1. MECHANICALLY STABILIZED EARTH (MSE) RETAINING WALL (revised 2-3-2022)

Description. Furnish all materials, labor, equipment, and additional geotechnical investigation information necessary to design and construct Mechanically Stabilized Earth (MSE) retaining wall(s) with extensible/inextensible reinforcement in accordance with these specifications and the lines, grades, and dimensions shown on the Plans or otherwise established by the Project Manager. Work includes all excavation and grading required for constructing Mechanically Stabilized Earth (MSE) retaining wall(s). Have a Professional Engineer licensed in Montana oversee the retaining wall design(s) and sign and seal the design calculations and drawings.

Preliminary dimensions given on the Plans are for estimating purposes only. Produce a design for an MSE retaining wall system that will establish:

Bottom elevation of the leveling pad (if required by manufacturer) and bottom elevation of MSE wall.

Backfill reinforcement type, locations and lengths.

Type and dimensions of facing materials.

Reinforcement connection to facing.

Size of concrete and/or crushed aggregate leveling pad.

Quantity of reinforced backfill.

A drainage system that will provide free drainage behind the reinforced soil mass.

Available Information. Available information developed by the Department or by the Department’s duly authorized representative includes the following items:

Project Geotechnical Reports dated August 2009, November 2010, and November 2013.

Boring Logs that were obtained in the area of the MSE retaining wall(s) are included in the Special Provisions.

Contract Drawings including detailed drawings, plan and profile drawings, and cross-section drawings for the proposed retaining wall. These drawings show right of way and construction limits, utilities, wall appurtenances, and culverts or other existing drainage facilities.

Design Soil Properties. Use the following soil properties to design the MSE wall:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Total Unit Weight, pcf | Drained Angle of Internal Friction, degrees | Undrained Cohesion, psf | Nominal (unfactored) Bearing Capacity, psf(1) |
| Reinforced Soil | 130 | 34 | ------ | ------ |
| Retained Soil | 125 | 30 |  | ------ |
| Foundation Soil\* | 115 | 30 |  | 6000 |

* + - * 1. Note: Nominal bearing capacity is based upon a minimum reinforcement length of 8 feet. Nominal bearing capacity will vary for different reinforcement lengths.

MSE Retaining Wall Design Requirements.

Design the wall(s) in accordance with the most current AASHTO LRFD Specifications for Highway Bridges including current Interim Specifications for retaining walls using the applicable resistance and load factors for mechanically stabilized earth walls.

Additionally, follow the guidelines given in the most current editions of the FHWA Manuals titled “Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume I and II” (Publication No. FHWA-NHI-10-024 and FHWA-NHI-10-025) and “Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes” (Publication No. FHWA-NHI-09-087). The following exceptions and additions apply.

Use Allowable Stress Design methods (ASD) to assess overall stability.

The design life of the MSE wall is 75 years.

The design Peak Ground Acceleration (PGA) is 0.064g. (USGS)

The required minimum wall embedment is 3 feet.

Ensure internal stability and provide analysis at critical sections that clearly show the Capacity/Demand Ratio equal to or greater than 1.0 for tensile resistance and pullout resistance.

The Department or Department’s representative evaluated the proposed wall layout(s) and determined adequate overall stability and bearing capacity. The design must include analyses at critical sections that clearly show acceptable limits for eccentricity, Capacity Demand Ratios equal to or greater than 1.0 for compound stability, sliding, and bearing capacity and a Factor of Safety greater than 1.3 for overall stability.

Design the wall with the maximum vertical distance between reinforcement layers of 2 feet.

Design the wall with the minimum length of reinforcement equal to 0.7 times the wall height or 8 feet, whichever is greater.

Design the wall to tolerate total and differential settlements of up to 1 inch without damage to the facing, whichever is smaller.

Design a drainage system behind the reinforced soil mass to drain water from the backfill and prevent hydrostatic pressure buildup within the reinforced zone.

Design the wall with a batter of 1:10 at the end of construction.

Design the wall to account for wall appurtenances and interferences such as pipes, utilities, or other appurtenances behind, passing through, passing under, or adjacent to the wall.

Existing utilities such as fiber optic or telephone are present near the foundation elevation of the MSE wall. Do not disturb these utilities.

