Construction Inspection of MSE Walls

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Manager, Office of Geotechnical Services, INDOT

101st Purdue Road School
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INDOT Mission:
- INDOT will plan, build, maintain and operate a superior transportation system enhancing safety, mobility and economic growth

INDOT Values:
- Respect
- Teamwork
- Accountability
- Excellence
INDOT Profile

- Six district offices
- 3,536 employees
- $1 billion/annual capital expenditures
- 28,400 total roadway lane miles
- 5,300 INDOT-owned bridges
- Assists 42 railroads in planning & development of more than 3,880 miles of active rail lines
- Supports 69 Indiana State Aviation System Plan airports
Mission statement:

The primary mission of the Office of Geotechnical Engineering Services is to deliver our customers the most accurate and cost-effective Geotechnical recommendations for the design and construction of Hoosier highways and bridges, in a timely manner.
Overview

- MSE Wall?
- Preconstruction Review
- Materials Inspection
- Construction Control
- Field Inspection Checklist
- Specification Changes
- Future Modifications
- Typical MSE Wall Problems
- Questions
MSE Walls

Term “MSE” : Mechanically Stabilized Earth

Types of MSE walls:

- Modular block wall: Typical extensible reinforcement
- Precast concrete panel type of wall: Uses both extensible or inextensible reinforcement

Note: Current Indiana specification only allows inextensible reinforcement with precast concrete panel type of MSE wall.
MSE Wall
MSE Wall
MSE Wall

Indiana Toll Road Improvement in Gary
INDOT Approved MSE Wall Systems

- Reinforced Earth Company
- Sanders
- Sine Wall
- Tricon
Preconstruction Review

- The plans and specifications
- The site conditions relevant to construction requirements
- Review of Geotechnical Report
- Material requirements
- Construction Sequences for the specific reinforcement system
- Shop Drawing Submittal & Approval
Shop Drawing
Shop Drawing
Materials Inspection

Prefabricated

- Precast Concrete Elements
- Reinforcing Elements

Other Materials

- Facing Joint Materials
- Reinforced backfill
- Retained backfill
Improper Panel Storage
Proper Panel Storage
Improper Storage of Reinforcement
Proper Storage of Reinforcement
Joint Material
Backfill material

- Type 3 structure backfill within reinforced backfill zone excluding # 30 sand meeting INDOT specs including uniformity coefficient of 4 and greater
- Unit weight shall not be less than 120 pcf unless light weight is specified
- Internal friction angle ($\phi$) of 34 degree for structure backfill within reinforced backfill zone
- “B” Borrow or structure backfill within retained backfill zone with Internal friction angle ($\phi$) of 30 degree
Construction Control

- Site Preparation
- Leveling Pad
- Erection of Facing Elements
- Reinforced Fill Placement and Compaction
- Placement of Reinforcing Elements
Site Preparation

- Cut to grade
- Remove unsuitable material as specified
- Proof roll the entire footprint area of MSE wall to delineate any loose and/or unsuitable materials
- Compact any loose material and remove and replace any unsuitable material
- Perform DCP tests for verification
Excavation to Grade
Excavation to Grade
### Factored Bearing Resistance Based on DCP Blow Counts

<table>
<thead>
<tr>
<th>DCP Blows for 12 inches</th>
<th>Factored Bearing Resistance (psf)</th>
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<tbody>
<tr>
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<td>10,691.00</td>
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<tr>
<td>31</td>
<td>11,025.00</td>
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</table>

**Note:** This table is applicable only for fine grained soils. For sand & gravel, please contact Office of Geotechnical Services.
Leveling Pad

- **Excavate**: for leveling pad
- **Pour**: unreinforced concrete leveling pad as specified
- **Curing time**: at least 12 hrs before placing Panels
- **Vertical tolerance**: 3mm to design elevation
- **Improperly Placed Leveling Pad**: may result in panel misalignment, cracking, and spalling
Leveling Pad
Leveling Pads at Panel Step-up

