Retaining Wall Design Notes

Unless specifically stated otherwise in the contract plans, the bidding for, the design of and the construction of retaining walls shown in the plans shall be governed by the *Tennessee Department of Transportation Special Provision 624 Regarding Retaining Walls*. This Special Provision shall be considered as one of those documents which the Bidder/Contractor has examined and made himself familiar with as described in *Section 102.04 – Examination of the Site, the Work, the Plans, and the Specifications in the TDOT Standard Specifications for Road and Bridge Construction.*

Excavation for the wall and/or its footing shall not be accomplished until the Contractor has submitted wall designs and calculations and has been issued an approved set of wall plans and has labor and material resources available to begin and continue wall construction immediately after excavation.

This wall shall be designed in accordance with LRFD design procedures and requirements as described in 1) AASHTO LRFD Bridge Design Specifications, 2007 and Interims and 2) Publication FHWA-NHI-10-024/FHWA GEC 011, *Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, November 2009* for MSE walls.

For proprietary wall systems that have been approved as shown in TDOT's Special Provision 624, the Wall Designer shall be responsible for providing wall designs incorporating materials and components (i.e. reinforcement connection devices, specific manufacturer and properties of reinforcing materials) as was submitted and approved. If a material and/or component of the wall system have been modified from the originally approved system, a wall design and set of plans and calculations for this wall system cannot be submitted for review and approval until the Wall System Designer who originally submitted the wall system for approval submits a request for re-approval utilizing the modified elements of the wall. This submittal does not guarantee approval of the modified system. If this re-approval process does not meet the Contractor's schedule or if the modified system is not approved, the Contractor/Wall Designer shall provide a wall design for one of the approved systems at no change in contract price for the retaining wall and no change in project schedule requirements will be allowed.

The Wall Designer shall provide retaining wall plans, details and calculations as required by Special Provision 624 and as required herein.

- The Wall Designer shall utilize the Geotechnical Parameters and Resistance Factors as provided for each project retaining wall on the Wall Concept Sheet and related Retaining Wall Sheets to prepare and submit design calculations. Load Factors and other pertinent design requirements provided in AASHTO LRFD Bridge Design Specifications, 2007 and Interims shall be used for non-MSE walls and in Publication FHWA-NHI-10-024/FHWA GEC 011, *Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, November 2009* for MSE walls. The cost for undercutting and replacement, if required, shall be included in the cost of the retaining wall.

- Calculations for both internal and external stability (sliding, eccentricity, bearing capacity-global stability and settlement) shall be provided for each critical wall section which demonstrates the required Capacity to Demand Ratio of 1.0 is met utilizing the design parameters provided. For MSE walls, the Wall Designer must adjust the reinforcement lengths beyond those minimum required lengths, if required, to meet both internal and external requirements, including global stability. The Wall Designer/Contractor plans must include any foundation improvements as required herein on the Wall Designer/Contractor's wall elevation views and any cross-sectional detail drawings.

- While the Wall Designer's design must demonstrate compliance with external stability requirements as discussed above, the Wall Designer may provide certification (by signing and stamping by Professional Engineer registered in State of Tennessee) of the wall plans and calculations.

- Load Combinations Strength I, Extreme Event I (EQ), and Extreme Event II (CT, as applicable) as given in Table 4-1 of Publication FHWA-NHI-10-024/FHWA GEC 011, *Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, November 2009* for MSE walls shall be evaluated for MSE walls. Load Combinations for other wall types shall be as given in AASHTO LRFD Bridge Design Specifications, 2007 and Interims.

- Soil slopes above the top of retaining walls should be independently checked for stability. Slopes not meeting the minimum required factor of safety against stability failure (1.30 for short and long-term static, and 1.10 for seismic) should be reinforced using geogrid or similar materials.

