MSE WALLS CASE STUDIES

by
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Geotechnical Branch
COMMON RETAINING WALL TYPES

**CONCRETE BLOCK**
- Gabions
- Tiedback

**MSE**
- Drilled Shaft
- Hybrid Walls – MSE/Soil Nail

**TEMPORARY EARTH**
- Soil Nail
- MSE with shoring
- Spread footing with shoring

**SPREAD FOOTING**
- MSE
- Concrete block
- Spread footing
- Temporary earth
- Gabion

**RETAINING WALL SELECTION**

**FILL SITUATIONS**
- MSE
- Concrete block
- Spread footing
- Temporary earth
- Gabion

**CUT SITUATIONS**
- Drilled shaft
- Tiedback
- Soil nail
- MSE with shoring
- Spread footing with shoring

**CUT/FILL SITUATIONS**
- Drilled shaft
- MSE with shoring
- Spread footing with shoring
- Hybrid – Soil Nail/MSE
# Wall Usage by TxDOT

(August 2010 through September 2011)

<table>
<thead>
<tr>
<th>Wall Type</th>
<th>Area (ft²)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE</td>
<td>3,196,417</td>
<td>72</td>
</tr>
<tr>
<td>Concrete block (no r/f)</td>
<td>47,791</td>
<td>1</td>
</tr>
<tr>
<td>Cantilever drilled shaft</td>
<td>72,286</td>
<td>2</td>
</tr>
<tr>
<td>Soil Nailed</td>
<td>146,793</td>
<td>3</td>
</tr>
<tr>
<td>Rock Nailed</td>
<td>197,216</td>
<td>5</td>
</tr>
<tr>
<td>Tied-back</td>
<td>161,827</td>
<td>4</td>
</tr>
<tr>
<td>Spread footing</td>
<td>505,019</td>
<td>12</td>
</tr>
<tr>
<td>Other</td>
<td>22,389</td>
<td>1</td>
</tr>
</tbody>
</table>
TxDOT has had relatively few problems.
MSE WALL ISSUES

• DESIGN
  - Global Stability
  - Strength Conditions
  - Presence of Water
  - Placement of Walls on Slopes

• CONSTRUCTION
  - Embankment/Backfill Placement
  - Foundation Soil Preparation
  - Obstructions
  - Damaged Reinforcements
  - Connections
  - Backfill Properties
DESIGN

- Global Stability
- Strength Conditions
- Presence of Water
- Placement of Walls on Slopes
GLOBAL STABILITY

Need to determine:
- geometry
- short term strength = undrained shear strength
- long term strength = drained shear strength
- water table
Design Parameters:

Design of retaining walls shall be based on the following design parameters unless stated elsewhere in the plans:

Random Backfill/Foundation

- unit weight = 125 pcf
- \( \Phi = 30^\circ \ C = 0 \) psf
IMPORTANCE OF ACCURATE STRENGTH PARAMETERS

• Active Earth Pressure

\[ K_a = \tan^2(45 - \Phi_r/2) \]

\[ \Phi_r = \text{Random Fill Friction Angle} \]

• Foundation Friction Angle

\[ \Phi_f = \text{Foundation Soil Friction Angle} \]

• Sliding and Overturning depend upon these values.
The presence of water and its effects are important.

Carefully evaluate placing a wall on a slope. May be false economy.

- Overall (global) stability and external stability (sliding, overturning, eccentricity) of every wall must be evaluated by the engineer who selects the wall (especially those on slopes).

- Short-term and Long-term conditions must be evaluated.

- Designers need to list in the plans the random fill and foundation soil strength parameters if they are different then those listed on the standard sheet.

The presence of water and its effects are important.
Carefully evaluate placing a wall on a slope.
May be false economy.
CONSTRUCTION
- Embankment/Backfill Placement
ITEM 423

Place the select and embankment backfill to the same elevation where possible, and operate the compaction equipment over the interface.

Do not complete the embankment prior to construction of the retaining wall.
ITEM 423

Prevent surface water or rainwater from damaging the retaining walls during construction.

Shape the backfill to prevent water from ponding or flowing on the backfill or against the wall face.

