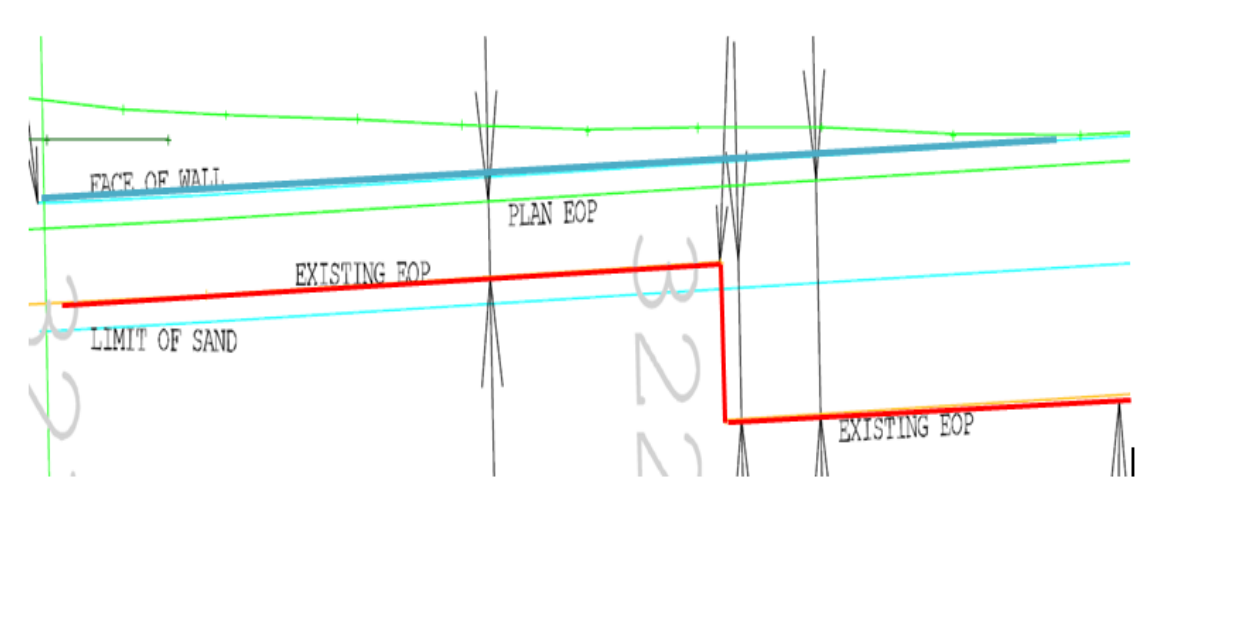
Common Plan Errors and Selection of RW and Riprap



- *This is a soil nail wall.*
- *Temporary special shoring is not required.*
- *The RW layout sheet is outdated.*

