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

July 15, 2016

To: Users of the Bridge Design Manual

From: Tim Keller, Administrator, Office of Structural Engineering

By: Sean Meddles, Assistant Administrator, Office of Structural Engineering

Re: 2016 Third Quarter Revisions

Revisions have been made to the ODOT Bridge Design Manual, January 2004. These revisions shall be implemented on all Department projects that begin Stage 2 plan development date after July 15, 2016. Implementation of some or all of these revisions for projects further along the development process should be considered on a project-by-project basis.

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 January 2004 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/Pages/default.aspx

Attached is a brief description of each revision.

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# Summary of Revisions to the January 2004 ODOT BDM

| BDM Section | Affected Pages | Revision Description |
|---|---|---|
| 200 TOC | 2-i through 2-ii | Update to BDM Section 200 Table of Contents |
| 201.1 | 2-1 | Removed old references to the Project Development Process |
| 201.2 | 2-1 | Removed old references to the Project Development Process |
| 202.2.3.1 | 2-11 through 2-12 | The section on spread footings was revised to clarify the proper location of the bottom footing elevation for structures founded both inside and outside of the 500-yr flood plain. |
| 203.5 | 2-21 through 2-21.1 | Clarification was provided for situations where project sale may occur before the waterway permits are issued. |
| 204.1 | 2-21.2 through 2-21.4 | Clarification was provided to distinguish spread footings from pile cap and drilled shaft footings. |
| 204.3 | 2-22 | Reference to BDM Section 202.2.3.1 was added for spread footing requirements. |
| 205.2 | 2-28 | Reference to BDM Section 202.2.3.1 was added for spread footing requirements. |
| 208.1 | 2-36 | A requirement to provide a General Note allowing contractors to design alternate temporary shoring has been removed. Alternate temporary shoring designs will require approval of a Value Engineering Change Proposal in accordance with C&MS 105.19. |
| Figure 211 | | This new BDM Figure illustrates the proper embedment depth of spread footings outside the limits of the 500-yr flood plain. |
| 300 TOC | 3-i through 3-v | Update to BDM Section 300 Table of Contents |
| 301.2 | 3-1 through 3-2 | Removed old references to the Project Development Process |

| BDM Section | Affected Pages | Revision Description |
|---|---|---|
| 301.4.3 | 3-3 | This revision updates ODOT policy for seismic design in accordance with the AASHTO LRFD Bridge Design Specifications, 7$^{th}$ Edition. Please note that the AASHTO LRFD specifications provide more current seismic design requirements than the AASHTO Standard Specifications. The Standard Specifications are still applicable for rehabilitation design for non-seismic loading. |
| 301.4.3.1 | 3-3 | This new section of the BDM addresses the ODOT requirements for Seismic Performance Zone 1 (SPZ 1). |
| 301.4.3.1.a | 3-3 | This new section of the BDM addresses the minimum support length requirements for SPZ 1. |
| 301.4.3.1.b | 3-3 Through 3-3.1 | This new section of the BDM addresses the Horizontal Connection Force requirements for SPZ 1. |
| 301.4.3.1.c | 3-3.1 | This new section of the BDM addresses the requirements for bearings in SPZ 1. |
| 301.4.3.2 | 3-3.2 | This new section of the BDM addresses requirements for existing structures located in SPZ 1. |
| 301.4.3.2.a | 3-3.2 | This new section of the BDM addresses superstructure requirements for existing structures located in SPZ 1. |
| 301.4.3.2.b | 3-3.2 | This new section of the BDM addresses substructure requirements for existing structures located in SPZ 1. |
| 302.2.2 | 3-14 | A provision to place shrinkage and temperature reinforcement in the underside of deck overhangs at the minimum concrete cover has been added. Also, references to standard bridge railings have been updated. |
| 302.4.2.3 | 3-29 | The requirements for detailing crossframe spacings have been revised. Allowing the steel detailer to locate the crossframes has been eliminated. Also, a requirement that crossframe locations be checked to prevent conflicts with bolted splices has been added. |
| 303.2.2.5 | 3-56 | Reference to BDM Section 202.2.3.1 was added for spread footing requirements. |
| 303.3.2.1 | 3-62 | New Sections for Pier Caps, 303.3.2.1.a, and Pier Columns, 303.3.2.1.b have been added. |

| BDM Section | Affected Pages | Revision Description |
|---|---|---|
| 303.3.2.1.a | 3-62 | This new section of the BDM includes information from the previous BDM Section 303.3.2.1 and provides a new reference for minimum bridge seat widths. |
| 303.3.2.1.b | 3-62 | This new section of the BDM enforces the transverse steel requirements of *LRFD 5.7.4* & *5.10.11* which were relaxed in the previous editions of the BDM. |
| 303.3.2.4 | 3-63 | References to BDM Section 202.2.3.1 was added for spread footing requirements. |
| 303.3.2.5 | 3-64 | Reference to BDM Section 301.4.4.1.b has been added to check capped pile pier connections for the seismic horizontal connection force. |
| 303.3.2.8 | 3-65 | Reference to BDM Section 301.4.4.1.a for minimum seat width requirements as well as reference to the design requirements in *AASHTO Standard Specifications 8.16* and *8.18* have been added. |
| 303.4.1 | 3-66 through 3-67 | This section has been revised to be consistent with BDM Section 202.2.3.1. |
| 305.1 | 3-88 | The purpose for vandal fencing has been clarified. |
| 305.2 | 3-88 | The scoring system used to determine the need for vandal fencing has been eliminated. A new criteria has been provided. An exemption form located in the listing of Design Data Sheets has also been referenced. |
| 305.3 | 3-88 through 3-89 | Required locations for fence terminations have been provided. |
| 305.4 | 3-89 | Aesthetic considerations for fencing have been provided. |
| 305.5.1 | 3-90 through 3-92 | Reference to *LRFD 15.8.2* has been provided for design loadings. |
| Figure 336 | | This new BDM Figure illustrates the minimum support length requirements at abutments. |
| 602.2 | 6-4 through 6-6 | The concrete class for drilled shaft concrete has been revised to QC5. |

| BDM Section | Affected Pages | Revision Description |
|---|---|---|
| 900 TOC | 9-i through 9-iii | Update to BDM Section 900 Table of Contents |
| Section 900 Various | 9-1 Through 9-51 | This section has been re-released to include load rating information regarding Special Hauling Vehicles (SHV's). |

# SECTION 200 - PRELIMINARY DESIGN

## 201 STRUCTURE TYPE STUDY

### 201.1 GENERAL

The project site should be studied in detail and evaluated to determine the best structure alternative. A site visit should be made. In many cases, it can be readily determined whether a particular bridge or culvert should be chosen for a particular site. If a bridge is the most appropriate structure for a particular site, then the Structure Type Study needs to be performed to determine the appropriate bridge type.

### 201.2 STRUCTURE TYPE STUDY SUBMISSION REQUIREMENTS

A Structure Type Study submission should include the following:

A. Profile for each bridge alternative .......... Section 201.2.1
B. Preliminary Structure Site Plan (for preferred bridge alternative) .......... Section 201.2.2
C. Hydrology & Hydraulics (H&H) Report .......... Section 201.2.3
D. Narrative of Bridge Alternatives.......... Section 201.2.4
E. Cost Analysis .......... Section 201.2.5
F. Foundation Recommendation .......... Section 201.2.6
G. Preliminary Maintenance of Traffic Plan .......... Section 201.2.7

The Structure Type Study shall be included in the review submission made directly to the District Office. A concurrent review submission shall be made to the Office of Structural Engineering if the proposed structure type contains non-standard bridge railing types, non-redundant designs, or fracture critical designs. The Office of Structural Engineering will forward review comments for these items to the responsible District Office.

### 201.2.1 PROFILE FOR EACH BRIDGE ALTERNATIVE

The profile for each bridge alternative considered shall generally be drawn to a scale of 1"=20' and shall generally be taken along the proposed centerline of survey for the full length of the bridge. The profiles shall include: the existing and proposed profile grade lines; existing ground line; the cross-section of channel; an outline of the structure; highest known high water mark; normal water elevation; Ordinary High Water Mark (OHWM); flow line elevation (thalweg); design and 100 year water surface elevations (WSE); overtopping flood elevation and frequency; existing and proposed profile grade elevations at 25 ft increments; and minimum and required vertical and horizontal clearances. Note: normal water elevation is the water elevation in the stream which has not been affected by a recent heavy rain runoff and could be found in the stream most of the year. Refer to BDM Section 203.4 for OHWM definition. Carry WSE in a FEMA Zone out to two decimal places.

### 201.2.2 PRELIMINARY STRUCTURE SITE PLAN

The Site Plan scale generally should be 1" = 20' [1 to 200]. For some cases to get the entire bridge on one sheet a smaller scale may be provided, if all details can be clearly shown. For bridges where the 1" = 20' [1 to 200] scale is too small to clearly show the Site Plan details, a 1" = 10' [1 to 100] scale may be considered. The following general information should be shown on the Preliminary Structure Site Plan:

A. The plan view should show the existing structures (use dashed lines); contours at 2 foot [0.5 meter] intervals showing the existing surface of the ground (for steep slopes contours at 5 foot [2.0 meter] or greater intervals may be used); existing utility lines and their disposition; proposed structure; proposed temporary bridge; proposed channel improvements; a north arrow; and other pertinent features concerning the existing topography and proposed work in an assembled form.

   In case of a highway grade separation or a highway-railway grade separation, the required minimum and actual minimum horizontal and vertical clearances and their locations shall be shown in the plan and profile views.

   For a bridge over a railway, the vertical clearance shall be measured from a point level with the top of the highest rail and 6 feet [2 meters] from the centerline of those tracks, or greater if specified by the individual railroad. Reference shall be made to Chapter 15, Section 1.2.6(a), AREMA Specifications for increased lateral clearances required when tracks are on a horizontal curve.

B. A profile as described in Section 201.2.1. The profile scale shall be the same as the plan view.

C. Horizontal and vertical curve data.

D. Size of drainage area. The elevation, discharge and stream velocity through the structure and the backwater elevation for the 100-year frequency base flood, the design year flood and if necessary the overtopping flood. Label discharge as "FIS" when taken from a FEMA Flood Insurance Study. The clearance from the lowest elevation of the bottom of the superstructure to the design year water surface elevation (freeboard) should be provided.

Prior to 1931 the slab bridge standard drawing required the main reinforcement to be placed perpendicular to the abutments when the skew angle was equal to or greater than 20 degrees. This angle was revised to 25 degrees in 1931, 30 degrees in 1933 and finally 35 degrees in 1946. The standard drawing in 1973 required the main reinforcement to be parallel with the centerline of roadway regardless of skew angle. Existing exposed reinforcing steel may be used to confirm the direction of the reinforcing steel.

If the skew angle of the bridge is equal to or greater than the angles listed above for the year built, a temporary longitudinal bent will have to be designed to support the slab where it is cut or if possible locate the cutline parallel to the reinforcing if sufficient room exists. For example a bridge built in 1938 with a 25 degree skew does not require a bent, however a bridge built in 1928 with a 25 degree skew does require a bent to be designed.

When utilizing semi-integral construction, the stability of the new part-width superstructure is to be considered. There exists the potential of the superstructure to move laterally either from the effects of the traffic using the new deck or the lateral earth pressure against the approach slab. See Standard Bridge Drawing "SEMI-INTEGRAL CONSTRUCTION DETAILS" for more information.

### 202.2.3 FOUNDATION REPORT

The Bridge Preliminary Design Report shall include a Foundation Report in accordance with the ODOT Specifications for Subsurface Investigations. The Foundation Report shall include:

A. Investigational Findings
B. Analyses and Recommendations
C. Boring Logs and Undisturbed Test Data

Substructures for bridges over waterways shall be supported by piling or drilled shaft foundations unless the footings can be founded on bedrock. Where the scour evaluation has been identified a potential problem, the probable scour depths, calculated in accordance with L&D Vol. 2, should be considered in the design of the substructures; the location of the bottom of footings; the minimum tip elevations for piles and drilled shafts; and the frictional capacity of piles and drilled shafts.

The Foundation Report for MSE wall supported abutments shall include calculations for bearing pressure and bearing capacity for the in-situ material below the MSE wall and calculations for MSE wall settlement. The report shall also consider the effect of settlement and include all construction constraints, such as soil improvement methods, that may be required.

Specific design considerations for each foundation type are presented in the following sections.

### 202.2.3.1 SPREAD FOOTINGS

Spread footings shall be designed in accordance with the AASHTO LRFD Bridge Design Specifications, Section 10. The footing dimensions shall be optimized for the controlling Limit State.

The use of spread footings shall be based on an assessment of the following: design loads; depth of suitable bearing materials; ease of construction; effects of flooding and scour analysis; liquefaction and swelling potential of the soils; frost depth; and amount of predicted settlement versus tolerable structure movement. If placing spread footings on soil, consider the effects of primary and secondary settlements on long-term maintenance costs of the structure and appurtenances and the effects on ride quality.

Elevations for the bottom of the footing shall be shown on the Final Structure Site Plan. The size of the footing, predicted settlement, maximum Strength and Service Limit State bearing pressures, eccentric load limitations, factored sliding resistance, factored bearing resistance and overall stability shall be provided for review with the Foundation Report. Adjust the footing size, the amount of predicted settlement and the factored bearing resistance during detail design as the design loads for Service, Strength and Extreme Event Limit State are refined.

The Department will not permit the use of spread footing supported structures on MSE as noted in BDM Section 204.4.

All spread footings not founded on bedrock shall have elevation reference monuments. These monuments allow for the measurement of footing elevations during and after construction for the

purpose of documenting the performance of the spread footings, both short term and long term. See Section 600 for notes and additional guidance.

### 202.2.3.1.a SPREAD FOOTING ELEVATIONS FOR FOUNDATIONS LOCATED OUTSIDE THE LIMITS OF THE 500-YR FLOOD PLAIN

The following requirements apply to spread footings located outside of the plan view limits of the 500-yr flood plain:

A. The bottom of footings founded on rock, shall be keyed at least 3-in into rock.

B. The top of footings founded on soil shall be embedded at least 1-ft from the nearest soil surface.

C. The bottom of footings founded on soil shall be embedded at least 5-ft from the nearest soil surface.

### 202.2.3.1.b SPREAD FOOTING ELEVATIONS FOR FOUNDATIONS INSIDE THE LIMITS OF THE 500-YR FLOOD PLAIN

The following requirements apply to spread footings located inside of the plan view limits of the 500-yr flood plain:

A. Locate the footings for 3-Sided Flat Top and Arch Section Culvert structure types (C&MS 706.051 and 706.052) according to L&D Vol. 2, Section 1008.9.
B. Except as noted in BDM Section 202.2.3.1.b.(A), locate the bottom of footings directly on scour resistant rock. If footings require lateral constraint, provide drilled and grouted steel anchors. Scour resistant rock shall have the following properties to an elevation at least 1-ft below the Thalweg:

1. Unconfined compressive strength ≥ 2.5 ksi
2. Remain intact when immersed in water (e.g. insoluble)
3. Unit weight ≥ 0.15 k/ft$^3$
4. Joint or bedding plane spacing that define large blocks (> 4-ft)

C. Except as noted in BDM Section 202.2.3.1.b.(A), locate the bottom of footings founded on non-scour resistant rock at least 7-ft below the Thalweg elevation and the top of the footing at least 1-ft below the Thalweg elevation. If historical evidence of scour deeper than 7-ft in the rock foundation material at or near the footing location is available, spread footings foundations shall not be used.

D. Except as noted in BDM Section 202.2.3.1.b.(A), footings founded on soil are prohibited. Substructures shall be founded on piling extending at least 15-ft below the Thalweg elevation or on drilled shafts.

### 202.2.3.2 PILE FOUNDATIONS

The type, size and estimated length of the piles for each substructure unit shall be shown on the Final Structure Site Plan. Preliminary pile design loads and approximate pile spacings shall be provided with the Foundation Report. This information will be furnished by the design agency preparing the plans. The estimated pay length(s) for the piling shall be measured from the pile tip to the cutoff elevation in the pile cap and shall be rounded up to the nearest five (5) feet [one meter]. Procedures for computing estimated pay length of the piles are given in the FHWA's "Design and Construction of Driven Pile Foundations, Vols. 1 & 2", FHWA-HI-97-013/014. Minimum pile tip elevations for friction designed piles may be required and should be shown on the Final Structure Site Plan.

When installing piles at a batter, the site conditions should be studied to determine if installation is practical. Piles under 15 feet [5 meters] in length should not be battered.

### 202.2.3.2.a STEEL 'H' PILES

When piles are driven to refusal on the bedrock, steel 'H' piles are generally used. The commonly used pile sizes are:

## 203.4 BRIDGE AND WATERWAY PERMITS

Impacts to bridges or waterways may require legal authorization in the form of permits or certifications issued by various regulatory agencies, including:

A. U.S. Army Corps of Engineers ........................................Section 404 and/or Section 10 Permit
B. U.S. Coast Guard .......................................................................... Section 9 Bridge Permit
C. Ohio EPA ................. Section 401 Water Quality Certification and/or Isolated Wetland Permit

The jurisdictional limit of the U.S. Army Corps of Engineers (USACE) is termed the "Waters of the United States" and, as noted in ODOT CMS 101.03, includes: rivers, streams, lakes and wetlands. For rivers and streams, the jurisdiction begins below the Ordinary High Water Mark (OHWM). The OHWM is defined by the USACE Regulatory Letter No. 05-05 which is available at: www.usace.army.mil/Missions/CivilWorks/RegulatoryProgramandPermits/GuidanceLetters.aspx.

The ODOT Office of Environmental Services – Waterway Permits Unit (OES-WPU) assumes the responsibility for determining project eligibility for different types of waterway permits, such as, but not limited to, Nationwide Permits (NWP) or ODOT's Regional General Permit (RGP). The designer and project manager shall coordinate with the DEC and the OES-WPU throughout the permit determination process to ensure that the final waterway permit applications are indicative of the final project design. For more information refer to the Waterway Permits Manual available from the ODOT Office of Environmental Services.

Special Provisions are the method ODOT uses to attach the waterway permits and certifications to the project construction plans. The waterway permits Special Provisions Package (SPP) is prepared by the Office of Environmental Services – Waterway Permits Unit and may contain the following:

A. All pertinent waterway permits, certifications and related conditions
B. Drawings and/or mapping submitted with a permit application
C. Specialized conditions associated with the waterway permits

The designer and the project manager shall confirm that the bridge design plans meet the requirements in the project waterway SPP (e.g. Sections 404 and 401 conditions, and infrequently Sections 9 and 10) and shall ensure the project waterway SPP is submitted with the Final Plan Package.

## 203.5 TEMPORARY ACCESS FILLS

A Temporary Access Fill (TAF) is a fill or structure that allows a contractor access to work on roads or bridges located within bodies of water. TAF's are work-type specific and are not required on every project. Examples of TAF's include: cofferdams; temporary structures for maintaining traffic; causeways and workpads; and demolition debris. The placement of all TAF's in "Waters of the United States" must be performed in accordance with the special provisions for waterway permits.

A contractor's means and methods of construction will dictate the TAF required for a project. However, the Department must estimate the potential impacts to "Waters of the United States" during project development to enable all permits to be in-place during contract letting. For most projects, the waterway permits are in place prior to sale. There may be instances where unforeseen delays dictate that the waterway permits will not be acquired until after sale and/or award. In those instances it is imperative that the waterway permits be obtained prior to the contractor beginning any work within any Waters of the United States. Furthermore, it is incumbent upon the Department that these permits provide all bidding contractors the ability to construct the project without resulting in expensive delays, change orders or fines. To that end, the Department partnered with the Ohio Contractor's Association to develop the following guidance to estimate the size of TAF's:

A. The TAF shall provide access to all piers located within the Ordinary High Water Mark (OHWM) of the waterway from at least one bank of the waterway.

   Access may be provided by construction staging of the TAF. When considering the constructability of staged TAF's, typical superstructure erection plans for lifting lengths of 50-ft or more require two cranes. Unless the access for member delivery is from an adjacent structure, the TAF must provide access to each end of the lift from one bank. In the case of staging, the permit application shall reflect the construction stage that impacts the largest area of the waterway.

B. The TAF shall be located directly beneath the superstructure. The surface width of the TAF shall be equal to the out-to-out width of the superstructure plus 50’-0” outboard on one side of the structure and 20’-0” outboard on the other side of the structure.

C. The TAF shall extend at least 40’-0” beyond the furthest pier accessed by the TAF.

D. Side slopes of the TAF shall be no steeper than 1.5:1 (H:V).

E. The top surface of the TAF shall be located 1’-0” above the OHWM.

F. The TAF shall be designed to maintain a flow equal to two times the highest average monthly flow (i.e. the largest of Q1, Q2, Q3, …Q12), as reported by the USGS web based application StreamStats (see L&D Vol. 2), such that no rise in the backwater above OHWM is permitted.

This information is intended for permit application purposes only and should not be included in the project plan set. However, to assist the OES-WPU in the determination process, Designers should use the guidance above to develop a plan view and cross-section and determine waterway impacts of a TAF. An example plan view and cross-section are shown in Figure 208. These details should be provided to the DEC along with a completed copy of the checklist shown in Figure 209. The minimum flow to be maintained during construction should be calculated according to item F above. Designers will need to estimate whether this flow can be maintained through conduits or if open channels will be required.

## 204 SUBSTRUCTURE INFORMATION

### 204.1 FOOTING ELEVATIONS

Substructure footing elevations shall be shown on the Final Structure Site Plan. Refer to BDM 202.2.3.1 for Spread Footing elevation requirements. The top of footing (e.g. pile and drilled shaft caps) shall be a minimum of one foot below the finished ground line and shall be at least one foot below the bottom of any adjacent drainage ditch. The bottom of footing (e.g. pile and drilled shaft caps) shall not be less than four feet below and measured normal to the finished groundline.

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## 204.2 EARTH BENCHES AND SLOPES

A bench at the face of abutment shall not be used. Rehabilitation projects may require special slope considerations.

Spill thru slopes should be 2:1, except where soil analysis or existing slopes dictates flatter slopes. The slope is measured normal to the face of the abutment.

For superelevated bridges over waterways, the intersection of the top of slope with the face of abutment shall be on a level line. For other superelevated structures the top of slope shall generally be made approximately parallel to the bridge seat. For structures over streets and roads having steep grades, the intersection of earth slope and face of abutment may be either level or sloping dependent upon which method fits local conditions and gives the most economical and 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”. For stub abutments on spread footing on soil, refer to BDM Section 202.2.3.1 for footing elevations. 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 use of MSE walls to shorten bridge spans and eliminate embankment slopes is acceptable. MSE wall supported abutments shall be supported on piling regardless of the proximity of bedrock to the MSE wall foundation. The Department will not permit

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## 205.2 SPAN ARRANGEMENTS

The length of a bridge will be determined by the requirements for horizontal clearance at grade (highway or railway) separations or by the requirements for waterway opening at stream crossings. Typically for any given bridge, there are a number of combinations of spans and lengths of spans that can be utilized. Generally a preferred span arrangement that minimizes the number of sub-structure units should be used (i.e. fewer piers with longer spans).

For grade separation structures spanning any divided highway a two-span bridge with spill-thru slopes is preferred.