Remove and replace any portion of the retaining wall damaged or moved out of tolerance by erosion, sloughing, or saturation of the retaining wall or embankment backfill.
Item 423
Place drilled shafts and piling located within the MSE volume prior to construction of the wall.

How does one compact the backfill around the abutment?

How does one compact against the embankment soil?
• Inspectors need to follow and enforce the specifications.

• The behavior of the wall is highly dependent upon the construction process
Perform proof rolling on retaining wall foundation area to identify any loose, soft or unsuitable materials in accordance with Item 216.

Material not meeting a maximum rut depth of 1 in per pass of pneumatic tired roller should continue to be rolled or removed and replaced with suitable material.

Item 423
Compact the foundation with a smooth-wheel vibratory roller or other approved roller. Remove and replace unsuitable foundation soils.
POOR PREPARATION OF RETAINING WALL FOUNDATION SOILS LEAD TO SETTLEMENT OF THE WALL
CONSTRUCTION

- Obstructions
- Drilled Shafts
- Drainage Features
Wall Construction Issues

Drilled Shaft Obstructions

Need a minimum of 3’ from back of wall to face of abutment cap to facilitate wall construction.
DETAIL A
SOIL REINFORCEMENTS AT VERTICAL OBSTRUCTION

IF LONGITUDINAL WIRES NEED TO BE BENT AROUND OBSTRUCTION, FIELD CUT ALL TRANSVERSE WIRES AND PAINT WITH ZINC RICH PAINT (TYP.)

PLACE SOIL REINFORCEMENTS AROUND OBSTRUCTION. BEND ALL LONGITUDINAL WIRES AT EACH LEVEL.

FRONT FACE OF RETAINING WALL

SOIL REINFORCEMENT WELDED WIRE MESH (TYP.)

FRONT FACE OF STRENGTHENED SOIL WALL

PROVIDE GENTLE CURVE TRANSITION FOR MESH; SHARP KINKS ARE NOT ALLOWED. (TYP.)
Incomplete connection with locking rod.

Soil reinforcing mat is rotated by wedging to the back of panel. This prevents bearing of the grid to the locking rod allowing potential of movement on the right side of the panel.
Earth reinforcement is cut and splayed.
Transverse wires have been completely removed from the longitudinal wires in the splayed zone.
This renders the earth reinforcement ineffective in pull out.
Obstructions - Drainage
Omitted Reinforcement = Panel Movement >> Unstable Wall

Differential Movement in Backfill = Pipe Separation >> Unstable Wall
Vertical Stand Pipe
Won’t the pipe under the leveling pad separate?

NO
Details for obstructions need to be:
- consistent with the design in regions without obstructions
- clear and should be easily constructed
TxDOT developed a shallow inlet standard 1’-10” in depth.
• When inlets have to be placed behind the wall, TxDOT uses the “vertical stand pipe” option and the new shallow inlet standard.

• Details for obstructions need to be:
  - consistent with the design in regions without obstructions
  - clear and should be easily constructed

• Inspection is critical to ensuring the obstruction detail is properly executed in the field.
CONSTRUCTION
- Damaged Reinforcements
• Inspectors need to inspect the reinforcements for potential damage

• Damaged reinforcements need to be rejected and removed from the job
CONSTRUCTION

- Connections
DETAIL AT CONNECTOR

- 3/8" DIA. TIE BAR
- LONGITUDINAL WIRE
- TRANSVERSE WIRES
- MINIMUM CLEARANCE

PLAN

- CONNECTOR (W7)
- FRACTURED FIN

ELEVATION

- 3/8" DIA. TIE BAR
- LONGITUDINAL WIRE IN REINFORCING MESH
- TRANSVERSE WIRES

- BACK FACE
- FRONT FACE
- CONNECTOR (W7)
- FRACTURED FIN
- PRECAST RECTANGULAR PANEL

- 5 1/2"
- 4"
- 1 1/2"
- 3/4" (MAX.)
• Inspectors need to be on the lookout for damaged connectors and to make sure the reinforcements are properly connected to the panels

TxDOT instituted the following:

Panels should be rejected if:

- 25% of the total panel anchorage are damaged
- Connectors are bent more than 30 degrees from perpendicular to the panel