Common Plan Errors and Selection of RW and Riprap

Miscommunication

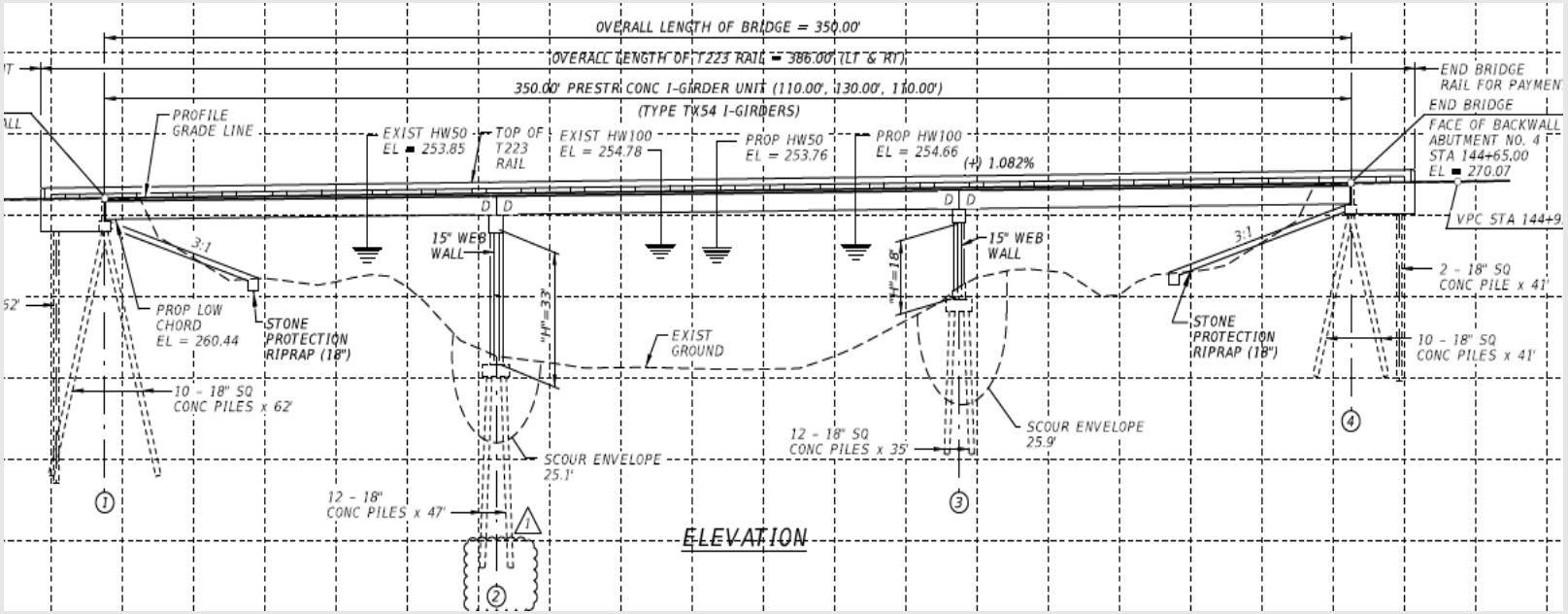


- *There was a miscommunication between engineers.*
- *There was limited space between face of wall and the existing edge of pavement for the wall reinforcements (MSE wall).*
- *The wall reinforcements were longer than the typical length of* 0.7H *due to the type of soil.*

- *Shifting the face of wall was a limited option.*
- *It generated a change of order.*

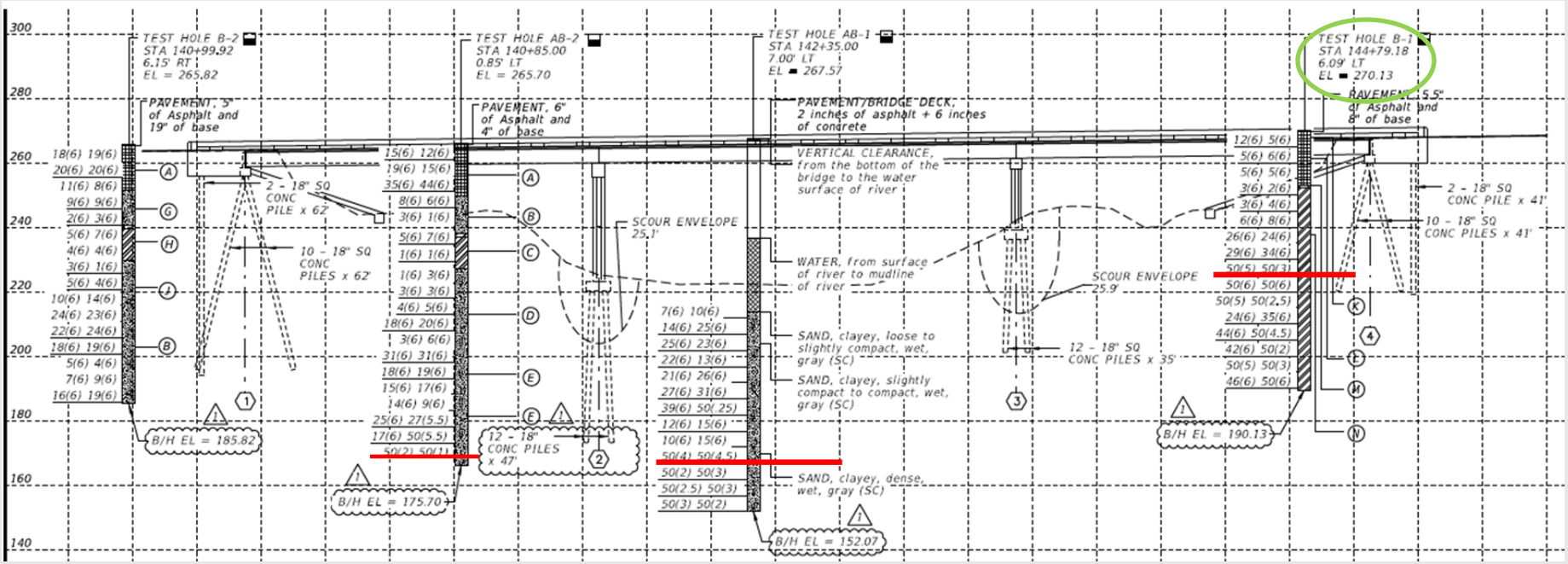
Common Plan Errors and Selection of RW and Riprap

