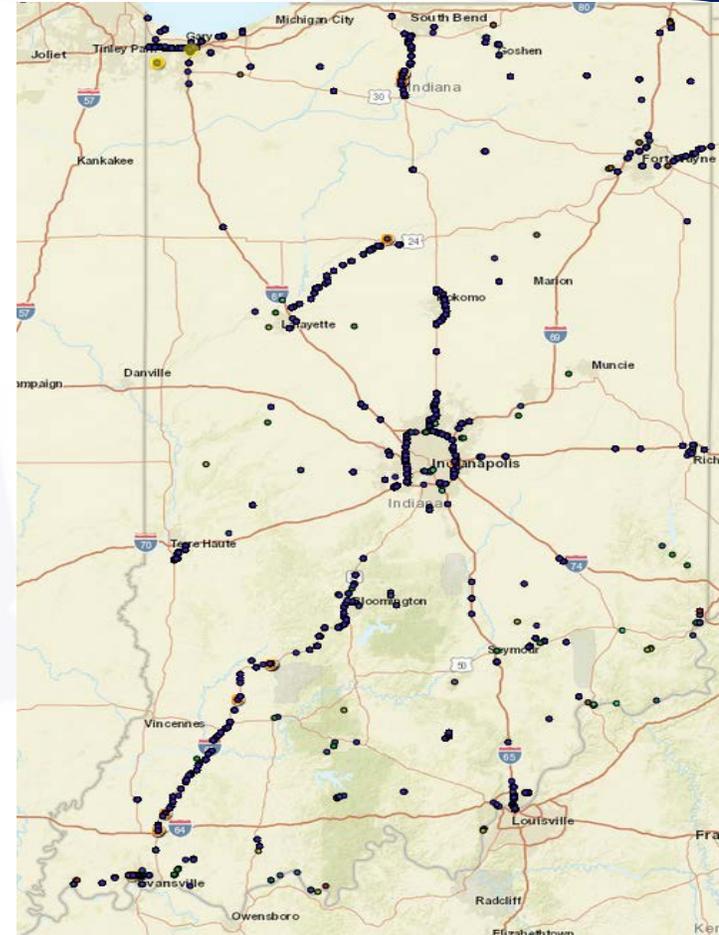


# MSE WALLS DESIGN IN INDIANA

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# There are many kinds of retaining structures



Reinforced Concrete Cantilever Retaining Wall  
from <http://NA.N.arcl-iexpo.c.:11n.>



Sheet Pile Wall

from <http://theconstructor.org/>



Soldier Pile Wall

<https://www.haywardbaker.com/solutions/techniques/soldier-piles-lagging>



Segmental Retaining Wall (SRW)

from <https://www.basalite.com/>



Steel Bin-type Retaining Wall

from <https://www.archiexpo.com>



# Common MSE wall applications for INDOT include...



Retaining wall



Wing wall



Bridge abutment

## Other Applications:

- Back to Back walls for Ramps
- Landslide repair
- Phased construction

# MSE Wall Design

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1. External Stability (deals with composite structure)
  - Sliding
  - Bearing Resistance
  - Overturning (Eccentricity)
2. Internal Stability (deals with soil reinforcement)
  - Reinforcement Pullout (pullout from reinforced soil mass)
  - Reinforcement Strength (tension rupture)
  - Reinforcing to Facing Connection
3. Global Stability
4. Compound Stability

# Design Codes/References

- Latest AASHTO LRFD Bridge Design Specifications
- Latest IDM(INDOT Design Manual)& DMs
- Latest INDOT Standard Specifications
- Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Volume I & II by FHWA (reference)-  
Developed following: **AASHTO LRFD Bridge Design** and **AASHTO LRFD Bridge Construction Specifications**