For waterway crossings, one or three span bridges are typically used. This span arrangement is preferred so that a pier is not located in the middle of the waterway. Refer to BDM Section 202.2.3.1 for spread footing requirements for a series of precast, three-sided structures are used to produce a multiple span structure over a waterway, spread footings on soil shall not be used to support any of the precast structures.

When a multiple span arrangement (4 spans or more) is required, the Cost Analysis should examine the most economical number of spans required based on total bridge costs, including a substructure and superstructure cost optimization study. Site conditions will govern the location of substructure units with respect to required horizontal clearances, foundation conditions and appearance.

On structures with steep grades, the designer should account for the load effects of the grade on the substructure units.

## 205.3 CONCRETE SLABS

Cast-in-place concrete slabs are normally used where site geometry dictates a curved alignment or variable superelevation and the use of prestressed concrete box beams is impractical. Since concrete slabs will generally yield the least superstructure depth they should be considered when vertical clearance is limited. For stream crossings where flood waters often inundate the structure, a concrete slab should be considered. When using cast-in-place concrete slabs the construction clearance requirements of the falsework should be considered.

Standard bridge drawings are available for the design of single span and three span continuous concrete slabs. The Standard Bridge Drawing for single span concrete slab bridges is SB-1-03. The spans range from 11 to 38 feet [3350 to 11 580 mm] with a maximum skew angle of 30 degrees. The Standard Bridge Drawing for three span continuous concrete slabs is CS-1-03. The spans range from 14’ - 17.5’ - 14’ [4260 mm - 5334 mm - 4260 mm] to 46’ - 57.5’ - 46’ [14 020 mm - 17 530 mm - 14 020 mm] with a maximum skew angle of 30 degrees. The drawings are based on a 60 $lb/ft^2$ future wearing surface and a live load of an HS25 truck and the alternate military vehicle. The edge beam is designed to support live load according to AASHTO 3.24.8 and the weight of the 42” BR-1 deflector parapet.

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Following are some conceptual ideas for the design of temporary shoring:

A. A cantilever sheet pile wall should generally be used for excavation up to approximately 12 feet [3.5 meters] in height. Design computations are necessary.

B. For cuts greater than 12 feet [3.5 meters] in height, anchored or braced walls will generally be required.

C. For anchored walls, the use of deadmen is preferred. Braced walls using waler and struts can sometimes be braced against another rigid element on the excavated side.

   The use of soil or rock anchors(tiebacks) is generally the last option considered in the design of anchored walls.

D. The use of steel "H" piles with lagging is also a practical solution for some sites. Please note that some railroad companies allow only interlocking steel sheet piling adjacent to their tracks.

E. Where sufficient embedment can not be attained by driving sheet piling because of the location of shallow bedrock, predrilled holes into the bedrock with soldier "H" piles and lagging should be considered.

   For cuts greater than 12-15 feet [3.5-4.5 meters], the "H" piles may need to be anchored.

F. The highway design live loading should be equal to two feet [600 mm] of equivalent soil height as a surcharge.

G. The following items at a minimum should be shown on the detail plans:

   1. Minimum section modulus

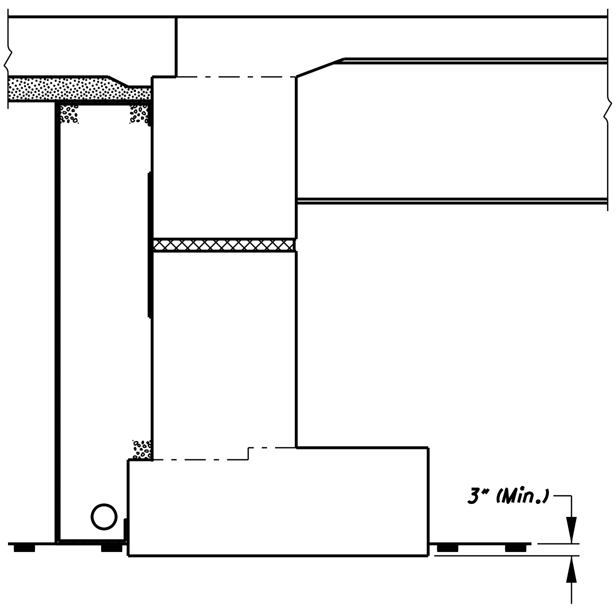
   2. Top and minimum bottom elevation of shoring

   3. Limits of shoring

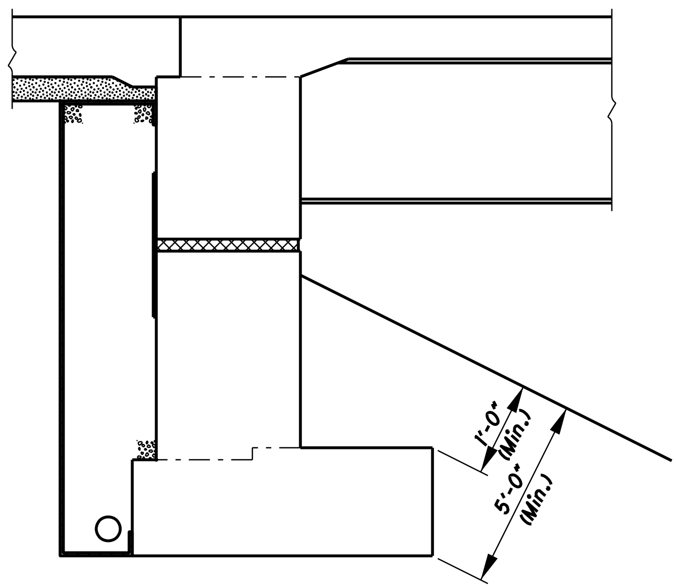
   4. Sequence of installation and/or operations.

   5. Method of payment

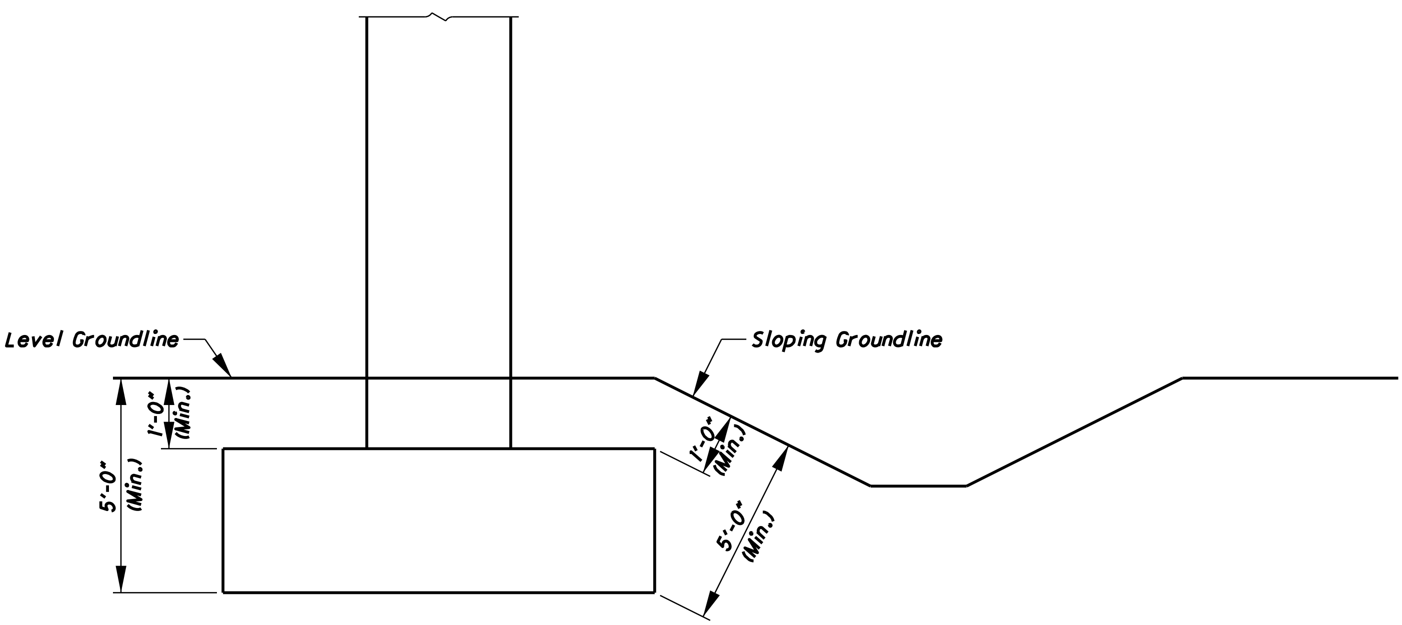
   6. If bracing or tiebacks are required, all details, connections and member sizes shall be detailed.




Abutment Founded on Rock




Abutment Founded on Soil




Pier Founded on Soil

Figure 211

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# SECTION 300 – DETAIL DESIGN

## 301 GENERAL

### 301.1 DESIGN PHILOSOPHY

Section 300 of this Manual establishes general design guidelines, details, special requirements and reasonable alternatives, which, when incorporated by the engineer in a set of bridge plans, will provide a bridge structure that meets load requirements, provides structural integrity, provides structural efficiency and reduces long term maintenance to a minimum level.

### 301.2 DETAIL DESIGN REVIEW SUBMISSIONS

The detail design review for structures is conducted as part of the Stage 2 and Stage 3 review submission.

The Stage 2 Detail Design submission should include an updated cost estimate and the items listed below. Not every item listed will apply to every project.

A. Bridge Plans generally consisting of the following:
   1. Site Plan in compliance with all Stage 1 review comments
   2. General Plan (if required)
   3. General Notes
   4. Phase Construction Details
   5. Foundation Plan
   6. Abutment Details with all dimensioning, bar marks and bar spacings properly shown
   7. Pier Details with all dimensioning, bar marks and bar spacings properly shown
   8. Superstructure Details with all dimensioning, bar marks and bar spacings properly shown
   9. Other Details as necessary
B. Retaining Wall Plans generally consisting of the following:
   1. General Notes
   2. Retaining wall details
   3. Other Details as necessary
C. Noise Barrier Plans generally consisting of the following:
   1. General Notes
   2. Plan and Profile Views
   3. Noise Barrier Details
   4. Foundations Table
   5. Subsurface Investigation Plan Sheets
   6. Other Details as necessary
D. Special Provisions
E. Load Rating Reports for bridges
F. Signed Office of Structural Engineering Bridge Stage 2 Plan Review Checklist

The Stage 3 Detail Design plan submission should include an updated cost estimate and the following:

A. Stage 2 Detail Design plans in compliance with all Stage 2 review comments.
B. Completed Estimated Quantities Table
C. Completed Reinforcing Steel Schedule
D. Estimated Quantities calculations
E. Load Rating Reports for bridges
F. Signed Office of Structural Engineering Bridge Stage 3 Plan Review Checklist

Refer to Section 1400 of the ODOT Location and Design Manual, Volume Three, for additional staged review submission requirements.

For structures with non-redundant and/or fracture critical design details, a complete Stage 2 Detail Design Review Submission shall be made to the Office of Structural Engineering for concurrent review and comment. The Office of Structural Engineering will forward all comments to the responsible District Office or LPA.

### 301.3 DESIGN METHODS

Ohio Department of Transportation bridge designs are to be developed in general conformance with the latest edition of the American Association of State Highway and Transportation Officials' Standard Specifications for Highway Bridges (AASHTO), including all interims. Exceptions to AASHTO standards are documented in this Manual. Bridges designed within the limitations placed on the various superstructure types by AASHTO and this Manual can be considered as "typical" or "normal" in that these designs make use of empirical formulae and methods rather than more refined analysis methods.

The Strength Design Method (i.e. Load Factor Design) is preferred over the Service Load Design Method (i.e. Allowable or Working Stress Design). If a designer determines that an existing superstructure is structurally deficient based on the Service Load Design Method, the designer shall re-analyze the structure based on the Strength Design Method before opting for a total superstructure replacement.

When site conditions require the use of a superstructure type that exceeds the recommended limits set forth by AASHTO and/or this Manual, a special design method may be required using either a two-dimensional or three-dimensional model and some type of numerical analysis to solve the model. When this occurs, the designer should place a note in the General Notes section of the detail construction plans listing the type of model used, method of analysis and assumptions made during the design. Examples of special design methods include grillage, finite element, finite strip and classical plate solutions. A sample note can be found in Section 600 of this Manual.

### 301.4.3 SEISMIC DESIGN

Earthquakes arise from the movement of underlying bedrock. Ground motion resulting from the movement of underlying bedrock can be amplified or dampened by the overlying soil profile. Designers shall analyze soil borings to identify overlying soil profiles that can amplify ground motion propagating from underlying rock according to *LRFD 3.10.3.1*. Bridges located in Site Class D, E and F may require additional design considerations as noted in BDM Section 301.4.3.1.

### 301.4.3.1 SEISMIC PERFORMANCE ZONE 1

All bridges in the State of Ohio are located within Seismic Performance Zone 1.

Seismic analysis is not required except as noted in BDM Sections 301.4.3.1.a and 301.4.3.1.b.

Designers may use the Seismic maps, *LRFD Figure 3.10.2.1-3* or the USGS US Seismic Design Maps web application to determine seismic data.

### 301.4.3.1.a MINIMUM SUPPORT LENGTH REQUIREMENTS

To prevent the partial or complete collapse of the superstructure during seismic events, the bearing supports at the end of a superstructure unit shall be sized according to *LRFD 4.7.4.4*.

As a minimum, the overlapping distance of the superstructure and bearing areas shall meet 100% of the minimal support length, *N*, calculated according to *LRFD EQ. 4.7.4.4-1*. The minimum support lengths shall be measured normal to the centerline of supports. Designers shall account for expansion/contraction movements of the bearings when establishing final seat widths. Refer to Figure 336 for the application of support length requirements to a typical expansion elastomeric bearing at an abutment.

### 301.4.3.1.b HORIZONTAL CONNECTION FORCE

All structures shall have some mechanism to transfer horizontally applied superstructure loads (e.g. vehicular braking force, centrifugal force, vehicular collision force, friction load, water load, wind load, and wind load on live load) to the substructure to ensure structural stability. Examples of mechanisms include fixed bearings, bearing guides, abutment diaphragms, diaphragm guides, wing walls and wind locks. During a seismic event, these mechanisms that prevent the free lateral translation of the superstructure in any direction relative to the substructure, shall be designed to transfer an applied horizontal connection force at the Extreme Event I Limit State. Additional restraint for seismic loads (e.g. seismic pedestals) shall only be provided where the mechanisms noted above do not provide sufficient capacity. Refer to BDM Section 301.4.3.1.c for bearing requirements.

The magnitude of the connection force shall be 0.15 or 0.25 times the tributary permanent load at the location of the restraint as determined in *LRFD 3.10.9.2*. The load factor for live load, $\gamma_{EQ}$, may be taken as 0.0. If sufficient geotechnical information is not available to determine Site Class, Designers shall assume the magnitude of the connection force is 0.25 times the tributary permanent load.

For restraint provided in multiple directions, *LRFD 3.10.8* applies.

The tributary permanent load defined in *LRFD 3.10.9.2* represents the factored dead load of the superstructure applying load to the device or object providing the directional restraint. If every bearing supporting the superstructure provides transverse restraint, the tributary permanent load applied to each restraint would equal the factored dead load reaction at each bearing. If only one transverse restraint was provided at each substructure unit, the tributary permanent load applied to each restraint would equal the sum of the factored dead load reactions for each bearing at the substructure unit. If only one transverse restraint was provided for the entire superstructure unit, the tributary permanent load applied to the restraint would equal the sum of the factored dead load reactions of every bearing. Longitudinal restraint connection forces would be determined similarly.

Because a structure in Seismic Performance Zone 1 is assumed to be able to carry the loads within the elastic strength range of its members, or is assumed to be properly detailed to prevent collapse beyond the elastic strength range of its members, analysis of the superstructure, substructure and foundation for the load effects resulting from the connection force is not required.

Crossframes to resist the horizontal connection force at the Extreme Event Limit state shall be provided to create a direct load path from the point of horizontal connection force application to the deck.

### 301.4.3.1.c REQUIREMENTS FOR BEARINGS

Unrestrained bearings that sustain irreparable damage during a seismic event are permissible provided loss of span is prevented by the design for the Horizontal Connection Force in BDM Section 301.4.3.1.b.

### 301.4.3.2 EXISTING STRUCTURES

Seismic vulnerability of a structure shall be considered for rehabilitation projects requiring complete deck or superstructure replacements. New substructure units shall be designed in accordance with *LRFD 3.10.9.2, 4.7.4.4* and *AASHTO Standard Specification 8.18.2*. If sufficient geotechnical information is not available, Designers may assume:

A. $A_S > 0.05$

B. $S_{D1} < 0.10$.

### 301.4.3.2.a SUPERSTRUCTURE

For projects where seismic vulnerability is considered, at bearing locations that will transmit the horizontal connection force from the substructure to the superstructure, crossframes designed to resist the horizontal connection force shall be provided to create a direct load path to the deck. For supports not in compliance with *LRFD 4.7.4.4*, seismic restrainers designed for the Horizontal Connection Force, specified in BDM Section 301.4.3.1.b, shall be provided.

### 301.4.3.2.b SUBSTRUCTURE

For projects where seismic vulnerability is considered, concrete columns at piers that transfer the seismic horizontal connection force, according to BDM Section 301.4.3.1.b, shall meet the spiral and tie ductility requirements of *AASHTO Standard Specification 8.18.2*. Designers may consider releasing restraint provided by existing pier bearings as a viable seismic retrofit provided the abutments can accommodate the additional horizontal Strength and Service loadings. Otherwise, Designers shall provide the required confinement of the primary steel in the axially loaded substructure members.

## 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 302.

### 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

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Where S is the effective span length in feet [millimeters]. Tmin shall be rounded up to the nearest one-quarter inch [5 mm].

The one inch [25 mm] wearing thickness, Section 302.1.3.1, is included in the calculations for minimum concrete deck thickness but not in the calculations during actual structural design of the deck slab.

For transversely reinforced concrete deck slabs supported on steel stringers the effective span length "S" shall be considered equal to the distance center-to-center of stringers minus 6 inches [150 mm].

For concrete I-beam stringers the effective span length shall meet the requirements of AASHTO 3.24.1.2.

### 302.2.2 CONCRETE DECK DESIGN

The concrete deck design shall be in conformance with AASHTO, latest edition, and additional requirements in this Manual. The design live load shall be HS25 for decks on new superstructures and HS20 for decks on existing superstructures.

For continuous slabs on three or more supports a continuity factor of 0.80 shall be applied to the simple span bending moments for both live load and dead load.

See Figures 312 & 313 for an illustration of a method of design for a reinforced concrete deck slab. Design data tables for HS25 (Fig. 314A) and HS20-44 (Fig. 314B) live loads are also provided.

Upon completing the concrete deck design from the example shown in Figure 312 & 313, or similar method, the designer should assure any cantilevered deck overhang will not over stress the initial deck design due to the dead load and the greater live load of either the vehicle wheel loads or the railing live loads. See relevant AASHTO sections for live load application requirements. See example Figures 315 & 316.

Transverse spacing of the top and bottom reinforcing in a deck design shall meet section 302.2.4.2.

Shrinkage and temperature reinforcement conforming to LRFD 5.10.8 shall be placed in the underside of deck overhang with the minimum clear cover measured to the transverse steel.

### 302.2.3 DECK ELEVATION REQUIREMENTS

#### 302.2.3.1 SCREED ELEVATIONS

Screed elevations are control elevations for concrete deck finishing machines that account for dead load deflections to ensure that the bridge deck is completed to the correct elevation. To establish screed elevations, the final surface elevations are adjusted for non-composite

Stiffener plates shall have corners in contact with both web and flange clipped. The clip dimensions shall be one inch [25 mm] horizontally and 2½ inches [65 mm] vertically. Dimensions are shown on the Standard Bridge Drawing.

Both sides of the stiffener shall be fillet welded to the beam web and both flanges.

### 302.4.2.3 INTERMEDIATE CROSS FRAMES

For structures with the stringers placed on tangent alignments, detail cross frames as follows:

A. Cross frames for rolled beams shall be connected directly to the web or to intermediate web stiffeners.

B. Cross frames shall be perpendicular to stringers and be in line across the total width of the structure.

C. Cross frame spacings between points of dead load contraflexure in the positive moment regions shall not exceed 25 ft [7.6 m].

D. Cross frame spacings between points of dead load contraflexure in the negative moment regions shall not exceed 15 ft [4.6 m].

E. Horizontal legs of cross frame angles shall align on both sides of the stringer.

F. The AASHTO 10.20.1 requirement for cross frames at each support should be waived.

See the General Steel Details Standard Bridge Drawing for standard cross frame configurations.

For structures with flared stringers, the following exceptions apply:

A. If the differential angle between individual stringers is 5 degrees or less, the cross frames shall be perpendicular to one stringer and in line across the total width of the structure.

B. If the differential angle between individual stringers is greater than 5 degrees, the differential angle shall be divided evenly between connections to both stringers.

The design plans shall show:

A. The cross frame spacing for each region along the length of the stringer.

B. The typical cross frame details or reference to the General Steel Details Standard Bridge Drawing for standard cross frame configurations.

The designer shall ensure crossframe locations do not conflict with bolted splices or shall provide appropriate details to attach crossframes at bolted splice locations.

A detail showing a completely bolted connection for cross frame to the steel member is shown in the Standard Bridge Drawing.

Holes for erection bolts are normally provided in the connection of cross frames to stiffeners. Refer to the Standard Bridge Drawing for details.

In phased construction of new steel structures cross frames should not be permanently attached between phases until all deadload (deck, parapet, etc.) has been applied to the members. The crossframes can then be permanently attached and a deck closure pour can be completed to finish the superstructure. See Section 302.2.9.

For curved or flared bridges with "dog-legged" stringers, cross frames should be placed near the bend points. The cross frames should be located approximately 1 foot [300 mm] from the bend point but not interfere with the splice material. The cross frame should be placed normal to the stringer used to set the 1 foot [300 mm] clearance dimension and should be connected to the adjacent stringer only on the same side of the centerline of the splice. The cross frame units should be similar to standard cross frames but should have an additional horizontal angle near the top flange of the stringers.

See Figure 319 for plan view layout of cross frames for dog-legged stringers.

Cross frames for curved stringers may be one of the types shown on the Standard Bridge Drawing with an additional top strut. The designer shall confirm that the standard cross frames and their connections meet the additional loading developed in a curved member design. Since cross frame components in a curved structure share the live loading, Charpy V-notch (CVN) testing shall be specified. If specially designed cross frames are used, they should be bolted to stiffeners with oversized holes. The designer shall recognize the reduction in allowable capacity associated with oversized holes. If the capacity reduction is too much to allow for oversized holes and standard holes are required, the designer shall denote on the plans that shop assembly of the specially designed cross frames and adjacent curved member is required.

Both doglegged stringer cross frames at the dogleg or curved stringer cross frames shall be connected to the main member by use of welded stiffeners.

### 303.2.2.1.a COUNTERFORTS FOR FULL HEIGHT ABUTMENTS

For full height abutments exceeding 30 feet [10 000 mm] in height, counterforts should be considered.

Reinforcing steel in the back, sloping, face of the counterfort should be placed in two rows with a 6 inch [150 mm] clearance between rows. Reinforcing steel splices should be staggered a minimum of 3'-0" [1000 mm], by row.

Reinforcing extending from the footing of a counterforted wall into the highly reinforced areas of the counterforts shall have reinforcing steel splices staggered.

