OHIO DEPARTMENT OF TRANSPORTATION

CENTRAL OFFICE, 1980 W. BROAD ST., COLUMBUS, OHIO 43216-0899

July 15, 2011

To: Users of the Bridge Design Manual

From: Tim Keller, Administrator, Office of Structural Engineering

By: Sean Meddles, Bridge Standards Engineer

Re: 2011 Third Quarter Revisions

Revisions have been made to the ODOT Bridge Design Manual, July 2007. These revisions shall be implemented on all Department projects with a Stage 1 plan submission date after July 15, 2011.

This package contains the revised pages. The revised pages have been designed to replace the corresponding pages in the book and are numbered accordingly. Revisions, additions, and deletions are marked in the revised pages by the use of one vertical line in the right margin. The header of the revised pages is dated accordingly.

To keep your Manual correct and up-to-date, please replace the appropriate pages in the book with the pages in this package.

To ensure proper printing, make sure your printer is set to print in the 2-sided mode.

The July 2007 edition of the Bridge Design Manual may be downloaded at no cost using the following link:

http://www.dot.state.oh.us/Divisions/Engineering/Structures/standard/Pages/default.aspx

Attached is a brief description of each revision.

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Summary of Revisions to the July 2007 ODOT BDM

BDM Section	Affected Pages	Revision Description
202.2.3.2.B	2-13 through 2-13.2	A sentence was added to clarify the plan specified Ultimate Bearing Value.
203.2.H	2-22	An overly restrictive provision for a maximum one foot rise in backwater for bridges located outside of NFIP jurisdictions was removed.
204.6	2-26	The “Prestressed Concrete” wall type was replaced by “Precast Concrete”
209.3	2-39	The provisions for drainage flumes for surface drainage at the end of bridges were revised in accordance with Standard Hydraulic Construction Drawing DM-4.1.
301.4.2	3-3	This revision identifies the AASHTO Guide Specifications for the Design of Pedestrian Bridges as the primary design specifications for pedestrian and bikeway bridges.
304	3-72 through 3-75	• Introduce the AASHTO “Manual for Assessing Safety Hardware” (MASH). • The new Deep Beam Bridge Retrofit Railing, DBR-3-11, has been added to the list of standard railing types. • Require DBR-2-73 to be upgraded to DBR-3-11 if this system is utilized on a new structure.
602.2	6-4	This revision changes the uniform design loading for pedestrian and bikeway bridges to be consistent with the AASHTO Guide Specifications for the Design of Pedestrian Bridges.
606.4	6-17	The contact information for the H-pile splicer has been revised.
Figure 801-2		Information was updated for Faddis Concrete Products.

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have steel points. Steel points should not be used when the piles are driven to bear on shale.

For projects where steel points are to be used, include the plan note entitled "Item 507, Steel Points, As Per Plan" with the Structure General Notes (Section 600 of this Manual).

202.2.3.2.b PILES NOT DRIVEN TO REFUSAL ON BEDROCK

Piles not driven to refusal on bedrock develop their geotechnical resistance by a combination of soil friction or adhesion along the sides of the pile and end bearing on the pile tip. These piles are typically referred to as friction piles. The preferred type of friction piles are cast-in-place reinforced concrete piles.

Cast-in-place reinforced concrete piles are closed end steel pipes that are filled with concrete after the piles have been driven into the ground to the required ultimate bearing value. Except for capped pile piers as mentioned below, the steel pipe provides sufficient reinforcement and no additional reinforcing steel is required.

The Ultimate Bearing Value (R_{ndr}) is the nominal driving resistance required to support the total factored load ($\sum \eta_i \gamma_i Q_i$) applied to a pile. Every pile in a single substructure unit shall be driven to the same Ultimate Bearing Value as the pile with the largest factored load in the unit. The Ultimate Bearing Value for each pile shall be provided in the structure general notes. The value listed in the notes shall be the calculated nominal driving resistance for the piles in the substructure unit and not the maximum Ultimate Bearing Value from the table for the selected pile type and size, unless the calculated nominal driving resistance is the same as the maximum Ultimate Bearing Value. A sample note is provided in BDM Section 600. The Ultimate Bearing Value may need to be adjusted during detail design as the design loads for the Service, Strength and Extreme Event Limit States are refined.

The Ultimate Bearing Value for each pile to be shown in the plans shall be determined as follows:

$$R_{ndr} = \frac{\sum \eta_i \gamma_i Q_i}{\phi_{DYN}}$$

Where:

R_{ndr} = Ultimate Bearing Value (Kips)

$\sum \eta_i \gamma_i Q_i$ = Total factored load for highest loaded pile at each substructure unit (Kips)

ϕ_{DYN} = Resistance factor for driven piles

ϕ_{DYN} = 0.70 for piles installed according to CMS 507 and CMS 523.

