Section 17 - Abutments and Walls

17.1 Design Criteria and Guidance

1. Design of abutments and walls shall be in accordance with Section 11 of the *AASHTO LRFD Bridge Design Specifications* (With Current Interims).
2. For contracts with long walls or several walls, design and detailing information may be conveniently presented in a panel-by-panel tabulation.

a. Panels should be identified numerically on the General Plan and Elevation and referred to in the tabulation. Similarly, various types of wall sections, reinforcement patterns, etc. should be detailed once and identified for use in the tabulation.

b. The tabulation should also indicate footing dimensions for each panel, panel end point elevations and footing elevations.

3. Details such as the placement and arrangement of non-stress reinforcement on wall stems, key construction, porous fill placement, drainage for back of walls and joint construction are common to all panels and should be presented once in a contract set of plans.
4. When "stepped" footings are used for long walls, the step should preferably not be greater than the depth of the footings, except that when the footing is on piles, the step may be twice the depth of the footing. A 1:1 slope of the concrete should be provided at each step.
5. Expansion and Contraction Joints. For reinforced concrete walls, contraction joints shall be provided at intervals not exceeding 30 feet. Expansion joints shall be provided at intervals not exceeding 90 feet. Abutment joints shall be located approximately midway between the longitudinal superstructure members that rest on the abutment seat.
6. Keyed contraction joints shall be provided in footings. They shall be located under the wall expansion joints.
7. Back of wall drainage shall be provided for all walls including U-Type semi-stub abutments. Weep holes through walls shall not be used where they empty onto pedestrian sidewalks or onto roadways where ponding and freezing could create a safety hazard.

   Roadway drainage provisions shall be detailed so that drainage pipes do not empty directly through abutment walls.
8. Wing stems ("elephant ears") shall be shown on the plans for U-Type and flared walls in accordance with the details shown on Guide Plate 3.4-5. The stems of walls shall be designed for combined axial load (including dead load of stem and of backfill acting on stem) and bending due to vertical loads and earth pressure.
9. Designers and detailers should be aware that form work is a substantial part of the construction cost for walls and abutments. Details that permit reuse of forms on as many sections as possible produce economies in the overall construction cost.
10. When battered cross sections are used, the batter of forms should always remain constant and the width of the wall at the top of the batter should be

wide enough so the form can extend beyond the top of the batter and still have enough room between the front and rear forms to easily place the concrete.

11. Batters that extend only part way up a wall should be avoided. If partial batters are used, the height of the battered portion should always be made a constant height. If the height of the battered portion is constant with respect to the top of the footing, then the variation in height shall be made up in the upper vertical portion of the wall. This will allow maximum reuse of the battered form.
12. Curved wingwalls should be avoided wherever possible and should not be battered since the shape of the form must be dish-shaped which is extremely difficult to form.
13. If it is absolutely necessary to provide a curved wingwall, it is best to place the footing and the wall on chords and curve only the top portion of the wall.
14. Subsection 11.6.3.3 – Overturning and 11.6.3.6 – Sliding of the AASHTO LRFD Specifications may be referred to for consideration of these phenomena in Abutment and Wall designs.
15. Due to the non-standardization of design parameters for assessing the use of bridge seat pedestals, planning for the construction of pedestals on abutment bridge seats is not permitted.
16. Use of corrosion protected reinforcement steel shall be scheduled for, initially, all abutment wall grillage reinforcement and the exposed side of retaining walls. Engineering judgment should be used to evaluate the project location toward possibly planning for the use of corrosion protected reinforcement steel for the entire abutment wall or retaining wall construction.

    Also, if it is determined that the project site environment is aggressive in nature, then use of a reinforcement steel other than epoxy coated reinforcement steel may be scheduled for the abutment wall or retaining wall construction.

    To further offset the potential of corrosion development, concrete mix designs for abutment or retaining wall construction may include a corrosion inhibitor admixture.

17.2 Design Parameters

1. f'c.....3000 psi
2. fc.....1200 psi
3. Shrinkage and Temperature Reinforcement:

    Shrinkage and temperature reinforcement for Abutment walls shall be provided in accordance with Subsection 5.10.8 of the *AASHTO LRFD Bridge Design Specifications*. Minimum reinforcement shall be provided in accordance with Subsection 5.7.3 of the *AASHTO LRFD Bridge Design Specifications*.