Miscommunication



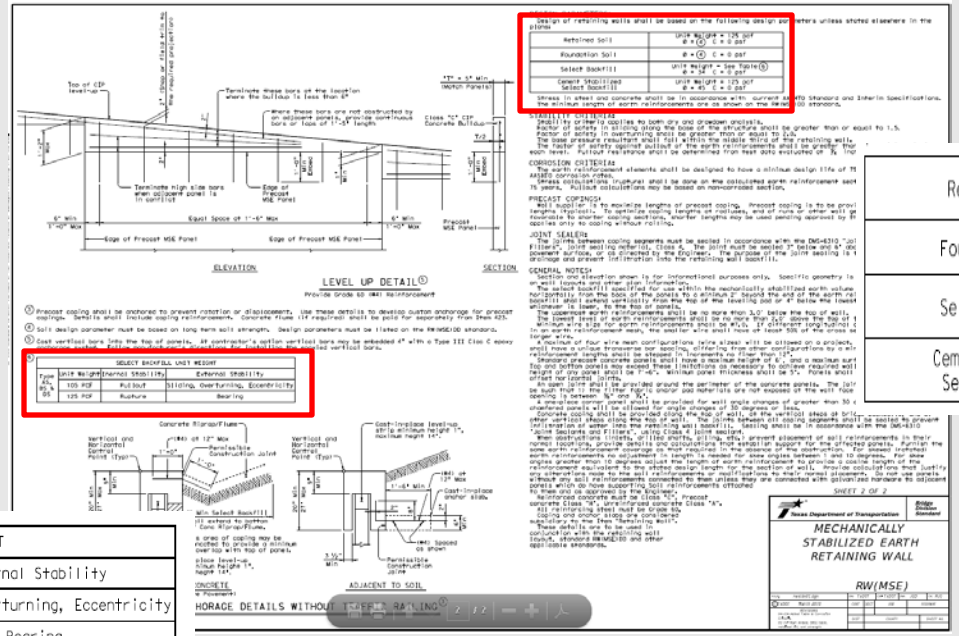
Common Plan Errors and Selection of RW and Riprap

Miscommunication & Misinterpretation



- *Miscommunication between hydrologist and foundation designer*
- *The foundation designer misinterpreted the scour and borehole information*
- *Bent 3 was designed based on borehole B-1 (on the right). The designer didn't consider that channel/rivers migrates.*
- *Piles of Bent 3 were extremely short.*
- *Change of order and additional cost.*

Common Plan Errors and Selection of RW and Riprap



Retained Soil	Unit Weight = 125 pcf Ø = 4 C = 0 psf
Foundation Soil	Ø = 4 C = 0 psf
Select Backfill	Unit Weight = See Table 6 Ø = 34 C = 0 psf
Cement Stabilized Select Backfill	Unit Weight = 125 pcf Ø = 45 C = 0 psf

SELECT BACKFILL UNIT WEIGHT			
Type AS, BS & DS	Unit Weight	Internal Stability	External Stability
	105 PCF	Pullout	Sliding, Overturning, Eccentricity
	125 PCF	Rupture	Bearing

The <u>design</u> parameters listed on the MSE Wall Standard sheet (RW(MSE)) were included for the following reasons:

1. *to represent the select fill or backfill materials typically used;*
2. *to conservatively represent the retained soil; and*
3. *to provide the properties to the MSE Wall vendors to obtain uniform bids.*

The properties listed are not absolute properties, but are representative of the various materials and yield conservative designs.

https://www.txdot.gov/business/resources/specifications/retaining-wall.html

Common Plan Errors and Selection of RW and Riprap

Why use representative values listed on the MSE Wall Standard sheet (RW(MSE)) for the properties instead of using the actual values?