Note Regarding Construction Slopes

The Contractor shall be responsible for making the excavation in accordance with OSHA and other applicable state and local regulations regarding construction slopes and trenches. In addition to following applicable regulatory requirements, as a minimum requirement, all temporary construction slopes shall be placed at a maximum of a 1:1 slope in soil and shall not be left open without shoring for any longer than absolutely necessary. The Contractor building the wall shall ensure that these temporary back slopes are not and do not become unstable. If slope is unstable, becomes unstable, is cut steeper than a 1:1 slope or is unacceptable for another reason, then temporary shoring shall be used. Any unusual soil conditions other than those assumed should be reported to the Project Engineer.

Acceptable Wall Types

The retaining wall shall be one of the wall types listed below. For retaining wall systems listed as Bin Wall, Crib Wall, MSE (either segmental panel or Modular Block) and Ground Anchor Wall, the specific Wall System Supplier/Installer shall be one of those listed as Pre–approved in the TDOT Special Provision 624.

- **Pile-supported, Cast-in-Place, L-Shaped Cantilever Walls**
- **Soil Nail/Anchor Wall**
- **Soldier Pile and Lagging Wall**
- **Anchored Sheet Pile wall**
- **Mechanically Stabilized Earth (MSE) Wall - Segmental Precast**
- **Mechanically Stabilized Earth (MSE) Wall – Modular Block**

Note: All non-pile-supported wall types will require ground improvement by means of installing aggregate piers, stone columns or similar methods. The cost for ground improvement should be included in the wall unit cost per square foot.

TABLE 1-DESIGN REQUIREMENTS AND PARAMETERS

Description	Value-MSE Walls	Value-Other Walls	Note *
Design Life	75 Years		
Design Ground Acceleration (A_s)	See AASHTO LRFD Bridge Design Specifications, 2007 and Interims		
Effective (Drained) Friction Angle			
Retained Backfill-Unclassified site or borrow soil	28◦	28◦	
Retained Backfill-Select Backfill	34◦ to max 40◦	34◦ to max 40◦	1
Reinforced Backfill	34◦ to max 40◦	NOT APPLICABLE	
Unit Weight-			
Unclassified site or borrow soil	120 pounds per cubic foot	120 pounds per cubic foot	
Select Backfill Material	Varies	Varies	1A
Minimum Length of soil reinforcement, B	Greater of 0.7H min or as required by Global Stability	As required by Global Stability	2,2A
Limiting eccentricity	B/3	B/3	
Coefficient of Sliding Friction	See Table 2 or 3	See Table 2 or 3	3
Nominal Bearing Capacity	See Table 2 or 3	See Table 2 or 3	3
Resistance Factors			
Sliding-Static	1.0	0.85	4
Sliding-Combined Static+Earthquake	1.0	1.0	4
Bearing-Static	0.65	0.45	5
Bearing- Combined Static+Earthquake	1.0	1.0	
Pullout resistance			
Static	0.90	NOT APPLICABLE	6
Combined static/earthquake	1.20	NOT APPLICABLE	6
Tensile resistance of metallic reinforcements and connectors		NOT APPLICABLE	
Static		NOT APPLICABLE	
-Strip reinforcement	0.75		7
-Grid reinforcement	0.65		7,8
Combined static/earthquake			
-Strip reinforcement	1.00		7
- Grid reinforcement	0.85	NOT APPLICABLE	7,8
Tensile resistance of geosynthetic reinforcements and connectors		NOT APPLICABLE	
Static	0.90	NOT APPLICABLE	
Combined static/earthquake	1.20	NOT APPLICABLE	
*Refer to Table 1.1 for notes.			