In counterforted walls, each pocket formed by the intersection of the counterfort and wall shall be drained.

### 303.2.2.1.b SEALING STRIP FOR FULL HEIGHT ABUTMENTS

Use an impervious fabric across the expansion joints in full height abutments or retaining walls to eliminate leakage. The impervious fabric should be CMS 512 Type 2 Waterproofing, 3 feet [1000 mm] wide, centered over, and extending the full length of the joint to the top of the footing. See Section 303.2.5 on requirements for expansion joints in abutments.

### 303.2.2.2 CONCRETE SLAB BRIDGES ON RIGID ABUTMENTS

For a continuous concrete slab bridge supported on rigid abutments, the joint between the deck slab and the top of the abutment shall be troweled smooth and a continuous strip of elastomeric material shall be recessed into the abutment seat before placement of the superstructure concrete.

The above bearing system for slabs on rigid abutments should conform to temperature movement and bearing design requirements of this Manual.

### 303.2.2.3 STUB ABUTMENTS WITH SPILL THRU SLOPES

If a stub abutment is to support a bridge having provision for relative movement between the superstructure and the abutment, two rows of piles are required and the front row shall be battered 1:4.

Where two rows of piles are used, the forward row shall have approximately twice the number of piles as the rear row, with the rear piles placed directly behind alternate front piles.

The perpendicular distance from the surface of the embankment to the bottom of the toe of the footing should be at least 4'-0" [1200 mm].

The maximum spacing of piles in a single row or in the front row of a double row shall be 8 feet [2500 mm].

For phased construction projects, do not design an abutment phase supported on less than three (3) piles or two (2) drilled shafts.

### 303.2.2.4 CAPPED PILE STUB ABUTMENTS

For capped pile stub abutments that do not provide for relative movement between the superstructure and the abutment, one row of vertical piles shall be used.

The construction joint at the top of the footing for cap pile abutments should be shown as optional.

For phased construction projects, do not design an abutment phase supported on less than three (3) piles or two (2) drilled shafts.

### 303.2.2.5 SPREAD FOOTING TYPE ABUTMENTS

Where foundation conditions warrant the use of an abutment on a spread footing, the footing shall be located in accordance with BDM Section 202.2.3.1.

### 303.2.2.6 INTEGRAL ABUTMENTS

Integral Abutment use is limited as defined in Section 200 of this Manual. Integral design should not be used with curved main members or main members that have bend points in any stringer line.

For an integral design to work properly, the geometry of the approach slab, the design of the wingwalls, (see section 303.2.4) and the transition parapets must be compatible with the freedom required for the integral (beams, deck, backwall, wingwalls and approach slab) connection to rotate and translate longitudinally.

See Figure 324.

The horizontal and vertical joint shall be sealed at the back face of the backwall by use of a 3'-0" [900 mm] wide sheet of nylon reinforced neoprene sheeting. The sheeting should only be

## 303.3 PIERS

### 303.3.1 GENERAL

A "free-standing" pier is defined as one that does not depend upon its attachment to the superstructure for its ability to resist horizontal loads or forces.

The width of footing for a free-standing pier generally shall be not less than one-fourth the height of the pier where founded on soil and not less than one-fifth the height of the pier where founded on bedrock.

The minimum width of footing supported by a drilled shaft is the diameter of the shaft.

Where piling is used to support free-standing piers, the distance between centers of outside piles, measured across the footing, generally shall be not less than one-fifth the height of the pier.

Widths greater than the above shall be provided if required for proper bearing area or to accommodate the required number of piles.

The height of the pier shall be measured from the bottom of the footing to the bridge seat.

For multiple span bridges with continuity over piers, where the height of pier is more than 50 percent of the length of superstructure from the point of zero movement to such pier, it may be assumed that the pier will bend or tilt sufficiently to permit the superstructure to expand or contract without appreciable pier stress. This assumption is not permissible if the piers are skewed more than 30 degrees. The above rule does not apply to rigid frame or arch bridges.

Slender columns of either concrete or steel may be designed to bend sufficiently to permit the superimposed superstructure to expand and contract, but the resulting bending stresses shall not exceed the allowable.

During phased construction of a capped pile pier, do not design a pier phase to be supported on less than three (3) piles. For cap and column piers, do not design a phase to be supported on less than two (2) columns.

For a new or replacement structure, individual free-standing columns without a cap are not permitted.

#### 303.3.1.1 BEARING SEAT WIDTHS

Pier bearing seat widths for reinforced concrete slab bridges should conform to Standard Bridge Drawing CPP-2-94. Also see Section 303.3.2.5 of this Manual.

Pier caps on piles, drilled shafts or on columns are normally a minimum of 3'-0" [915 mm] wide.

This is the standard width used for continuous span prestressed box beams and I-beams. Bearing seat widths of 3'-0" [915 mm], while normally adequate must be verified by the designer of the structure. Large bearings, skew angle, intermediate expansion devices, AASHTO earthquake seat requirements, etc. may require additional width.

### 303.3.1.2 PIER PROTECTION IN WATERWAYS

See Section 200 of this Manual for piling protection requirements and Section 600 for a plan note to be added to design drawings when the Capped Pile Pier Standard Bridge Drawing is not referenced.

### 303.3.2 TYPES OF PIERS

### 303.3.2.1 CAP AND COLUMN PIERS

### 303.3.2.1.a CAPS

The cantilever arms of cap and column piers shall be designed for the same impact fraction as the superstructure. When designing the cantilever portions of cap and column piers, the design moments shall be calculated at the actual centerline of the column. A reduction in design moments based on *AASHTO Section 8.8.2* will not be acceptable for the cantilever portion.

The uppermost layers of longitudinal reinforcing steel in the pier cap shall not be lap spliced at the centerline of a column.

Cap dimensions should be selected to meet strength requirements and to provide necessary bridge seat widths according to BDM Section 301.4.3.1.a. Caps should be cantilevered beyond the face of the end column to provide approximately balanced moments in the cap. The end of the cantilevered caps should be formed perpendicular to the longitudinal centerline of the cap to allow for uniform development lengths for the reinforcing steel. Cantilevered pier caps may have the bottom surface of the cantilever sloped upward from the column toward the end of the cap. Cantilevered caps may be eliminated for waterway crossing where debris removal access is an issue.

### 303.3.2.1.b COLUMNS

Columns shall be designed as compression members according to *AASHTO 8.16* and *8.18*.

Round columns are preferred and normally should be 36" [915 mm] diameter. Round columns shall be reinforced with spiral reinforcing placed directly outside the longitudinal bars.

### 303.3.2.2 CAP AND COLUMN PIERS ON PILES

Piers supported on piles generally should have separate footings under each column.

Column piers shall have at least 4 piles per footing.

For grade separation structures, the top of the pier's footings should be a minimum of 1'-0" [300 mm] below the level of the bottom of the adjacent ditch. This applies even though the pier is located in a raised earth median barrier.

### 303.3.2.3 CAP AND COLUMN PIERS ON DRILLED SHAFTS

Where columns are supported on a drilled shaft foundation, the drilled shaft should be at least 6 inches [150 mm] larger in diameter than the column. This is to allow for field location tolerances of the drilled shaft. A drilled shaft foundation is defined as starting 1 foot [0.3 meter] below ground level or 1 foot [0.3 meter] above normal water.

### 303.3.2.4 CAP AND COLUMN PIERS ON SPREAD FOOTINGS

Cap and column piers on spread footings, placed on existing soils or on embankment fills, shall have continuous footings which should extend beyond the center of the end column a distance equal to approximately 1/3 of the distance between the end column and the adjacent column, in order to provide approximately balanced moments.

Cap and Column piers with spread footings on bedrock shall have separate footings under each column.

For grade separation structures, the top of pier footings shall be located in accordance with BDM 202.2.3.1. In no case shall the bottom of the footings in existing soil or on embankment fills be above the frost line.

The width of footing for a free-standing pier shall be not less than one-fourth the height of the pier where founded on soil and not less than one-fifth the height of the pier where founded on bedrock.

### 303.3.2.5 CAPPED PILE PIERS

Steel H piles shall be a minimum HP12x53 [HP310 x 79]. The piles should be shown on the plans with the flanges of the H-section perpendicular to the face of the pier cap.

The distance from the edge of a concrete pier cap to the side of a pile shall be not less than 8 inches [200 mm].

The diameter of the exposed portions of cast-in-place reinforced concrete piles generally should be 16 inches [400 mm], but if exposed length, design load or other conditions make it necessary, larger diameter cast-in-place piles should be used. Cast-in-place piles shall be reinforced with a reinforcement cage composed of 8-#6 [#19M] reinforcing bars with a 12 inch [300 mm] outside diameter, #4 [#13M] spiral, with a 12 inch [300 mm] pitch. The cage length should extend from the finished top of the pile to 15 feet [5 meters] below ground level. The reinforcing steel shall be shown in the structure's reinforcing bar list and be included in item 507 for payment. The use of cast-in-place piles greater than 16 inches [400 mm] in diameter will require an increase in the width of the cap of Standard Bridge Drawing CPP-2-94. See Section 303.3.3.

Exposed H piles and unreinforced concrete piles shall have pile protection. Refer to the description in Standard Bridge Drawing CPP-2-94. A plan note is also available. Also See Section 200 for a description of pile protection.

For pile embedment requirements into concrete, see Section 303.3.3.

An optional construction joint shall be shown at the top of pier caps for reinforced concrete slab bridges. This joint is optional as some machine finishing equipment for slab bridge decks require a uniform depth of freshly placed concrete in order to obtain best results.

The design of the cap for a capped pile pier supported on bearing piles should be based on the assumption that any one pile in any three consecutive piles does not have sufficient bearing to support axial loads. The cap design doesn't need to assume the end piles cannot support axial loads.

Although actual performance of this type of pier indicates this condition to be rare, this conservatism is recommended.

For phased construction projects, do not design a pier or abutment phase to be supported on less than three (3) piles.

The connection between the pile cap and the superstructure shall be designed for the horizontal connection force specified in BDM 301.4.3.1.b. When using Standard Bridge Drawing, CPP-1-08, Designers shall verify the spacing of the P501 bars to resist this force. No additional seismic analysis for capped pile piers is required.

### 303.3.2.6 STEEL CAP PIERS

If at all possible this alternative should not be selected. This is a fracture critical design that has historically shown both steel member and weld metal cracking problems. As specified in Section 301.2, these structure types require a concurrent detail design review to be performed by the Office of Structural Engineering.

If a steel box girder is required as a pier cap, the design shall allow reasonable access to the interior for maintenance, inspection and repair purposes. The physical dimensions of the box shall be large enough to allow access to the interior for inspection. Access hatches of the box girder should be bolted and sealed with a neoprene gasket. Access hatches should also be light enough for an inspector to easily remove them. One recommended lightweight material is ABS plastic.

Designers shall ensure that all governmental agency regulations regarding to enclosed spaces, ventilation, lighting, etc. are complied with within any enclosed steel pier cap design.

Box designs with cut away webs to allow for stringers to continue through the box are generally not considered acceptable alternatives.

Situations that require stringers to be continuous through, and in the same plane with a steel pier cap or crossbeam should be avoided if at all possible.

Designers should review all weld details for possible fatigue problems. Consult the Office of Structural Engineering for assistance in this area.

### 303.3.2.7 POST-TENSIONED CONCRETE PIER CAPS

Where vertical clearance or geometric considerations require stringers to be continuous through and/or in the same plane as the pier cap, a post-tensioned concrete cap should be investigated as a first option in lieu of a steel pier cap. However, this is a non-redundant design, and, as specified in Section 301.2, these structure types require a concurrent detail design review to be performed by the Office of Structural Engineering.

### 303.3.2.8 T-TYPE PIERS

The cantilever arms of T-type piers are to be designed for the same impact fraction AASHTO requires for the superstructure.

In the cap of a T-type pier, the top layer of reinforcing bars shall extend the full length of the cap and be turned down at the end face the necessary development length. The second layer of reinforcing steel shall extend into the stem of the pier at least the necessary development length plus the depth of the cantilever at its connection to the stem. Cap widths shall provide sufficient bearing seat width according to BDM Section 301.4.3.1.a.

Stems of T-type piers and wall type piers shall be designed as compression members according to *AASHTO 8.16* and *8.18*. Wall type piers are characterized by the absence of clearly defined cap member.

### 303.3.2.9 PIER USE ON RAILWAY STRUCTURES

For clearance requirements see Section 200 of this Manual. Items listed in Section 200 are only general rules and vary from railroad to railroad. The designer shall confirm with the individual railroad the actual physical dimension and design requirements.

### 303.3.2.10 PIERS ON NAVIGABLE WATERWAYS

Piers in the navigation channel of waterways, unless protected from collision by an adequate fendering system, shall be designed to resist collision forces based on AASHTO Guide Specification for Vessel Collision Design of Highway Bridges.

### 303.3.2.11 PIER CAP REINFORCING STEEL STIRRUPS

Stirrups for concrete beams of constant depth, such as pier caps, should be detailed using either 2 "U" bars with the vertical legs long enough to furnish the required lap length or a single bar closed type stirrup with 135º bends at both ends of the rebar. The single bar closed type stirrup should only be selected when minimum required lap lengths cannot be provided with the "U" type stirrup. The corner with the 135º bends of the closed type stirrup should be placed in the compression zone of the concrete beam.

### 303.3.3 FOOTING ON PILES

Piles supporting capped pile piers shall be embedded 1'-6" [450 mm] into the concrete cap. Other substructure units on a single row of piles should have the piles embedded 2'-0" [600 mm] into the concrete. A 1'-0" [300 mm] embedment depth into the concrete footing is required for all other cases. In every case, there shall be at least 1'-6" [450 mm] cover over top of pile.

The distance from the edge of a footing to the center of a pile shall be not less than 1'-6" [450 mm]. The distance from the edge of a concrete pier cap to the side of a pile shall be not less than 8 inches [200 mm].

## 303.4 FOUNDATIONS

### 303.4.1 MINIMUM DEPTH OF FOOTINGS

Refer to BDM Section 202.2.3.1 for Spread Footing Elevation requirements.
Pile and drilled shaft footings shall be founded as follows:

A. For footings partially or totally located inside the plan view of the OHWM, the top of the footing shall be at least 1-ft below the Thalweg.

B. For footings located entirely outside the plan view of the OHWM:

1. The top of footing shall be a minimum of 1-ft below the finished ground line. The top of footing shall be at least 1-ft below the bottom of any adjacent drainage ditch.
2. The bottom of footing shall not be less than 4-ft below, measured normal to, the finished groundline.

### 303.4.1.1 FOOTING, RESISTANCE TO HORIZONTAL FORCES

The safety factor against horizontal movement at the base of a structure; i.e., the ratio of available resistance to movement to the forces tending to cause movement, shall be not less than 1.5 except as specified below for footings on bearing piles.

The friction resistance between a concrete footing and a cohesionless soil may be taken as the vertical pressure on the base times the coefficient of friction "f" of concrete on soil.

For coarse-grained soil without silt.................................................................... f = 0.55

For coarse-grained soil with silt.......................................................................... f = 0.45

For silt ................................................................................................................ f = 0.35

If the footing bears upon clay, the resistance against sliding shall be based upon the cohesion of the clay, which may be taken as one-half the unconfined compressive strength provided, however, that the frictional resistance against sliding should not be considered to be greater than that obtained using the coefficient "f" of 0.35. If the clay is very stiff or hard, the surface of the clay shall be roughened before the concrete is placed.

If the footing bears upon bedrock, consideration shall be given to features of the bedrock structure that may constitute planes of weakness such as laminations or inter-bedding. If there is no evidence of such weakness, the coefficient of friction "f" may be taken as 0.55 for shale and 0.7 for rock.

If the frictional or shearing resistance of the supporting material is inadequate to withstand the horizontal force, one or more of the following means shall provide additional resistance:

A. Increase the footing width and/or use footing keys.

B. Make allowance for the passive pressure developed at the face of the footing.

C. Use battered piles , footing struts, sheeting or anchors .

For footings with keys, allowance shall be made for the shearing resistance furnished by the supporting material at the elevation of the bottom of the key. Keys generally shall be located within the middle-half of the footing width.

For footings on piles, no allowance shall be made for the frictional resistance of the footing concrete on soil. For such footings, the horizontal component of the axial load on battered piles shall be taken at full value, without the application of the safety factor of 1.5. The safety factor shall apply for any required additional resistance provided by the passive pressure developed in the soil in front of such foundations. The above may be expressed by the following formula:

$$\frac{A}{B - C} \geq 1.5$$

Where:

A = passive pressure developed in the soil in front of the footing
B = force tending to cause movement
C = horizontal component of the axial load in battered piles

For structures on piles or soils, the passive resistance developed on the face of a foundation (assuming a level ground surface) may be based on an equivalent passive fluid weight $W_p$ (lb/ft$^3$) [kN/m$^3$] for the undisturbed material encountered or anticipated. The equivalent passive fluid weight may be based on the following equation:

$$W_p = W \tan^2(45 + q/2) \text{ lb/ft}^3 \; [\text{kN/m}^3]$$

Where:

W = unit soil weight, lb/ft$^3$ [kN/m$^3$]
q = angle of internal friction, in degrees.

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# 305 FENCING

## 305.1 GENERAL

The primary purposes of protective fencing are to provide for the security of pedestrians and to discourage the throwing or dropping of objects from bridges onto traffic below.

The Vandal Protection Fencing Standard Bridge Drawing provides standard details for fencing attached to bridges. The designer may need to enhance this standard to deal with requirements for the specific structure.

## 305.2 WHEN TO USE

Fencing shall be installed on all bridges over vehicular traffic except as noted herein. Fencing shall be installed on bridges over rail traffic if required in an agreement with the affected railroad. Bridges that carry vehicular traffic over county/township routes shall be exempt from fencing. For existing bridges, fencing shall be provided when new concrete or refaced concrete barriers are installed. At locations where fencing will adversely affect public safety (e.g. reduced sight distance), submit a written request for exemption to the Deputy Director Engineering. The request for exemption shall include supporting documentation.

| Under Bridge Feature | Fence Required |
|---|---|
| Interstate | Yes |
| US Route | Yes |
| State Route | Yes |
| County/Township Route | No * |
| City Route | Yes |
| Railroad | Yes/No (Based on RR agreement) |
| Waterway | No |
| * – Bridges carrying only pedestrian/bicycle traffic shall have vandal protective fencing. | |

## 305.3 FENCING CONFIGURATIONS

For structures without sidewalks, the top of fence shall be a minimum height of 8-ft above the pavement surface. For structures with sidewalks, the top of fence shall be a minimum height of 8-ft above the sidewalk. For a greater degree of protection against objects being thrown from the bridge, the fence may be curved to overhang the sidewalk. For curved fence the posts shall be vertical for at least 8-ft above the sidewalk before curving inward over the sidewalk. The overhang shall be at least 1-ft less than the width of the sidewalk. See Figures 326 & 327.

For pedestrian bridges, use bent pipe frames with pipe bend radii of 24" at the upper corners and the start of the radii about 8-ft above the sidewalk surface. The fabric shall start at the deck line, top of curb or parapet and may stop at the upper end of the bent portion of the frame. Fabric on the top horizontal area of the frame is not required to prevent an individual from walking on the top of the enclosure. See Figure 328 for an illustration of this configuration. Alternatively, the frame may be designed to form a peak at the center of the structure, similar to a house roofline.

The maximum gap at the bottom of the fence shall be 1-in. A detail to close the bottom of a fencing section is included on the standard bridge drawing.

Posts and frames may be either plumb or perpendicular to the longitudinal grade of the bridge, subject to considerations of aesthetics or practicality of construction. Complete details of base plates, pipe inserts or other types of base anchorage shall be provided on the plans. If applicable to the specific project, details from the standard bridge drawing may be referred to in the project plans.

Fencing on the bridge shall extend between its End Posts placed at the locations selected from the following list that creates the shortest length:

A. 30-ft ± 2.5-ft beyond the under bridge route's edge of traveled way nearest the fence terminal

B. The centerline of the abutment expansion joint (-2.5-ft, + 0-ft)

C. The end of the bridge barrier (-2.5-ft, +0-ft)

Designers shall also place fence on structures parallel to traffic and that carry sidewalks located 30-ft or less from the nearest edge of the traveled way below.

For bridges where a snooper truck will be used for inspection, use only straight fence with the top of the fence located 10-ft or less above the deck.

## 305.4 SPECIAL DESIGNS

The design loading for non-standard fence designs shall be in accordance with LRFD 15.8.

For fence installation projects on new structures, the installation of a traffic railing (steel tubing) is not required if the top concrete parapet or concrete wall is 36-in above roadway for structures without sidewalks or 36-in above the top of sidewalk for structures with sidewalks. See Figure 326.

Where the standard gray chain link fence mesh detracts from a project's aesthetic enhancements, designers may select an optional color from the following: green, olive green, brown and black. Designers shall consider the welded wire fabric, BDM Section 305.5.B, for additional color options. Color coating of posts and rails shall utilize a two coat shop applied epoxy/urethane system in accordance with C&MS 708.02. Plan notes for this coating system are available from OSE upon request.

For special fence designs, plan notes shall be required to define non-standard color, materials, traffic maintenance, construction procedures and other requirements. The designer should follow the example of standard bridge drawing for development of required notes.

## 305.5 FENCE DESIGN GENERAL REQUIREMENTS

Fencing mesh should consist of either of the following materials:

A. Chain-link wire mesh with one inch [25 mm] diamonds. The core wire shall be 11 gage [3.05 mm] with a Polyvinyl chloride coating. (C&MS 710.03)

B. Welded wire fabric with ½" x 3" [12 mm x 75 mm] opening size. The core wire shall be 10.5 gage [3.25 mm]; galvanized after welding (1.2 oz zinc/ft²), and PVC coated (10 mil [0.25 mm]).

Brace and bottom rails shall be clamped to posts or post frames.

The top rail, if any, of a free-standing fence should be continuous over two or more posts and suitable cap fittings provided.

Bent pipe frames for narrow pedestrian bridges are permitted. Bent pipe frames for narrow pedestrian bridges should be fabricated in two or more sections and field spliced at the top with sleeves bolted to the frame sections.

To prevent pipe blow-ups during galvanizing, both ends of pipe should be open. Therefore base plates should have holes in them almost equal to the pipes' inside diameter.

### 305.5.1 WIND LOADS

The design wind loading for non-standard fence designs shall be in accordance with *LRFD 15.8.2*.

The projected area for wind forces on 11 gage polyvinyl chloride coated one inch wire mesh shall be 20% of the gross horizontally projected area.

Additional area for posts, rails and other hardware need not be considered.

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# 306 EXPANSION DEVICES

## 306.1 GENERAL

Expansion devices should provide a total seal against penetration and moisture. Standard bridge drawings are available for expansion devices for typical bridge superstructure types.

Expansion devices as shown in the standard bridge drawings and their support systems are designed for an HS25 [MS22.5] loading with 100% impact. Special expansion devices including finger joints and modular joints and their support systems shall also be designed for an HS25 [MS22.5] loading with 100% impact.

For fabricated steel expansion devices, the designer should specify the type of steel required. Type of steel should be included as a plan note if requirements in the plans are not covered by a selected standard bridge drawing.

