NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION

BUREAU OF BRIDGE DESIGN

BDM CHAPTER 4 - REVISION HISTORY

Date of Revision	Action	Location of Change	Revision Description	Background
3/14/2016	Section 4.3. Replace all pages.	Section 4.3.2, page 4.3-1	NHDOT Unit Weights Table 4.3.2-1: Revised unit weight of Granular Backfill (Bridge) from 125 pcf to 120 pcf.	The unit weight in the table didn't get revised when the value in Section 4.3.3 Select Backfill and Prepared Foundation Material Properties was revised.
2/8/2016	Section 4.3. Replace all pages.	Section 4.3.3, page 4.3-3,4	B. At-Rest Lateral Earth Pressure Coeffiecient (k_0): **Revised sentence to** : *The resultant lateral earth force is assumed to act parallel to the backfill.* From: ~~The resultant lateral earth force is assumed to act parallel to the angle of the back slope.~~ **Added last paragrah**: *Most retaining walls are not designed for the at-rest earth pressure condition. Minimum wall movements required to reach the active pressure condition are given in AASHTO LRFD Table C3.11.1-1. Walls that can tolerate little or no movement should be designed for the at-rest lateral earth pressure condition. Even if the retaining wall is bearing on bedrock, it may still be able to rotate and meet the minimum wall movement to reach active pressure. The Geotechnical Engineer will recommend if an At-Rest condition should be used.* C. Active Lateral Earth Pressure Coefficient (k_a), **1) Put Rankine Therory under numberical 1) and replaced 1st & 2nd paragraph:** **To:** *The Rankine theory is intended to be used for determining earth pressure on a frictionless vertical plane within a soil mass and not directly against the wall. The resultant lateral earth force acts on the vertical plane at an angle β that is assumed to be parallel to the backfill.* **From:** ~~*The Rankine theory is intended to be used for determining earth pressure on a frictionless vertical plane within a soil mass and not directly against the wall. The resultant lateral earth force on the vertical plane (virtual vertical back of wall) acts at an angle parallel to the back slope. In general the Rankine theory applies to concrete cantilever walls with long hell projections and mechanically stabilized earth walls.*~~ **2) Revised 1st paragraph To:** *Coulomb theory is based on the static equilibrium of an assumed sliding wedge of cohesionless soil and takes into account the friction that develops along the back of the retaining wall and along the failure surface in the backfill. The resultant lateral earth force acts at an angle δ measured from a line normal to the back of the wall, where δ is the angle of friction between the backfill and back of wall. Refer to AASHTO LRFD Table 3.11.5.3-1 for values of angle δ.*	Clarification that At-Rest lateral earth pressures should be used with the recommendation from the Geotechnical Engineer. Typically most cantilever concrete walls have movement to reach the active pressure even if bearing on bedrock.

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			From: ~~Coulomb theory is based on the static equilibrium of an assumed sliding wedge of cohesionless soil and takes into account the friction that develops along the back of the retaining wall and along the failure surface in the backfill. The resultant lateral earth force acts at an angle measured from a line normal to the back of the wall, where is the angle of friction between the backfill and back of wall. Refer to AASHTO Table 3.11.5.3-1 for values of angle . In the case of a concrete cantilever wall the resultant lateral earth force acts at an angle to the plane extending vertically up from the heel of the footing (vertical virtual back of wall). The angle in this case may be taken as 0.33 f to 0.67 f b.~~ **Deleted last paragraph:** ~~In general the Coulomb theory applies to gravity; semi-gravity; prefabricated modular; nongravity cantilevered (e.g., sheetpile); and concrete cantilever walls with short or long heel projections.~~ **Replaced:** ~~3) Rankine Active Earth Pressure - Equivalent Fluid Method~~ **To:** *3) Adjustment for Broken Back Backfill Surface Condition:* *For situations with a broken back backfill, the lateral active earth pressure may be determined assuming a projected infinite back slope of angle β', as shown in Figure 4.3.3-1 (AASHTO LRFD Figure 3.11.5.8.1-3). For determining the active lateral earth pressure coefficient, ka, the angle β' is substituted for the angle β in the equations given herein.*	
		Section 4.3.3, page 4.3-5	**Deleted:** ~~4) Active Earth Pressure - Broken Back Slope Surface:~~ **Replaced:** ~~5) Active Earth Pressure - Application to Concrete Cantilever Walls:~~ **To:** *D. Cantilever Retaining Walls and Abutments (with heel projections):*	NHDOT has been using the Rankine Theory for many years in the design of concrete cantilever walls; which produces a more conservative design for level backfill and similar to Coulomb Theory designs as the backfill slope increases. There have been no issues with NHDOT's designs, therefore, it was decided to use Rankine Theory for all concrete cantilever wall designs.