LEVELING PADS AT PANEL STEP-UP

(6”-12”) 1.23’ or 2.46’
Erection of Facing Elements

- Always begin adjacent to any existing structure and proceed toward the open end of the wall.
- Horizontal joint material or wooden shims should not be permitted between the first course of panels and the leveling pad except for panel battering.
- Vertical Backward Batter should not be more than 0.05 inch/foot of wall height.
Erection of Facing Elements

- Use panel spacing bars for horizontal spacing between panels.
- First row of panels must be continuously braced until several layers of reinforcements and backfill have been placed.
- Adjacent panels should be clamped together to prevent individual panel displacement.
- Since variety of panel types used on a project, facing element types must be checked to verify the installation exactly as shown on the plans.
Erection of Facing Elements

Note: Numbers in squares show order of placement

Direction of construction

Panel being placed

USE OF 3/4” SPACER BLOCK TO SET PANEL SPACING
Erection of Facing Elements

Bearing Blok horizontal-joint material

1'-6" Typical

Filter cloth

(Not to scale - joint spacing expanded for illustration)

JOINT MATERIAL
Erection of Facing Elements
Reinforced Fill Placement & Compaction

- **Mark** your 6” compacted lift on the back side of the wall panels
- **Place backfill** parallel to the wall and starting approximately 3 feet from the back of wall panel
- **Level** the fill by machinery moving parallel to the wall, windrowing toward the reinforcement ends
- **Lock** the reinforcement and the panels in position
- **Place the backfill** not exceeding 5 “ in loose thickness within 3 feet behind the wall by windrowing after locking the reinforcement
Reinforced Fill Placement & Compaction

- **Compacting lift** not exceeding 5 “ in loose thickness with a minimum of 5 passes using vibratory roller or plate weighing less than 1000 pounds

- **Except** for the initial layer the fill must be brought up uniformly for the whole layer

- **Soil layers** should be compacted up to or even slightly above the elevation of each level of reinforcement connections prior to placing that layer of reinforcement elements
Reinforced Fill Placement & Compaction

12” - 36”

Do not backfill against panel until connecting first layer of strips and backfilling over them.

FIRST COURSE OF BACKFILL
**Reinforced Fill Placement & Compaction**

- **Roll the compactor parallel to the wall face.**
  - **Compaction equipment:**
    - 0 – 3', 1000 lbs or less
    - 3 – 10', 8 tons or less
    - >10', not restricted

- **Start compacting 3' from the wall panel and work toward the reinforcement ends.**

- **Compact the remaining 3' after the rest of the backfill has been compacted.**
Lift Thickness Marking on Facing Panel
Backfill Measurement Solution Template
Reinforced Fill Placement & Compaction
Sheepfoot Rollers Not Allowed

Reinforced Fill Placement & Compaction
Reinforced Fill Placement & Compaction
Placement of Reinforcing Elements

Note: Scoop out only enough backfill to make connection.

REINFORCING STRIP CONNECTION
TO FACING
Improper bolting at connections
Placement of Reinforcing Elements

Reinforcing Strip Connection to Facing
Placement of Reinforcing Elements

- Straps not installed perpendicular to wall
- Bent straps
Placement of Reinforcing Elements

Getting Around Obstructions
Placement of Reinforcing Elements

Broken connections with new brackets
Improper Fabric Installation

- Not providing full coverage of joint
Backfill Leakage
The following is a general checklist to follow when constructing a Mechanically Stabilized Earth wall (MSE wall). The answer to each of these should be yes unless plans, specifications or specific approval has been given otherwise.

<table>
<thead>
<tr>
<th>YES</th>
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Check List

YES  NO

5. □ □ Have the shop drawings been approved?
6. □ □ Has the geotechnical report been checked for undercutting?
7. □ □ Did the contractor receive the correct panels (shape, size and soil reinforcement connection layout) per the approved shop drawings?
8. □ □ Did the contractor receive the correct reinforcement (proper length and size)?
9. □ □ Have the panels and the reinforcement been Inspected for damage as outlined in the Specs?
Check List

YES NO

10. □ □ If any panels or soil reinforcement were found damaged have they been rejected or repaired in accordance with the specifications?

