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**Remarks and Instructions**

The complete manual, revision packages, and individual chapters can be accessed at [www.wsdot.wa.gov/publications/manuals/m46-03.htm](http://www.wsdot.wa.gov/publications/manuals/m46-03.htm).

Please contact Tony Allen at 360-705-5450 or [allent@wsdot.wa.gov](mailto:allent@wsdot.wa.gov) with comments, questions, or suggestions for improvement to the manual.

**Instructions for Printed Manuals**

Page numbers indicating portions of the manual that are to be removed and inserted are shown below.

Chapter	Remove Pages	Insert Pages
Title Page	i-ii	i-ii
Chapter 15 Abutments, Retaining Walls, and Reinforced Slopes	15-71– 15-72	15-71– 15-72
Appendix 15-C Wall/Reinforced Slope Systems Evaluation: Submittal Requirements	15-C-1 – 15-C-10	15-C-1 – 15-C-8

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TECHNICAL MANUAL

# **Geotechnical Design Manual**

M 46-03.03

November 2010

**Environmental and Engineering Programs**

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As described previously, temporary structures are typically not designed for seismic loads, provided the design life of the shoring system is 3 years or less. Similarly, geologic hazards, such as liquefaction, are not mitigated for temporary shoring systems.

The design of temporary shoring must also take into account the loading and destabilizing effect caused by excavation dewatering.

#### 15.7.3.4 Design Property Selection

The procedures provided in WSDOT GDM [Chapter 5](#) shall be used to establish the soil and rock properties used for design of the shoring system.

Due to the temporary nature of the structures and cut slopes in shoring design, long-term degradation of material properties, other than the minimal degradation that could occur during the life of the shoring, need not be considered. Therefore, corrosion for steel members, and creep for geosynthetic reinforcement, need to only be taken into account for the shoring design life.

Regarding soil properties, it is customary to ignore any cohesion present for permanent structure and slope design (i.e., fully drained conditions). However, for temporary shoring/cutslope design, especially if the shoring/cutslope design life is approximately 6 months or less, a minimal amount of cohesion may be considered for design based on previous experience with the geologic deposit and/or lab test results. This does not apply to glacially overconsolidated clays and clayey silts (e.g., Seattle clay), unless it can be demonstrated that deformation in the clayey soil resulting from release of locked in stresses during and after the excavation process can be fully prevented. If the deformation cannot be fully prevented, the shoring/cutslope shall be designed using the residual shear strength of the soil (see WSDOT GDM [Chapter 5](#)).

If it is planned to conduct soil modification activities that could temporarily or permanently disturb or otherwise loosen the soil in front of or behind the shoring (e.g., stone column installation, excavation, etc.), the shoring shall be designed using the disturbed or loosened soil properties.

#### 15.7.4 Special Requirements for Temporary Cut Slopes

Temporary cuts slopes are used extensively in construction due to the ease of construction and low costs. Since the contractor has control of the construction operations, the contractor is responsible for the stability of cut slopes, as well as the safety of the excavations, unless otherwise specifically stated in the contract documents. Because excavations are recognized as one of the most hazardous construction operations, temporary cut slopes must be designed to meet Federal and State regulations in addition to the requirements stated in the WSDOT GDM. Federal regulations regarding temporary cut slopes are presented in CFR Part 29, Sections 1926. The State of Washington regulations regarding temporary cut slopes are presented in Part N of the Washington Administrative Code (WAC) Section 296-155. Key aspects of the

WAC with regard to temporary slopes are summarized below for convenience. To assure obtaining the most up to date requirements regarding temporary slopes, the WAC should be reviewed.

WAC 296-155 presents maximum allowable temporary cut slope inclinations based on soil or rock type, as shown in Table 15-8. WAC 296-155 also presents typical sections for compound slopes and slopes combined with trench boxes. The allowable slopes presented in the WAC are applicable to cuts 20 feet or less in height. The WAC requires that slope inclinations steeper than those specified by the WAC or greater than 20 feet in height must be designed by a registered professional engineer.