To protect steel expansion devices, metallizing of the exposed surfaces with a 100% zinc coating shall be specified. Standard bridge drawings define the requirements for metallizing. The design agency will need to develop plan notes for special expansion devices, such as finger joints and modular joints. Use the note for shop-applied metallizing located in the appendix as a guideline. Consult the Office of Structural Engineering for recommendations prior to completion of the project plans.

### 306.1.1 PAY ITEM

Expansion devices, except as specifically listed in this section, shall be paid for as Item 516.

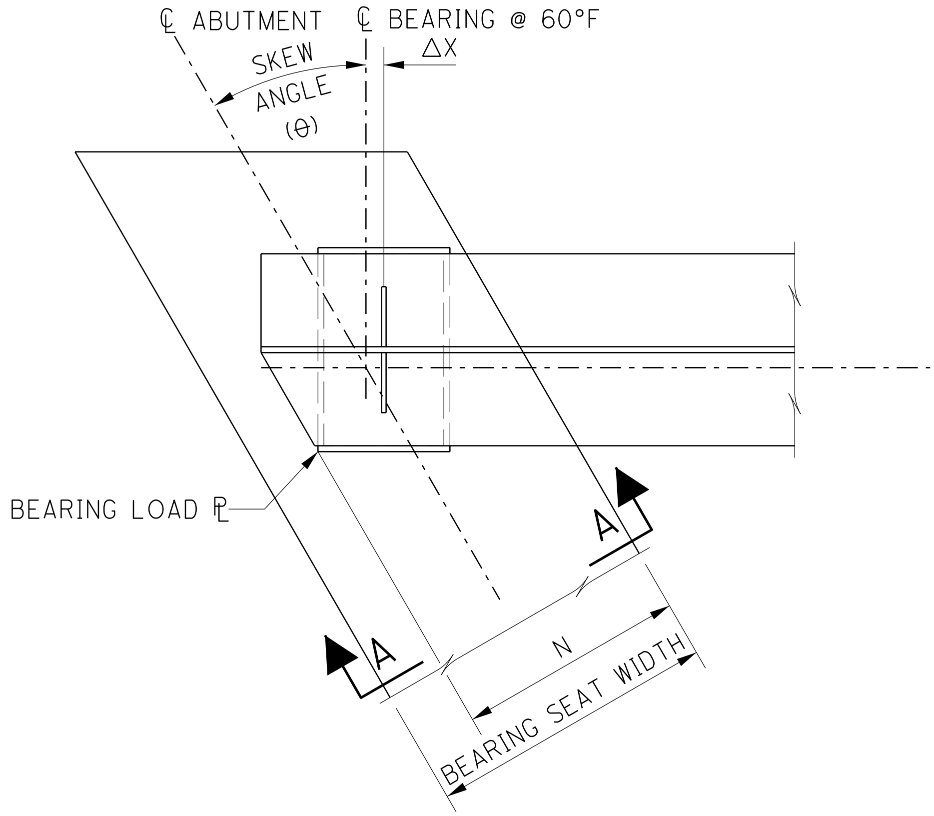
For sealed expansion devices the elastomeric seal, either strip or compression, shall be included in the pay Item 516.

The plans shall clearly show what components are included with the expansion devices, Item 516. As an example, cross frames, which are field welded to both the superstructure girders and the expansion devices, are part of the 513 structural steel item. The seal is considered part of the expansion device and should be included in the 516 pay item.

### 306.1.2 EXPANSION DEVICES WITH SIDEWALKS

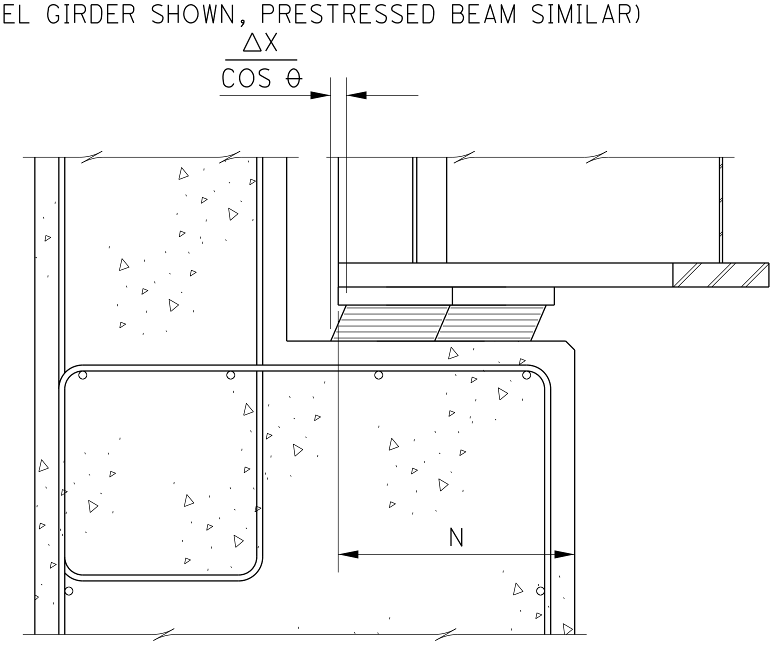
On structures with sidewalks, the expansion devices shall be the same type as furnished for main bridge deck expansion joint.

## MINIMUM SUPPORT LENGTH MEASUREMENTS




## TYPICAL ABUTMENT BEARING - PLAN VIEW

(STEEL GIRDER SHOWN, PRESTRESSED BEAM SIMILAR)




## SECTION A-A

NOTES:

ΔX IS THE MAXIMUM MOVEMENT ALLOWED BY THE ELASTOMERIC BEARING BEFORE SLIDING OCCURS.
N AS DEFINED BY LRFD EQ. 4.7.4.4-1.

FIGURE 336

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**[3]** DESIGN LOADING: HS25 (#), Case________(I or II)** and the Alternate Military Loading.

Future Wearing Surface (FWS) of __60 *__ Lbs/ft$^2$.

**[3M]** DESIGN LOADING: MS-22.5 (#), Case______(I or II)** and the Alternate Military Loading.

Future Wearing Surface (FWS) of __2.87 *__ kPa.

* Designer to modify load if appropriate.
** The statement "Case (I or II)" applies only to steel bridges.

\# Replace vehicle type with HS-20, or metric equal, if the design is for a rehabilitation of an existing structure

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

**[4]** DESIGN LOADING **:** __*__ Lb/ft$^2$

**[4M]** DESIGN LOADING **:** __*__ kN/m$^2$

* As defined for the specific structure in accordance with the AASHTO Guide Specifications for Design of Pedestrian Bridges

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

**[5]** DESIGN LOADING **:** __*__ Lb/ft$^2$ and H15-44 vehicle

**[5M]** DESIGN LOADING **:** __*__ kN/m$^2$ and M13.5 vehicle

* As defined for the specific structure in accordance with the AASHTO Guide Specifications for Design of Pedestrian Bridges

## 602.2 DESIGN STRESSES

### A. General Design Data For Load Factor design:

**[6]** DESIGN DATA :

Concrete __*__ - compressive strength 4500 psi (superstructure)

Concrete __*__ - compressive strength 4000 psi (substructure)

# Concrete QC5 - compressive strength 4000 psi (drilled shaft)

* Class QC2 Concrete for superstructure
  Class QC1 Concrete for substructure

# Only included if drilled shafts are being constructed

Reinforcing steel - ASTM A615 or A996Grade 60 minimum yield strength 60,000 psi
Spiral reinforcement may be plain bars, ASTM A82 or A615

If spiral reinforcing bars are not used, omit the portion of the note beginning with “spiral”.

** Structural Steel

ASTM A709 Grade 50W or A709 Grade 50 - yield strength 50,000 psi
A709 Grade 36 - yield strength 36,000 psi

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

**[6M]** DESIGN DATA :

Concrete __*__ - compressive strength 31.0 MPa (superstructure)

Concrete __*__ - compressive strength 27.5 MPa (substructure)

# Concrete QC5 - compressive strength 27.5 MPa (drilled shaft)

* Class QC2 Concrete for superstructure
  Class QC1 Concrete for substructure

# Only included if drilled shafts are being constructed

Reinforcing steel - A615M or A996M
Grade 420 minimum yield strength = 420 MPa
Spiral reinforcement may be plain bars, ASTM A82 or A615M

If spiral reinforcing bars are not used, omit the portion of the note beginning with “spiral”.

** Structural Steel

ASTM A709 Grade 50W or A709 Grade 50 - yield strength 350 MPa
A709 Grade 36 - yield strength 250 MPa

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

**B. General Design Data For Service Load Design (Working Stress Design):**

**[7]** DESIGN DATA **:**

Concrete __*__ - unit stress 1500 psi (superstructure)

Concrete __*__ - unit stress 1300 psi (substructure)

# Concrete QC5 - unit stress 1300 psi (drilled shaft)

* Class QC2 Concrete for superstructure
Class QC1 Concrete for substructure

# Only included if drilled shafts are being constructed

Reinforcing Steel - ASTM A615 or A996
Grade 60 - unit stress 24,000 psi
Spiral reinforcement may be plain bars, ASTM A82 or A615

If spiral reinforcing bars are not used, omit the portion of the note beginning with "spiral".

** Structural Steel

ASTM A709 Grade 50W or A709 Grade 50 - yield strength 27,000 psi
A709 Grade 36 - yield strength 20,000 psi

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

**[7M]** DESIGN DATA **:**

Concrete __*__ - unit stress 10.3 MPa (superstructure)

Concrete __*__ - unit stress 9.2 MPa (substructure)

# Concrete QC5 - unit stress 9.2 MPa (drilled shaft)

* Class QC2 Concrete for superstructure
Class QC1 Concrete for substructure

\#  Only included if drilled shafts are being constructed

Reinforcing Steel - ASTM A615M or A996M
Grade 420 - unit stress 165 MPa
Spiral reinforcement may be plain bars, ASTM A82 or A615M

If spiral reinforcing bars are not used, omit the portion of the note beginning with "spiral".

** Structural Steel

ASTM A709 Grade 50W or A709 Grade 50 - yield strength 186 MPa
A709 Grade 36 - yield strength 138 MPa

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

**C. Additional Design Data for Prestressed Concrete Members:**

Provide the following note in addition to either note **[6]** or **[7]**.

**[8]** DESIGN DATA:

Concrete for prestressed beams:
Compressive Strength (final) - 5500 psi **
Compressive Strength (release) - 4000 psi **

Welded Wire Fabric:
Yield Strength – 70 ksi***

Prestressing strand:
Area = 0.153 $in^2$ **
Ultimate Strength = 270 ksi
Initial stress = 202.5 ksi (Low relaxation strands)

** Revise the prestressed concrete strength values for final strength and strength at release if a design strength is different than the values listed above. Also, modify the diameter and area of the strands as required.
*** Reference to Welded Wire Fabric applies to I-beam only.

**[8M]** DESIGN DATA:

Concrete for prestressed beams:
Compressive Strength (final) - 38 Mpa **
Compressive Strength (release) - 27.5 Mpa **

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# SECTION 900 – BRIDGE LOAD RATING

## 901 PURPOSE

The purpose of this Section is to provide consistency and uniformity in the procedures, guidelines and policies for determining safe live load carrying capacity or load rating of the highway bridges in the State of Ohio.

## 902 SCOPE

The guidelines, policies and recommendations provided in this Section are meant to assist bridge owners and bridge raters by establishing evaluation practices that meet the Ohio Revised Code (ORC), the National Bridge Inspection Standards (NBIS), ODOT Bridge Design Manual (BDM) and American Association of State Highway Transportation Officials (AASHTO). The intent of this Section is to establish standardized load rating procedures conforming to FHWA reporting requirements and posting of bridges in the State of Ohio.

## 903 APPLICABILITY

### 903.1 APPLICABILITY OF AASHTO DESIGN SPECIFICATIONS

BDM Section 900 is consistent with the current AASHTO LRFD Bridge Design Specifications and Standard Specifications for Highway Bridges (14th edition). Where this Section is silent, the current AASHTO LRFD Bridge Design Specifications or Standard Specifications for Highway Bridges shall govern for LRFR and LFR methods respectively.

### 903.2 APPLICABILITY TO HIGHWAY BRIDGES

The provisions of this Section apply to all highway structures in Ohio that qualify as bridges in accordance with the definition for a bridge set herein. These provisions may be applied to smaller structures which do not qualify bridges, as such.

## 904 QUALITY MEASURES

To maintain the accuracy and consistency of load rating, bridge owners should implement appropriate quality assurance and quality control (QA/QC) measures. Typical quality control procedures include the use of checklists to ensure uniformity and completeness, the review of reports and computations by a person other than originating individual and periodic field review of the inspection teams and their work.

Each load rating analysis shall be performed under the supervision of an Ohio registered professional engineer (i.e. the load rater) who will sign and stamp (seal) the final load rating report before submission to the bridge owner.

## 905 DEFINITIONS AND TERMINOLOGY

**ASR:** Allowable Stress Rating (also known as Working Stress Rating)

**ADT:** Average Daily Traffic volume

**ADTT:** Average Daily Truck Traffic volume

**Bridge:** A structure, including supports, erected over a depression or an obstruction such as water, highway, bikeway or railway; and having a roadway to carry vehicular traffic and having an opening measured along the centerline of the roadway of 10-ft or more between under-copings of abutments or spring lines of arches or extreme ends of openings for multiple boxes. It may also include multiple pipes where the clear distance between openings is less than half that of the smaller contiguous opening.

**Bridge Number:** A combination of 3-letter County Abbreviation − Route Number − County Log Point in miles followed by parallel designation, if any (e.g., HAM-00071-10.680R); 3-letter County Abbreviations are given in ODOT L&D Manual, Volume I

**Bridge Management System (BMS):** A system designed to optimize the use of available resources for the inspection, maintenance, rehabilitation, and replacement of bridges

**Bridge Owner:** A public or private entity that has jurisdiction over the bridge or an agency having major maintenance responsibility for a bridge

**Buried Structure:** A structure, including a flat slab, an arch, a frame, a box section, etc. that has a fill or pavement material of 2-ft or more on top of it

**Collapse:** A major change in the geometry of the bridge rendering it unfit for its intended use

**Condition Rating**: The result of the assessment of the functional capability and the physical condition of a bridge's components by considering the extent of deterioration and other defects. Generally, Condition Rating is evaluated on a scale "0" through "9" (where "9" is the best) and is also referred to as General Appraisal (GA).

**Control Authority Program Manager (CAPM):** The designated person at a public transportation entity (Control Authority) responsible for overseeing FHWA's National Bridge Inspection Program for that entity

**County Log Point:** Distance in miles from the point where a route enters the county or the starting point of a route within the county traveling in the up-station direction from south-to-north or west-to-east

**Exemption List:** A list of structures exempt from the requirements of load rating given in this section

**Failure:** A condition where a limit state is reached or exceeded. This may or may not involve collapse or other catastrophic occurrences.

**FHWA:** Federal Highway Administration – U.S. Department of Transportation

**General Appraisal (GA)**: See Condition Rating

**GVW:** Gross Vehicle Weight

**Inventory Rating:** Load ratings based on the inventory level allow comparisons with the capacity for new structures and, therefore, result in a live load that can safely utilize a structure for an indefinite period of time

**Health Index:** An indicator of the structural health of an element, a bridge or a group of bridges expressed as a value (0 to 100), where 100 corresponds to best possible condition

**LFR:** Load Factor Rating

**Limit State:** A condition beyond which a bridge or a component ceases to satisfy the criteria for which it was designed

**Load Effect:** The response (axial force, shear force, bending moment, torque, etc.) in a member or an element due to the loading

**Load Factor:** A load multiplier accounting for the variability of the loads, the lack of accuracy in analysis and the probability of simultaneous occurrence of different loads

**Load Rater:** An individual person responsible for the load rating of a bridge. The Load Rater shall be a professional engineer registered in the State of Ohio.

**Load Rating:** The determination of the safe live-load carrying capacity of a bridge

**Long Span Bridge:** Any single or multi-span bridge that has at least one span greater than 200-ft

**LRFD:** Load and Resistance Factor Design

**LRFR:** Load and Resistance Factor Rating

**MBE:** AASHTO Manual for Bridge Evaluation

**NBI:** National Bridge Inventory; the aggregation of structure inventory and appraisal data collection to fulfill the requirements of National Bridge Inspection Standards (NBIS)

**NBIS:** National Bridge Inspection Standards; Federal regulations establishing requirements for the bridge inspection organization, its inspection procedures, the frequency of inspection, the qualification of personnel, inspection reports, and preparation and maintenance of bridge inventory records. The NBIS applies to all structures defined as NBIS bridges located on or over all public roads.

**NBIS Bridge:** A structure including supports over a depression or an obstruction such as water, highway, or railway; having a roadway to carry vehicular traffic and having an opening measured along the centerline of the roadway of more than 20-ft between under-copings of abutments or spring lines of arches or extreme ends of openings for multiple boxes. It may also include multiple pipes, where the clear distance between openings is less than half that of the smaller contiguous opening.

**Nominal Resistance:** Resistance of a component or connection to load effect, based on its geometry, permissible stresses and specified strength of materials

**Non-Buried Structure:** A structure, including a flat slab, an arch, a frame, a box section, etc., that has a fill or pavement material of less than 2-ft on top of it

**Non-ODOT Bridge:** A bridge on which ODOT does not have jurisdiction or major maintenance responsibility

**ODOT:** Ohio Department of Transportation

**ODOT Bridge:** A bridge on which ODOT has jurisdiction or major maintenance responsibility

**Operating Rating:** Load ratings based on the operating rating level generally describe the maximum permissible live load to which the structure may be subjected. Allowing unlimited numbers of vehicles to use the bridge at operating level may shorten the life of the bridge.

**ORC:** Ohio Revised Code (as amended and adopted)

**OSE:** ODOT Office of Structural Engineering

**Pavement of a Roadway:** The pavement of a roadway includes all the paved or unpaved portions of a roadway including graded shoulders that may support vehicular traffic

**PDF:** Portable Document Format, a type of industry standard electronic file format developed by the Adobe Corporation

**Posting:** Signing a bridge for load restriction

**Posting Load:** Rating Factor (RF) times legal GVW of Ohio Legal Load; posting load cannot be more than the legal GVW of the legal load

**Preliminary Design Date:** The date when Federal-aid funds are obligated for the studies or design activities related to identification of the type, size, and/or location of bridges.

**Quality Assurance:** The use of sampling and other measures to assure the adequacy of quality control procedures in order to verify and measure the quality level of the entire bridge inspection and load rating program

**Reliability Index:** A computed quantity defining the relative safety of a structural element or structure expressed as the number of standard deviations that the mean of the margin of safety falls on the safe side

**Resistance Factor:** A resistance multiplier accounting for the variability of material properties, structural dimensions, workmanship and the uncertainty in the prediction of resistance

**RF:** Rating Factor, an indicator of live load carrying capacity of a member or a bridge for a specific truck or load

**Safe Load Capacity:** A live load that can safely utilize a bridge repeatedly over the duration of a specified inspection cycle

**Service Limit State:** Limit state related to stress, deformation and cracking

**Serviceability:** A term that denotes restrictions on stress, deformation, and crack opening under regular service conditions

**Serviceability Limit State:** Collective term for service and fatigue limit states

**Strength Limit State:** Safety limit state relating to strength and stability

**Structure Management System (SMS):** ODOT's new Bridge Information & Collection System which replaced the old BMS, designed to optimize the use of available resources for the inspection, maintenance and rehabilitation of structures. SMS is based on Bentley's Inspect Tech System.

**Superload:** In Ohio, a Superload is any highway vehicular load with the total gross load equal to or more than 120,000 pounds (60 tons)

**Target Reliability:** A desired level of reliability in a proposed evaluation

## 906 REFERENCES FROM OHIO REVISED CODE

References from the ORC related to bridge load rating and posting are as follows:

**5577.042 [Effective 6/29/2011] Weight provisions for farm, log and coal trucks and farm machinery**

(A) As used in this section:

(1) "Farm machinery" has the same meaning as in section 4501.01 of the Revised Code.

(2) "Farm commodities" includes livestock, bulk milk, corn, soybeans, tobacco, and wheat.

(3) “Farm truck” means a truck used in the transportation from a farm of farm commodities when the truck is operated in accordance with this section.

(4) “Log truck” means a truck used in the transportation of timber from the site of its cutting when the truck is operated in accordance with this section.

(5) “Coal truck” means a truck transporting coal from the site where it is mined when the truck is operated in accordance with this section.

(6) “Solid waste” has the same meaning as in section 3734.01 of the Revised Code.

(7) “Solid waste haul vehicle” means a vehicle hauling solid waste for which a bill of lading has not been issued.

(B)(1) Notwithstanding sections 5577.02 and 5577.04 of the Revised Code, the following vehicles under the described conditions may exceed by no more than seven and one-half per cent the weight provisions of sections 5577.01 to 5577.09 of the Revised Code and no penalty prescribed in section 5577.99 of the Revised Code shall be imposed:

(a) A coal truck transporting coal, from the place of production to the first point of delivery where title to the coal is transferred;

(b) A farm truck or farm machinery transporting farm commodities, from the place of production to the first point of delivery where the commodities are weighed and title to the commodities is transferred;

(c) A log truck transporting timber, from the site of its cutting to the first point of delivery where the timber is transferred;

(d) A solid waste haul vehicle hauling solid waste, from the place of production to the first point of delivery where the solid waste is disposed of or title to the solid waste is transferred.

(2) In addition, if any of the vehicles listed in division (B) (1) of this section and operated under the conditions described in that division does not exceed by more than seven and one-half per cent the gross vehicle weight provisions of sections 5577.01 to 5577.09 of the Revised Code, no wheel or axle-load limits shall apply and no penalty prescribed in section 5577.99 of the Revised Code for a wheel or axle overload shall be imposed.

(C) If any of the vehicles listed in division (B) (1) of this section and operated under the conditions described in that division exceeds by more than seven and one-half per cent the weight provisions of sections 5577.01 to 5577.09 of the Revised Code, both of the following apply without regard to the seven and one-half per cent allowance provided by division (B) of this section:

(1) The applicable penalty prescribed in section 5577.99 of the Revised Code;

(2) The civil liability imposed by section 5577.12 of the Revised Code.

(D) (1) Division (B) of this section does not apply to the operation of a farm truck, log truck, or farm machinery transporting farm commodities during the months of February and March.

(2) Regardless of when the operation occurs, division (B) of this section does not apply to the operation of a vehicle on either of the following:

(a) A highway that is part of the interstate system;

(b) A highway, road, or bridge that is subject to reduced maximum weights under section 4513.33, 5577.07, 5577.071, 5577.08, 5577.09, or 5591.42 of the Revised Code.

Amended by 129th General Assembly File No. 7, HB 114, § 101.01, eff. 6/29/2011.

Effective Date: 03-31-2003; 09-16-2004

This section is set out twice. See also § 5577.042, effective until 6/29/2011.

**5577.043 [Effective 6/29/2011] Permissible weight variations for certain vehicles**

(A) Notwithstanding sections 5577.02 and 5577.04 of the Revised Code, the following vehicles under the described conditions may exceed by no more than five per cent the weight provisions of sections 5577.01 to 5577.09 of the Revised Code and no penalty prescribed in section 5577.99 of the Revised Code shall be imposed:

(1) A surface mining truck transporting minerals from the place where the minerals are loaded to any of the following:

(a) The construction site where the minerals are discharged;

(b) The place where title to the minerals is transferred;

(c) The place of processing.