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		Section 4.3.3, page 4.3-7	Replaced: D. Passive Lateral Earth Pressure Coeffiecient (kp): **From:** ~~Values of the passive lateral earth pressure coefficient, kp, should be approximated using AASHTO Figures 3.11.5.4-1 & 2 which are based on the Log-Spiral Method. Both Rankine and Coulomb theories assume the failure surface to be a straight plane, which is a reasonable assumption for active earth pressure; however, for passive earth pressure this assumption may give unsafe results. For passive earth pressure, most failure surfaces are curved and commonly assumed to be the arc of a logarithmic spiral.~~ ~~Passive resistance at the front of a retaining wall should typically be neglected due to the potential for erosion or future excavation of the material. Passive resistance should not be included in stability calculations, unless permitted herein or approved by the Design Chief of the Bureau of Bridge Design.~~ ~~Passive resistance may be considered for retaining wall stability analysis for seismic loading cases.~~ ~~Passive resistance should be considered for integral abutment and sheet pile retaining wall design (See Chapter 6, Substructure).~~ **To:** E. Passive Lateral EArth Pressure Coefficient (kp):	Clarification.

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		Section 4.3.3, page 4.3-8	**Replaced:** ~~E. Select Backfill Properties:~~ ~~NHDOT uses material conforming to Item 209.20x Granular Backfill (Bridge) for backfilling all retaining structures. This material gradation is the same as Item 304.2, Gravel and is a free draining, very dense, granular material. The following properties should be used for this backfill material unless recommended otherwise by the Geotechnical Report:~~ ~~$\phi'f$ = effective angle of internal friction of backfill = 34°~~ ~~γs = unit weight of backfill = 125-pcf (2002-kg/m3)~~ **To:** *F. Select Backfill and Prepared Foundation Material Properties* *NHDOT uses material conforming to Item 209.20x Granular Backfill (Bridge) for backfilling all retaining structures. This material gradation is the same as Item 304.2, Gravel and is a free draining, very dense, granular material. The following properties shall be assumed for this backfill material and for the in-situ soil mass within the failure wedge, unless otherwise recommended by the Geotechnical Report:* *$\phi'f$ = effective angle of internal friction of backfill = 34°* *γs = unit weight of backfill = 120-pcf (1922-kg/m3)* *NHDOT uses material conforming to Item 508 Structural Fill under foundations for providing a well graded support of structures. This material consists of crushed gravel gradation as noted in the specification. The investigating foundation failure by sliding, the following properties shall be assumed for this material unless otherwise recommended by the Geotechnical Report:* *ϕf = effective angle internal friction of structural fill = 36°*	Unit weight of backfill for MSE walls = 125-pcf, so originally it was decided to make the backfill unit weight the same as the MSE wall backfill. However, NHDOT Bridge Design has typically used 120-pcf for the unit weight of backfill for abutments and wingwalls. NHDOT Geotechnical Engineer agreed 120-pcf unit weight reflects the Granular Backfill (Bridge) material. Effective angle of internal friction for structural fill was added.

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		Section 4.3.4, page 4.3-8	**Revised**: 4.3.4 Surcharge Loads: **From:** ~~Lateral earth pressures due to surcharge loads shall be taken into consideration and applied in accordance with AASHTO 3.11.6.~~ ~~Live load surcharge shall be applied in accordance with AASHTO 3.11.6.4. Equivalent heights of soil for vehicular loading for various abutment heights are shown in AASHTO Tables 3.11.6.4-1& 2.~~ ~~Where reinforced concrete approach slabs of sufficient length are provided at bridge ends, live-load surcharge need not be considered; however, the bridge designer shall consider the reactions on the abutment due to the axle loads on the approach slabs. Retaining walls that retain soil supporting a roadway must be able to resist the lateral pressure due to the live-load surcharge, except the sections of U-back wingwalls adjacent to an approach slab (See Chapter 6, Substructure).~~ **Added:** Figure 4.3.4-1	Clarified the application of surcharge loads. Load cases should be investigated with and without vertical load due to surcharge for when calculating bearing stress and structure design. The veritcal load due to surcharge is not applied for calculating sliding or eccentricity. The equivalent horizontal pressure due to surcharge is applied for all calcualtions.
		Section 4.3.5, page 4.3-10	4.3.5 Live Loads: C. Dynamic Load Allowance, **Revised:** Dynamic load allowance shall be applied to the following : **Added bullet:** • Counterforts and caps of spilled through abutments **Revised bullet:** to read: "• Integral abutment caps and piles" **Revised:** Dynamic load allowance shall not be applied to the following: Revised 5th bullet **To:** *• All foundation components entirely below ground, including abutment stem (except as specified for integral abutments)* **From:** ~~*• All foundation components entirely below ground(except as specified for integral abutments)*~~	Clarification. It was decided that dynamic load allowance does not need to be applied to the abutment stem but should be applied to the integral abutment caps since it's applied to the integral abutment piles and to counterfort abutments.
		Section 4.3.6, page 4.3-11	4.3.6 Vehicular Breaking Force: **Added 3rd open bullet to 3rd bullet**: *o For bridges with fixed and sliding bearings, any amount of force above the friction force of the sliding bearings must be distributed to the fixed bearings.*	Clarification.