11. □ □ Are the panels and the soil reinforcement properly stored to prevent damage?

12. □ □ Has the MSE wall area been excavated to the proper elevation?

13. □ □ Has the area been proof rolled (a minimum of five passes by a roller weighing a minimum of 8 tons)?

14. □ □ Has all soft or unsuitable materials been compacted or removed and replaced?
<table>
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<tr>
<th></th>
<th>YES</th>
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22. Yes No Is the filter fabric stored properly away from sunlight and protected from UV radiation?

23. Yes No Is the contractor using correct panels (size, shape & # of connections) for that panel’s wall location & elevation?

24. Yes No Is fill being placed and compacted in 6 inch lifts?

25. Yes No Is the equipments are kept off the reinforcement until a minimum of 6 inches of fill is placed?

26. Yes No Are the lifts being placed by the proper method and sequence?

27. Yes No Is the fill being compacted by the correct equipment and in the correct pattern?
<table>
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<th>Check List</th>
<th>YES</th>
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<tbody>
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<td>28. Is the proper compaction being met within 3 feet of wall and greater than 3 feet from the wall based on DCP criteria?</td>
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<tr>
<td>29. Is the fill being brought up to or slightly above the soil reinforcement elevation before the reinforcement are connected?</td>
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<tr>
<td>30. Is the reinforcement being properly connected?</td>
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<tr>
<td>31. Is the soil reinforcement in the proper alignment?</td>
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<td>32. Is the vertical and horizontal alignments are checked periodically and adjusted as needed?</td>
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<tr>
<td>33. Is the contractor removing the wooden wedges as per specification?</td>
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</table>
34. □ □ At the end of each day’s operation is the contractor shaping the last level of backfill to permit a positive drainage away from the wall such as temporary pipe etc.?

35. □ □ Has the contractor backfilled the front of the wall?

36. □ □ Is the correct coping being installed?
Specification Changes

- **Design:**
  - **Contractor:** Responsible for Internal & External stability of the wall
  - **Engineer:** Responsible for Global stability
  - **Design Method:** AASHTO LRFD Bridge Design Specification

- **Material:** Unit weight of structure backfill should at least 120pcf with uniformity coefficient of 4 or greater, design values for foundation soil should be as per the Geotechnical report
Specification Changes

- **Construction Requirements:**
  - **731.07(a) General:** Changed to no more subsection
  - **731.07(b) Leveling Pad Foundation:**
    Change to no more subsection
    Proofrolling shall be performed under the entire reinforced backfill zone
    Perform verification with DCP for every 500 sq ft instead of 50 ft of linear MSE wall Plus 5 DCP measurements for each end bent
DCP Tests for Foundation Requirement
The frequency of DCP measurements is:

1 DCP test for every 500 sq ft
Or
5 DCP tests per end bent

Unsuitable areas shall be removed, replaced, and compacted in accordance with 203 and 211.
Specification Changes

- **The Use of Geotextile:**

  **Section 731.11:** If contractor elect to use open graded material such as No. 5, 8, 9, or 11 aggregate in reinforced backfill zone, geotextile shall be used at the interface between the reinforced and retained backfill zones or adjacent soil.

  **Section 731.12:** Geotextile in conjunction with MSE wall construction will not be measured for payment.

  **Section 731.13:** The cost of Geotextile used in MSE wall construction shall be included in the cost of pay items in this section.
Future Modifications

- Finalize Bearing Capacity verification Chart/Table
- A check List for construction Inspection
- Possible inclusion of Time lapse Cameras
- Any other changes as needed
Typical MSE Wall Problems
Typical MSE Wall Problems

Backfill Leakage
Typical MSE Wall Problems

Bulging Panels
Typical MSE Wall Problems
Typical MSE Wall Problems
Typical MSE Wall Problems

Cracked Panels
Typical MSE Wall Problems
Typical MSE Wall Problems

Variation in Joint Width / Gaps
Typical MSE Wall Problems
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Typical MSE Wall Problems
Construction Video of MSE Wall

Questions?