# MSE Wall Geotechnical Considerations: Boring Location Plan

- A minimum of two borings
- Borings at the proposed extremities and along the proposed alignment as closely as possible
- Boring Spacing
  - Along alignment
    - $\leq 100$  feet for  $H \leq 20$  feet.
    - $\leq 50$  feet for  $H > 20$  feet.
  - Back Boring
    - 100 feet at 1.0 to 1.5 times the proposed wall height

# MSE Wall Geotechnical Considerations: Boring Location Plan

- Boring Depth:
  - Minimum of  $2H$
  - Specified depth + minimum of 2 SS samples for  $N \geq 15$
  - If  $N < 15$ , boring shall be extended until this requirement is met.
- **If rock is encountered within the planned depth**
  - A minimum of one 5-foot rock core for every 150 feet.
  - Minimum of two cored boreholes for each wall.

# MSE Wall Geotechnical Considerations: Geotechnical Report

- Foundation soil details
  - Soil Parameters such as friction angle, cohesion and unit weight that can be used for design
  - Foundation soil's factored bearing resistances for different heights of wall.
  - Minimum length of reinforcement as function of height of wall for different sections.
- Foundation soil improvement detail, if required, including depth and extent of improvement and the design parameters for the improved foundation soil
- Settlement Analysis for MSE wall

# MSE Wall Geotechnical Considerations: Geotechnical Report

- Wall lengths and Maximum height of the wall
- Should also cater for all the requirements mentioned in the latest document of Indiana Standard Specifications.
- MSEW input data and the MSEW output for external and Global Stability.
  - Any assumptions, for example back slopes for calculating the height of the wall.
- Any other information that can effect the feasibility of the MSE wall.
- The information must be summarized in tabular form as shown on the next slide.

## MSE Wall Design Parameter and Geotechnical Check Table

| Design Parameter                              | Value (area 1)*                     |
|---|-------------------------------------|
| Maximum Calculated Settlement                 | "x" inches                          |
| Maximum Differential Settlement               | "y" inches                          |
| Time for settlement completion                | "z" days                            |
| Maximum wall height                           | XX ft                               |
| <b>Design Recommendations</b>                 |                                     |
| Minimum Reinforcement Length/Height Ratio     | 0.75H (example)                     |
| Undercut required                             | yes/no                              |
| Undercut depth                                | X feet                              |
| Undercut area                                 | from Sta. XX to XX line "XX"        |
| Undercut Backfill Material                    | XXXXXXX                             |
| <b>Seismic recommendation</b>                 |                                     |
| Site Class                                    |                                     |
| Seismic Zone                                  |                                     |
| Peak Ground Acceleration As                   |                                     |
| <b>Geotechnical Analysis Checks</b>           |                                     |
| Sliding                                       | CDR<br>≥1.0                         |
| Eccentricity                                  | ≥1.0                                |
| Global Stability                              | Factor of safety/ resistance factor |
| Factored Bearing Resistance                   | 5400 psf (example value)            |
| <b>Foundation Soils Strength Parameters**</b> |                                     |
| Cohesion                                      |                                     |
| internal friction angle                       |                                     |

### Notes:

\*more sheets can be added to include recommendations for each area of concern.

\*\*if varying soil conditions encountered underneath the MSE wall, the table can be expanded to include all soil profile information

<https://www.in.gov/indot/2804.htm>

## Geotechnical Design Manual

- [Chapter 1 Introduction](#)
- [Chapter 2 Geology and Pedology](#)
- [Chapter 3 Geotechnical Investigation and Sampling](#)
- [Chapter 4 Field Identification and In-situ Testing](#)
- [Chapter 5 Lab Testing](#)
- [Chapter 6 Geotechnical Analysis](#)
- [Chapter 7 Design Recommendations](#)
- [Chapter 8 Geotechnical Report](#)
- [Appendix A - Description of Geotechnical Pay Items](#)
- [Appendix D - Schedule of Geotechnical Pay Items](#)
- [References and Appendices 1 - 14](#)
- [INDOT Check List For Retaining Structures](#)
- [Geosynthetics Guidance](#)

# Feasibility of MSE Wall

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- Considered in place of conventional gravity, cantilever, or counterfort concrete and prefabricated modular retaining walls.
  - Particularly where substantial total and differential settlements are anticipated.