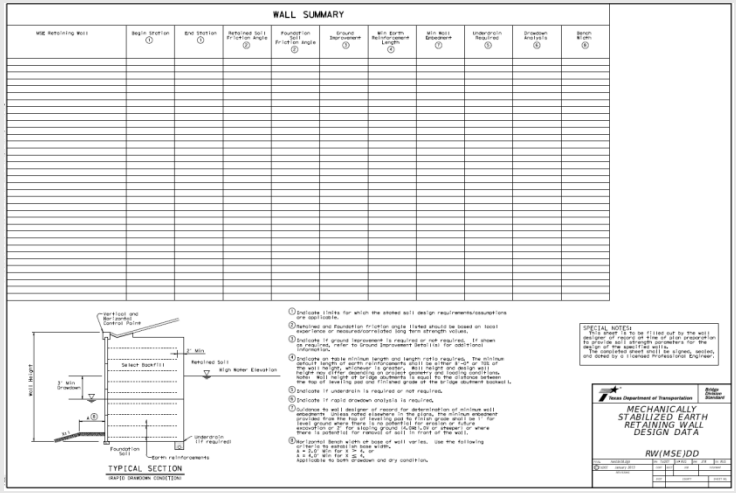
This is done to prevent having to test all of the various soil properties on the standard and to create a margin of safety due to the uncertainty in various properties throughout the construction of the wall.

TxDOT specification Item 423 – Retaining Walls does not list any testing method for either the unit weight or the friction angle of either the reinforced backfill, retained fill, or foundation soil.

TxDOT does not require testing of the design parameters listed on MSE Wall Standards.

The design parameters used for MSE Walls were selected to try to obtain conservative designs when they are used together.

Common Plan Errors and Selection of RW and Riprap



The biggest contributors to problems and failures of MSE Walls are the:

1. *friction angle of the foundation soil;*
2. *friction angle of the retained fill; and*
3. *global stability.*

All of ***<u>these are the responsibility of the designer</u>****.*

The friction angle of the foundation soil and retained fill both have to be selected and included on the Design Data sheet for MSE Walls (RW(MSE)DD) and are based on boring and/or on lab data. The Design Data sheet has to be signed/sealed by an Engineer.

The global stability analysis has to be performed by the designer to ensure the wall will be stable.

Common Plan Errors and Selection of RW and Riprap

Common Types of Retaining Walls

MSE

Concrete Block Wall

Spread Footing Wall

Gabions Wall

Drilled Shaft Wall

Soil Nail Wall

Tiedback Wall

Temporary Earth Wall

Hybrid Walls – MSE/Soil Nail

Common Plan Errors and Selection of RW and Riprap

General Requirements

Retaining walls are designed to withstand:

- *Lateral earth pressure*
- *Water pressure*
- *Effect of surcharge loads*
- *Self-weight of the wall*
- *Temperature and shrinkage effects*
- *Provide a lateral support with an efficient and cost effective system*