Soil or Rock Type	Maximum Allowable Temporary Cut Slopes (20 feet maximum height)
Stable Rock	Vertical
Type A Soil	¾H:1V
Type B Soil	1H:1V
Type C Soil	1½H:1V

**WAC 296-155 Allowable Temporary Cut Slopes**  
*Table 15-8*

**Type A Soil.** Type A soils include cohesive soils with an unconfined compressive strength of 3,000 psf or greater. Examples include clay and plastic silts with minor amounts of sand and gravel. Cemented soils such as caliche and glacial till (hard pan) are also considered Type A Soil. No soil is Type A if:

- It is fissured;
- It is subject to vibrations from heavy traffic, pile driving or similar effects;
- It has been previously disturbed;
- The soil is part of a sloped, layered system where the layers dip into the excavation at 4H:1V or greater; or
- The material is subject to other factors that would require it to be classified as a less stable material.

**Type B Soil.** Type B soils generally include cohesive soils with an unconfined compressive strength greater than 1000 psf but less than 3000 psf and granular cohesionless soils with a high internal angle of friction, such as angular gravel or glacially overridden sand and gravel soils. Some silty or clayey sand and gravel soils that exhibit an apparent cohesion may sometimes classify as Type B soils. Type B soils may also include Type A soils that have previously been disturbed, are fissured, or subject to vibrations. Soils with layers dipping into the excavation at inclinations steeper than 4H:1V can not be classified as Type B soil.

**Instructions**

The submittal requirements outlined below are intended to cover multiple wall types. Some items may not apply to certain wall types. If a wall system has special material or design requirement not covered in the list below, the WSDOT Bridge Design Office and the WSDOT Geotechnical Division should be contacted prior to submittal to discuss specific requirements.

To help WSDOT understand the functioning and performance of the technology and thereby facilitate the Technical Audit, Applicants are urged to spend the time necessary to provide clear, complete and detailed responses. A response on all items that could possibly apply to the system or its components, even those where evaluation protocol has not been fully established, would be of interest to WSDOT. Any omissions should be noted and explained.

Responses should be organized in the order shown and referenced to the given numbering system. Additionally, duplication of information is not needed or wanted. A simple statement referencing another section is adequate.

**Part One: Wall System Overview**

Provide an overview of the wall system. Product brochures will usually fulfill the requirements of this section.

**Part Two: Plan Details**

As a minimum, provide the following plan sheet details:

1. All system component details.
2. Typical plan, profile, and section views.
3. Details that show the facing batter(s) that can be obtained with the wall system (example details that illustrate the permissible range are acceptable).
4. Corner details
  - Acute inside corner
  - Obtuse inside corner
  - Orthogonal inside corner
  - Acute outside corner
  - Obtuse outside corner
  - Orthogonal outside corner

5. Radius Details (inside and outside radii, include system limitations).
  - Inside radii
  - Outside radii
  - System limitations for inside and outside radii
6. Traffic barrier systems
  - Guardrail
  - Precast barrier
  - Moment slab barrier
7. Horizontal obstruction details for obstructions
  - Horizontal obstructions up to 24 inches oriented parallel to the wall face
  - Horizontal obstructions up to 48 inches oriented perpendicular to the wall face
8. Vertical obstruction details for obstructions up to 48 inches.
9. Culvert Penetration
  - Up to 48 inch culverts oriented perpendicular to the wall face.
  - Up to 24 inch culverts oriented up to a 45 degree skew angle as measured from perpendicular to the wall face.
10. Leveling pad details in accordance with Section 6-13 of the WSDOT *Standard Specifications for Road, Bridge, and Municipal Construction*.
  - Minimum dimensions
  - Steps
  - Corners
11. Coping and gutter details.

All plan sheet details should be provided as 11×17 size, hard or electronic copies. All dimensions shall be given in English Units (inches and feet). The plan sheet shall as a minimum identify the wall system, an applicable sheet title, the date the plan sheet was prepared, and the name of the engineer and company responsible for its preparation.



## Part Three: Materials and Material Properties

WSDOT has established material requirements for certain non-proprietary wall components. These requirements are described in the WSDOT Standard Specifications for Road, Bridge, and Municipal Construction, and WSDOT General Special Provisions (GSP) available at [www.wsdot.wa.gov/design/projectdev/gspamendments.htm](http://www.wsdot.wa.gov/design/projectdev/gspamendments.htm). Specifically, GSP 130201.GB6 covers welded wire faced structural earth wall materials, GSP 130202.GB covers precast concrete panel faced structural earth wall materials, and GSP 130203.GB6 covers concrete block faced structural earth wall materials. All wall components falling into the categories currently defined by WSDOT should meet the WSDOT material requirements.