(2) A vehicle transporting hot mix asphalt material from the place where the material is first mixed to the paving site where the material is discharged;

(3) A vehicle transporting concrete from the place where the material is first mixed to the site where the material is discharged;

(4) A vehicle transporting manure, turf, sod, or silage from the site where the material is first produced to the first place of delivery;

(5) A vehicle transporting chips, sawdust, mulch, bark, pulpwood, biomass, or firewood from the site where the product is first produced or harvested to first point where the product is transferred.

(B) In addition, if any of the vehicles listed in division (A) of this section and operated under the conditions described in that division does not exceed by more than five per cent the gross vehicle weight provisions of sections 5577.01 to 5577.09 of the Revised Code, no wheel or axle load limits shall apply and no penalty prescribed in section 5577.99 of the Revised Code for a wheel or axle overload shall be imposed.

(C) If any of the vehicles listed in division (A) of this section and operated under the conditions described in that division exceeds by more than five per cent the weight provisions of sections 5577.01 to 5577.09 of the Revised Code, both of the following apply without regard to the allowance provided by division (A) of this section:

(1) The applicable penalty prescribed in section 5577.99 of the Revised Code;

(2) The civil liability imposed by section 5577.12 of the Revised Code.

(D) Divisions (A) and (B) of this section do not apply to the operation of a vehicle listed in division (A) of this section on either of the following:

(1) A highway that is part of the interstate system;

(2) A highway, road, or bridge that is subject to reduced maximum weights under section 4513.33, 5577.07, 5577.071, 5577.08, 5577.09, or 5591.42 of the Revised Code.

Added by 129th General Assembly File No. 7, HB 114, § 101.01, eff. 6/29/2011.

**5577.071 Reduction of weight of vehicle or load or speed on deteriorated or vulnerable bridge.**

(A) When deterioration renders any bridge or section of a bridge in a county insufficient to bear the traffic thereon, or when the bridge or section of a bridge would be damaged or destroyed by heavy traffic, the board of county commissioners may reduce the maximum weight of vehicle and load, or the maximum speed, or both, for motor vehicles, as prescribed by law, and prescribe whatever reduction the condition of the bridge or section of the bridge justifies. This section does not apply to bridges on state highways.

(B) A schedule of any reductions made pursuant to division (A) of this section shall be filed, for the information of the public, in the office of the board of county commissioners in each county in which the schedule is operative. A board of county commissioners that makes a reduction pursuant to division (A) of this section shall, at least one day before a reduction becomes effective, cause to be placed and retained on any bridge on which a reduction is made, at both ends of the bridge, during the period of a reduced limitation of weight, speed, or both, signs of substantial construction conspicuously indicating the limitations of weight or speed or both which are permitted on the bridge and the date on which these limitations go into effect. No person shall operate upon any such bridge a motor vehicle whose maximum weight or speed is in excess of the limitations prescribed. The cost of purchasing and erecting the signs provided for in this division shall be paid from any fund for the maintenance and repair of bridges and culverts.

(C) Except as otherwise provided in this division, no reduction shall be made pursuant to division

(A) of this section on a joint bridge as provided in section 5591.25 of the Revised Code unless the board of county commissioners of every county sharing the joint bridge agrees to the reduction, the amount of the reduction, and how the cost of purchasing and erecting signs indicating the limitations of weight and speed is to be borne. A board of county commissioners may make a reduction pursuant to division (A) of this section on a section of a joint bridge, without the agreement [of] any other county sharing the bridge, if the section of the bridge on which the reduction is to be made is located solely in that county.

**5591.42 Carrying capacity of bridges - warning notice.**

The board of county commissioners together with the county engineer or an engineer to be selected by the board, or the director of transportation, may ascertain the safe carrying capacity of the bridges on roads or highways under their jurisdiction. Where the safe carrying capacity of any such bridge is ascertained and found to be less than the load limit prescribed by sections 5577.01 to 5577.12 of the Revised Code, warning notice shall be conspicuously posted near each end of the bridge. The notice shall caution all persons against driving on the bridge a loaded conveyance of greater weight than the bridge's carrying capacity.

Effective Date: 11-02-1989

## 907 BRIDGE FILES (RECORDS)

Bridge owners shall maintain a complete, accurate and current record of each bridge under their jurisdiction. Complete information, in good usable form, is vital to the effective management of bridges. Such information provides a record that may be important for repair, rehabilitation, replacement and future planning.

Items that shall be assembled as part of the bridge record are discussed below. Some or all of the information pertaining to a bridge may be stored in electronic format as part of a bridge management system.

### 907.1 CONSTRUCTION PLANS

Each bridge record should include one clear and readable set of all drawings used to construct, repair and/or rehabilitate the bridge. In lieu of hard copies, the construction plans may be stored in an electronic format in such a way that clear and readable paper copies can easily be reproduced from the electronic records.

### 907.2 CONSTRUCTION & MATERIAL SPECIFICATIONS

Each bridge record should include the reference to the construction and material specification used during the construction of the bridge. Where general technical specifications were not used, only the special technical provisions need to be incorporated in the bridge record.

## 907.3 SHOP AND WORKING DRAWINGS

One set of all shop and working drawings approved for the construction or repair of a bridge should be saved or preserved as a part of the bridge record.

## 907.4 AS-BUILT DRAWINGS

Each bridge record should include one set of final drawings showing the "as-built" condition of the bridge, complete with signature of the individual responsible for recording the as-built conditions.

## 907.5 CORRESPONDENCE

Include all pertinent letters, memoranda and notices of project completion, telephone memos and other related information directly concerning the bridge in chronological order in the bridge record.

## 907.6 INVENTORY DATA

A complete inventory of a bridge in the ODOT BMS/SMS shall be done as soon as a bridge is open to traffic. FHWA mandates an ODOT bridge shall be inventoried within 90 days and a non-ODOT bridge shall be inventoried within 180 days from the day the bridge was open to traffic. The same rule applies to modifications in the inventory record of replaced bridges or bridges that have been reopened after repairs are done. Initial inventory can be completed using the bridge plans. However, a history of dates of physical closing or opening of the traffic on the bridge should be maintained in the bridge record.

## 907.7 INSPECTION HISTORY

Each bridge record shall include a chronological record of the date and the type of all inspections performed on the bridge. When available, scour, seismic, wind and fatigue evaluation studies; fracture critical information; deck evaluations; field load testing, and; corrosion studies should be part of the bridge record.

## 907.8 PHOTOGRAPHS

Each bridge record shall at least contain photographs of the bridges showing top view, approach views and the elevation. Other photos necessary to show major defects, damages or other important features such as utilities on or under the bridge should also be included.

## 907.9 RATING RECORDS

The bridge record shall include a complete record of the determination of bridge's load-carrying capacity.

## 907.10 ACCIDENT DATA

Details of accidents or damage occurrences including date, description of accident, member damage and repairs, as supported by photographs and investigation reports, shall be included in the bridge record.

## 907.11 MAINTENANCE AND REPAIR HISTORY

Each bridge record shall include a chronological record documenting the maintenance and repairs that have occurred since the initial construction of the bridge. Include details such as date, description of project, contractor cost and related data for in-house projects as well as contracted work.

## 907.12 POSTING HISTORY

Each bridge record shall include a summary of all load posting and rescinding actions taken for the bridge, including load capacity calculations, date of posting and description of signing used.

# 908 GENERAL

## 908.1 APPLICATION

The provisions of BDM Section 900 apply to ODOT bridges. All provisions of BDM Section 900 may also be applied to non-ODOT bridges at the discretion of the bridge owner. Refer to BDM Section 928.

For load rating of new bridges, BDM Sections 911 through 926 shall apply.

For load rating of existing bridges, BDM Sections 911 through 925 & 927 shall apply.

## 908.2 INVENTORY AND OPERATING RATING LOADS

Inventory and Operating rating loads are shown in Figures 908.2-1

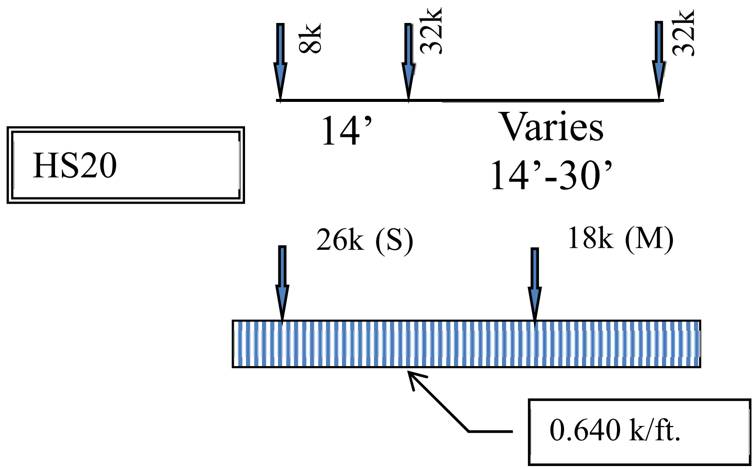



**Figure 908.2-1: AASHTO HS20 LOADING**

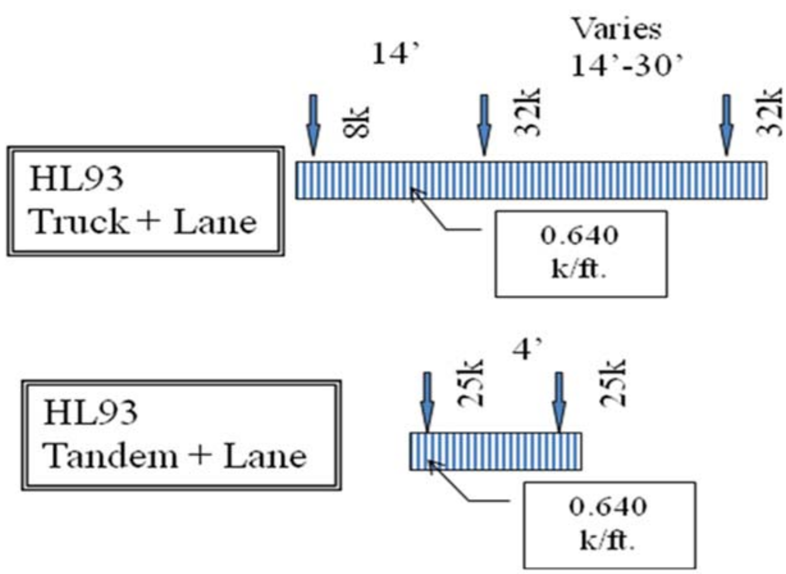



**Figure 908.2-2: AASHTO HL93 LOADING**

## 908.3 OHIO LEGAL LOADS

Ohio Legal Loads consists of Old Ohio Legal Trucks and SHVs as shown in Figure 908.3-1 and Figure 908.3-2.

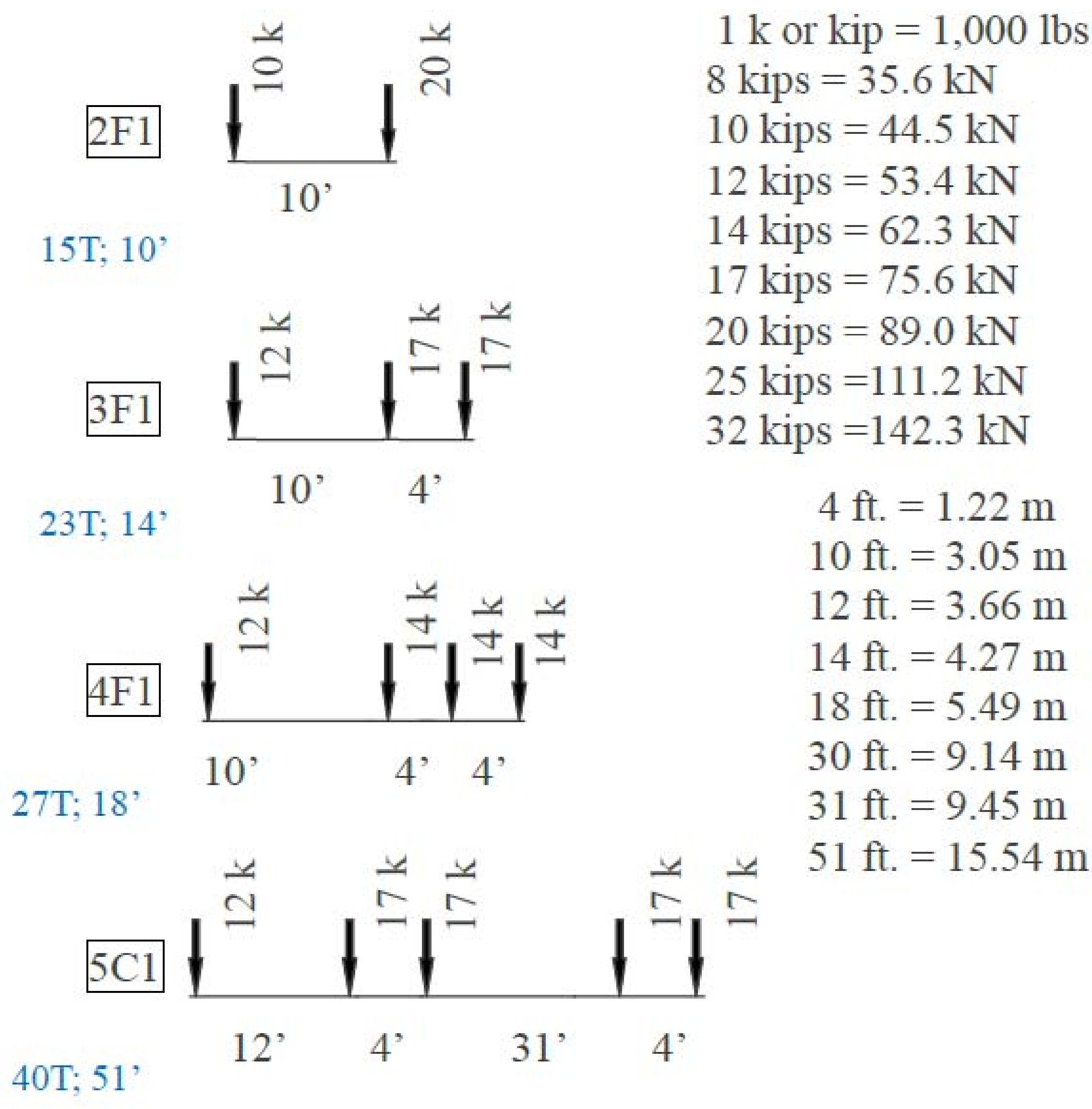



**Figure 908.3-1: OHIO LEGAL TRUCKS**

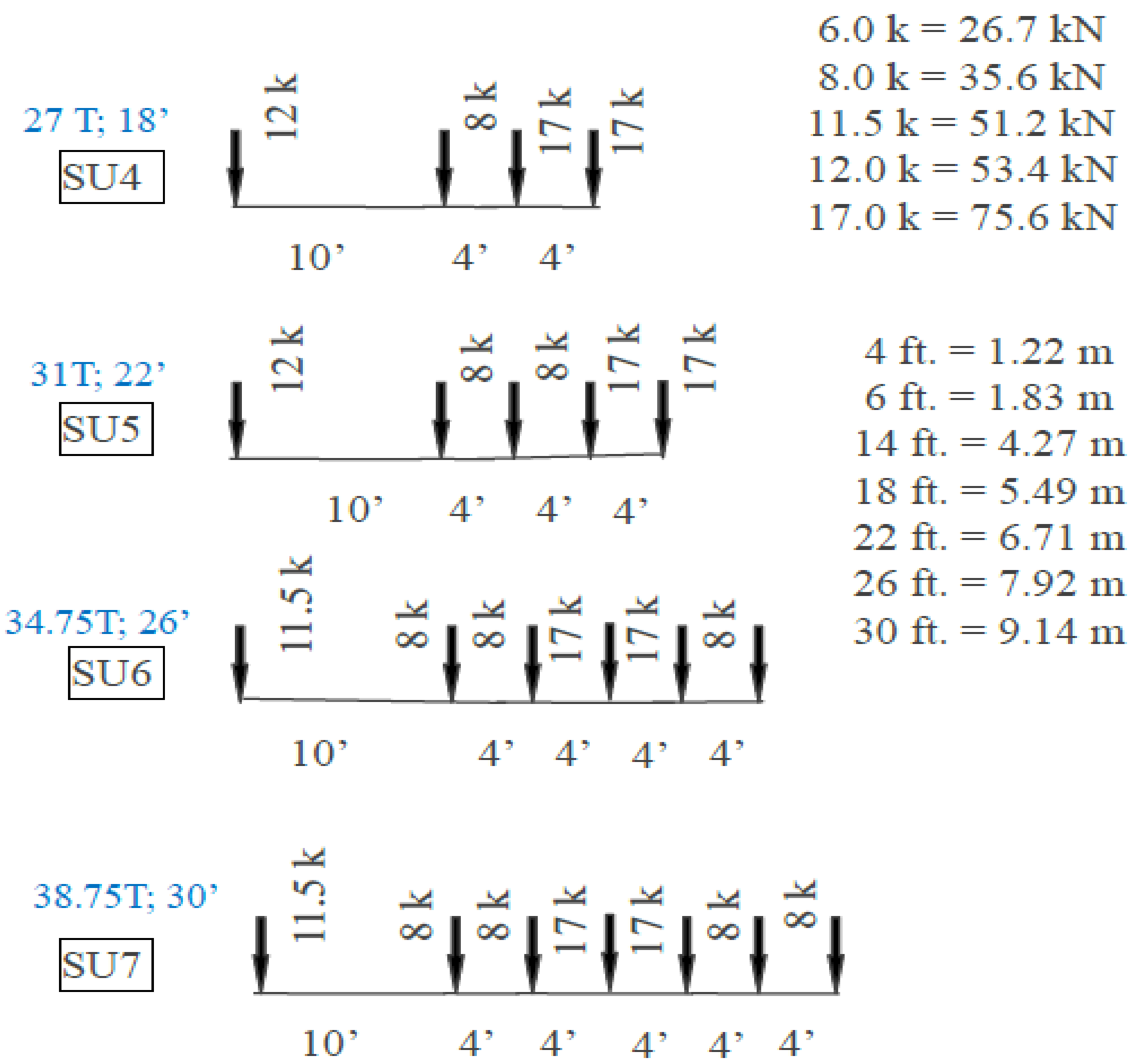



**Figure 908.3-2: SPECIAL HAULING VEHICLE (SHV)**

## 909 UNIT WEIGHTS & DENSITIES

The following assumptions should be made while performing the load rating analysis unless more accurate site information is available:

A. Unit weight of asphalt ........ 145 lb/ft$^3$

B. Unit weight of concrete ........ 150 lb/ft$^3$

C. Unit weight of latex modified concrete ........ 150 lb/ft$^3$

D. Unit weight of soil ........ 120 lb/ft$^3$

E. Unit weight of steel ........ 490 lb/ft$^3$

F. Water density ........ 62.4 lb/ft$^3$

## 910 STRUCTURES EXEMPT FROM LOAD RATING

The following types of buried structures are exempt from load rating under the provisions of this Section.

A. Circular plastic pipes

B. Concrete pipes (circular, or elliptical)

C. Buried metal frames

D. Junction chambers

E. Manholes

F. Inlets and outlets

## 911 STRUCTURES UNDER 6.5-FT OR MORE FILL

A research conducted by the Ohio State University (sponsored by ODOT) has concluded that when a buried structure has 6.5-ft (2 m) or more fill on the top, the live load effect on the structure due to vehicular traffic is negligible.

Ref: http://cdm16007.cotentdm.olclc.org/cdm/ref/collection/P267401ccp2/id/4590). In such case, a load rating analysis of the structure is not needed provided there are no other signs of distress, structural damage or deterioration. Load rating factors of 1.000 for inventory, 1.300 for operating and 1.500 for Ohio legal loads will be assigned.

## 912 WHICH PORTION OF BRIDGES SHALL BE LOAD RATED

Any structural member of a bridge that could carry vehicular traffic shall be load rated. Typically, the structural members of only the bridge superstructure are load rated. Substructure elements such as pier caps and columns should be analyzed for their load carrying capacity in situations when they are either scoped to be analyzed or when the bridge owner or the rating engineer has reason to believe that the capacity of a substructure element may control the capacity of the bridge.

## 913 PROCEDURE FOR LOAD RATING

A. New Bridges

The load ratings for each bridge shall be determined in the following manner:

1. Load rate new (proposed) bridges at the design stage per BDM Section 926.
2. The Project Manager shall forward the load rating report, bridge structure plans and data input files to the OSE Load Rating Engineer for review.

B. Existing Bridges

1. Perform a field inspection of the existing bridge according to the ODOT Manual of Bridge Inspection to determine its condition and the percent of effectiveness of the various members for carrying load if included in the scope. All information shown in the Bridge Inventory and the Inspection Reports shall also be carefully checked.
2. If a field inspection of the bridge is not a part of the Scope of Services, as a minimum, review the most current inspection report (and inspection notes, if available).
3. Use the date of construction to determine the yield stresses for the construction materials in older bridges for which plan information is not available.
4. For a load rating analysis request on an existing ODOT bridge, the District Bridge Engineer shall submit to the OSE Load Rating Engineer, a complete inspection report (including comments), bridge photographs, field measurements and a copy of the previous rating calculation sheets. OSE will review the submitted material, analyze the bridge and return a copy of the final calculations or computer output to the District Bridge Engineer along with any recommendations concerning the proposed ratings.
5. The District Bridge Engineer/Bridge Owner shall keep the final calculations or computer output along with any recommendations concerning the proposed ratings on file.
6. Using pertinent current information and load rating analysis, the District Bridge Engineer/Bridge Owner shall determine and record the Inventory, Operating and Ohio Legal Load Ratings.

## 914 WHEN LOAD RATING SHALL BE REVISED

The load rating of a bridge should be revised when:

A. There is a physical change in the condition of a structural member of the bridge

B. Rusting or damage to a slab, beam, girder or other structural element has resulted in section loss

C. There is structural damage to steel, like a hit by a vehicle or excessive deflection or elongation under temperature or highway loads

D. When the inspection GA rating of the superstructure of a bridge drops below 5

E. There is an addition of a new beam or girder

F. A new deck is added or the existing deck width is changed

G. There is a change in the dead load on the superstructure, like addition or removal of wearing surfaces, addition or removal of sidewalks, parapets, railings, etc.

The load rating of a bridge does not need to be revised when:

A. The change in the thickness of external wearing surface is less than 1-inch

B. The change in the dead load on a beam member is not more than 10-lbs/ft.

## 915 ANALYSIS OF BRIDGES WITH SIDEWALKS

Pedestrian loads on sidewalks are not typically considered in a load rating analysis of a highway bridge, regardless of if a sidewalk on the bridge is present or not. If a bridge owner has reasons to believe that the sidewalk loads shall be included in the load rating analysis of a bridge, a pedestrian load of 75-lbs/ft$^2$ shall be applied to all sidewalks wider than 2-ft and considered simultaneously with the live load in the vehicle lane.

When pedestrian load is present, the pedestrian load effect multiplied with applicable load factor should be subtracted from the capacity of the member at the location being investigated when calculating the RF.

For bridges load rated according to the AASHTO Standard Specifications for Highway Bridges, AASHTO Table 3.22.1A applies. For bridges load rated according to the AASHTO LRFD Bridge Design Specifications, refer to BDM Section 925.2.