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Date of Revision	Action	Location of Change	Revision Description	Background
		Section 4.3.8, page 4.3-15	4.3.8 Friction Force: **Added 5th paragraph:** *A friction-acting bearing can only transmit the longitudinal force that causes the bearing to move. Any amount of force above the friction force must be distributed to the fixed bearings.* **Revised PTFE description:** **To:** *PTFE (Teflon) surface: unfilled sheet slides across a smooth stainless steel plate (typical NHDOT bearing).* **From:** ~~PTFE (Teflon) surface slides across a smooth stainless steel plate~~ **Added:** *"*Choose one"* ** Note: If a lower coefficient of friction is needed for the design, then the filled, dimpled-lubricated can be specified and the thickness of the PTFE increased for the machining of the dimples as noted in AASHTO LRFD 14.7.2.1. The dimpled condition is rarely used, requires longer fabrication time, and is expensive.*	Clarification.
		Section 4.3.11, page 4.3-18	4.3.11 Wind Loads: **Revised A. Wind Velocity:** **To:** *The design 3-second gust wind speed, V, shall be the wind speed at the project location as interpolated from AASHTO LRFD Figure 3.8.1.1.2-1 (ASCE 7-10, 2010, MRI 700 years). For the Special Wind Region (i.e. regions along the NH-VT border and Franconia Notch) as shown in AASHTO LRFD Figure 3.8.1.1.2-1, the maximum-recorded wind speed in this area shall be used if it is greater than 115-mph (185-kph), else use 115-mph (185-kph). See Chapter 10, Appendix 10.2-A1 and weather stations in the special wind region for recorded wind speeds.* **From:** ~~Basic wind speed of 100-mph (161 km/hr) shall be used for the entire state of NH except in the Special Wind Region (i.e. regions along the NH-VT border and Franconia Notch) as shown in figure 6-1 of ASCE 7-05. The maximum-recorded wind speed in this area shall be used as the basic wind speed if it is greater than the NH basic wind speed of 100-mph (161 km/hr). See Chapter 10, Appendix 10.2-A1 and weather stations in the special wind region for recorded wind speeds. If the structure or components of the structure are more than 30 ft. (9.1 m) above the ground or water level, the design wind velocity shall be adjusted in accordance with AASHTO 3.8.1.1-1.~~	AASHTO LRFD 2016 Interims updated the wind speed map to ASCE 7-10. The designer will need to interpolate the wind velocity from the map.

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			B. Wind Load to Superstructure: **Revised 1st paragraph to:** *The design wind pressures, Pz, shall be applied to the superstructure elements as specified in AASHTO LRFD 3.8.1.2.* **From:** ~~To determine WS, the base wind pressures, PB, shall be applied to the superstructure elements as specified in AASHTO 3.8.1.2.~~ **Revised E. Vertical Wind Load, 3rd bullet:** **To:** • *For typical bridges the pressure is applied only in the Strength III and Service IV load combination when the wind skew angle with respect to the superstructure is zero degrees.* **From:** ~~• For typical bridges the pressure is applied only in the Strength III load combination when the wind skew angle with respect to the superstructure is zero degrees.~~	
		Section 4.3.14, page 4.3-21	4.3.14 Vehicular Collison Force: **2nd Bullet: Added 2nd clear bullet:** "*Vehicular collision force is not required for MSE walls supporting shallow stub abutments or MSE retaining walls (NHDOT Bridge Deisgn policy). The vehicular impact would be limited to the panel facing where some loss of adjacent backfill would occur. The tension reinforcement directly above the voids at the impact location should provide enough 'bridging' support until the wall is repaired."* **3rd clear bullet: Deleted word:** "~~foundations~~"	Clarification that MSE walls do not need a 54" single slope barrier to protect it from a vehciular impact.