For materials not currently covered by WSDOT specifications, provide material specifications describing the material type, quality, certifications, lab and field testing, acceptance and rejection criteria along with support information for each material items. Include representative test results (lab and/or field) clearly referencing the date, source and method of test, and, where required, the method of interpretation and/or extrapolation. Along with the source of the supplied information, include a listing of facilities normally used for testing (i.e., in-house and independent).

All geosynthetic reinforced wall systems shall use a soil reinforcement product listed in the WSDOT Qualified Product List (QPL). Inclusion of geosynthetic reinforcement products on the QPL will be a necessary prerequisite to wall system approval.

1. For facing units, provide the following information:
  - Standard dimensions and tolerances
  - Joint sizes and details
  - Facing unit to facing unit shear resistance
  - Bearing pads (joints)
  - Spacers
  - Connectors (pins, etc.)
  - Joint filler requirements: geotextile or graded granular
  - Other facing materials, such as for reinforced slopes, or other materials not specifically identified above

2. For the soil reinforcement (applies to structural earth walls and reinforced slopes), provide the following information:
  - Manufacturing sizes, tolerances, lengths
  - Ultimate and yield strength for metallic reinforcement
  - Corrosion resistance test data for metallic reinforcement (for metallic materials other than those listed in the GSP's)
  - Pullout interaction coefficients for WSDOT Gravel Borrow (*Standard Specification* 9-03.14(4)), or similar gradation, if default pullout requirements in the AASHTO LRFD Bridge Design Specifications are not used or are not applicable.
3. For the connection between the facing units and the soil reinforcements (applies to structural earth walls and reinforced slopes), provide the following information:
  - Photographs/drawings that illustrate the connection
  - Connection strength as a percent of reinforcement strength at various confining pressures for each reinforcement product, connection type, and facing unit.
4. For the coping, provide the following information:
  - Dimensions and tolerances
  - Material used (including any reinforcement)
  - Method/details to attach coping to wall top
5. For the traffic railing/barrier, provide the following information:
  - Dimensions of precast and cast-in-place barriers and reaction slabs
  - How barrier/railing is placed on/in and/or attached to wall top
  - How guard railing is placed on/in and/or attached to wall top
6. Regarding the quality control/quality assurance of the wall system material suppliers, provide the following information:
  - QC/QA for metallic or polymeric reinforcement
  - QC/QA for facing materials and connections
  - QC/QA for other wall components
  - Backfill (unit core fill, facing backfill, etc.)

## Part Four: Design

Walls shall be designed in conformance with the WSDOT *Geotechnical Design Manual (GDM)*, *LRFD Bridge Design Manual (BDM)*, and the *AASHTO LRFD Bridge Design Specifications*. Provide design assumptions and procedures with specific references (e.g., design code section) for each of the design requirements listed below. Clearly show any deviations from the WSDOT *Geotechnical Design Manual (GDM)*, *LRFD Bridge Design Manual (BDM)* and the *AASHTO LRFD Bridge Design Specifications*, along with theoretical or empirical information which support such deviations. In general, proprietary wall suppliers will only be responsible for internal stability of their wall system. However, if there are any special external stability considerations for the wall system, those special considerations should be identified and explained in the wall system submittal.

Provide detailed design calculations for a 25 ft high wall with a 2H:1V sloping soil surcharge (extending from the back face of the wall to an infinite distance behind the wall). The calculations should address the technical review items listed below. The calculations shall include detailed explanations of any symbols, design input, materials property values, and computer programs used in the design of the walls. The example designs shall be completed with seismic forces (assume a PGA of 0.50g). In addition, a 25 ft high example wall shall be performed with no soil surcharge and a traffic barrier placed on top of the wall at the wall face. The barrier is to be of the “F shape” and “single slope” configuration and capable of resisting a TL-4 loading in accordance with WSDOT *LRFD Bridge Design Manual (BDM)* Section 10.2.1 for barrier height and test level requirement. With regard to the special plan details required in Section 2, provide an explanation of how the requirements in the WSDOT *Geotechnical Design Manual (GDM)*, *LRFD Bridge Design Manual (BDM)*, and the *AASHTO LRFD Bridge Design Specifications* will be applied to the design of these details, including any deviations from those design standards, and any additional design procedures not specifically covered in those standards, necessary to complete the design of those details. This can be provided as a narrative, or as example calculations in addition to those described earlier in this section.