Pedestrian loads shall not be considered when performing Special or Permit Load Analysis as per BDM Section 917.

## 916 ANALYSIS OF MULTILANE LOADING

Traffic lanes to be used for rating purposes shall be in accordance with AASHTO Specifications.

For rating analysis of floor beams, trusses, non-redundant girders or other non-redundant main structural members, position identical rating vehicles in one or more of the through traffic lanes on the bridge, spaced and shifted laterally on the deck within the traffic lanes so as to produce the maximum stress in the member under consideration.

Apply the multiple presence factors of AASHTO Standard Specification for Highway Bridges, Section 3.12 or AASHTO LRFD Bridge Design Specification, Section 3.6.1, accordingly.

## 917 ANALYSIS FOR SPECIAL OR PERMIT LOAD

When the Scope of Services requires a structure to be analyzed for a special or permit load vehicle, two analysis shall be performed. First analysis shall be performed as for a normal load rating analysis at Operating level using Special or Permit Load. A second analysis shall be performed for a single lane loading of the special or permit load vehicle condition with the special or permit load vehicle placed laterally on the structure to produce maximum stresses in the critical member under consideration.

The analysis for special or permit load vehicle shall be performed at the operating level only. Multilane loading factors shall be applied as applicable per AASHTO Specifications.

### 917.1 FIRST ANALYSIS OF BRIDGES WITH THREE OR MORE LANES

A. In the right-most lane, place the permit load vehicle positioned to produce the maximum live load effect on the component to be rated vehicle. No partial 5C1 vehicles shall be used.

B. In all adjacent lanes in the same direction, simultaneously place single 5C1 vehicles. These vehicles shall be positioned to produce the maximum live load effect on the component to be rated. Apply the multiple presence factors, per AASHTO Standard Specification for Highway Bridges - Section 3.12, accordingly.

C. For bridges with two-way traffic, place the permit load vehicle in the right-most lane in the direction of travel. In all other lanes, simultaneously place single 5CI vehicles in the direction of traffic positioned to produce maximum live load effect. No partial 5C1 vehicles shall be used. Apply the multiple presence factors, per AASHTO Standard Specification for Highway Bridges - Section 3.12, accordingly.

### 917.2 FIRST ANALYSIS OF BRIDGES WITH TWO LANES

A. In the right-most lane, place one permit load vehicle positioned to produce the maximum live load effect on the component to be rated.

B. In the other lane, place a series of Ohio 5C1 vehicles. The 5C1 vehicles should be spaced such that the distance between the rear axle of the leading vehicle and the front axle of trailing vehicle shall be 36 ft. Place as many 5C1 vehicles as necessary to produce the maximum load effect on the component to be rated. No partial 5C1 vehicles shall be used.

### 917.3 FIRST ANALYSIS OF BRIDGES WITH A SINGLE LANE

The live load shall be the one permit vehicle positioned to produce the maximum live load effect on the component to be rated.

# 918 LOAD RATING OF LONG SPAN BRIDGES

## 918.1 WHEN THE LOAD RATING SHALL BE DONE

Perform the load rating of long span bridges according to BDM Sections 926.3.3, 927.2.2, or 927.3.2.

## 918.2 HOW THE LOAD RATING SHALL BE DONE

### 918.2.1 INVENTORY & OPERATING LEVEL RATING USING HL93 LOADING

The HL93 live load, shown in Figure 908.2-2, shall be used and applied as per AASHTO LRFD Design Specification.

Multilane loading factors shall be applied as per BDM Section 916.

### 918.2.2 INVENTORY & OPERATING LEVEL RATING USING HS20 TRUCK

The HS20 live load, shown in Figure 908.2-1, shall be applied as follows:

A. In the right-most lane, place a series of HS20 trucks to simulate a train of vehicles. The vehicle train shall consist of the HS20 trucks spaced with 30-ft clear distance between the rear axle of the leading vehicle and the front axle of the trailing vehicle. The distance between the second axle and the rear axle shall be fixed at 14-ft. Place as many fixed-axle spacing HS20 trucks as necessary to produce the maximum load effect on the component to be rated. No partial HS20 trucks shall be used.

B. In all other lanes in the same direction, simultaneously place single, variable-axle spacing HS20 trucks positioned to produce the maximum load effect on the component to be rated.

C. For bridges with two-way traffic, apply the live load as described in A. and B. above to the lanes in the opposite direction.

D. Multilane loading factors shall be applied as per BDM Section 916.

### 918.2.3 LOAD RATING FOR OHIO LEGAL LOADS

The Ohio Legal Loads shown in Figure 908.3-1 & Figure 908.3-2 shall be used. The provisions of BDM Sections 912 through 916 and 918 shall apply.

Multilane loading factors shall be applied as per BDM Section 916.

#### 918.2.3.1 BRIDGES WITH THREE OR MORE LANES

a. In the right-most lane, place a series of Ohio 5C1 vehicles. The 5C1 vehicles should be spaced such that the distance between the rear axle of the leading vehicle and the front axle of trailing vehicle shall be 36 ft. Place as many 5C1 vehicles as necessary to produce the maximum load effect on the component to be rated. No partial 5C1 vehicles shall be used.

b. In all other lanes in the same direction, simultaneously place single 5C1 vehicles. These vehicles shall be positioned to produce the maximum live load effect on the component to be rated.

c. For bridges with two-way traffic, apply the live load for the opposing traffic in the same manner as the one-way traffic.

#### 918.2.3.2 BRIDGES WITH TWO LANES

a. In the right-most lane, place a series of Ohio 5C1 vehicles. The 5C1 vehicles should be spaced such that the distance between the rear axle of the leading vehicle and the front axle of trailing vehicle shall be 36 ft. Place as many 5C1 vehicles as necessary to produce the maximum load effect on the component to be rated. No partial 5C1 vehicles shall be used.

b. For bridges with one-way traffic, in the other lane simultaneously place a single 5C1 vehicle positioned to produce the maximum live load effect on the component to be rated.

c. For bridges with two-way traffic, in the other lane place a series of Ohio 5C1 vehicles. The 5C1 vehicles should be spaced such that the distance between the rear axle of the leading vehicle and the front axle of trailing vehicle shall be 36 ft. Place as many 5C1 vehicles as necessary to produce the maximum load effect on the component to be rated. No partial 5C1 vehicles shall be used.

#### 918.2.3.3 BRIDGES WITH A SINGLE LANE

The live load shall be a series of Ohio 5C1 vehicles. The 5C1 vehicles should be spaced such that the distance between the rear axle of the leading vehicle and the front axle of trailing vehicle shall be 36 ft. Place as many 5C1 vehicles as necessary to produce the maximum load effect on the component to be rated. No partial 5C1 vehicles shall be used.

## 919 BRIDGE POSTING FOR REDUCED LOAD LIMITS

### 919.1 PURPOSE

The Procedure outlined in this section is to be followed for posting or rescinding warnings of bridge strength deficiencies on ODOT bridges. Owners of non-ODOT bridges may modify and adapt the guidelines given in this section to post or rescind warnings of bridge strength deficiencies on their bridges.

## 919.2 REFERENCE

Ohio Revised Code, Section 5591.42:

## 919.3 PROCEDURE FOR BRIDGE POSTING

### 919.3.1 BRIDGE POSTING FOLLOWING LOAD RATING ANANLYSIS

A. A load rater performs the bridge load rating per the ODOT Bridge Design Manual (BDM).

B. For a bridge being designed, if the rating factor (RF) at inventory level (for design load) is less than 1.00, the design shall be revised to bring up the RF to 1.0 or higher.

C. For an existing or in-service bridge, the bridge shall be load rated based on current dead loads and the last field inspection report. The current operating status, inspection comments, photographs, and condition rating of structural elements shall be considered in the load rating.

D. Any structural deficiencies discovered during the most current field inspection, as recorded on the Bridge Inspection Report (BIR),) shall be considered during the load rating process. The Control Authority Program Manager (CAPM) shall contact the load rater to request to reanalyze a bridge in service.

E. If load rating is performed by load testing, the test load configuration shall be noted.

F. The Load Rating Report shall be signed, sealed and dated by an Ohio registered Professional Engineer. The load rating results shall be communicated to the CAPM who will enter/update the load rating results in the ODOT SMS.

G. Subsequent to load rating, if it is determined that the bridge needs to be posted for reduced loads (i.e., below Ohio Legal Loads), the CAPM shall mark in the SMS, “Bridge Posting Required.” The CAPM shall initiate the process to have the posting and early warning signs made and erected on the bridge no later than 90 days from the date of load rating.

H. It will be the responsibility of the CAPM to periodically verify that the posting signs are in place.

**Table 919.3-1: ODOT Bridge Posting Policy (Effective July 1, 2011)**

| **Controlling RF = Min. Calculated RF of Ohio Legal Loads**<br>% Ohio Legal Value = Controlling RF x 100 | | |
|---|---|---|
| **% Ohio Legal Value** | **Reported % Ohio Legal in SMS** | **Posting for Reduced Loads Needed** |
| ≥150% | 150% | NO |
| ≥100% and <150% | Actual percentage rounded to the nearest 5 (i.e., 100, 115, etc.) | NO |
| **<100%** | **Actual percentage rounded to the nearest 5 (i.e., 95%, 30%, etc.)** | **YES** |

### 919.3.2 PROCEDURE FOR PLACING POSTING ON ODOT BRIDGES

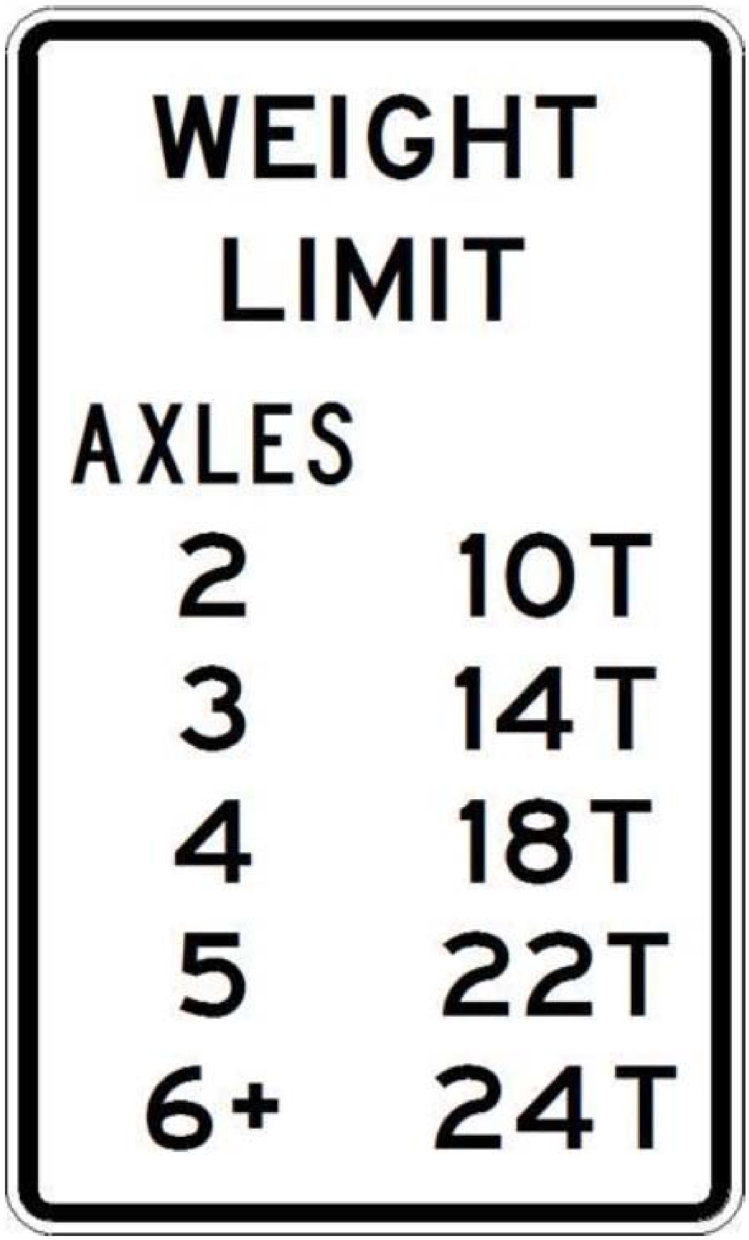
A. The ODOT District Bridge Engineer shall submit a written bridge posting request according to BDM Section 919.6 to the OSE Bridge Rating Engineer.

B. After the Director signs the posting request:

1. The OSE Bridge Rating Engineer shall send a copy to each of the following:
    a. District Bridge Engineer
    b. Manager, ODOT Special Hauling Permits
    c. Superintendent of State Highway Patrol
    d. Executive Director Ohio Trucking Association
    e. Board of County Commissioners
    f. Respective County Engineer's Office
2. The District Roadway Services Manager shall prepare, erect and maintain all necessary signs until the bridge is either strengthened or replaced.
3. The District Bridge Engineer shall update all Bridge Inventory and Inspection records to show the latest official posted capacity.

C. Where posting of a bridge is determined necessary and no unusual or special circumstance at the bridge dictates otherwise, Ohio standard regulatory signs (as per the Ohio Manual of Uniform Traffic Control Devices, an example of the standard wording to be used on the signs is given in Figure 919.3.2-1), shall be placed in sufficient numbers and at the specific locations required below:

1. AHEAD signs shall be erected at intersecting state roads located just prior to the bridge to allow approaching vehicles to by-pass the bridge or turn around safely with a minimum of interference to other traffic.
2. Bridge Weight Limit signs shall be erected at each end of the bridge.




**WEIGHT LIMIT Sign R12-5H**

**Figure 919.3.2-1: LOAD POSTING SIGN**

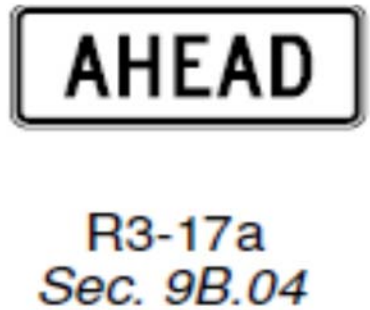



**Figure 919.3.2-2: AHEAD sign**

D. When the RF for a Legal Load falls below 0.30, that load configuration shall not be allowed on the bridge. A bridge must be closed to all traffic when the RF for each Ohio Legal Load falls below 0.30, until the bridge is rehabilitated or replaced. Bridges that are determined to be incapable of carrying 3 tons shall be closed.

## 919.4 PROCEDURE FOR RESCINDING POSTING OF ODOT BRIDGES

A. When a posted bridge has been strengthened or replaced and no longer needs posting, the District Bridge Engineer shall forward to the Bridge Rating Engineer a written request to rescind the existing signed posting. The request shall include a complete statement of the reason for the action as specified in BDM Section 919.6.

B. The Bridge Rating Engineer shall review the data submitted by the District Bridge Engineer and upon concurrence, shall forward to the Director a request to rescind the posting.

C. The Bridge Rating Engineer shall distribute copies of the rescind notice as described in Section 919.3.2.B.1.

## 919.5 PROCEDURE FOR CHANGING POSTING OF ODOT BRIDGES

When the rated capacity of a posted bridge changes, so as to require a revised posting level, the procedures in BDM Section 919.3 apply. Additionally, the existing posting must be rescinded as set forth in BDM Section 919.4.

## 919.6 REQUIRED INFORMATION FOR POST, RESCIND AND CHANGE REQUESTS FROM ODOT DISTRICTS

The following minimum information is required on all post, rescind and change requests:

A. Posting Request (Reduction in Load Limits)

   1. Current Bridge Number

2. Structure File Number
3. Feature intersected (over or under bridge)
4. Posting Load for each Ohio Legal Load
5. Rating of the bridge expressed as a percent of legal loads
6. Explanation as to why the posting is required
7. Attach copies of all official documentation for any associated actions by involved agencies other than the state.

B. Rescinding Request (Removal of Existing Load Limits)

1. Current Bridge Number
2. Structure File Number
3. Feature intersected (over or under bridge)
4. Existing posting (% reduction or weight limit currently in effect for each of the Ohio Legal Loads)
5. Date existing posting was effective
6. Explanation as to why the posting restrictions can now be removed (include: contract project numbers or indicate force account or other work method used to correct problem, if applicable)
7. New load rating for the rehabilitated or new structure (for each Ohio legal load)

C. Change Request (Revision of Existing Posted Limits)

1. Current Bridge Number
2. Structure File Number
3. Feature intersected (over or under bridge)
4. Existing posting (% reduction or weight limit currently in effect for each of the Ohio Legal Loads)
5. Revised posting request (revised weight limit for each of the Ohio Legal Load)
6. Date of existing posting
7. Explanation as to why posting change is necessary (include project numbers etc., involved, if applicable)

# 920 SOFTWARE TO BE USED FOR LOAD RATING OF ODOT BRIDGES

## 920.1 LIST OF ODOT PREFERRED LOAD RATING PROGRAMS

A. AASHTO BrR (formerly Virtis): BrR is a load rating and analysis program developed and licensed by AASHTO. BrR can rate the bridges by LRFR and LFR methods. BrR can load rate a variety of bridge types including reinforced concrete box culverts and curved beam bridges. ODOT has a site license for AASHTO BrR. Through a special pricing option, Counties, Cities and Consultants working on bridges in Ohio can obtain a stand-alone single user license of the BrR program from AASHTO. Please contact the ODOT Load Rating Engineer in the Central Office for a reference Email.

B. Bentley LARS Bridge: LARS Bridge is a bridge analysis program maintained and licensed by Bentley Systems. It can load rate bridges by LRFR and LFR methods. Through a special pricing option, Counties, Cities and Consultants working on bridges in Ohio can obtain a stand-alone single user license of the LARS Bridge program. Please contact the ODOT Load Rating Engineer in the Central Office for a reference Email. (http://www.bentley.com)

## 920.2 OTHER LOAD RATING PROGRAMS

For the analysis of the structures that cannot be accurately modeled using one of the ODOT Preferred Load Rating Programs stated in 920.1, contact the OSE Load Rating Engineer for software pre-approval prior to performing any load rating. The Department will not accept load rating performed using any software not on ODOT's preferred load rating program list or pre-approved for a bridge. Currently ODOT licenses following bridge analysis programs:

C. AASHTO BrD (formerly Opis): BrD is a bridge design check program developed and licensed by AASHTO. BrD can perform design check of a bridge by LRFR and LFR methods for compliance with current AASHTO Specifications. BrD program is fully compatible with BrR program, as data files created in BrD program can be used in BrR program to load rate a bridge. ODOT has a site license for AASHTO BrD from AASHTO. Through a special pricing option, Counties, Cities and Consultants working on bridges in Ohio can obtain a stand-alone single user license of the BrD program from AASHTO. Please contact the ODOT Load Rating Engineer in the Central Office for a reference Email.

D. WYDOT BRASS-Culvert: BRASS-Culvert can load rate reinforced concrete flat-topped 3-sided frames and 4-sided boxes buried under the fill by LRFR and LFR methods. The BRASS family of programs is developed, maintained and licensed by the Wyoming Department of Transportation. Technical support on BRASS-Culvert program is available to the BRASS licensed users from the Wyoming DOT.

(http://www.dot.state.wy.us/wydot/engineering_technical_programs/bridge/brass)

E. MDX Software: MDX software can only be used to load rate ODOT slab-girder/beam bridges that have horizontal curvature of more than 4 degrees. This program supports Load Factor or Load and Resistance Factor methods. Do not use this program to load rate straight or low curvature bridges that can be accurately modeled using the AASHTO BrR. (http://www.mdxsoftware.com/)

F. DESCUS I: Design and Analysis of Curved I-girder Bridge Systems, marketed by OPTI-MATE, Inc. Use the most current version of the software; (www.opti-mate.com)

G. Midas Civil: Midas Civil is a finite element analysis program by Midas IT Co., Ltd., Use this program to load rate only complex bridges that cannot be accurately modeled using the AASHTO BrR. (http://www.midasuser.com).

## 921 LOAD RATING REPORT SUBMISSION

The load rating report shall be submitted to the ODOT project manager, ODOT District Bridge Engineer or the respective owner (in case of a non-ODOT bridge). The submission shall include:

A. Two printed copies of the Load Rating Report with the Summary Sheet. The Load Rating Reports shall be signed, sealed and dated by an Ohio Registered Professional Engineer.

B. One electronic copy of the Load Rating Report in PDF format

C. One copy of all electronic input data files

For an ODOT-bridge the District Bridge Engineer or the Project Manager will send one printed copy, an electronic copy of the report, all the electronic data files and a copy of the final bridge plans to the OSE for review.

The report summary must list final inventory and operating ratings of each main bridge member, overall ratings of each structure unit (mainline, ramps, etc.), and the final ratings of the entire bridge summarized in a tabular form. The ratings of each member and the overall ratings of the structure shall be presented for each Ohio Legal Load and either AASHTO HS20 or HL93 live load.

An example of a Bridge Load Rating Report Summary is given as Figure 921-1.

For existing bridges, the report shall state how the material properties were determined. Any specific details about the current conditions and bridge geometry shall be listed.

All calculations related to the load rating should be included with the load rating report.

Submit copies of the input & output computer files in electronic format. Input files must be error free and ready to be run. The engineer who performed the load rating shall be responsible to incorporate any changes in the input files recommended by ODOT subsequent to its review.

**BRIDGE LOAD RATING SUMMARY REPORT**
**OFFICE OF STRUCTURAL ENGINEERING**
**OHIO DEPARTMENT OF TRANSPORTATION**

| SFN | BRIDGE NUMBER | DISTRICT |
|---|---|---|
| | | From BRIDGE NUMBER or Enter District |

| ORIGINAL CONSTRUCTION YEAR | REHABILITATION YEAR | OVERALL STRUCTURE LENGTH | FEATURE INTERSECTION |
|---|---|---|---|
| | | | |

| | |
|---|---|
| SPECIAL ASSUMPTIONS & COMMENTS | |
| | PLEASE SELECT ON RIGHT, WHERE APPROPRIATE, BY USING THE DROP DOWN ARROW BUTTON |
| LOAD RATING PURPOSE: | 1 - Initial Load Rating |
| LOAD RATING SOFTWARE: | 3 - AASHTO BrR (VIRTIS) |
| RATING SOURCE: | 1 - Plan information available for load rating analysis (Default) |
| RATING METHOD: | 6 - Load Factor (LF) rating reported by rating factor (RF) |
| ORIGINAL DESIGN LOADING: | 6 - HS20-44 & Alternate Military Loading |

STRUCTURE RATING SUMMARY

| OHIO LEGAL | | | | | SPECIALIZED HAULING VEHICLES (SHV) | | | |
|---|---|---|---|---|---|---|---|---|
| Loading Type | GVW (Tons) | Rating Factor - RF Inv. | Rating Factor - RF Oper. | Legal Weight (Tons) | Loading Type | GVW (Tons) | Rating Factor - RF Oper. | Legal Weight (Tons) |
| HS20 Loading | 36 | 1.250 | 1.500 | 36.00 | | | | |
| Ohio - 2F1 | 15 | | 1.500 | 15.00 | SU4 | 27 | 1.500 | 27.00 |
| Ohio - 3F1 | 23 | | 1.500 | 23.00 | SU5 | 31 | 1.500 | 31.00 |
| Ohio - 4F1 | 27 | | 1.500 | 27.00 | SU6 | 34.75 | 1.500 | 34.75 |
| Ohio - 5C1 | 40 | | 1.500 | 40.00 | SU7 | 38.75 | 1.500 | 38.75 |

| Overall Posting Rating | Sign Posting Recommendation: |
|---|---|
| 150% | |
| BRIDGE POSTING REQUIRED BY RATING | |
| No load posting is recommended | |

| AGENCY/FIRM | | REPORT DATE: | 4/12/2016 |
|---|---|---|---|
| RATED BY | PE# | PHONE NUMBER | EMAIL |
| | | | |
| REVIEWED BY | PE# | PHONE NUMBER | EMAIL |
| | | | |

BR-100_SHV (05/2016)

**Figure 921.1-1: BR100 - LOAD RATING SUMMARY FORM**

# 922 LOAD RATING USING AASHTO BrR PROGRAM

## 922.1 GENERAL

BrR (formerly Virtis) is a load rating program licensed from AASHTO. BrR runs on Microsoft Windows and can load rate a variety of bridges by LFR as well as LRFR methods.