Determine the estimated length for friction piles using static analysis methods to calculate the length of pile necessary to develop the Ultimate Bearing Value as follows:

$R_{ndr} = R_S + R_P$

Where:

R_S = Nominal resistance (i.e. **Unfactored** resistance) provided along the side of the pile,

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LRFD 10.7.3.8.6

R_P = Nominal resistance (i.e. **Unfactored** resistance) provided at the pile tip, *LRFD 10.7.3.8.6*

The commonly used pipe pile sizes and the maximum Ultimate Bearing Value allowed for each are listed below:

Pipe Pile Diameter	Maximum R_{ndr}
12 inch	330 kips
14 inch	390 kips
16 inch	450 kips

Pipe Pile Diameter	Maximum R_{ndr}
300 mm	1470 kN
350 mm	1730 kN
400 mm	2000 kN

When H-piles are used as friction piles, the maximum Ultimate Bearing Value for commonly used H-pile sizes are listed below:

H-Pile Size	Maximum R_{ndr}
HP10x42	350 kips
HP12x53	380 kips
HP14x73	440 kips

H-Pile Size	Maximum R_{ndr}
300 mm	1550 kN
350 mm	1690 kN
400 mm	1960 kN

For pipe piles, the Maximum R_{ndr} values listed in the table above are in accordance with the CMS 507.06 requirements assuming typical pile wall thicknesses available for each pile diameter. For H-piles, the Maximum R_{ndr} values listed in the tables above are based on pile drivability using commonly available pile hammers. For both pile types, these values may be significantly less than the structural capacity of a pile in axial compression. Because there is a large degree of variability inherent in the estimation of these maximum values, these tables should be used as a guide. Designers shall perform a Drivability Analysis in accordance with *LRFD 10.7.8* to determine the plan specified Ultimate Bearing Value. Consult the Office of Structural Engineering prior to specifying Ultimate Bearing Values in excess of those shown above.

For capped-pile piers with cast-in-place piles, 16 inch [400 mm] diameter piles shall be used. 16 inch [400 mm] diameter piles with additional reinforcing steel are preferred because the need for pile encasement is eliminated. Additional reinforcing steel which consists of 8 - #6 [19M] epoxy coated reinforcing bars with #4 [13M] spiral at 12 inch [300 mm] pitch should be provided for 16 inch [400 mm] diameter piles. Reinforcing steel shall be detailed on the plans, included in the average daily traffic (ADT) as follows:

1. Freeways or other multi-lane facilities with limited or controlled access .... 50 years
2. Other Highways (2000 design ADT and over) and freeway ramps......................... 25 years
3. Other Highways (under 2000 design ADT)... 10 years

B. The total backwater produced for the design flood should be calculated by WSPRO (HY-7), HEC-2, HEC-RAS or other comparable backwater calculation methods.

C. The allowable backwater depth shall generally be governed by the nature of the upstream area at the structure location and/or the induced mean velocity through the structure.

D. Local Flood Plain Coordinators will need to be contacted so they may be made aware of planned waterway crossings and proposed backwater effects. A listing of Local Flood Plain Coordinators is maintained by the Ohio Department of Natural Resources (ODNR) and may be obtained by calling (614) 265-6750 or visiting ODNR's, Division of Water website: http://www.dnr.state.oh.us/water/.

   The Local Flood Plain Coordinator may require a permit for any proposed waterway crossing regardless of the drainage area size. The District Production Administrator should be contacted, by the responsible governmental agency which initiated the project, as to how they wish to coordinate the permit process. The granted permit becomes a record which is kept by ODOT, at the appropriate District office. The governmental agency will be required to make application for the permit and to secure a granted permit prior to the initiation of any detail plan preparation.

E. In areas where the topography is flat, backwater should not be permitted to flood unreasonably large areas of usable land, if possible.

F. In urban areas the waterway opening for proposed structures shall be designed so that the allowable backwater elevation corresponds with the backwater elevation which currently exists.

G. When a proposed structure is subject to the approval of a Conservancy District, the waterway shall be designed to comply with their regulations if more restrictive than ODOT's.

H. The design of all highway encroachments on the 100 year flood plain shall comply with the regulations as stated in the Code of Federal Regulations (23 CFR 650 A). Engineers responsible for bridge hydraulics should read these regulations to become familiar with their contents. When a highway encroachment is located in a detailed NFIP study area, create a duplicate of the original NFIP water surface model. Actual field survey data may be used to supplement the original NFIP data.

   When making an encroachment, the proposed structure size submitted for preliminary design review shall be supported by an analysis of design alternatives with consideration given to capital costs and risk. "Risk" is defined as the consequences attributable to an encroachment. Risk includes the potential for property loss and hazard to life (A Flood Hazard Evaluation).

   When making an encroachment on a NFIP designated flood plain in the floodway fringe, the rise in the water surface is limited to one foot [0.3 meters] above the natural 100 year flood elevation as given by the NFIP study. No increase in the 100 year water surface is allowed when encroaching on a NFIP designated floodway (44 CFR 60.3(d)(3)). See Figure 203.2-1.

For bridges located outside NFIP jurisdiction regions, the responsible government agency which initiated the project will be responsible for contacting and coordinating with the Local Flood Plain Coordinator.

Longitudinal encroachments require alternative location studies to be summarized in the Conceptual Alternatives Study (L&D Section 1403.3). Evaluation of specific bridge hydraulics may not be necessary when alternative highway alignments are under consideration for the project. Refer to the Code of Federal Regulations (23 CFR 650 A) for more specific information.

I. It should not be assumed that an attempt should be made to lower existing high water elevations. However, for bridge replacement projects where the existing structure is severely hydraulically taxed, an effort should be made to improve the hydraulics for both the design and 100 year recurrence interval discharges, with consideration of the one foot [0.3 meters] rise criterion discussed in Section 203.2.h. No allowable backwater requirements are set by these criteria; rather the allowable backwater should be determined by good engineering judgment considering the area inundated and the mean velocities induced through the structure.

