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

Dina Dewane, P.E.
TxDOT-BRG Division-Geotechnical Branch
<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General Errors</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Boreholes, General Notes</td>
<td>4-8</td>
</tr>
<tr>
<td>3</td>
<td>Typical Cross Sections, Temporary Special Shoring</td>
<td>9-11</td>
</tr>
<tr>
<td>4</td>
<td>Miscommunication/Misunderstanding of Information</td>
<td>12-14</td>
</tr>
<tr>
<td>5</td>
<td>TxDOT MSE Standard Sheets</td>
<td>15-17</td>
</tr>
<tr>
<td>6</td>
<td>Retaining Walls</td>
<td>18-24</td>
</tr>
<tr>
<td>7</td>
<td>Riprap</td>
<td>25-38</td>
</tr>
</tbody>
</table>
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• Outdated information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

- Boreholes without station & offset information.
- Boreholes ground elevations are missing.
- Inconsistency of information between TCP values and soils density/consistency. (e.g., 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.
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
  o Are those recommendations consistent with TxDOT-Item 416?
  o 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.).
General Notes

- 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.)
General Notes

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

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.
General Notes

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?
**Typical Cross sections**

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

Drainage system: Drain strip and underdrain (RW-Detail Sheet).
Temporary Special Shoring?
• This is a soil nail wall.
• Temporary special shoring is not required.
• The RW layout sheet is outdated.
**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
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.
The design 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
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.
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 these are the responsibility of the designer.

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 Wall
- Gabions Wall
- Tiedback Wall
- Concrete Block Wall
- Drilled Shaft Wall
- Temporary Earth Wall
- Spread Footing Wall
- Soil Nail Wall
- Hybrid Walls – MSE/Soil Nail
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
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

- **FILL SITUATIONS**
  - MSE
  - CONCRETE BLOCK
  - SPREAD FOOTING
  - TEMPORARY EARTH
  - GABION WALLS

- **CUT SITUATIONS**
  - DRILLED SHAFT
  - TIEDBACK
  - SOIL NAIL
  - SPREAD FOOTING
  - WITH SHORING

- **CUT/FILL SITUATIONS**
  - DRILLED SHAFT
  - MSE WITH SHORING
  - SPREAD FOOTING
  - WITH SHORING
  - HYBRID – SOIL NAIL/MSE
Placement of Walls On Slopes: **Beware**
Common Plan Errors and Selection of RW and Riprap
• 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.
**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

BANK PROTECTION

RIGID

Impermeable

Does NOT conform to changes in the supporting surface

FLEXIBLE

Permeable

Conforms to changes in the supporting surface
**RIGID BANK PROTECTION**

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

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
## 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
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
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
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.
QUESTIONS?
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.


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
Safety: Mission ZERO

Safety Never Stops!