The BrR Vehicle library can be customized to include ODOT Legal Loads. Alternatively, ODOT's BrR library can be requested from OSE or downloaded using the web address below.

ftp://ftp.dot.state.oh.us/pub/structures/bms/Web_download_files/ODOT_Custom_Files/

## 922.2 BrR LOAD RATING REPORT SUBMISSION

The load rating report shall be submitted to the project manager, the district bridge engineer or the non-ODOT bridge owner.

## 922.3 BrR COMPUTER INPUT AND OUTPUT FILES

Submit the error-free and working electronic copies of the input file exported as an "XML" file. To get the electronic copy of a bridge data file in BrR, open the "Bridge Workspace," select File>Export from the main menu and save the export when prompted to do so by BrR.

# 923 LOAD ANALYSIS USING LARS PROGRAM

## 923.1 GENERAL

LARS (Load Analysis and Rating System) is a family of bridge load analysis and rating programs maintained and licensed by Bentley Systems.

LARS can run on any Microsoft Windows compatible machine.

LARS Vehicle library can be customized to include ODOT Legal Loads.

## 923.2 LARS LOAD RATING REPORT SUBMISSION

The load rating report shall be submitted to the project manager, the district bridge engineer or the non-ODOT bridge owner.

### 923.3 LARS COMPUTER INPUT AND OUTPUT FILES

Submit the error-free and working electronic copies of all the input & output files of LARS program.

## 924 LOAD ANALYSIS USING BRASS-CULVERT PROGRAM

### 924.1 GENERAL

Wyoming DOT BRASS-Culvert program can be used to analyze reinforced concrete three-sided flat-topped frames and four-sided box sections.

If haunch dimensions are not constant, use the smallest dimension in the analysis.

BRASS can run on any Microsoft Windows compatible machine.

The BRASS Vehicle library can be customized to include ODOT Legal Loads. An ODOT customized BRASS-Culvert Vehicle library is available on the ODOT FTP which can be downloaded and copied in the C:\\BRASS\Culvert folder.

### 924.2 BRASS-CULVERT LOAD RATING REPORT SUBMISSION

The load rating report shall be submitted to the project manager, the district bridge engineer or the non-ODOT bridge owner.

### 924.3 BRASS COMPUTER INPUT AND OUTPUT FILES

Use the Structural File Number (SFN) of the bridge with prefix "R" to name and appropriate extension to name the input and output files. For example, if the SFN of a bridge is 4729854, the input and output file names should be "R4729854.dat" and R4729854.cus and R4729854.xml, etc.

## 925 LOAD RATING OF BRIDGES USING LRFR SPECIFICATIONS

### 925.1 APPLICABILITY OF AASHTO DESIGN SPECIFICATIONS

This Section is consistent with the current AASHTO LRFD Bridge Design Specifications. Where this Section is silent, the current AASHTO LRFD Bridge Design Specification shall govern.

### 925.2 GENERAL LOAD RATING EQUATION

The following general equation shall be used in determining the load rating of each component and connection subject to a single force effect (axial force, flexure or shear) [MBE 6A.4.2]:

$$RF = \frac{C - (\gamma_{DC})(DC) - (\gamma_{DW})(DW) \pm (\gamma_P)(P) - (\gamma_{PL})(PL)}{(\gamma_{LL})(LL)(1 + IM/100)}$$

For Strength Limit States:

$C = \varphi_c \cdot \varphi_s \cdot \varphi \cdot R_n$

Where the following lower limit shall apply:

$\varphi_c \cdot \varphi_s \geq 0.85$

For Service Limit States:

$C = f_R$

Where:

$C$ = Capacity

$DC$ = Dead load effect due to structural components and attachments

$DW$ = Dead load effect due to wearing surface and utilities

$f_R$ = Allowable stress specified in LRFD Code

$IM$ = Dynamic load allowance expressed as percentage (%)

$LL$ = Live Load effect

$P$ = Permanent loads other than dead loads, such earth pressure, shrinkage etc.

$PL$ = Pedestrian Load effect only to be applied when a sidewalk is present

$RF$ = Rating Factor

$R_n$ = Nominal member resistance

$\gamma_{DC}$ = Load factor for DC load

$\gamma_{DW}$ = Load factor for DW load

$\gamma_p$ = Load factor for P load = 1.0

$\gamma_{LL}$ = Evaluation live load factor

$\gamma_{PL}$ = Load factor for Sidewalk load = 1.0

$\varphi_c$ = Condition factor

$\varphi_s$ = System factor

$\varphi$ = LRFD Resistance factor

For Limit States and factors see BDM Section 925.3.

## 925.3 LIMIT STATES AND LOAD FACTORS FOR LOAD RATING

Strength is the primary limit state for load rating; service and fatigue limit states are selectively applied in accordance with the provisions of AASHTO Manual of Bridge Evaluation [MBE 6A.4.2]:

For Inventory and Operating Rating for AASHTO HL93 Loading, use the following limit states and load factors:

**Table 925.3-1: LRFR Design Load Limit States and Load Factors [MBE 6A.4.2.2-1]**

| Bridge Type | Limit State | Dead Load $\gamma_{DC}$ | Dead Load $\gamma_{DW}$ | HL93 Loading Inventory $\gamma_{LL}$ | HL93 Loading Operating $\gamma_{LL}$ |
|---|---|---|---|---|---|
| Steel | Strength I | 1.25 | 1.50 | 1.75 | 1.35 |
| | Service II | 1.00 | 1.00 | 1.30 | 1.00 |
| | Fatigue | 0.00 | 0.00 | 0.75 | |
| Reinforced Concrete | Strength I | 1.25 | 1.50 | 1.75 | 1.35 |
| Prestressed Concrete | Strength I | 1.25 | 1.50 | 1.75 | 1.35 |
| | Service III | 1.00 | 1.00 | 0.80 | |
| Wood | Strength I | 1.25 | 1.50 | 1.75 | 1.35 |

For Rating for Ohio Legal Loads, use the following limit states and load factors:

**Table 925.3-2: Legal Loads Limit States and Load Factors [MBE 6A.4.4.2.3a-1]**

| Bridge Type | Limit State | Dead Load $\gamma_{DC}$ | Dead Load $\gamma_{DW}$ | Ohio Legal Loads $\gamma_{LL}$ |
|---|---|---|---|---|
| Steel | Strength I | 1.25 | 1.50 | 1.40 |
| | Service II | 1.00 | 1.00 | 1.30 |
| Reinforced Concrete | Strength I | 1.25 | 1.50 | 1.40 |
| | Service I | 1.00 | 1.00 | ------ |
| Prestressed Concrete | Strength I | 1.25 | 1.50 | 1.40 |
| | Service III | 1.00 | 1.00 | 1.00 |
| Wood | Strength I | 1.25 | 1.50 | 1.40 |

For Rating for Special and Permit Loads, use the following limit states and load factors:

**Table 925.3-3: Permit Load Limit States and Load Factors [MBE 6A.4.5.4.2a-1]**

| Bridge Type | Limit State | Dead Load $\gamma DC$ | Dead Load $\gamma DW$ | Permit or Special Loads $\gamma_{LL}$ |
|---|---|---|---|---|
| Steel | Strength II | 1.25 | 1.50 | 1.35 |
| | Service II | 1.00 | 1.00 | 1.00 |
| Reinforced Concrete | Strength II | 1.25 | 1.50 | 1.35 |
| | Service I | 1.00 | 1.00 | 1.00 |
| Prestressed Concrete | Strength II | 1.25 | 1.50 | 1.35 |
| | Service I | 1.00 | 1.00 | 1.00 |
| Wood | Strength II | 1.25 | 1.50 | 1.35 |

## 925.4 DYNAMIC LOAD ALLOWANCE (IM)

A. A dynamic load allowance of 33% shall be used for all non-buried bridges except for fatigue evaluation.

B. For fatigue evaluation a dynamic load allowance of 15% shall be used.

C. Dynamic load allowance shall only be applied to the truck or tandem portion of HL93 loading (dynamic load allowance shall not be provided to the lane portion).

D. Dynamic load allowance need not to be applied to wood components of a bridge.

E. Dynamic allowance may be ignored for slow moving (speed less than 10 mph), special or permit loads under controlled conditions.

F. For buried bridges, dynamic allowance (IM) shall be taken as:

$IM = 33\ (1.0 - 0.125\ DE) \geq 0\%$ ............................................................ [AASHTO 3.6.2.2-1]

Where:

DE = the minimum depth of cover above the structure (ft)

## 925.5 CONDITION FACTOR ($\varphi_c$)

A Condition Factor shall be applied to the calculated capacity of the structure, as follows:

**Table 925.5-1: Condition Factors [MBE 6A.4.2.3]**

| Structural Condition of a member | NBI General Appraisal | Condition Factor $\varphi_c$ |
|---|---|---|
| Good or Satisfactory | 6 or higher | 1.00 |
| Fair | 5 | 0.95 |
| Poor | 4 or lower | 0.85 |

## 925.6 SYSTEM FACTOR ($\varphi_S$)

System factors are multiplied to the nominal resistance to reflect the level of redundancy of the complete superstructure [MBE 6A.4.2.4]. Bridges that are less redundant will have their factored member capacities reduced.

The following system factors may be used for Flexural and Axial Effects:

**Table 925.6-1: System Factors [MBE 6A.4.2.4]**

| Superstructure Type | $\varphi_S$ |
|---|---|
| Welded members in two-girder/truss/arch bridges | 0.85 |
| Riveted members in two-girder/truss/arch bridges | 0.90 |
| Multiple eye bar members in truss bridges | 0.90 |
| Three-girder bridges with girder spacing 6 ft. | 0.85 |
| Four-girder bridges with girder spacing ≤ 4 ft. | 0.95 |
| Floor beams with spacing > 12.0 ft. and non-continuous stringers | 0.85 |
| Redundant stringer subsystems between floor-beams | 1.00 |
| All other girder and slab bridges | 1.00 |

## 925.7 RESISTANCE FACTOR ($\varphi$)

Resistance factor ($\varphi$) for the load rating has the same value as for a new design as given in AASHTO LRFD Specification. Also, $\varphi = 1.0$ for all non-strength limit states [MBE C6A.4.2.1]. See appropriate section in the LRFD Specification for recommended values for resistance factors [LRFD 5.5.4.2, 6.5.4.2, 8.5.2, 12.5.5]

Some of the commonly used Resistance Factors are given here:

**Table 925.7-1: Resistance Factors**

| Type | φ |
|---|---|
| Tension controlled reinforced concrete section | **0.90** |
| Tension controlled prestressed concrete section | **1.00** |
| Shear and torsion in normal weight concrete | **0.90** |
| Flexure in steel | **1.00** |
| Shear in steel | **1.00** |
| Axial Compression in steel only | **0.90** |
| Axial Compression in composite | **0.90** |
| Shear connectors, steel | **0.85** |
| Web crippling, steel | **0.80** |
| For block shear | **0.80** |
| For shear rupture in connection element | **0.80** |
| For weld metal in partial penetration and fillet weld | **0.80** |
| Flexure in wood | **0.85** |
| Shear in wood | **0.75** |
| Wood connections | **0.65** |
| RC cast-in-place buried box structures in flexure | **0.90** |
| RC cast-in-place buried box structures in shear | **0.85** |
| RC precast buried box structures in flexure | **1.00** |
| RC precast buried box structures in shear | **0.90** |
| RC precast buried 3-sided structures in flexure | **0.95** |
| RC precast buried 3-sided structures in shear | **0.90** |
| Structural steel pipe, minimum wall area & buckling | **1.00** |
| Structural steel pipe, minimum longitudinal seam strength | **0.67** |

### 925.8 EFFECT OF SKEW

Effect of skew on the distribution of live loads shall be considered according to AASHTO LRFD Specifications (LRFD 4.6.2.2.2 and 4.6.2.2.3).

## 926 LOAD RATING OF NEW BRIDGES

### 926.1 LOADS TO BE USED FOR LOAD RATING

All new and replacement bridges whose preliminary design was started **after October 1, 2010** and requiring load rating shall be load rated by the AASHTO LRFR method to comply with FHWA requirements. The load to be used for inventory and operating rating based on the LRFR method shall be AASHTO's HL93 loading (truck & lane or tandem & lane), according to Figure 926.1-1.

All bridges shall also be load rated for the four Ohio Legal Loads (2F1, 3F1, 4F1, and 5C1 given in Figure 926.1-1) using LRFR method of rating.

Newly designed timber bridges shall be load rated using the LRFR method.

All trucks used for analysis shall have transverse spacing, between centerline of wheels or wheel groups of 6-ft.

Long span bridges shall use the special load configurations given in BDM Section 918.

The inventory and operating ratings for the AASHTO HL93 loading shall be expressed in terms of rating factors, rounded to the nearest third decimal point. The minimum acceptable RF for AASHTO design load at inventory level is 1.000.

The operating ratings for each of the Ohio Legal Loads shall also be expressed in terms of rating factors of respective legal load rounded to the nearest third decimal point. The Ohio Legal Loads Rating shall be the smallest rating factor of the four legal loads expressed as a percentage rounded off to the nearest 5 (i.e. smallest RF multiplied by 100).

The Bridge Owner may also require load rating to be done for special loads in addition to those specified above. The owner shall include full configurations of the special load used in the analysis, including, but not limited to, axle weights and spacing, number of tires on each axle, tire gauges and overall dimensions of the load. All special loads are to be analyzed by the LRFR method of analysis at the operating level as per BDM Section 917 unless specified otherwise by the Owner.

## 926.2 LOAD RATING OF NEW BURIED BRIDGES

### 926.2.1 CAST-IN-PLACE CONCRETE BOX & FRAME STRUCTURES

A. Cast-in-place bridges shall be load rated by the designer of the bridge.

B. The AASHTO BrR or the BRASS-Culvert program shall be used to load rate the structure.

### 926.2.2 PRECAST CONCRETE BOXES

#### 926.2.2.1 PRECAST CONCRETE BOXES OF SPAN GREATER THAN 12-FT

The load rating analysis is provided in SS940.

#### 926.2.2.2 PRECAST BOXES OF SPAN EQUAL TO OR LESS THAN 12-FT

A. The manufacturer shall submit the actual information about the dimensions and reinforcing bars/cage to the OSE along with the shop drawings before the placement of structure.

B. The load rating analysis will be performed by the OSE using AASHTO BrR or the BRASS-Culvert program.

### 926.2.3 PRECAST FRAMES, ARCHES, AND CONSPANS & BEBO TYPE STRUCTURES

A. The load rating analysis will be performed by the manufacturer.

B. The load rating report shall be submitted along with the shop drawings before the placement of the precast units.

C. Use the design software to load rate the bridge.

### 926.2.4 ANALYSIS OF CONCRETE BOX SECTIONS & FRAMES

Unless more accurate soil data exists, calculate the rating based on a lateral pressure as specified in AASHTO.

Apply a live load surcharge as per AASHTO.

The effect of soil-structure interaction shall be taken into account as per AASHTO.

Assume hinged connections between the walls and the top and bottom slabs unless there is adequate reinforcing steel continuous between the slab and the walls at the joint. In that case continuity between the slab and the walls can be assumed.

## 926.3 LOAD RATING OF NON-BURIED STRUCTURES

### 926.3.1 GENERAL

All structures, including flat slabs, arch structures, frames, box sections, etc., having a fill or pavement material of less than 2-ft on top shall be load rated according to the provisions of this Section.

All main structural members of the superstructure affected by live load shall be analyzed.

### 926.3.2 HOW THE LOAD RATING SHALL BE DONE

The designer shall analyze and load rate all spans that are designed to carry vehicular traffic.

The load rating analysis shall be based on the final design plans. At the inventory level, the load rating shall be equal to or greater than the design loading.

All members shall have actual net section and current conditions incorporated into the member analysis.

Bridge members designed as non-composite with the deck slab should be analyzed as non-composite.

All dead loads are to be calculated based on the actual field conditions. Future dead loads shall not be applied unless directed otherwise.

The total thickness of the composite concrete slab shall be used in load rating for the calculations of section properties. Do not subtract for the monolithic wearing surface.

Live load distribution factors, as defined in the current AASHTO LRFD, shall be used.

### 926.3.3 WHEN THE BRIDGE LOAD RATING SHALL BE DONE

The load rating of new bridges shall be done as per the following sub-sections:

#### 926.3.3.1 BRIDGES DESIGNED UNDER PATH 2, 3, 4 OR 5 OF THE PDP

For bridges designed under Paths 2, 3, 4 or 5 of the Plan Development Process (PDP), perform the load rating and include the load rating report in the Stage 2 Detail Design Submission. When design modifications that affect the previously submitted load rating analysis occur after Stage 2 and prior to contract sale, revise and resubmit the load rating report to the District Project Manager. The District Project Manager will forward the final load rating report to the District Bridge Engineer.

#### 926.3.3.2 BRIDGES DESIGNED UNDER PATH 1 OF THE PDP

For bridges designed under Path 1 of the Plan Development Process (PDP), perform the load rating and include the load rating report in the Stage 3 Detail Design Submission. When design modifications that affect the previously submitted load rating analysis occur after Stage 3 and prior to contract sale, revise and resubmit the load rating report to the District Project Manager. The District Project Manager will forward the final load rating report to the District Bridge Engineer.

#### 926.3.3.3 BRIDGES DESIGNED UNDER DESIGN-BUILD PROCESS

Unless otherwise indicated in the project scope, include the load rating report for bridges designed as part of a Design Build project with the Stage 2 Detail Design Submission. When design modifications that affect the previously submitted load rating analysis occur after Stage 2, revise and resubmit the load rating report to the District Project Manager. The District Project Manager will forward the final load rating report to the District Bridge Engineer.

### 926.3.3.4 BRIDGES DESIGNED UNDER VALUE ENGINEERING CHANGE PROPOSAL

For bridges re-designed under a Value Engineering Change Proposal (VECP), perform a load rating of the altered bridge design and submit the load rating report to the District Construction Engineer (DCE) with the Final VECP submission. The DCE will supply this information to the District Bridge Engineer.

## 927 LOAD RATING OF EXISTING BRIDGES

### 927.1 LOADS TO BE USED FOR LOAD RATING

Existing bridges may be load rated at inventory and operating rating by either LFR or LRFR method with the prior approval of the bridge owner. When the LFR method is used, the load for inventory and operating rating shall be AASHTO HS20. When the LRFR method is used, the load for inventory and operating rating shall be AASHTO HL93.

Existing timber bridges shall be load rated using the ASR method.

All bridges shall also be load rated for the Ohio Legal Loads using the same method of analysis as used for the inventory and operating ratings.

All legal loads used for analysis shall have transverse spacing, between centerline of wheels or wheel groups, of 6-ft.

For long span bridges, as defined in BDM Section 905, use the special load configurations given in BDM Section 918.

The inventory and operating ratings for the AASHTO HL93 or HS20 loading shall be expressed in terms of rating factors, rounded to the nearest three decimal points.

The operating ratings for each of the Ohio Legal Loads shall also be expressed in terms of rating factors of the respective legal loads, rounded to the nearest three decimal points. The Ohio Legal Loads Rating shall be the smallest rating factor of the four legal loads expressed as a percentage rounded to the nearest 5 (i.e. smallest RF multiplied by 100).

The Bridge Owner may also require load rating to be done for special loads in addition to those specified above. The Owner shall include full configurations of the special load used in the analysis, including but not limited to, axle weights and spacing, number of tires on each axle, tire gauges and overall dimensions of the load. All special loads are to be analyzed by the LRFR method of analysis at the operating level as per BDM Section 917 unless specified otherwise by the Owner.

## 927.2 LOAD RATING OF BRIDGES TO BE REHABILITATED

### 927.2.1 HOW THE LOAD RATING SHALL BE DONE

The designer shall analyze and load rate all spans that are designed to carry vehicular traffic.

The load rating analysis shall be based on the final design or as-built plans.

All members shall have actual net section and current conditions incorporated into the member's analysis. Any known section losses, defects or damage to the existing structural members shall be considered in the rating analysis.

Bridge members designed as non-composite with the deck slab should be analyzed as non-composite.

Structures to be rehabilitated shall be analyzed using the original design plans, the actual field conditions, and all major changes in the final rehabilitation plans.

A complete review of all the available inspection information as well as a thorough site inspection of the existing bridge must be performed to establish the current conditions prior to proceeding with the analysis.

Future wearing surface dead loads shall not be applied in load rating calculations unless directed otherwise.

The total thickness of the composite concrete slab shall be used in load rating for the calculations of section properties. Do not subtract for the monolithic wearing surface.

Live load distribution factors, in accordance with the governing AASHTO specifications, shall be used.

For existing bridges, the rater should review the original design plans as the first source of information for material strengths and stresses. If the material strengths are not explicitly stated on the design plans, ODOT Construction and Material Specifications (C&MS) applicable at the time of the bridge construction shall be reviewed. This may require investigations into old ASTM or AASHTO Material Specifications active at the time of construction.

Ultimate or yield strengths of materials shall be as specified on the original design plans unless it is required in the scope of services to conduct specific tests to determine the material strengths.

General information about Allowable Stresses in bending and shear and material strengths based on the year of construction provided in Tables 927.2.1-1 and 927.2.1-2. Any material stresses and strengths specified on the design plans shall supersede the values given in Tables 927.2.1-1 and 927.2.1-2 & 927.2.1-3.

The rater is cautioned to pay extra attention to the design plans and the year of construction when determining material strengths for structures built during the transition years of Tables 927.2.1-1, 927.2.1-2 and 927.2.1-2 (e.g. for member type SS, years 1964-68, or 1988-93, etc. ), as materials of the newer (or older) specifications may have been substituted.