J. In general, the bridge should be designed to clear the design year frequency flood. This criterion may be waived because of roadway design constraints such as existing at-grade intersections, perpetuating existing profile grades, existing backwater elevations, presence of existing road overflow or other reasons.

K. Spill-thru type structures are generally preferred for cost effectiveness and hydraulic efficiency.

203.3 SCOUR

For bridges over waterways, armor the entire spill-through slope in front of the abutments and wingwalls, including the corner cones with Rock Channel Protection of the type determined from the following table. Rock Channel Protection requires the use of a filter. A 6 inch [150 mm] bed of crushed aggregate is allowed as an alternate in CMS 601.09 and should be specified when the rock is to be placed below water. The Item Master pay item descriptions allow for the differentiation between all options: with filter, with fabric filter or with aggregate filter.

aesthetically pleasing structure.

The spill-thru slope should intersect the face of abutment a minimum of one foot [300 mm], or as specified in a standard bridge drawing, below the bridge seat for stringer type bridges. For concrete slab and prestressed box beam bridges this distance should be 1'-6" [450 mm].

204.3 ABUTMENT TYPES

Preference should be given to the use of spill-thru type abutments. Generally for stub abutments on piling or drilled shafts the shortest distance from the surface of the embankment to the bottom of the toe of the footing should be at least 4'-0" [1200 mm]. For stub abutments on spread footing on soil, the minimum dimension shall be 5'-0" [1525 mm]. For any type of abutment, integral design shall be used where possible, see Section 205.8 for additional information.

Wall type abutments should be used only where site conditions dictate their use.

204.4 ABUTMENTS SUPPORTED ON MSE WALLS

When conditions are appropriate, the designer may consider stub type abutments with piling or spread footings supported on MSE walls. Use spread footings to support the abutment if the MSE wall is on bedrock or shale. If the MSE wall is on soil, then the selection of spread footings or piles to support the abutment should consider possible settlement of the MSE wall. Use piles to support the abutment if the bridge is a continuous multi-span structure, or if the bridge is constructed part width in phases. If the bridge is a single-span structure and is not constructed part width in phases, then either spread footings or piles may be used to support the abutment. Piles require a minimum 15-foot embedment below the MSE wall.

Refer to Sections 201.2.6, 202.2.3 and 204.6.2 for the staged review requirements for MSE walls. Consult the Office of Structural Engineering for additional design recommendations.

204.5 PIER TYPES

For highway grade separations, the pier type should generally be cap-and-column piers supported on a minimum of 3 columns. The purpose for this provision is to reduce the potential for total pier failure in the event of an impact involving a large vehicle or its cargo. This requirement may be waived for temporary conditions that require caps supported on less than 3 columns. Typically the pier cap ends should be cantilevered and have squared ends.

For bridges over railroads generally the pier type should be T-type, wall type or cap and column piers. Preference should be given to T-type piers. Where a cap and column pier is located within 25 feet [7.6 meters] from the centerline of tracks, crash walls will be required.

For waterway bridges the following pier type should be used:

A. Capped pile type piers; generally limited to an unsupported pile length of 20 feet [6 meters]. For unsupported pile lengths greater than 15 feet [4.5 meters], the designer should analyze the piles as columns above ground. Scour depths and the embedded depth to fixity of the driven piles shall be included in the determination of unsupported length.

B. Cap-and-column type piers.

C. Solid wall or T-type piers.

Note the use of T-type piers, or other pier types with large overhangs, makes the removal of debris at the pier face difficult to perform from the bridge deck. For low stream crossings with debris flow problems and where access to the piers from the stream is limited, T-type piers, or other similar pier types, should not be used.

For unusual conditions, other types may be acceptable. In the design of piers which are readily visible to the public, appearance should be given consideration if it does not add appreciably to the cost of the pier.

204.6 RETAINING WALLS

In conformance with Section 1400 of the ODOT Location and Design Manual, Volume Three, a Retaining Wall Justification shall be included in the Preferred Alternative Verification Review Submission for a Major Project or in the Minor Project Preliminary Engineering Study Review Submission. A description of the Retaining Wall Justification is provided in Section 1404 of the ODOT Location and Design Manual, Volume Three. Generally, the justification compares the practicality, constructability and economics of the various types of retailing walls listed below:

A. Cast-in-place reinforced concrete

B. Precast concrete

C. Tied-back

D. Adjacent drilled shafts

E. Sheet piling

F. H-piling with lagging

G. Cellular (Block, Bin or Crib)

H. Soil nail

I. Mechanically Stabilized Earth (MSE)

Refer to SS840 for accredited MSE wall systems. Contact the Office of Structural Engineering for modular block wall systems.

The number of scuppers used for collecting the deck surface drainage should be minimized or eliminated if possible. The allowable spread of flow, which is used to help determine the need for scuppers, can be computed by the procedures as described in Section 1103 of the ODOT Location and Design Manual. Scuppers when provided, should preferably be located inside the fascia beam.

Drainage collection systems should be sloped as steeply as practical, generally not less than 15 degrees. The system should have a minimum bend radius of 18 inches [450 mm], no 90 degree bends, adequate pipe supports and cleanouts at the low ends of runs. The cleanout plugs should be easily and safely accessible. The necessary deck drainage outlet locations should be included in the Structure Type Study, Hydraulics Report.

Scuppers with drainage collection systems should be placed as closely as possible to the substructure unit which drains them. Uncollected scupper downspouts should be as far away from any part of the structure as possible.