    Refer to Guide Plates 3.3-1, 3.3-2, and 3.4-1 for more information.

4. The Designer shall verify the need for batter in walls under 10 feet in height. Walls over 10 feet in height shall have a minimum batter of 12:1. The wall

height shall be measured from the top of the footing at the rear face of the stem to the top of the wall.

5. The rear face of abutments shall be plumb.
6. The design of sheet pile retaining walls shall be based on a permissible lateral deflection that will be equal to 1% of the exposed height of the wall but not greater than two (2) inches. This limitation shall account for the action on a wall by construction activities and equipment.
7. Vertical load of approach slab reacting on abutment back wall:

   Treat approach slab as a simple span beam, assuming that the one third length of approach slab is uniformly supported on soil at the end.

17.3 Alternate Retaining Wall Systems

1. Designers are encouraged to use alternate retaining wall systems at select project locations. Mechanically Stabilized Earth Wall (MSE) systems, the Prefabricated Modular Walls (i.e. Doublewal system, T-Wall system), instead of a conventional cast-in-place reinforced concrete cantilever retaining wall system, should be evaluated for use in a project that involves retaining wall construction.

   The design criteria of Subsections 11.10 and 11.11 of the AASHTO LRFD Specifications shall be adhered to for the design, respectively, of MSE wall systems and Prefabricated Modular Wall systems.

   The submission methodology presented in Subsection 6.2 of this Manual shall be followed for submission of MSE wall systems, the Doublewal system or the T-Wall system. However, the use of the methodology shall only be used for those instances where such walls are to be built to a maximum height of thirty (30) feet.

   MSE wall systems, the Doublewal system or T-Wall system in heights greater than this height may be provided. However, for heights greater than 30 feet complete wall plans must be provided with the final construction plans. The wall plans must include the internal stability design and this design must be reviewed by the project Designer.
2. Approved Alternate Retaining Wall Systems are listed in the NJDOT Approved Materials Database. Following is a link to this Database: www.state.nj.us/transportation/eng/materials/qualified.
3. When alternate retaining wall systems are identified for use in a project, unless otherwise directed, a design for the cast-in-place cantilever wall system is not required.
4. As advised in Subsection 6.2 of this Manual, based on the suitability of a site for an Alternate Retaining Wall System, Control Plans may be developed with the intent that only one type wall system will be constructed.
5. For those projects where use of Proprietary Walls is not feasible, a presentation for a cast-in-place reinforced concrete cantilever retaining wall system shall be provided.
6. Sections 6 and 7 of this Manual may be referred to for guidance in providing Preliminary and Final submission Control Plans for alternate retaining wall presentations. The following guidance shall also be followed:

a. For MSE Walls, a prefabricated modular walls (Doublewal or T-Wall systems) a drainage system consisting of an 8 inch P.C.M.P. and 2' x 2' stone pocket shall be placed parallel to and behind the wall. The area above the stone pocket behind the wall shall be backfilled with I-9 porous fill or broken stone same as the broken stone selected for the backfill behind the wall system.

b. For MSE wall systems that are located adjacent to roadways that may be chemically deiced, to intercept any flows that may contain the deicing chemicals, an impervious membrane shall be placed below the pavement and just above the first row of reinforcements. The membrane shall be sloped to drain away from the wall facing. Refer to the Standard Specifications for the type of material to be used.

c. The NJDOT Standard Specifications permit the use of select granular borrows excavation material or broken stone as backfill material. When broken stone is used, geotextile filter fabric material shall be placed at the interface of the broken stone and regular roadway materials and/or embankments.

d. In submitting calculations, the wall supplier shall account for the use of the two type backfill materials. The soil unit weight and the frictional factor of broken stone shall be included in the design calculations.

e. The minimum unbalanced hydrostatic pressure for design of MSE Wall systems shall be based on a 3 foot lag. This unbalanced hydrostatic pressure shall be considered as a permanent condition when designing MSE Wall systems.

f. External Stability Design shall conform to the criteria specified in Subsection 11.10.5 of the *AASHTO LRFD Bridge Design Specifications*.