## Table 927.2.1-1: Custom Allowable Stresses in Bending

| | | Type of Rating | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Material of Construction | Year of Construction | Fy / Fc' (ksi) | Fy / Fc' (MPa) | Inventory (ksi) | Inventory (MPa) | Operating (ksi) | Operating (MPa) | Posting (ksi) | Posting (MPa) |
| Structural Steel (SS),(CSC) | < 1900 | 26.00 | 179 | 14.00 | 97 | 19.00 | 131 | 19.00 | 131 |
| | 1901 To 1930 | 30.00 | 207 | 16.00 | 110 | 22.00 | 152 | 22.00 | 152 |
| | 1931 To 1965 | 33.00 | 228 | 18.00 | 124 | 25.00 | 172 | 25.00 | 172 |
| | 1966 To 1990 | 36.00 | 248 | 20.00 | 138 | 27.00 | 186 | 27.00 | 186 |
| | 1991 To Date | 50.00 | 345 | 27.00 | 186 | 37.50 | 259 | 37.50 | 259 |
| Reinforcing Steel (RC) | < 1935 | 32.00 | 221 | 16.00 | 110 | 24.00 | 165 | 24.00 | 165 |
| | 1936 To 1950 | 36.00 | 248 | 18.00 | 124 | 27.00 | 186 | 27.00 | 186 |
| | 1951 To 1983 | 40.00 | 276 | 20.00 | 138 | 30.00 | 207 | 30.00 | 207 |
| | 1984 To Date | 60.00 | 414 | 24.00 | 165 | 36.00 | 248 | 36.00 | 248 |
| Prestress. Strands (Fs') (CPS),(PSC) | All Years | 270.0 | 1862 | - | - | - | - | - | - |
| Cast-in-Place Reinf. Conc. (Compression in Bending) (RC),(CSC) | < 1930 | 2.00 | 14 | 0.70 | 5 | 1.30 | 9 | 1.30 | 9 |
| | 1931 To 1950 | 3.00 | 21 | 1.00 | 7 | 1.50 | 10 | 1.50 | 10 |
| | 1951 To 1980 | 4.00 | 28 | 1.30 | 9 | 2.00 | 14 | 2.00 | 14 |
| | 1981 To Date | 4.50 | 31 | 1.50 | 10 | 2.20 | 15 | 2.20 | 15 |
| Prestressed Concrete (Fc') (PSC),(CPS) | All Years | 5.50 | 38 | - | - | - | - | - | - |
| Cast-in-Place Comp. Slab for Prestress. Conc. (Fc') (CPS) | All Years | 4.00 | 28 | - | - | - | - | - | - |
| Timber (fb) (TMB) | All Years | - | - | 1.6 | 11 | 2.128 | 15 | 2.128 | 15 |
| Cast-in-Place Slab for Composite Reinforced Concrete | < 1930 | 2.00 | 14 | 0.70 | 5 | 1.30 | 9 | 1.30 | 9 |
| | 1931 To 1950 | 3.00 | 21 | 1.00 | 7 | 1.50 | 10 | 1.50 | 10 |
| | 1951 To 1980 | 4.00 | 28 | 1.30 | 9 | 2.00 | 14 | 2.00 | 14 |
| | 1981 To Date | 4.50 | 31 | 1.50 | 10 | 2.20 | 15 | 2.20 | 15 |

## Table 927.2.1-2: Custom Allowable Stresses in Shear

| | | Type of Rating | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Material of Construction | Year of Construction | Fy / Fc' (ksi) | Fy / Fc' (MPa) | Inventory (ksi) | Inventory (MPa) | Operating (ksi) | Operating (MPa) | Posting (ksi) | Posting (MPa) |
| Structural Steel (SS),(CSC) | < 1900 | 26.00 | 179 | 8.50 | 59 | 11.50 | 79 | 11.50 | 79 |
| | 1901 To 1930 | 30.00 | 207 | 9.50 | 66 | 13.50 | 93 | 13.50 | 93 |
| | 1931 To 1965 | 33.00 | 228 | 11.00 | 76 | 15.00 | 103 | 15.00 | 103 |
| | 1966 To 1990 | 36.00 | 248 | 12.00 | 83 | 16.00 | 110 | 16.00 | 110 |
| | 1991 To Date | 50.00 | 345 | 17.00 | 117 | 22.50 | 155 | 22.50 | 155 |
| Reinforcing Steel (RC) | < 1935 | 32.00 | 221 | 16.00 | 110 | 24.00 | 165 | 24.00 | 165 |
| | 1936 To 1950 | 36.00 | 248 | 18.00 | 124 | 27.00 | 186 | 27.00 | 186 |
| | 1951 To 1983 | 40.00 | 276 | 20.00 | 138 | 30.00 | 207 | 30.00 | 207 |
| | 1984 To Date | 60.00 | 414 | 24.00 | 165 | 36.00 | 248 | 36.00 | 248 |
| Cast-in-Place Reinforced Conc. (RC),(CSC) | < 1930 | 2.00 | 14 | 0.70 | 5 | 1.30 | 9 | 1.30 | 9 |
| | 1931 To 1950 | 3.00 | 21 | 1.00 | 7 | 1.50 | 10 | 1.50 | 10 |
| | 1951 To 1980 | 4.00 | 28 | 1.30 | 9 | 2.00 | 14 | 2.00 | 14 |
| | 1981 To Date | 4.50 | 31 | 1.50 | 10 | 2.20 | 15 | 2.20 | 15 |
| Prestressed Concrete (Fc') (PSC),(CPS) | All Years | 5.50 | 38 | | | | | | |
| Timber (Horizontal Shear Stress) (fb) (TMB) | All Years | - | - | 0.09 | 1 | 0.12 | 1 | 0.12 | 1 |

## Table 927.2.1-3: Custom Allowable Stresses for Fasteners

| Material | Constructed | LRFR | ASD | | |
|---|---|---|---|---|---|
| | | $\Phi F_v$ | Inventory | Operating | Posting |
| Riveted | <1939 | 18.0 ksi | 9.5 ksi | 12.5 ksi | 12.5 ksi |
| | 1936 to 1950 | 21.0 ksi | 11.0 ksi | 15.0 ksi | 15.0 ksi |
| | 1950 to Date | 25.0 ksi | 13.5 ksi | 18.0 ksi | 18.0 ksi |
| Bolted – Bearing | < 1965 | 17.0 ksi | 11.0 ksi | 15.0 ksi | 15.0 ksi |
| | 1965 to Date | 36.5 ksi * | NA | NA | NA |
| | | 32.0 ksi ** | NA | NA | NA |
| Bolted – Slip Critical | < 1965 | NA | NA | NA | NA |
| | 1965 to Date | 17.0 ksi * | 15.0 ksi * | 20.0 ksi * | 20.0 ksi * |
| | | 15.0 ksi ** | 13.0 ksi ** | 17.5 ksi ** | 17.5 ksi ** |

* Diameter ≤ 1”.
** Diameter > 1”.

## 927.2.2 WHEN THE BRIDGE LOAD RATING SHALL BE DONE

The load rating of bridges to be rehabilitated shall be done as per following:

### 927.2.2.1 BRIDGES DESIGNED UNDER PATH 2, 3, 4 OR 5 OF THE PLAN DEVELOPMENT PROCESS

For bridges designed under Path 2, 3, 4, or 5 of the Plan Development Process (PDP), perform the load rating and include the load rating report in the Stage 2 Detail Design Submission. When design modifications that affect the previously submitted load rating analysis occur after Stage 2 and prior to contract sale, revise and resubmit the load rating report to the District Project Manager. The District Project Manager will forward the final load rating report to the District Bridge Engineer.

### 927.2.2.2 BRIDGES DESIGNED UNDER PATH 1 OF THE PLAN DEVELOPMENT PROCESS

For bridges designed under Path 1 of the Plan Development Process (PDP), perform the load rating and include the load rating report in the Stage 3 Detail Design Submission. When design modifications that affect the previously submitted load rating analysis occur after Stage 3 and prior to contract sale, revise and resubmit the load rating report to the District Project Manager. The District Project Manager will forward the final load rating report to the District Bridge Engineer.

### 927.2.2.3 BRIDGES DESIGNED UNDER DESIGN-BUILD PROCESS

Unless otherwise indicated in the project scope, include the load rating report for bridges designed as part of a Design Build project with the Stage 2 Detail Design Submission. When design modifications that affect the previously submitted load rating analysis occur after Stage 2, revise and resubmit the load rating report to the District Project Manager. The District Project Manager will forward the final load rating report to the District Bridge Engineer.

### 927.2.2.4 BRIDGES DESIGNED UNDER VALUE ENGINEERING CHANGE PROPOSAL

For bridges re-designed under a Value Engineering Change Proposal (VECP), perform a load rating of the altered bridge design and submit the load rating report to the District Construction Engineer (DCE) with the Final VECP submission. The DCE will supply this information to the District Bridge Engineer.

## 927.2.3 LOAD RATING OF BURIED BRIDGES

### 927.2.3.1 CAST-IN-PLACE STRUCTURES

A. Cast-in-place bridges shall be load rated by the designer of the bridge.

B. The AASHTO BrR or the BRASS-Culvert program shall be used to load rate the structure. For information on the BRASS-Culvert Analysis, also see BDM Section 924.

### 927.2.3.2 PRECAST BOXES OF SPAN GREATER THAN 12-FT.

A. The load rating analysis will be performed by the OSE.

B. The AASHTO BrR or the BRASS-Culvert program shall be used to load rate the structure. For information on the BRASS-Culvert Analysis, see BDM Section 924.

### 927.2.3.3 PRECAST BOXES OF SPAN EQUAL TO OR LESS THAN 12-FT

The load rating analysis will be performed by the OSE using AASHTO BrR or the BRASS-Culvert program.

### 927.2.3.4 PRECAST FRAMES, ARCHES, AND CONSPANS & BEBO TYPE STRUCTURES

A. The load rating analysis for any new or replacement precast sections will be performed by the manufacturer; otherwise, the load rating analysis will be performed as per the scope of services.

B. The load rating report shall be submitted along with the shop drawings before the placement of the units.

C. The design software shall be used to load rate the bridge.

### 927.2.3.5 ANALYSIS OF CONCRETE BOX SECTIONS & FRAMES

Unless more accurate soil data exits, calculate the rating based on a lateral pressure as specified in AASHTO.

Apply a live load surcharge according to AASHTO.

The effect of soil-structure interaction shall be taken into account according to AASHTO.

Assume hinged connections between the walls and the top and bottom slabs unless there is adequate reinforcing steel continuous between the slab and the walls at the joint. In that case, continuity between the slab and the walls can be assumed.

### 927.2.4 LOAD RATING OF NON-BURIED STRUCTURES

All structures, including flat slabs, arch structures, frames, box sections, etc., having a fill or pavement material of less than 2-ft on top shall be load rated according to the provisions of BDM Sections 912 through 925 (as applicable).

## 927.3 LOAD RATING OF EXISTING BRIDGES WITH NO REPAIR PLANS

### 927.3.1 HOW THE LOAD RATING SHALL BE DONE

The rater shall analyze and load rate all spans that are designed to carry vehicular traffic.

Existing structures shall be analyzed using the information from the original design plans and the actual field conditions.

A complete review of all the available inspection information as well as a thorough site inspection of the existing bridge must be performed to establish the current conditions prior to proceeding with the analysis.

The bridges rated using design plans shall be noted as such in the load rating report.

Allowable stresses for the working stress and the ultimate or yield strengths of materials for Load Factor ratings shall be as specified on the original design plans unless it is required in the scope of services to conduct specific tests to determine the material strengths.

For existing bridges, the rater should review the original design plans as the first source of information for material strengths and stresses. If the material strengths are not explicitly stated on the design plans, ODOT Construction and Material Specifications (C&MS) applicable at the time of the bridge construction shall be reviewed. This may require investigations into old ASTM or AASHTO Material Specifications active at the time of construction.

The total thickness of the composite concrete slab shall be used in load rating for the calculations of section properties. Do not subtract for the monolithic wearing surface.

General information about ODOT Allowable Stresses in bending and shear and material strengths based on the year of construction is provided in Tables 927.2.1-1 and 927.2.1-2.

The rater is cautioned to pay extra attention to the design plans and the year of construction, when determining material strengths for bridges built during transition years of Tables 927.2.1-1 and 927.2.1-2 (e.g., for member type SS, years 1964-68, or 1988-93, etc.), as materials of the newer (or older) specification may have been substituted.

Any material stresses and specifications specified on the design plans shall supersede the values given in Tables 927.2.1-1 and 927.2.1-2.

### 927.3.2 WHEN THE BRIDGE LOAD RATING SHALL BE DONE

The load rating of existing bridges shall be done as per the Scope of Services.

### 927.3.3 LOAD RATING OF EXISTING BURIED BRIDGES

A. The load rating analysis will be performed as per the Scope of Services.

B. Unless specified otherwise, structures shall be load rated for the Loads as per BDM Section 927.2.3.

### 927.3.4 LOAD RATING OF NON-BURIED STRUCTURES

All structures, including flat slabs, arch structures, frames, box sections, etc., having a fill or pavement material of less than 2-ft on top of the structures shall be load rated according to the provisions of BDM Sections 911 through 925 (as applicable).

## 928 LOAD RATING OF NON-ODOT BRIDGES

Provisions of BDM Section 900 may also be applied to load rating of Non-ODOT buried and non-buried bridges at the discretion of the respective bridge owners.

The load rating files and reports of a Non-ODOT bridge shall be submitted to the respective bridge owners. The bridge owner shall keep the bridge load rating report in the bridge file for future reference and use.

Based on the field conditions and the load rating calculations, if the rating engineer determines a bridge should be posted for reduced load capacity, the engineer shall forward the recommendation to the respective bridge owner. Applicable portions of BDM Section 918, Bridge Posting for Reduced Load Limits may be followed.

It is the responsibility of the respective bridge owner (or designated consultant/rating engineer) to ensure that the load rating information is finally updated in the ODOT SMS.

## 929 CULVERT TYPE BRIDGES DESIGNED USING ASTM C1577 (LRFD), C1433 (LFD), C789 (LFD) AND C850 (LFD)

When all of the following conditions apply:

A. A structure is designed and manufactured by an AASHTO method using any of the above referred ASTM Specifications;

B. The ASTM Specifications are referenced via pay item in the design plans and the structure was built in accordance with the ASTM Specifications.

C. No changes to loading conditions or the structure conditions have occurred that could reduce the load rating below the design load level;

D. In case of an existing structure, a field evaluation has been completed and the structure has not developed excessive cracks, deflections or signs of deterioration.

E. The design plans and the relevant ASTM Specification are accessible and referenced or included in the individual bridge records to form a basis for assigned load rating under FHWA 23 CFR 650.309(c);

F. The main structural members of the bridge have not been damaged or repaired since the structure was originally built;

G. During the last inspection, the General Appraisal (GA) was not less than 5 and the bridge was neither posted nor closed.

Appropriate load rating factors may be assigned to the structure, as follows:

- Inventory Rating Factor for HL93 loading = 1.00
- Operating Rating Factor for HL93 loading = 1.30
- Ohio Legal Loads Rating Factor = 1.50 (150%)
- Method of Rating = Assigned Load & Resistance Factor Rating (LRFR) using HL93 loadings OR

- Inventory Rating Factor for HS20 loading = 1.00
- Operating Rating Factor for HS20 loading = 1.30
- Ohio Legal Loads Rating Factor = 1.50 (150%)
- Method of Rating = Assigned Load Factor Rating (LFR) using HS20 loadings

A load rating summary of the assigned load rating (using BR100 Form, given as Figure 921.1-1), demonstrating above conditions are met, is to be included in the bridge records. An Ohio PE shall sign, seal and date the Load Rating Summary sheet.

If any of the above conditions (A through G) cannot be met for a bridge at any point during its service life, load ratings cannot be assigned and must be determined by the methods defined elsewhere in the BDM Section 900.

## 930 REFERENCES


A. AASHTO, LRFD Bridge Design Specifications, most current Edition and all subsequent Interims

B. AASHTO, The Manual for Bridge Evaluation, 2nd Edition and all subsequent Interims

C. AASHTO, Standard Specifications for Highway Bridges, 17th Edition

D. AASHTO, Guide Specifications for Fatigue Evaluation of Existing Steel Bridges, most current Edition and all subsequent Interims

E. AASHTO, Guide Specifications for Strength Evaluation of Existing Steel and Concrete Bridges

F. AASHTO, Manual for Maintenance Inspection of Bridges

G. AASHTO, Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members, most current Edition and all subsequent Interims

H. AASHTO Bridge Rating and AASHTO Bridge Design Software, developed by Baker Corp, Moon Township, Pittsburgh,

I. WYDOT, BRASS-Culvert software developed by the Wyoming Department of Transportation

J. Duncan, J.M., 1979, “Design Studies For Aluminum Structural Plate Box Culverts,” Kaiser Aluminum and Chemical Sales, Inc.

K. FHWA, 1995, “Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation’s Bridges, Report No. FHWA-PD-96-001, December 1995

L. NCSPA, “Load Rating & Structural Evaluation of In-Service Corrugated Steel Structures,” & Design Data Sheet No. 19, National Corrugated Steel Pipe Association (NCSPA, 202-452-1700)

## 931 LOAD RATING FLOW CHART

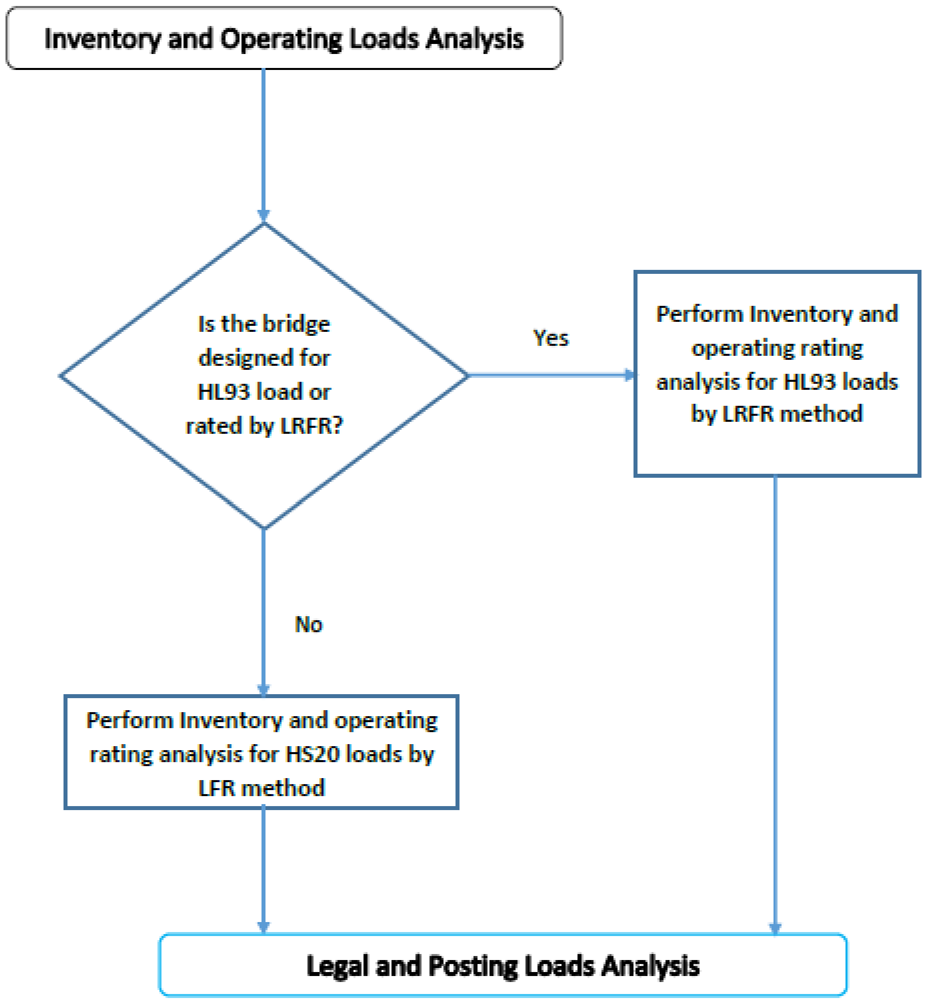



**Figure 931-1: Inventory and Operating Load Rating Flow Chart**

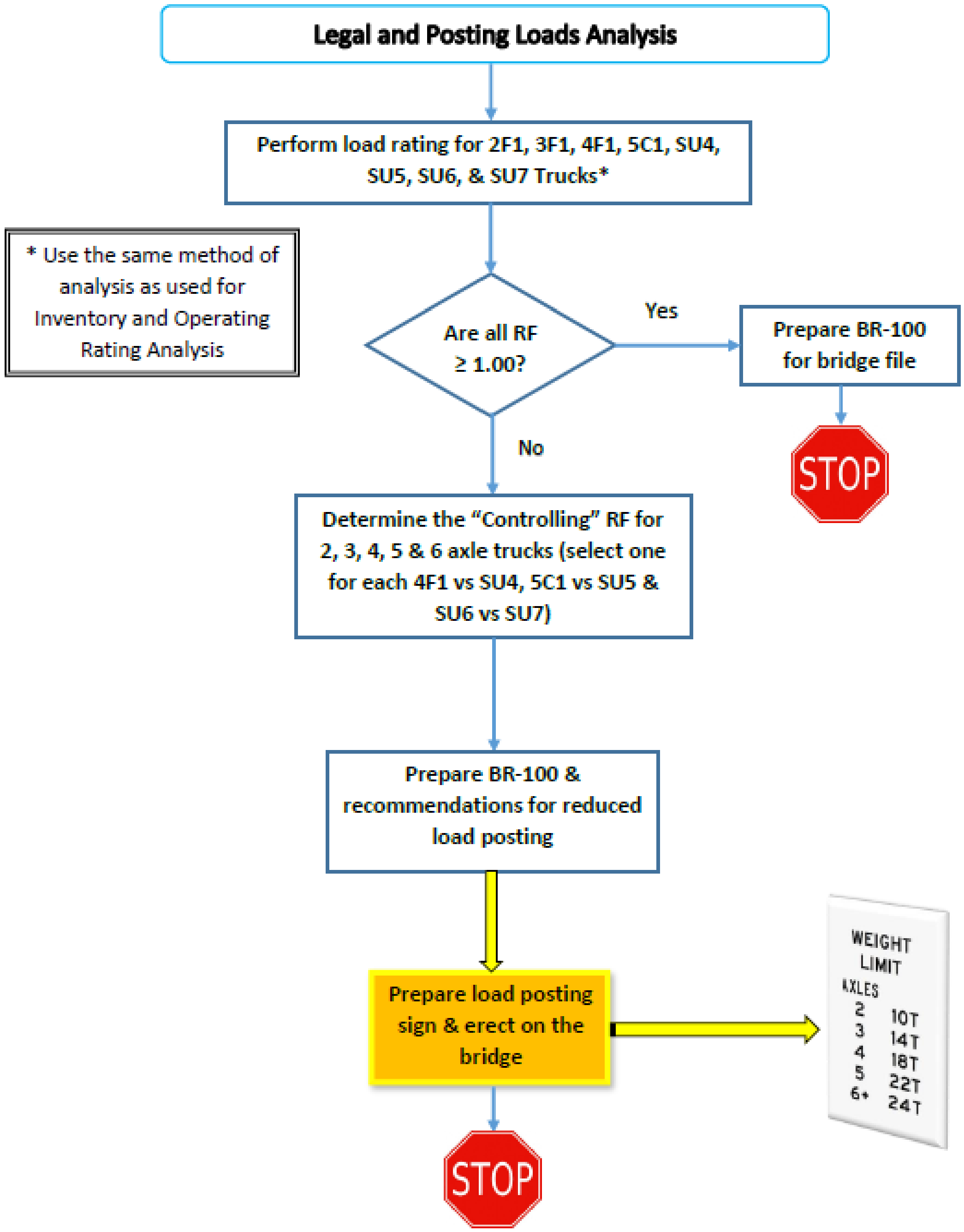



**Figure 931-2: Ohio Legal and Posting Load Rating Flow Chart**

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