When the deck drainage is to flow off the ends of the bridge, provisions must be made to collect and carry away this run-off. On bridges without MSE walls at the abutments and where the pavement flow from the deck is no more than 0.75 ft^3/s [0.021 m^3/s], a flume, as shown on Standard Construction Drawing DM-4.1, should be provided. On grade separation structures with 2:1 approach embankment slopes and where the pavement flow from the deck exceeds 0.75 ft^3/s [0.021 m^3/s], an integral curb shall be provided on the approach slab with a standard catch basin located off the approach slab in lieu of the flume. At the trailing end of bridge barriers, a bridge terminal assembly is required to protect this curb. The catch basin should be a Catch Basin No. 3A, as shown on Standard Construction Drawing CB-2.2. A properly sized conduit (Type F, 707.05 Type C) shall be used to provide an outlet down the embankment slope and the outlet shall be armored to prevent erosion.

Control of drainage is especially critical at abutments with MSE walls. On structures with MSE walls at the abutments, a barrier shall be provided on the approach slab with a standard catch basin to collect the drainage. Where possible, the catch basin shall be located at least 25 ft [7.6 m] beyond the limits of the MSE wall soil reinforcement. Continue the barrier 10 ft [3.0 m] past the catch basin. Use the same type of catch basin and conduit as described above.

For bridges that have deck joints consisting of finger joints or sliding plates with a trough collector system scuppers should be considered near the joint to minimize the amount of deck drainage flow across the joint.

For bridges that have over the side drainage a stainless steel drip strip should be provided to protect the deck edge and beam fascia from the deck surface run-off.

209.4 SLOPE PROTECTION

For structures of the spill-thru type where pedestrian traffic adjacent to the toe of the slope is anticipated or the structure is located in an urban area within an incorporated city limit, the slope under the structure shall be paved with Concrete slope protection, CMS 601.07. Consideration of slope protection should be given to all areas under freeway bridges over city streets not covered by pavement or sidewalk. Drainage discharge from the bridge should be checked to ensure that discharge is not crossing sidewalks, etc. so that ice, dirt and debris build-ups are prevented.

On spill-thru slopes under grade separation structures, areas that are not protected by concrete slope protection, shall be protected by crushed aggregate material as provided in CMS 601.06.

The slope protection, either concrete or rock, shall extend from the face of the abutment down to the toe of the slope and shall extend in width to 3 feet [1 meter] beyond the outer edges of the superstructure, except that at the acute corners of a skewed bridge the outside edge of the slope protection shall intersect the actual or projected face of the abutment 3 feet [1 meter] beyond the outer edge of the superstructure and shall extend down the slope, normal to the face of the abutment, to the toe of the slope. The base of the slope protection shall be toed in. Note that the natural vegetation on the slopes when shaded by a new structure will die out. For this case additional slope protection should be considered.

209.5 APPROACH SLABS

Approach slabs should be used for all ODOT bridges. Determine the length of the approach slab using the following formula:

$$L = [1.5(H + h + 1.5)] \div \cos\theta \leq 30 \text{ ft}$$

$$L = [1.5(H + h + 0.45)] \div \cos\theta \leq 9.15 \text{ m}$$

Where:
- L = Length of the approach slab measured along the centerline of the roadway rounded up to the nearest 5 ft [1.5 m]
- H = Height of the embankment measured from the bottom of the footing to the bottom of the approach slab (ft) [m]
- h = Width of the footing heel (ft) [m]
- θ = Skew angle

For four lane divided highways on new embankment, the minimum approach slab length shall be 25 ft [7.6 m] (measured along the roadway centerline). For structures with MSE walls at the abutments, the minimum approach slab length shall be 30 ft [9.1 m]. For all other structures the minimum length shall be 15 ft [4.6 m]. Refer to the approach slab standard bridge drawing for details.

Provide detail drawings for approach slabs which differ from the standard approach slabs. Examples include approach slabs that are a non-standard length, tapered, have a non-uniform width, or other such variation. When an approach slab falls within the limits of a vertical curve

301.4 LOADING REQUIREMENTS

301.4.1 HIGHWAY BRIDGES

All bridges designed to carry highway traffic shall be designed for an HL-93 loading as specified in *LRFD 3.6.1.2.1* and a future wearing surface (FWS) of 60 psf [2.87 kPa].

301.4.2 PEDESTRIAN AND BIKEWAY BRIDGES

Pedestrian and bikeway bridges shall be designed in accordance with the latest edition of the AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges; ODOT design guidelines; and this Manual. ODOT's most current design guidelines are available at ODOT'S Office of Local Projects website, www.dot.state.oh.us/local/.

Where sidewalks, pedestrian, and/or bicycle bridges are intended to be used by maintenance and/or other incidental vehicles, an H15-44 [M13.5] vehicle, as shown in Figure 301.4.2-1, shall be included in the design loading. The H15-44 lane loading should not be considered. The vehicle live load shall not be placed in combination with the pedestrian live load and the dynamic load allowance need not be applied to the H15 vehicle.

301.4.3 RAILROAD BRIDGES

Facilities that are operated and maintained by the railroad shall be designed according to the specifications and design standards used by the railroad in its normal practice. Facilities that are operated and maintained by ODOT or other local agency shall conform to the AASHTO LRFD Bridge Design Specifications and this Manual.

301.4.4 SEISMIC DESIGN

Seismic design shall be in accordance with the AASHTO LRFD Bridge Design Specifications and BDM Section 1000.

Abutment and pier designs with raised pedestal bearing seats shall not be used.