Design the wall to account for surcharge loading from adjacent highway traffic.

Design the wall to account for guardrail placement, fence, signage, luminaires, or other appurtenances at the top of the wall.

Materials. Use materials meeting the following requirements to construct the MSE wall.

All steel or iron materials permanently incorporated into the work must meet the requirements of Subsection 106.09 of the Specifications.

Concrete for Leveling Pads. Provide Class General Concrete for leveling pads meeting the requirements of Section 551.

Reinforced Backfill Material. Use material meeting the requirements of these Special Provisions and the following additional requirements:

Gradation. Use backfill material meeting the following gradation requirements:

 US Sieve Size Percent Passing

 3 inch 100

 1 inch 70 - 90

 No. 4 20 – 40

 No. 40 10 – 20

 No. 200 0 – 8

 Provide a minimum of 35% of the +No. 4 material with at least one fractured face.

Modular Block Fill (if used). Fill the voids in all modular blocks with aggregate meeting the following gradation:

 US Sieve Size Percent Passing

 1 inch 100

 ¾ inch 50-75

 No. 4 0-60

 No. 40 0-50

 No. 200 0 – 5

Electrochemical Properties. Use backfill meeting the following electrochemical requirements:

 For Steel Reinforcements:

 Requirements Test Methods

 Resistivity >3,000 ohm-cm AASHTO T-288

 pH 5-10 AASHTO T-289

 Chlorides <100 parts per million AASHTO T-291

 Sulfates <200 parts per million AASHTO T-290

 Organic Content <1% AASHTO T-267

 For Geosynthetic Reinforcements:

 Requirements

 Polyester (PET) 3<pH<9 AASHTO T-289

 Polyolefin (PP &HDPE) pH>3 AASHTO T-289

 If the resistivity is greater than or equal to 5000 ohm-cm, the chloride and sulfates requirements may be waived.

Soundness. Use materials that are substantially free of shale or other soft, poor durability particles. Use material having a magnesium sulfate soundness loss of less than 30 percent after four cycles, measured in accordance with AASHTO T-104, or a sodium sulfate less of less than 15 percent after five cycles determined in accordance with AASHTO T-104.

Reinforcement Material. Use extensible/inextensible reinforcement material that will not degrade over the design life of the structure. When specifying the reinforcement material, use the criteria given in the FHWA Publication “Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes” (Publication No. FHWA-NHI-09-087).

Facing. Use modular block, welded wire grid, or precast concrete panel facing.

Use modular concrete blocks in conformance with ASTM C 1372, Standard Specification for Segmental Retaining Wall Units.

Use precast concrete panels meeting the requirements set forth for precast members in AASHTO Section 5, “Concrete Structures”, with the following exceptions and additions:

Provide Portland cement concrete, meeting the requirements for Class Structure Concrete with a minimum compressive strength of 4000 psi. The lot strength pay factor (Table 551-5) does not apply.

Casting – Cast the panels in metal forms on a flat area, the front face at the bottom, and the back face at the top. Set attachment devices in the rear face. Do not allow galvanized attachment devices to contact or be attached to panel reinforcement steel. Set all attachment devices, reinforcing steel, PVC sleeves, and lifting devices in place to the dimensions and tolerances shown on the fabrication drawings prior to casting.

Curing – Cure the panels in accordance with Section 554.

Form Liners - Acceptable form liner manufacturers and options are: ***Various options*** or acceptable equal.Maintain a minimum concrete thickness of 4 inches, excluding the form liner depth, for pre-cast panels.Screed the rear face of the panel to eliminate open pockets of aggregate and surface distortions in excess of 1/4 inch. Finish on exposed surfaces must conform to Section 554.

Rejection *-* Units will be rejected for failure to meet any of the requirements specified above. Repair or replace units with thefollowing defects.

* Defects that indicate imperfect molding.
* Defects that indicate honeycombing or open texture concrete.
* Cracked or severely chipped panels.
* Any damage that prevents a satisfactory joint between panels.

Drainage Geotextile – Cover all joints between panels on the backside of the wall with geotextile meeting the minimum requirements of Section 716 for High Survivability Subsurface Drainage Geotextile Class A. Overlap the geotextile a minimum of 1 foot.