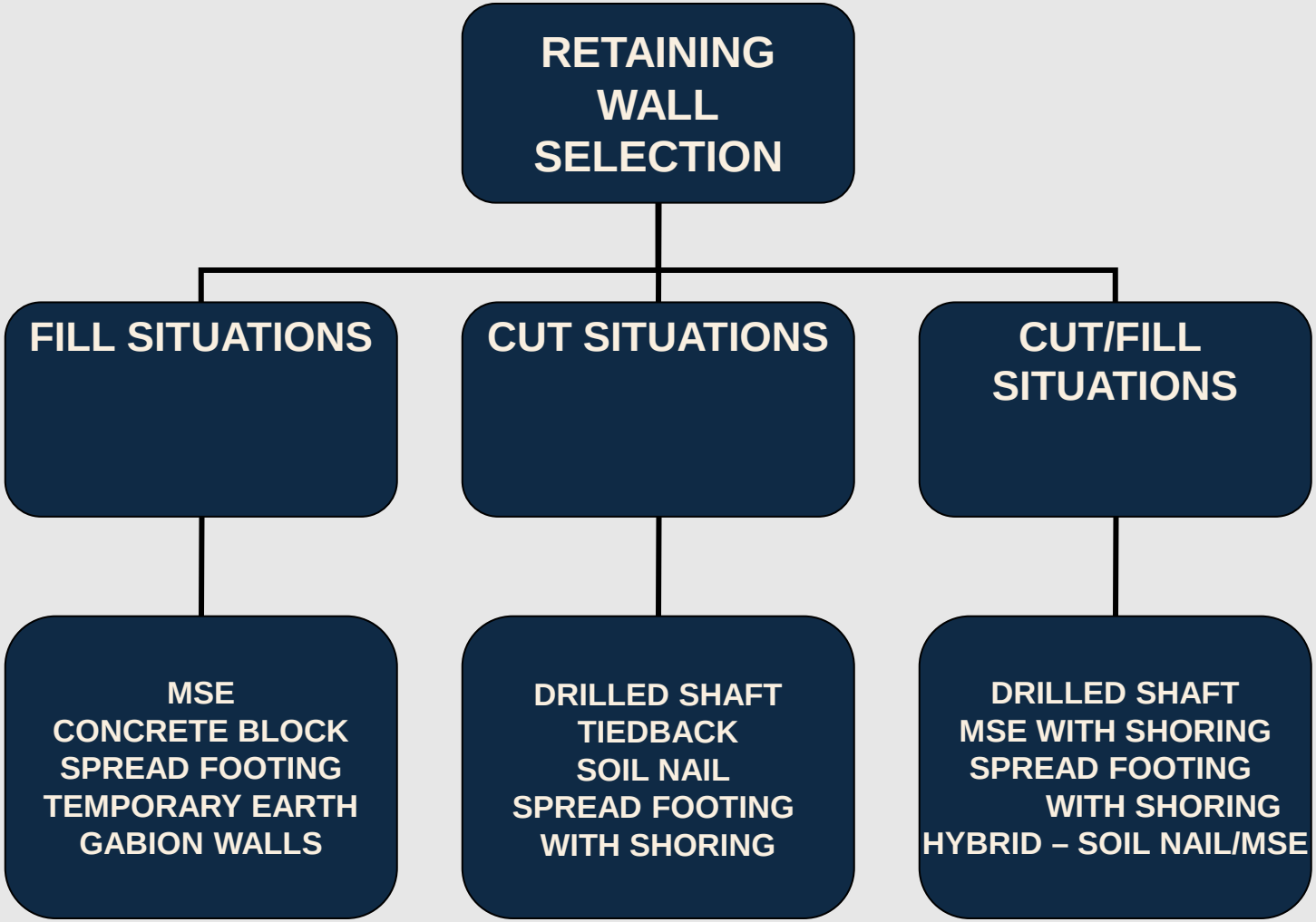
Common Plan Errors and Selection of RW and Riprap

WALL SELECTION CRITERIA

- *GEOMETRY.- ROW, existing roadway location, wall placement (fill walls, cut walls or cut/fill walls)*
- *STABILITY.- External, internal and global stability. External stability: sliding, overturning, eccentricity, bearing pressure. Internal stability: pullout and rupture for earth reinforcements (MSE, Block walls); Size of anchors for Tieback walls.*
- *CONSTRUCTABILITY .- Adequate horizontal and vertical clearance.*
- *ECONOMICS.– MSE: $21-$41/SF, Soil Nail Wall: $21-$30/SF Fascia plus soil nail anchor $13/LF. Availability of materials, ROW purchase, Traffic Control, etc.*
- *AESTHETICS TREATMENT.- Form liners, paint, stain, color concrete, sculpted gunite, wall geometry to accommodate landscape.*