301.4.5 APPLICATION OF LONGITUDINAL FORCES

For bearing types that permit rotation about the transverse axis of the bridge, all longitudinal load types shall be applied at the bearing elevation and moments resulting from eccentricity shall be ignored. The total factored longitudinal loading applied to the substructure at each expansion bearing shall not exceed the bearing's nominal (i.e. **unfactored**) resistance to longitudinal loading. Resistance in this instance is nominal because it is applied to the substructure as a loading.

301.5 REINFORCING STEEL

Reinforcing steel - ASTM A615 or A996, Grade 60, F_y = 60,000 psi.

Reinforcing steel - ASTM A615M or A996M, Grade 420, F_y= 420 MPa

All reinforcing steel shall be epoxy coated.

301.5.1 MAXIMUM LENGTH

Generally maximum length of reinforcing steel should be 40 feet [12.2 meters]. This limit is for both transit purposes and construction convenience. The maximum length before a lap splice is required is 60 feet [18.4 meters]. To facilitate an economical design using 60 foot bar stock, where multiple sets of lapped bars are required (i.e. longitudinal slab reinforcement) consideration should be given to using multiple sets of 30 foot long bars.

The length of the short dimension of L-shaped bars should be limited in order not to extend beyond the sides of a highway vehicle of maximum legal width. The short dimension should preferably be not greater than 7'-6" [2300 mm], and in no case greater than 8'-0" [2450 mm].

301.5.2 BAR MARKS

Bar marks shall be used on detail plans to identify the bar's size and general location and to reference the bar to the reinforcing bar list.

Letters should be incorporated into the bar marks to help identify their location in the detail plans: "A" for abutments, "P" for piers, "S" for superstructure, “SP” for spirals, “DS” for drilled shafts, etc.

The following bar mark represents a #5 [16M] abutment bar ....A501 [A16M01]

The following bar mark represents a #4 [13M] spiral bar .... SP401 [SP13M01]

The following bar mark represents a #9 [29M] drilled shaft bar .... DS901 [DS29M01]

A note or legend within the bar list sheet in the plans shall describe each bar mark's meaning. See Figure 301.5.2-1.

301.5.3 LAP SPLICES

Bar splice lengths shall be shown on the plans.

Development and splice lengths shall conform to AASHTO requirements.

Reinforcing steel at construction joints should extend into the next pour only by the required

C. Typical Sections showing: (Refer to Figures 303.5.1-2, 303.5.1-3, 303.5.1-4 303.5.1-5, 303.5.1-6 & 303.5.1-7)

1. Coping details
2. Parapet and sleeper slab details
3. Abutment footing details including the dimensions from the back of the proprietary wall to the centerline of bearing at the abutment, dimensions from the back of the proprietary wall to the toe of the abutment footing, and dimensions from the back of the proprietary wall to the centerline of the nearest row of piles.
4. Minimum clearance between the bottom of the footing/sleeper slab and the uppermost wall reinforcement strap. Six inches [150 mm] is preferred.
5. Locations of abutment footing, piles, utilities, catch basins, and other possible obstructions
6. Backfill drainage
7. Soil reinforcements attached to abutments

   Regardless of abutment type and foundation type, one row of soil reinforcements shall be attached to the backside of the abutment footing. These additional reinforcements are necessary to resist horizontal bridge and backwall forces, and prevent load transfer to the coping and facing panels. To estimate select granular backfill quantities, Designers may assume these additional reinforcements are the same length as those attached to the facing panels.
8. Limits of select granular material

   Show the limit of the select granular. The top elevation of the select granular backfill shall be at least six inches above the uppermost layer of soil reinforcement, but not lower than six inches above the bottom of the abutment footing.
9. Limits of wall excavation

   Supplemental Specification 840 requires a minimum one foot undercut beneath the leveling pad elevation for all MSE walls. If more undercut is required, show it on the plans. The backfill material is specified in SS 840.
10. Pay limits of wall and roadway quantities
11. Pile sleeves (if required)

    Pile sleeves shall be shown extending from the bottom of the abutment footing to the bottom of the wall excavation
12. Location of sheeting and bracing (if required)

13. Limits of concrete sealer

D. Requirements for wall surface textures or other aesthetic treatments (i.e. show panel size and shape restrictions specific to the project in the plans)

E. Wall design criteria including:

1. Factored bearing resistance at the base of the reinforced soil mass
2. The following factored loads applied to the reinforced soil mass from the bridge: vertical dead and live loads, horizontal loads and total bearing load.

Plan notes are provided in Section 600.

F. Final copy of the Special Provisions for proprietary wall types other than MSE walls.

G. Estimated Quantities Table (list each wall on a project separately)

Include all pay items listed in SS 840. Also include as necessary; Item 203 – Embankment; Item 512 – Sealing of concrete surfaces (epoxy urethane); and Item 503 - Cofferdams and Excavation Bracing.

303.5.2 WORK PERFORMED BY THE PROPRIETARY WALL COMPANIES

The proprietary wall companies will be responsible for designing the internal stability of the wall in accordance with the project plans and either Supplemental Specification 840 for MSE walls or the special provisions for other proprietary wall types.

304 RAILING

304.1 GENERAL

All bridge railing shall meet acceptance criteria contained in NCHRP Report 350 or the AASHTO "Manual for Assessing Safety Hardware" (MASH). The minimum acceptance level shall be TL-3 unless supported by a rational selection procedure described herein.