Retaining Wall Design Submittals. Submit electronic copies (PDF format preferred) of the complete design calculations and working drawings to the MDT Geotechnical Section for review a minimum of 20 working days before the planned start of wall excavation. Include all details, dimensions, quantities, ground profiles, and cross-sections necessary to construct the wall. Verify the limits of the wall and ground survey data before preparing drawings.

Design Calculations. Submit design calculations including, but not limited to, the following items:

Applicable code requirements and design references.

Retaining wall critical design cross-section geometry including soil/rock strata and location, magnitude, and direction of design slope or external surcharge loads and piezometric levels along with the Capacity Demand Ratios for, long-term conditions.

Design parameters including drained and undrained soil/rock shear strengths, unit weights, and any other assumptions for each soil/rock strata along with reinforcing material properties and facing materials.

Capacity Demand Ratios calculated from LRFD.

Factor of Safety Calculations (ASD) for overall stability.

Design calculation sheets with the project number, wall location, stationing, date of preparation, initials of designer and checker, and page number at the top of each page. Provide an index page with the design calculations.

Design notes including an explanation of any symbols and computer programs used in the design. Accompany computer output submitted with supporting hand calculations detailing the calculation process.

Design calculations for wall facing units, connection pins, and reinforcing material, and connections between the reinforcing material and the facing.

Other design calculations.

Working Drawings. Provide drawings designed, signed and sealed by a registered Montana licensed Professional Engineer. Working drawings must include, but are not limited to, the following items:

A plan view of the wall(s) identifying:

A reference baseline and elevation datum.

The offset from the construction centerline or baseline to the face of the wall at its base at all changes in horizontal alignment.

Beginning and end of wall stations.

Right-of-way and permanent or temporary construction easement limits, location of all known active and abandoned existing utilities, adjacent structures or other potential interferences within the limits of the wall excavation.

The centerline of any drainage structure or drainage pipe behind, passing through, adjacent to, or passing under the wall.

An elevation view of the wall(s) identifying:

The elevation at the top of the wall, at all horizontal and vertical break points, and at least every 20 feet along the wall.

Elevations at the wall base.

Beginning and end of wall stations.

The distance along the face of the wall to all steps in the wall base.

Wall elevation view showing the location of wall drainage elements along the wall length.

Existing and finish grade profiles both behind and in front of the wall.

Specifications for reinforcing material and connection pins.

General notes for constructing the wall including construction sequencing, wall excavation, foundation preparation, wall erection, backfill placement and any other special construction requirements.

Horizontal and vertical curve data affecting the wall and wall control points. Provide match lines or other details to relate wall stationing to centerline stationing.

A listing of the summary of quantities on the elevation drawing of each wall showing estimated square yards of wall face areas.

Retaining wall typical sections including excavation elevations, and wall face batter.

Details, dimensions, and schedules for all connection pins, facing, and reinforcement materials.

Details and dimensions for wall appurtenances such as barriers, guardrails, coping, drainage gutters, fences, signage, etc. Clearly show all details and requirements to place guardrail posts.

Details for constructing walls around utilities and drainage facilities (if applicable).

Details for terminating walls and adjacent slope construction.

Have a Professional Engineer licensed in Montana sign and seal the drawings and calculations. If the retaining wall Contractor uses a Consultant designer subcontractor or manufacturer’s representative to prepare the design, the retaining wall Contractor still has overall contract responsibility for both the design and the construction.

Submit copies of the wall drawings to the Department with the initial submission. The MDT Geotechnical Section will review the Contractor's submittals in accordance with Subsection 105.02. If revisions are necessary, make the necessary corrections and resubmit copies of the revised sets. After the drawings have been reviewed and found acceptable, furnish copies of the final drawings.

* Do not begin wall construction or incorporate materials into the work until the submittal requirements are satisfied and found acceptable to the Department. Changes or deviations from the accepted submittals must be re-submitted and reviewed.
* No adjustments in contract time will be allowed due to incomplete submittals.
* Revise the drawings when plan dimensions are revised due to field conditions or for other reasons. Within 30 working days after completion of the work, submit as-built drawings to the Project Manager. Provide revised design calculations signed by a Montana licensed Professional Engineer for all design changes made during the construction of the wall.