# Feasibility of MSE Wall: Should Not be Recommended

- Intersecting angle of walls is less than  $70^\circ$
- Where utilities other than highway drainage are to be constructed within the reinforced zone unless access is provided to utilities without disrupting reinforcements and breakage or rupture of utility lines will not have a detrimental effect on the stability of the structure. No Water Mains, Gas lines are allowed under the reinforced zone
- Erosion/Scour potential exists that may undermine the reinforced backfill area

# Feasibility of MSE Wall: Should Not be Recommended

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- Corrosive material environment or presence of stray electrical currents. (See publication No. FHWA-NHI-09-087 for details)
- Groundwater flow or a high groundwater level within the reinforced fill area exists
- Walls with curved alignments (<50 ft radius)

# Feasibility of MSE Wall: Should Not be Used

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- Buried utilities within the reinforced zone exist
- Highly vegetated area where placing trees or plants within the reinforced zone is expected
- Where Right of Way (ROW) is enough for reinforcement lengths anticipated and any needed clearance for utilities or/and future excavations

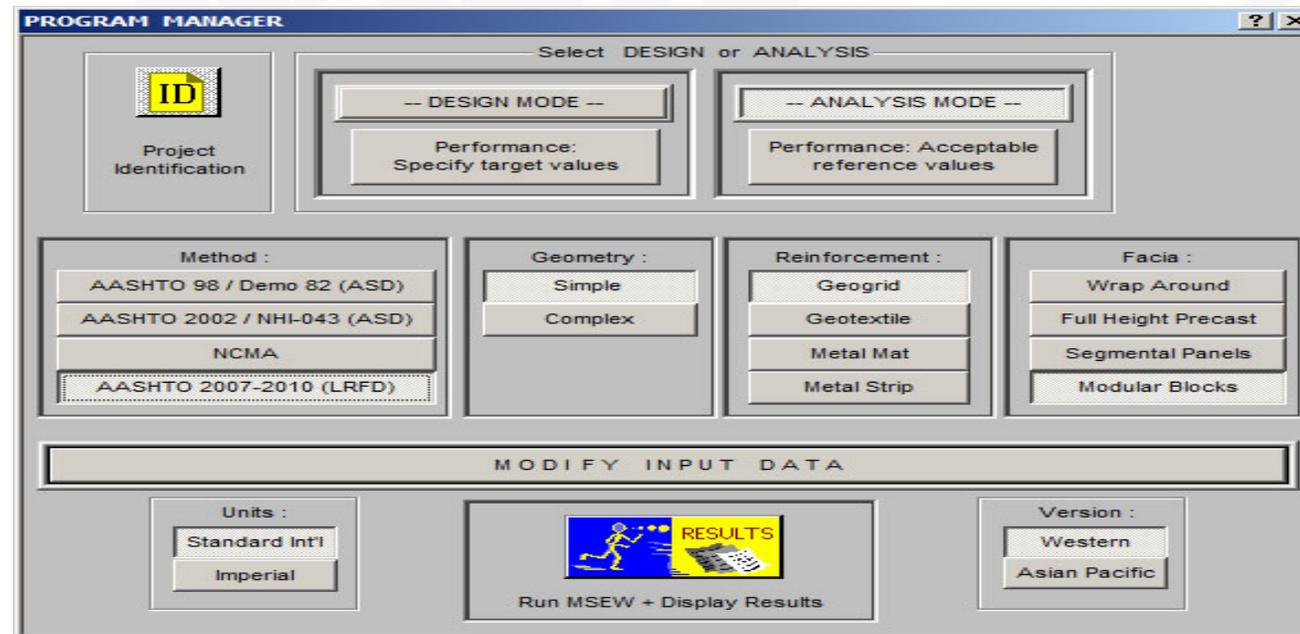
# Feasibility of MSE Wall: Other Considerations