For internal stability design, provide design procedures, assumptions, and any deviations from the design standards identified above required to design the wall or reinforced system for each of the design issues: listed below. Note that some of these design issues are specific to structural earth wall or reinforced slope design and may not be applicable to other wall types.

1. Assumed failure surface used for design
2. Distribution of horizontal stress

3. How surcharge loads are handled in design
  - Concentrated dead load
  - Sloped surcharge
  - Broken-back surcharge
  - Live load
  - Traffic impact
4. Determination of the long-term tensile strength of reinforcement
5. Pullout design of soil reinforcement or facing components that protrude into wall backfill
6. Determination of vertical and horizontal spacing of soil reinforcements (including traffic impact requirements)
7. Facing design
  - Connections between facing units and components
  - Facing unit strength requirements
  - Interface shear between facing units
  - Connections between facing and soil reinforcement/reinforced soil mass
  - How facing batter is taken into account for the range of facing batters available for the system
  - Facing compressibility/deformation, if a flexible facing is used
8. Seismic design considerations
9. Design assumptions/parameters for assessing mobilization of backfill weight internal to wall system (primarily applies to prefabricated modular walls as defined in the AASHTO LRFD Bridge Design Specifications)

List all wall/slope system design limitations, including:

- Seismic loading
- Environmental constraints
- Wall height
- External loading
- Horizontal and vertical deflection limits
- Tolerance to total and differential settlement
- Facing batter
- Other

#### Computer Support:

If a computer program is used for design or distributed to customers, provide representative computer printouts of design calculations for the above typical applications demonstrating the reasonableness of computer results. All computer output submitted shall be accompanied by supporting hand calculations detailing the calculation process. If MSEW 3.0, or later version, is used for the wall design, hand calculations supporting MSEW are not required.

#### Quality Control/Quality Assurance for design of the wall/slope systems:

Include the system designer's Quality Assurance program for evaluation of conformance to the wall supplier's quality program.

### **Part Five: Construction**

Provide the following information related to the construction of the system:

1. Provide a documented field construction manual describing in detail and with illustrations as necessary the step-by-step construction sequence, including requirements for:
  - Foundation preparation
  - Special tools required
  - Leveling pad
  - Facing erection
  - Facing batter for alignment
  - Steps to maintain horizontal and vertical alignment
  - Retained and backfill placement/compaction
  - Erosion mitigation
  - All equipment requirements
2. Include sample construction specifications, showing field sampling, testing and acceptance/rejection requirements. Provide sample specifications for:
  - Materials
  - Installation
  - Construction
3. Quality Control/Quality Assurance of Construction:

Describe the quality control and quality assurance measurements required during construction to assure consistency in meeting performance requirements.

## Part Six: Performance

Provide the following information related to the performance of the system:

1. Provide a copy of any system warranties.
2. Identify the designated Responsible Party for:
  - System performance
  - Material performance
  - Project-specific design (in-house, consultant)
3. List insurance coverage types (e.g., professional liability, product liability, performance) limits, basis (i.e., per occurrence, claims made) provided by each responsible party
4. Provide a well documented history of performance (with photos, where available), including:
  - Oldest
  - Highest
  - Projects experiencing maximum measure settlement (total and differential)
  - Measurements of lateral movement/tilt
  - Demonstrated aesthetics
  - Project photos
  - Maintenance history
5. Provide the following types of field test results, if available:
  - Case histories of instrumented structures
  - Construction testing
  - Pullout testing
6. Regarding construction/in-service structure problems, provide case histories of structures where problems have been encountered, including an explanation of the problems and methods of repair.
7. Provide a list of state DOT's that have used this wall system, including contact persons, addresses and telephone numbers.