Bridge railings that have been found acceptable under the crash testing acceptance criteria defined in NCHRP Report 230 and the AASHTO Guide Specification for Bridge Railing, 1989 including all interims, will be considered as meeting the requirements of NCHRP Report 350 without further testing as indicated in the following table.

Bridge Railing Testing Criteria	Acceptance Equivalencies					
NCHRP 350	TL-1	TL-2 TL-	3 TL-4 TL-5	TL-6		
NCHRP 230		MSL-1 MSL-2		MSL-3		
AASHTO Guide Specification		PL-1		PL-2	PL-3	

The AASHTO Guide Specification provides a Performance Level Selection Criteria for bridge railings that is considered an acceptable alternative to NCHRP Report 350 and may be used for railing designs on any project.

Section 304.2 of this Manual lists standard ODOT bridge railing types available along with the corresponding NCHRP 350 level of acceptability. For non-standard railing designs, a review submission, concurrent with the Structure Type Study, shall be made to the Office of Structural Engineering as stated in Section 201 of this Manual. The design of all non-standard railing systems shall be based on the NCHRP 350 or MASH level of acceptability. Designers may be required to submit actual crash test report data to verify the level of acceptability of a proposed design.

Modifications to the ODOT standard railing types or other NCHRP 350 or MASH approved railing system should be avoided. Additional structural steel tubing added to satisfy pedestrian concerns does not require additional crash testing provided these elements do not protrude nearer to the roadway than the rail elements on the tested design and they do not present any type of snagging potential to an impacting vehicle. If an accepted crash tested railing system is modified, the face geometry (i.e. offset, rail height, spacing, etc.) shall match the tested design and the static strength and deflections shall remain at least equal to the tested design. Include with the preliminary design submission to the Office of Structural Engineering, strength and deflection calculations to support these modifications. The calculations shall follow the procedure defined in the *AASHTO LRFD Bridge Design Specifications, Sections A13.1-3*. The intent of any modification shall be to maintain the original NCHRP 350 or MASH acceptability level.

All railing elements fabricated with ASTM A500 steel tubing shall specify a drop-weight tear test per CMS 707.10. Provisions shall be made at tube splices for expansion and contraction. Steel railing systems shall also allow for structural movement at expansion joints without adversely affecting the system's level of acceptability.

Aesthetically pleasing railing systems have been successfully crash tested but are for use only where TL-2 acceptability requirements are allowed. These systems include the Texas Classic Traffic Railing, Type T411 with open windows, a smooth stone masonry barrier with reinforced concrete core wall and an artificial stone precast concrete barrier. Detailed information regarding the latter two systems may be found in FHWA Report No. FHWA-RD-90-087 "Guardrail Testing Program: Final Report", June 1990 and FHWA Report No. FHWA-SA-91-051 "Summary Report on Selected Aesthetic Bridge Rails and Guardrails", June 1992.

The recommended railing design for bridges with combination vehicular and pedestrian traffic is detailed in Standard Bridge Drawing BR-2-98. Other designs are allowed as previously mentioned above, provided the following requirements are met:

A. The curb height shall be 8".

B. The sidewalk width shall be 5'-0" or greater.

A pedestrian railing may be used in lieu of a crash tested barrier at the deck edge provided a crash tested barrier system meeting the minimum requirements for the specific location is used to separate the vehicular and pedestrian traffic. Pedestrian railing shall be designed in accordance with AASHTO.

304.2 STANDARD RAILING TYPES

Drawing No.	Description	NCHRP Level
BR-1	36" Deflector Parapet Type	TL-4
BR-1	42" Deflector Parapet Type	TL-5
BR-2-98	Bridge Sidewalk Railing with Concrete Parapet	TL-4
DBR-2-73	Deep Beam Bridge Guardrail	TL-2
DBR-3-11	Deep Beam Bridge Retrofit Railing	TL-3
PCB-91	Portable Concrete Barrier (Fully Anchored)	TL-4
	Portable Concrete Barrier (Unanchored)	TL-3
SBR-1-99	42" Single Slope Parapet Type	TL-5
TST-1-99	Twin Steel Tube Bridge Railing	TL-4

304.3 WHEN TO USE

304.3.1 PARAPET TYPE (BR-1 & SBR-1-99)

The department currently has three (3) standard concrete parapet type bridge railing systems: a 36" New Jersey shape, a 42" New Jersey shape and a 42" single slope shape. These systems are for use on roadway and railroad overpass structures with no sidewalks and structures where the finished deck surface is 25 ft [7.62 m] or more above the ground line or water surface. Details for these parapet types, including end transitions to terminal assemblies, are provided in the Standard Bridge Drawings. The transition section may be placed on a structure’s turned back wingwalls, widened approach slab or directly on the actual structure. If the transition section is placed directly on the structure, a curb is required for the full length of the approach slab.

The 36" barrier section is for use on structures located on two (2) lane routes with an ADTT in one direction less than 2500.

The 42" barrier sections are for use on structures located on interstates, divided highways of four (4) lanes or more, and two (2) lane routes with an ADTT in one direction of 2500 or more. Final decision of which section to use rests with the districts and should be finalized during the preliminary structural design review. The single slope barrier section is unaffected by the placement of future overlays, but weighs 23% more than the 42" New Jersey type parapet.

A 50" deflector type median barrier and a 57" single slope median barrier are for use on structures where protection against oncoming headlight glare is required. The structure's barrier height and type shall match the design of the adjoining roadway median barrier.