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- Bench and Embedment Requirement
- Uniform Reinforcement Length
- Distance between pile sleeves and Back of panels
- Internal Wall Drainage, Path of drainage, outlets, drainage flow to ditch or collection system away from wall
- Please also note that we do not allow I B subgrade treatment (No lime or cement stabilized subgrade treatment) for pavement on top of MSE walls. To be safe for pavement on top of MSE walls use/allow I C treatment only.

# MSEW

- MSEW (3.0)-Available for all (Design and Analysis software)- It is based on AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS-originally developed for FHWA exclusively for use by US State Highway Agencies and by US Federal agencies.



# Specification Changes

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- Leveling-pad steps shall be in 2.5 ft increments
- The splay angle of soil reinforcement measured from a line perpendicular to the wall face, in order to avoid an obstruction, shall not be more than  $15^\circ$ . The tensile capacity of the splayed reinforcement shall be reduced by the cosine of the splay angle
- The design for the compound stability shall include the slope present on top of and at the toe of the MSE wall

# Specification Changes

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- The minimum embedment at the front face of the wall shall be in accordance with the AASHTO LRFD Bridge Design Specifications, section 11.10.2.2. However, the minimum embedment depth to the top of the leveling pad shall never be less than 3 ft unless founded on rock. A 4 ft horizontal bench in front of the wall shall be provided for slopes steeper than 4.0H:1.0V
- The embedment and bench material, at the front face of the wall, shall match the structural backfill material used for the wall
- Design Life not more than 75 years

# Pile Sleeve USP

## DESCRIPTION

This work shall consist of installing 24 in. diameter, Type 3 Pipe as pile sleeves through mechanically stabilized earth retaining wall fill at the locations shown on the plans and in accordance with 105.03.

## MATERIALS

Materials shall be in accordance with the following:

|   |         |
|---|---------|
| Bentonite Grout. . . . .                      | 913.06  |
| Corrugated Aluminum Alloy Pipe. . . . .       | .908.04 |
| Profile Wall Polyvinyl Chloride Pipe. . . . . | .907.22 |
| Ribbed Polyethylene Pipe. . . . .             | .907.20 |
| Smooth Wall Polyethylene Pipe. . . . .        | 907.21  |
| Smooth Wall Polyvinyl Chloride Pipe. . . . .  | 907.23  |

The minimum thickness of 2 5/8 in. by 1/2 in. corrugated aluminum alloy pipe, lock seam, shall be 1/16 in. The minimum thickness of 2 5/8 in. by 1/2 in. corrugated aluminum alloy pipe, riveted, shall be 1/16 in. The dimension ratio for smooth wall polyethylene pipe shall be 26.

The piles shall be backfilled with uncrushed gravel, class E or higher, in accordance with 904 and the following gradation requirements.

| <u>Sieve Size</u> | <u>% Passing</u> |
|-------------------|------------------|
| 1/2 in. (12.5 mm) | 100              |
| No. 50 (300 µm)   | 0-5              |
| No. 100 (150 µm)  | 0-2              |



# Feasibility

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- MSE walls might be a more economical option for retaining wall. However, it has become a common practice to choose MSE wall without providing an alternate solution.
- Mechanically stabilized earth walls should only be used on projects where the roadway designer has verified that the ground water table is below the elevation of the proposed leveling pad AND that all drainage systems installed behind the wall can be day lighted to a ditch or subsurface drainage system. If these conditions cannot be met or verified by the roadway designer this type of wall system should not be specified. Design or installation of mechanically stabilized earth walls in “bath tub” conditions or in undrained soils is prohibited



# Vegetation



# Backfill



# Backfill Loss



# Backfill Loss





# Backfill Loss





DEPARTMENT OF

# Questions