Common Plan Errors and Selection of RW and Riprap

RETAINING WALL TYPES



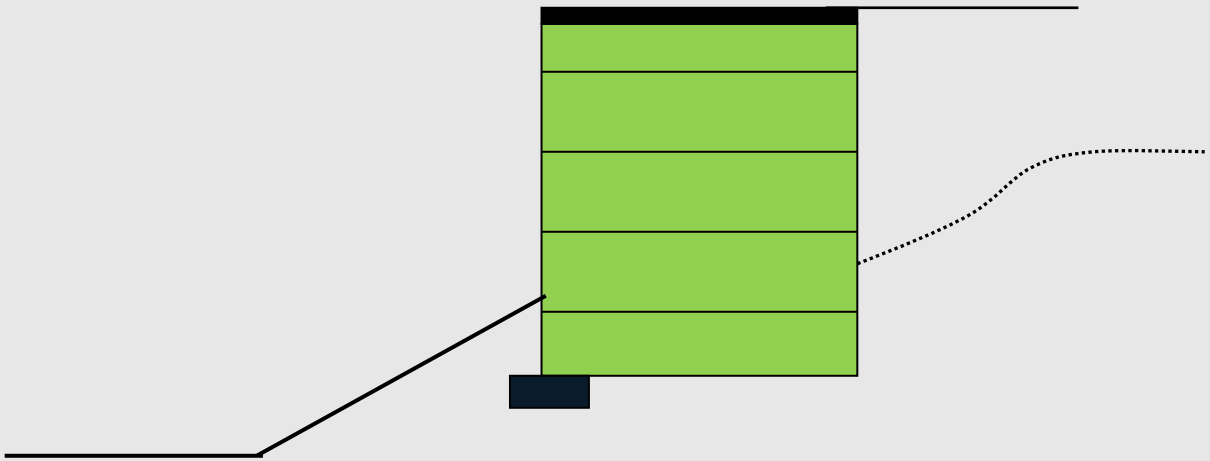
Common Plan Errors and Selection of RW and Riprap

Placement of Walls On Slopes: ***BEWARE***

Common Plan Errors and Selection of RW and Riprap

Common Plan Errors and Selection of RW and Riprap

FILL TYPE RETAINING WALLS ON SLOPES

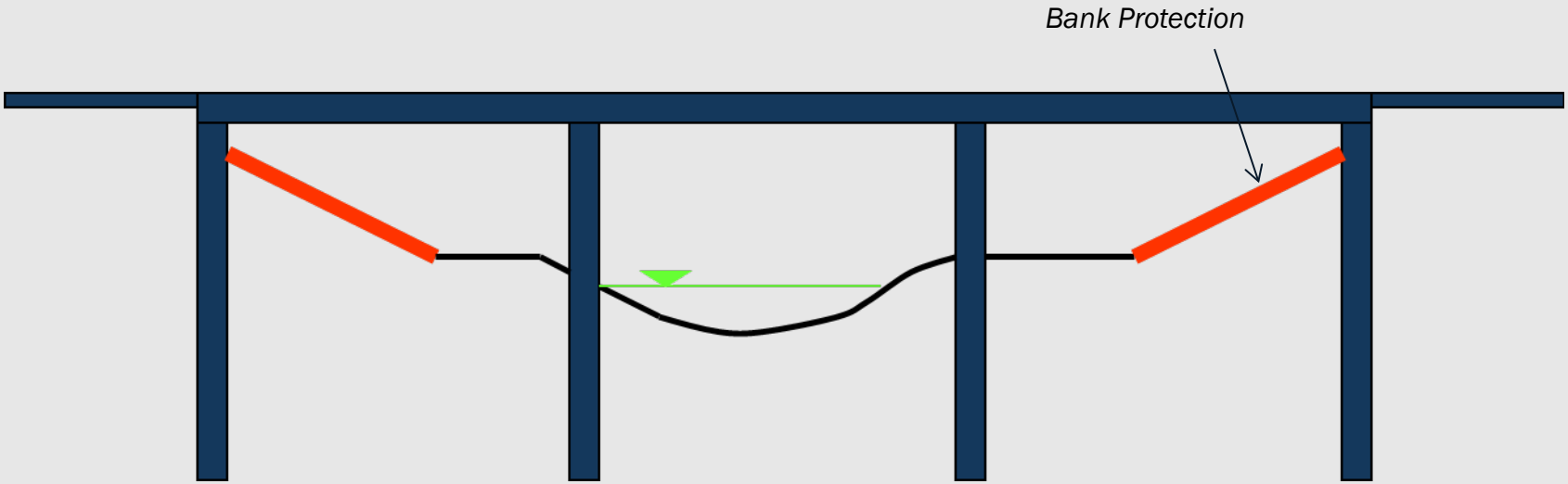


- Generally, do not place walls on slopes steeper than 4:1.
- In areas with poor soils, even 6:1 slopes may not be stable with the addition of a wall.
- Carefully evaluate placing a wall on a fill slope in order to minimize retaining wall square footage. May be false economy.