For each of the above listed barrier types, designers are required to confirm the structural adequacy of the concrete deck slab as described in the "Concrete Deck Design" Section 302.2 of this manual.

All concrete parapet type barriers shall be designed and detailed as follows:

A. All horizontal reinforcing steel shall be detailed as continuous for the total length of the structure.
B. Crack control joints shall be sawed into the concrete parapets. The distance between the saw-cut joints on the structure shall be between 6'-0" and 10'-0". The detailed locations of the crack control joints and vertical reinforcing bars shall be shown in the contract plans for all parapet types.
C. The saw-cut crack control joint shall be detailed as 1 ¼ inch deep and shall be filled with a polyurethane or polymeric material conforming to ASTM C920, Type S. The bottom one-half inch of both the inside and outside face shall be left unsealed to allow any water that enters the joint to escape. This requirement is established in the Standard Bridge Drawings; however, a plan note is required for special designs. See Section 600.

304.3.2 DEEP BEAM BRIDGE GUARDRAIL (DBR-2-73)

This railing configuration does not meet the Department's minimum NCHRP 350 acceptance criteria (i.e. TL-3) for use on any project unless supported by the selection procedures described in Section 304.1 of this manual and upgraded to DBR-3-11. In no case, shall this railing system be used on an overpass structure or a project where the finished deck surface is greater than 25 feet above the normal water surface elevation or final ground line.

The standard configuration for this rail type does not meet the minimum requirements specified by AASHTO for pedestrian and bicycle railings and shall not be used where pedestrian or bicycle traffic is expected. A modified railing design meeting these requirements and using the Type 1 post design may be justified.

Use of Type A anchors, as detailed on the Standard Bridge Drawing, is not recommended. The Type B alternative is recommended because they are easier to install in a deck or box beam and easier to replace if damaged in a collision.

Designers should recognize that variable post lengths may be required along the length of a structure due to beam camber. A design data sheet is available from the Office of Structural Engineering to address these concerns.

304.3.3 TWIN STEL TUBE BRIDGE RAILING (TST-1-99)

This railing configuration was developed as a replacement to the Deep Beam Bridge Guardrail system on projects requiring a higher NCHRP acceptance level. The Twin Steel Tube Bridge Railing is for use over rural stream crossings on two (2) lane routes with an ADTT in one direction less than 2 500 where the finished deck surface is less than 25 feet above the normal water surface elevation or final ground line. This system shall not be used on an overpass structure.

The standard configuration for this rail type does not meet the minimum requirements specified by AASHTO for pedestrian and bicycle railings and shall not be used where pedestrian or bicycle traffic is expected. A modified railing design meeting these requirements may be justified.

The required bridge terminal assembly section used to transition from Type 5 or 5A approach roadway guardrail to the bridge railing is detailed on Standard Construction Drawing GR-3.6.

The typical post spacing is 6'-3". The standard drawing enables the designer to reduce the first, last and one additional post spacing per span on each side of the bridge to account for construction clearances. The designer should carefully review the position of the posts that are near the corner of a structure for possible interference with wingwalls, tie rods, etc. For box beam bridge types, post spacing dimensions shall be referenced to each box beam end.

The site plan shall show the station of the center of the first inlet-mounted post on each corner of the bridge.

304.3.4 PORTABLE CONCRETE BARRIER (PCB-91)

This system is for use on construction projects to protect project personnel and to provide a temporary barrier system when a permanent bridge railing system does not exist. Application guidelines for PCB-91 are provided in Design Data Sheet, PCB-DD, available at the Office of Structural Engineering web site.

The designer is required to detail the installation requirements, including the number of anchor bolts per barrier, in the bridge plans. The pay item for this barrier system is Item 622 - Portable Concrete Barrier, 32 inch, Bridge Mounted. Although temporary railing is to be specified and completely described in the bridge plans, temporary railing is a roadway item and shall be included in the roadway quantities.

602.1 LRFD LOAD MODIFIERS

For bridges with non-redundant components, the following note shall be included:

[602.1-1] REDUNDANCY: The following item (s) were considered non-redundant for design and include a load modifier equal to 1.05 in accordance with the AASHTO LRFD Bridge Design Specifications, Article 1.3.4:

NOTE TO DESIGNER:
Include a list of all items considered non-redundant for design in accordance with BDM Section S*1.3.4*.

For bridges with non-redundant foundation components, the following notes shall be included:

[602.1-2] REDUNDANCY: The piles supporting the following substructure(s) were considered non-redundant for design and include a modified resistance factor equal to (1) in accordance with the AASHTO LRFD Bridge Design Specifications, Article 10.5.5.2.3:

[602.1-3] REDUNDANCY: The drilled shafts supporting the following substructure(s) were considered non-redundant for design and include a modified resistance factor equal to (1) in accordance with the AASHTO LRFD Bridge Design Specifications, Article 10.5.5.2.4:

NOTE TO DESIGNER:
Include a list of all substructures with pile foundations or drilled shafts considered non-redundant for design in accordance with *AASHTO LRFD 10.5.5.2.3* & *10.5.5.2.4*.

(1) Provide the modified resistance factor value. This should be equal to 80% of the resistance factor used for design on redundant pile foundations.

For all bridges the following note shall be included:

[602.1-4] OPERATIONAL IMPORTANCE: A load modifier of ___ has been assumed for the design of this structure in accordance with the AASHTO LRFD Bridge Design Specifications, Article 1.3.5 and the ODOT Bridge Design Manual, 2007.