   Internal Stability Design shall conform to the criteria specified in Subsection 11.10.6 of the *AASHTO LRFD Bridge Design Specifications*.

g. When designing the moment (anchor) slab for concrete barrier installation, the design of the barrier section shall follow the criteria stated in Subsection 23.3 of this Manual. The design of the moment slab section shall be based on a 10 kip transverse force. For stability analysis, a 20 feet length of moment slab shall be used to counteract sliding and overturning.

   The Designer is encouraged to refer to the *NCHRP Project 22-20 Report Design of Roadside Barrier Systems Placed on MSE Retaining Walls* for more guidance.

h. When site conditions permit the construction of either the Doublewal system, the T-Wall system or a MSE Wall system, a coefficient of base friction shall not be indicated on the Control Plan. Soil parameters for the following areas, shall be specified on the Control Plan:

   - Foundation Material
   - Fill Material within the wall system
   - Fill Material behind the wall system

   The specified soil parameters shall be the friction angle of the soil and the unit weight of the soil.

7. Subsections 11.10.1 and 11.11.1 of the *AASHTO LRFD Bridge Design Specifications* establish conditions that preclude construction of respectively,

MSE wall and Prefabricated Modular Wall Systems. The following limitations should be adhered to in the proposed use of alternate retaining wall systems:

a. MSE walls should not be used under the following conditions:
   - When utilities other than highway drainage must be constructed within the reinforced zone.
   - When the floodplain erosion may undermine the reinforced fill zone, or where the depth of scour cannot be reliably determined.
   - When aggressive soil conditions exist, steel reinforced systems shall not be used.

b. Prefabricated modular wall systems shall not be used under the following conditions:
   - On curves with a radius of less than 800 feet, unless the curve can be substituted by a series of chords or unless fabrication techniques may be used to overcome the curvature limitations.
   - Steel modular systems shall not be used where the ground water or surface runoff is acid contaminated or where de-icing spray is anticipated.

8. Use of MSE wall systems that include extensible reinforcements (polymeric reinforcement) is permitted with prior approval from the Manager, Structural Engineering. However, their use is restricted to locations where the maximum height of the wall is 20 feet.

9. Based on the guidance provided in Subsection 2.3.3.3.1 of the *AASHTO LRFD Specifications*, a proprietary wall system may be protected by Guide Rail against a vehicular impact. The Guide Rail installation shall conform to Department standards.

17.4 Alternate or Proprietary Type Abutments

1. Alternate type abutments; such as, sheet pile abutments, or Mechanically Stabilized Earth (MSE), Doublewal or T-Wall type systems may be considered. Their use is subject to the approval of the Manager, Structural Engineering.

2. These type abutment systems shall be designed based on a 100 service year life.

3. Corrosion protection for steel sheet piles and tie backs shall include the provision of galvanizing, epoxy coating, additional thickness, sheathing of tie backs and/or other methods to assure the 100 year service life.

4. Sheet pile abutments should not be used under the following conditions:

   a. When tie backs are required and utilities other than highway drainage must be constructed within the reinforced zone.

   b. When metallic tie bars exposed to surface or ground water that is contaminated by acid mine damage or industrial pollutants, as indicated by low pH and low chlorides and sulfates, are required.

5. Refer to 17.3 for MSE, Doublewal and T-Wall wall system requirements. Criteria stated therein shall be applied in such Abutment designs.

17.5 Landscape Walls

1. Retaining walls that are six (6) feet or less in height shall be considered to be Landscape Walls.

2. As discussed in Subsection 11.6.1.2 of the *AASHTO LRFD Bridge Specifications*, the following minimum design provisions shall be considered in designing Landscape walls:
    a. Lateral earth and water pressures, including any live and dead load surcharge.
    b. The self weight of the wall.
    c. Temperature and Shrinkage deformation effects.
3. Appropriate drainage provisions shall be provided to prevent hydrostatic and seepage forces from developing behind the wall.
4. Dependent on site conditions and type of backfill to be used, consideration should be given to the need to reinforce the backfill zone area.
5. Plans for the construction of landscape walls should not be provided with structural plans. Typically, they should be included in a project plan set as part of Landscape plans.