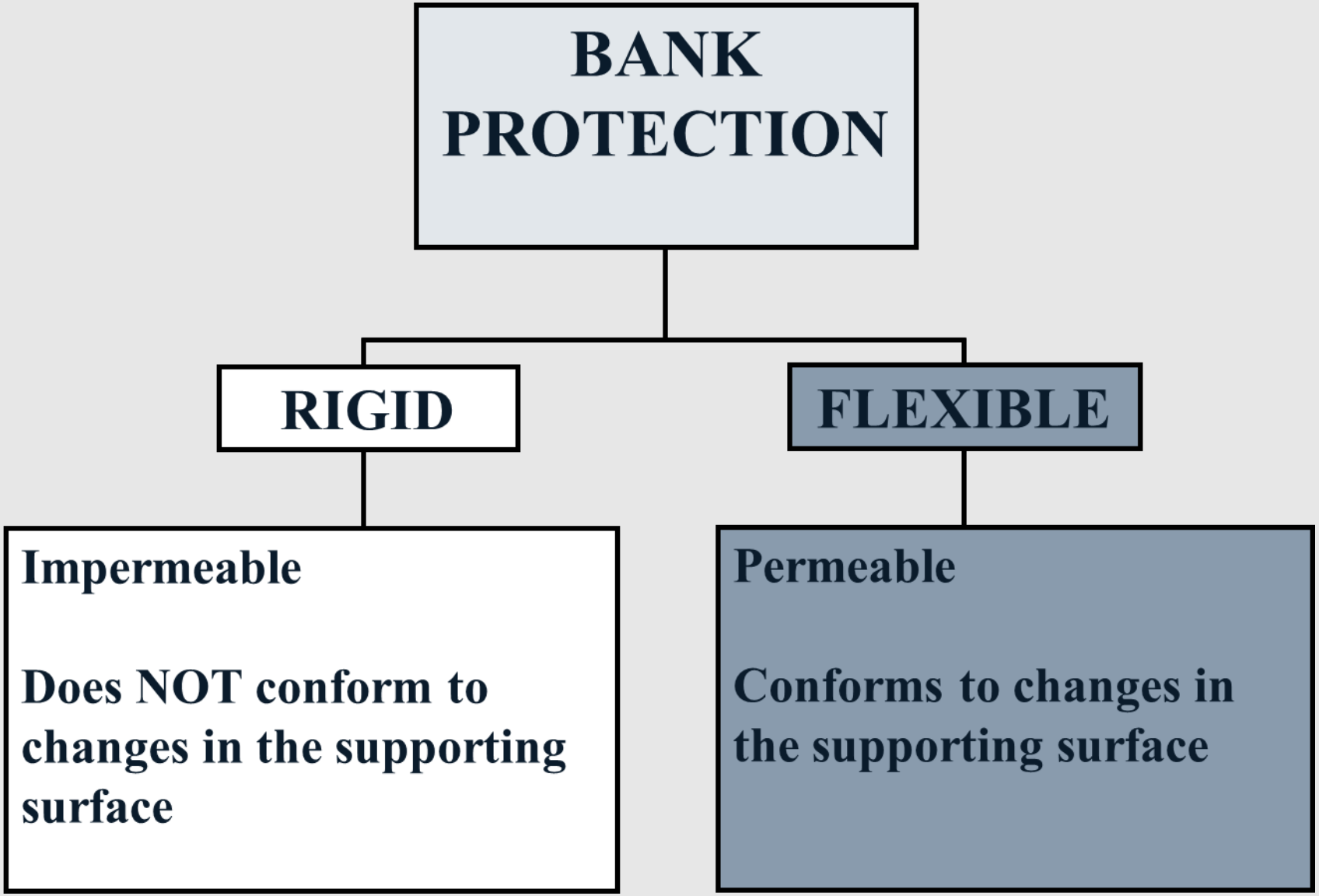
Common Plan Errors and Selection of RW and Riprap

RIPRAP

A material placed on the surface of a bank or an embankment to prevent erosion or scour



Common Plan Errors and Selection of RW and Riprap



Common Plan Errors and Selection of RW and Riprap

RIGID BANK PROTECTION

- ***CONCRETE RIPRAP***
- ***GROUTED STONE PROTECTION***

Concrete Riprap

Grouted Stone Protection: the voids between stones are filled with either concrete or grout. The technique attempts to create a roughened surface.