Galvanization on a straightened connector should be restored to yield a 75 year design life
MSE WALL ISSUES

• MATERIAL
  - Backfill Properties
### 2004 Backfill Specifications

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SIEVE SIZE</th>
<th>PERCENT PASSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3 in.</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>½ in.</td>
<td>0 – 50</td>
</tr>
<tr>
<td></td>
<td>No. 40</td>
<td>0 – 15</td>
</tr>
<tr>
<td>B</td>
<td>3 in.</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>No. 40</td>
<td>0 – 60</td>
</tr>
<tr>
<td></td>
<td>No. 200</td>
<td>0 – 15</td>
</tr>
<tr>
<td>C</td>
<td>3 in.</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>No. 200</td>
<td>0 – 30</td>
</tr>
<tr>
<td>D</td>
<td>3 in.</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>3/8 in.</td>
<td>0 - 15</td>
</tr>
</tbody>
</table>

For Types A, B, and C if ≥ 15% passes a No. 4 sieve the backfill is considered to be rock backfill.

- Resistivity > 3000 ohms-cm
- Chloride <100 ppm
- pH from 5 to 10
- Sulfate <200 ppm
Rock Backfill
Type A or D
Type B Backfill
Type ????
Backfill
MSE Backfill Selection and Testing

<table>
<thead>
<tr>
<th>MATERIAL OR PRODUCT</th>
<th>TEST FOR</th>
<th>TEST NUMBER</th>
<th>LOCATION OR TIME OF SAMPLING</th>
<th>FREQUENCY OF SAMPLING</th>
<th>LOCATION OR TIME OF SAMPLING</th>
<th>FREQUENCY OF SAMPLING</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMBANKMENT (Retaining Wall Select Backfill)</td>
<td>In-Place Density (J)</td>
<td>Tex-115-E</td>
<td>As designated by the Engineer</td>
<td>One per backfill lift (K)</td>
<td></td>
<td></td>
<td>Tex-115E or other approved method</td>
</tr>
<tr>
<td>Gradation</td>
<td>Tex-110-E</td>
<td>At source, stockpile, or in place (2)</td>
<td>Each 4,000 CY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistivity (L)</td>
<td>Tex-129-E</td>
<td>At source, stockpile, or in place (2)</td>
<td>Each 4,000 CY</td>
<td></td>
<td></td>
<td></td>
<td>(O) Engineer will select any one of these three locations or any combinations thereof with the proviso that at least one of 10 samples will be taken in place.</td>
</tr>
<tr>
<td>pH</td>
<td>Tex-130-E</td>
<td>At source, stockpile, or in place (2)</td>
<td>Each 4,000 CY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(J) Place rock backfill or material that the engineer determines too coarse for density testing by the “ordinary compaction” method of Item 132, “Embankment.”

(K) For walls greater than 500 ft in length, one test per lift per 500 ft.

(L) For material with resistivity between 1,500 and 3,000 ohm-cm, perform Test Method Tex-620J to determine chloride and sulphate content.

Backfill should be tested prior to construction and then tested using the above schedule, unless the backfill changes and then it should be tested again to make sure it meets the specifications.
Improper backfill causes potential for:
- reduced pullout
- water pressure buildup
- wall failure
Gradation of the backfill significantly affects the performance of MSE walls.

Backfill should be tested from an onsite stockpile and should use a wet sieve method to determine percentage of fines.

Backfill should not break down under compaction or in the presence of water.

Backfills with significant fine material:

- have lower drained shear strength
- larger lateral earth pressures
- retains water and allows pore pressures to build up
- can undergo large settlements.
CONCLUSIONS

• TxDOT has used MSE Walls since the 80’s and they are the most utilized wall type.

• In spite of the high use of MSE Walls, TxDOT has had relatively few issues with them.

• The issues found can be categorized into two different types: design, and construction/inspection.

• TxDOT has reviewed and analyzed all the issues to better understand why they occurred and what caused them.

• The lessons learned from the issues observed have helped TxDOT to formulate corrective actions (workshops, presentations, updated specifications, etc.) to help prevent future problems.

• Treat the construction of the walls as a structure (bridge) not as an embankment
QUESTIONS?