TABLE 1.1	
NOTES FOR TABLE 1	
#	**Note**
1	A minimum friction angle of 34 degrees can be assumed for material meeting specifications in Section F, Part 1, and Item e of *Tennessee Department of Transportation Special Provision 624 Regarding Retaining Walls.* A higher friction angle can be utilized if the Contractor submits independent testing and it is verified by TDOT. However, in no case shall the friction angle for analysis exceed 40-degrees.
1A	Select Backfill unit weight to be determined by Contractor/Designer depending on actual backfill material used. Select backfill is defined as material meeting specifications in Section F, Part 1, and Item e of *Tennessee Department of Transportation Special Provision 624 Regarding Retaining Walls*. In order to utilize ϕ for select backfill design, select backfill must be placed for a minimum zone formed by a 1:1 slope from 2 feet behind the bottom of back of wall footing or reinforced soil zone for MSE walls up to finished grade.
2	H is the design height of the wall and is defined as the difference in elevation between from the finished grade at the top of the wall and the top of leveling pad. The top of the leveling pad shall always be below the minimum embedment reference line as indicated on the plans for that location. The length of the soil reinforcement, B, is measured from the backface of the wall facing unit. In case of grid type reinforcements the length of the soil reinforcement is measured from the backface of the wall facing unit to the last full transverse member. For modular block facing units, the total length of the reinforcement, Br as measured from the front face of the wall is the length B as defined above plus the width of the modular block unit (the horizontal dimension of the block unit measured perpendicular to the wall face).
2A	Wall Designer must adjust the reinforcement lengths beyond those minimum required lengths, if required, to meet both internal and external (global stability included) stability requirements.
3	These values will be provided in Tables 2 and/or 3
4	Passive resistance shall **NOT** be considered in evaluation of sliding resistance.
5	For all limit states, the design loading for the MSE retaining wall system shall not exceed the factored general and local bearing resistance specified in Tables 2.
6	Live load due to vehicular traffic shall be included in the computations to determine the maximum tensile forces in reinforcement layers, but shall be neglected in the computations for pullout resistance.
7	Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with Article 6.8.3 of AASHTO (2007) and apply to net section less sacrificial area.
8	Applies to grid reinforcements connected to a rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.
	Unless otherwise specified, all resistance factors shall be taken as 1.0 when investigating an extreme event limit state.

TABLE 2-FOUNDATION PARAMETERS AND REQUIREMENTS FOR MSE WALLS, GRAVITY OR SEMI-GRAVITY WALLS

FOUNDATION DESIGN PARAMETERS FOR GRAVITY / SEMI GRAVITY WALLS / MSE WALLS			
Wall No.	Foundation (Reinforced Zone) Bearing Condition Requirement	Nominal Bearing Capacity (psf)	Coefficient of sliding Friction
1	On In-Place Soil	3,700	0.35
2	On In-Place Soil	4,000	0.35
3	On In-Place Soil	4,000*	0.35*

*: Values are based on a subsurface exploration done by others. Subsurface conditions for this wall should be verified prior to wall construction. The design values above may be accordingly modified.

Note Regarding Global Stability

Pile-supported or soil nail wall designer/contractor must account for global stability of wall. Pile lengths should be of sufficient depth to obtain adequate factors of safety against global stability failure for static and seismic conditions.

The minimum required factor of safety for global stability, short and long-term static: 1.30
The minimum required factor of safety for global stability, seismic: 1.10

For MSE or grade-support CIP walls, ground improvement is required to meet the minimum required factors of safety for global stability mentioned above.

TABLE 3- SOIL DESIGN PARAMETERS FOR PILE SUPPORTED WALL

Depth (ft.)	Elevation (ft.)	Soil Type	Total Unit Weight (pcf)	Effective Unit Weight (pcf)	Undrained Shear Strength (psf)	Internal Friction Angle (deg.)	Soil Strain, E50	Soil Modulus (pci)
0-35	Surface to 200	Soft to Medium Stiff Clay	118	56	750	--	0.02	30
35-45	200 to 190	Medium Dense Silty Sand	120	58	--	32	--	60
45-60	190 to 175	Dense Sand with Silt	125	63	--	35	--	90

Other Design Requirements

The wall shall have a drainage gutter at the top designed to carry surface runoff to either or both ends of walls. Details of this drainage feature shall be provided in Wall Designer/Contractor's wall design plans. If a Concrete Cantilever Wall is used, the wall designer must provide for a drainage layer behind the wall stem with adequate drainage provided via weep holes.