Common Plan Errors and Selection of RW and Riprap

Common Plan Errors and Selection of RW and Riprap

Common Plan Errors and Selection of RW and Riprap

RIGID BANK PROTECTION

ADVANTAGES

- Long history of use
- Impermeable if not compromised
- Resists impact damage
- TxDOT standard
- Contractor's familiarity
- No specialty equipment required

DISADVANTAGES

- Smooth surface
- Erosion at the perimeters
- Susceptible to undermining
- Susceptible to movement and cracking due to removal of underlying support
- Hydrostatic pressures can build up behind the protection
- Problems not always visible and are not easily repaired

Common Plan Errors and Selection of RW and Riprap

FLEXIBLE BANK PROTECTION

1. STONE PROTECTION RIPRAP
2. PARTIALLY GROUTED STONE PROTECTION RIPRAP
3. INTERLOCKING ARTICULATED CONCRETE BLOCKS
4. GABIONS
5. GABION MATTRESS
6. CONCRETE ARMOR UNITS

Common Plan Errors and Selection of RW and Riprap

STONE PROTECTION

PARTIALLY GROUTED STONE PROTECTION RIPRAP

INTERLOCKING ARTICULATED CONCRETE BLOCKS

GABIONS

GABION MATTRESS

CONCRETE ARMOR UNITS

Common Plan Errors and Selection of RW and Riprap

- *Erosion at the toe*
- *Rock slide down slope*

Common Plan Errors and Selection of RW and Riprap

Problems:

- *Undermined*
- *Settled*

FLEXIBLE BANK PROTECTION

ADVANTAGES

- Design is adaptable
- Construction is not complicated and does not require specialty equipment
- Has a natural appearance
- Failures are easily identified and can be fixed
- Easily inspected and repaired
- Rough surface
- Adjusts to distortions and local displacement of the foundation soil
- Movements can occur without complete failure and protection is still functional

DISADVANTAGES

- No standard – must be designed
- May be hard to obtain in some parts of Texas
- Near vertical gabions can be difficult to repair

Common Plan Errors and Selection of RW and Riprap

IN RIVER ENVIRONMENTS FLEXIBLE

BANK PROTECTION IS RECOMMENDED

CONCLUSIONS

- *Historically, rigid bank protection has been used.*
- *Rigid bank protection:*
  - *is impermeable;*
  - *is susceptible to undermining;*
  - *obscures the identification of problems;*
  - *when problems occur it is no longer functional in protecting the embankment;*
  - *problems are costly to repair and the repair options are limited.*

CONCLUSIONS

- Flexible bank protection is recommended for use in river environments, because:
  - It can be used in wide variety of conditions;
  - It is effective in preventing erosion/scour;
  - It is permeable;
  - It is flexible to adapt to ground movements;
  - It is easy to identify problems; and a failure occurs it is readily visible and can be easily repaired.

Common Plan Errors and Selection of RW and Riprap

QUESTIONS?

Common Plan Errors and Selection of RW and Riprap

Copyright 2019 • Texas Department of Transportation • All Rights Reserved

Entities or individuals that copy and present state agency information must identify the source of the content, including the date the content was copied. Entities or individuals that copy and present state agency information on their websites must accompany that information with a statement that neither the entity or individual nor the information, as it is presented on its website, is endorsed by the State of Texas or any state agency. To protect the intellectual property of state agencies, copied information must reflect the copyright, trademark, service mark, or other intellectual property rights of the state agency whose protected information is being used by the entity or individual. Entities or individuals may not copy, reproduce, distribute, publish, or transmit, in any way this content for commercial purposes. This presentation is distributed without profit and is being made available solely for educational purposes. The use of any copyrighted material included in this presentation is intended to be a "fair use" of such material as provided for in Title 17 U.S.C. Section 107 of the US Copyright Law.

Common Plan Errors and Selection of RW and Riprap

MANUALS FOR USE IN DESIGN OF FLEXIBLE BANK PROTECTION

- FHWA Hydraulic Engineering Circular 23 (HEC -23) – Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance

  (http://isddc.dot.gov/OLPFiles/FHWA/010592.pdf)

- NCHRP Report 587 – Countermeasures to Protect Bridge Abutments from Scour

  (http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_587.pdf)

- NCHRP Report 568 – Riprap Design Criteria, Recommended Specifications, and Quality Control

  (http://www.trb.org/news/blurb_detail.asp?id=7023)

Safety: Mission

ZERO

Safety Never Stops!