Construction Requirements. Construct the wall according to the approved set of working drawings, the special provisions, and the appropriate sections of the Specifications.

Reinforced Backfill Source Approval. At least 30 calendar days before beginning MSE wall construction, submit a sample from the proposed borrow source for backfill material.

Reinforcement Source Approval. Submit a manufacturer’s certificate of compliance signed by an authorized manufacturer’s official stating that the reinforcement material meets the requirements specified in the working drawings. Submit a sample at least 5 feet in length by the full reinforcement width for testing. After the sample and the required information have been submitted to the Project Manager, allow 30 calendar days for evaluation. Remove and replace any material not meeting the specified requirements at the Contractor’s expense.

Have a technical representative of the wall manufacturer on site a minimum of 2 business days during the beginning of MSE wall construction to ensure that the wall is installed properly.

Coordinate guardrail placement with wall construction.

Excavation. Complete the excavation in conformity to the limits and construction stages shown on the plans. The contractor is responsible for temporary excavation support (as required).

Foundation Preparation. Grade the foundation for the structure level for a width equal to the length of reinforcement plus 1 foot or as shown on the plans. Prior to wall construction, except where constructed on rock, compact the foundation soils in accordance with Section 203. The surface should be smooth and level so that any shallow depressions or humps do not exceed 6 inches in depth or height. Compact the subgrade in accordance with MT 219, Control – Strip A and remove and replace any unsuitable foundation soils with backfill material meeting the requirements of this special provision.

Concrete Leveling Pad. After placement of the leveling pad concrete, cure the concrete a minimum of 12 hours prior to wall construction.

Backfill Placement. Place backfill following each course of facing. Place backfill in a manner that prevents any disturbance of the wall materials or misalignment of the facing or reinforcing elements. Remove and replace any wall materials that become damaged during construction at Contractor’s expense.

At each reinforcement level, place and compact the backfill to the level of the connection before placing the reinforcement.

Place, spread, and compact backfill in a manner that minimizes development of wrinkles in, or movement of, the reinforcement.

Place backfill near the facing in a manner that prevents voids directly beneath the reinforcing elements.

Place backfill in maximum 8 inch loose lifts. Compact backfill to a minimum of 95 percent of the maximum density as determined by MT-230 within +/- 2 percent of the optimum moisture content.

Compact the backfill within 4 feet of the wall face using a lightweight mechanical tamper, roller, or vibratory system.

At the end of each day’s operation, slope the level of the backfill away from the wall facing to rapidly direct runoff away from the face. Do not allow surface water from adjacent areas to enter the wall construction site.

Reinforcement Placement. Place reinforcement on a smooth horizontal surface. Pull the reinforcement material tight before covering it with backfill.

If geosynthetic reinforcement is used, place the reinforcement so that the principal strength direction is perpendicular to the wall face. Proper orientation of the reinforcement is critical as the strength of geosynthetic reinforcement varies with direction.

Use soil piles, pins, or the manufacturer’s approved methods to hold the reinforcement material tight during backfill placement.

Do not operate equipment directly on the reinforcement material. Do not splice or overlap geosynthetic reinforcement in the principal strength direction.

Modular Block Fill (if used). Fill the voids in all modular blocks with aggregate meeting the of this special provision:

Wall Batter. The vertical tolerance of the completed wall must not exceed 1/2 inch per 10 feet of wall height from the batter shown on the approved set of working drawings.

Corrective Action. If any defects are found in the wall, begin repairing the wall by a method or methods approved by the Geotechnical Section. Within 7 calendar days of determining the need for wall repairs, submit 4 copies of revised calculations and working drawings, stamped by the Engineer of Record for the wall design, to the Project Manager for modifications to the wall caused by the remedial action. Furnish all material and labor necessary to correct the wall at no cost to the Department.

Method of Measurement. Mechanically Stabilized Earth (MSE) retaining wall(s) is measured per square yard of wall face (including the embedded portion of the wall), complete and in-place.

Basis of Payment. Payment is full compensation for all labor, equipment, materials, tests, investigations, and incidentals necessary to acceptably design and construct the MSE retaining walls.

Mechanically Stabilized Earth (MSE) retaining wall(s) will be paid for under the following pay item:

 Pay Item Measurement Unit

 Design, Construct MSE Retaining Wall Square Yard