NOTE TO DESIGNER:
Refer to BDM Section S*1.3.5* for guidance.

602.2 DESIGN LOADING

For bridges designed for highway loads, the design loading shall be:

[602.2-1] DESIGN LOADING: HL-93

Future Wearing Surface (FWS) of 0.060 kips/ft ^{2}.

For bikeway/pedestrian bridges that will not accommodate vehicular traffic the design loading shall be:

[602.2-2] DESIGN LOADING**:** 0.090 kips/ ft^2

For bikeway/pedestrian bridges subject to vehicular traffic the design loading shall be:

[602.2-3] DESIGN LOADING**:** 0.090 kips/ft^2 and H15-44 vehicle

602.3 DESIGN STRESSES

A. General Design Data:

[602.3-1] DESIGN DATA :

Concrete Class __(1)__ - compressive strength 4.5 ksi (superstructure)

Concrete Class __(2)__ - compressive strength 4.0 ksi (substructure)

Concrete Class S Modified - compressive strength 4.0 ksi (drilled shaft)

Reinforcing steel - minimum yield strength 60 ksi

Structural Steel - ASTM A709 Grade __(3)__ - yield strength __(3)__ ksi

Steel H-piles - ASTM A572 - yield strength 50 ksi

NOTE TO DESIGNER:

Modify note **[602.3-1]** as necessary. Delete references that are not applicable to project.

(1) Class S, Class HP or Class QSC2 Concrete for superstructure

(2) Class C, Class HP or Class QSC1 Concrete for substructure

(3) Grade 50 - yield strength 50 ksi, or

Grade 50W - yield strength 50 ksi, or

Grade HPS70W - yield strength 70 ksi, or

Grade 36 - yield strength 36 ksi

If more than one grade of steel is selected, the description shall clearly indicate where the different grades are used in the structure.

B. Additional Design Data for Prestressed Concrete Members:

Provide the following note in addition to note **[602.2-1]**.

Associated Pile and Fitting Corporation

8 Wood Hollow Rd. Plaza 1

Parsippany, New Jersey 07054

Install and weld the splicer to the pile sections in accordance with the manufacturer's written assembly procedure supplied to the Engineer before the welding is performed.

606.5 PILE ENCASEMENT

The following note shall be used where capped pile piers and steel "H" piles are being used for a bridge structure crossing a waterway. The exposed steel piling corrodes at the waterline, or near there. The note should not be used if the capped pile pier standard drawing is being used as standard drawing already specifies pile encasement methods.

[606.5-1] ITEM SPECIAL - PILE ENCASEMENT

Encase all steel H-piles for the capped pile piers in Class C concrete. Provide a concrete slump between 6 to 8 inches with the use of a superplasticizer. Place the concrete within a form that consists of polyethylene pipe (707.33), or PVC pipe (707.42). The encasement shall extend from 3 feet below the finished ground surface up to the concrete pier cap. Position the pipe so that at least 3 inches of concrete cover is provided around the exterior of the pile.

In lieu of encasing the pile in concrete, galvanize the piles according to 711.02. The galvanizing shall be continuous from a minimum of 3 feet below the finish ground surface up to the concrete pier cap. The galvanized coating thickness shall be a minimum of 4 mils. Repair all gouges, scrapes, scratches or other surface imperfections caused by the handling or the driving of the pile to the satisfaction of the Engineer.

The Department will measure pile encasement by the number of feet. The Department will determine the sum as the length measured along the axis of each pile from the bottom of the encasement to the bottom of the pier cap. The Department will not pay for galvanizing provided beyond the project requirements. The Department will pay for accepted quantities at the contract price for Item - Special, Pile Encasement.

606.6 SPREAD FOOTING FOUNDATIONS

Provide the following note, with the blanks filled in as appropriate for each individual project, if there are abutments or piers which are supported by spread footings.

[606.6-1] FOUNDATION BEARING RESISTANCE: __(1)__ footings, as designed, produce a maximum Service Load pressure of __(2)__ kips per square foot and a maximum Strength Load pressure of __(2)__ kips per square foot. The factored bearing resistance is __(3)__ kips per square foot.

NOTE TO DESIGNER:

(1) Specify the location of the spread footing.

(2) Specify the maximum factored bearing pressures.

(3) Specify the factored bearing resistance according to *LRFD 10.6.3* and BDM Section 202.2.3.1.

When abutments or piers are supported by spread footings on soil, include the following note to require that reference monuments be constructed in each footing. The purpose of the reference monuments is to document the performance of the spread footings, both short and long term.

[606.6-2] ITEM 511, CLASS __*__ CONCRETE, __*__ , AS PER PLAN : * In addition to the requirements of Item 511*, install a reference monument at each end of each spread footing. The reference monument shall consist of a #8, or larger, epoxy coated rebar embedded at least 6" into the footing and extended vertically 4 to 6 inches above the top of the footing. Install a six inch diameter, schedule 40, plastic pipe around the reference monument. Center the pipe on the reference monument and place the pipe vertical with its top at the finished grade. The pipe shall have a removable, schedule 40, plastic cap. Permanently attach the bottom of the pipe to the top of the footing.

Establish a benchmark to determine the elevations of the reference monuments at various monitoring periods throughout the length of the construction project. The benchmark shall be the same throughout the project and shall be independent of all structures.

Record the elevation of each reference monument at each monitoring period shown in the table below.

The original completed tables will become part of the District's project plan records. Send a copy of the completed tables to the Office of Structural Engineering.