New Hampshire DOT
Department of Transportation

Bridge Design Manual

Chapter 7

Superstructure

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Chapter 7 Superstructure

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7.4 Expansion Joints

7.4.1 General Considerations

Expansion joints must accommodate cyclic and long-term structure movements in such a way as to minimize imposition of secondary stresses in the structure. Expansion joints must be water tight to prevent water runoff (particularly deicing chemicals) from damaging the supporting structural elements, and provide a relatively smooth riding surface over a long service life.

Expansion joints shall be designed according to the current *AASHTO LRFD Section 14.5, Bridge Joints*. Designers should carefully consider all factors for the design, including lateral displacements and/or bridge rotation on heavily skewed bridges, horizontal curved structures or very wide bridges. The limitation with respect to movement parallel to the joint (racking) must be considered when selecting and sizing the expansion joint.

Deck expansion joints add cost to the structure, increase maintenance requirements and should be used only when necessary. For all new designs, consideration shall be given to integral or semi-integral bridges with the expansion joint located between the end of the approach slab and sleeper slab (see Chapter 6 for details).

It is preferred that all deck expansion joints be located *behind* the backwall for movements less than or equal to 4-in. This type of joint would include: the asphaltic plug; compression; and strip seal expansion joint. For tall abutments, the backwall shall be a broken back type. If the deck expansion joint cannot be located behind the backwall due to scope of work, bridge geometry, or the movement is greater than 4-in., the deck expansion joint shall be placed in front of the backwall. The location of the deck expansion joint shall be approved by the Bridge Design Chief.

NHDOT's current practice is to limit the number of bridge deck expansion joints due to numerous problems associated with the joints. Expansion joints shall be placed on the high end of a bridge if only one joint is placed on the bridge. This is done to prevent the bridge from creeping downhill and to minimize the amount of water passing over the joint. Expansion joints located over bridge piers shall be avoided.

All bridges with membrane and pavement shall have an asphaltic plug for crack control at the fixed ends. The detail shown on Appendix 7.4-B1 shall be included in the contract plans.

NHDOT snowplows can now adjust to any angle, but typically the blade is set at 37°. The snowplows are equipped with the JOMA 6000 plow edge carbide blades that conform to the shape of the roadways *and* into bridge joints openings. If an expansion joint has a skew between 32° and 42° left ahead (either direction on the interstate) or near this range *or* the joint opening (inside extrusions) is greater than 4-in. (102-mm) in the longitudinal direction [AASHTO LRFD 4.5.3.2], communication shall be made with the Bridge Design Chief, Bureau of Bridge Maintenance, and the District Engineer on whether a plow protection plate should be placed on the expansion joint. The use of a plow plate will be decided on a project to project basis. See Appendix 7.4-A8 for standard dimensions of the plow protection plate design.

7.4.2 NHDOT Expansion Joint Types

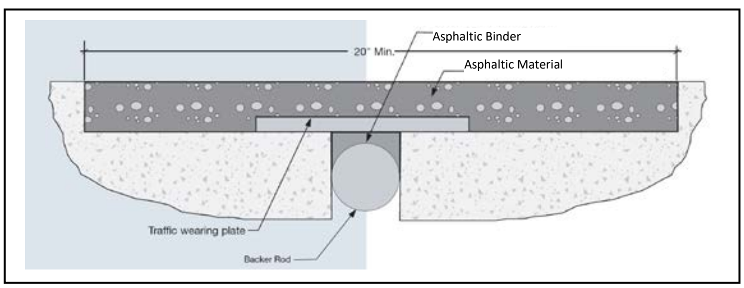
Typical NHDOT expansion joints include: asphaltic plug; compression seal; strip seal; finger joint; modular joint; and preformed closed cell. Information indicating the joints expansion range, limitations and design examples are shown in Appendix 7.4-A1 through 7.4-A7. Details of each joint type are shown in Appendix 7.4-B1 through 7.4-B8. A preliminary expansion joint selection diagram is located in Appendix 7.4-A1.

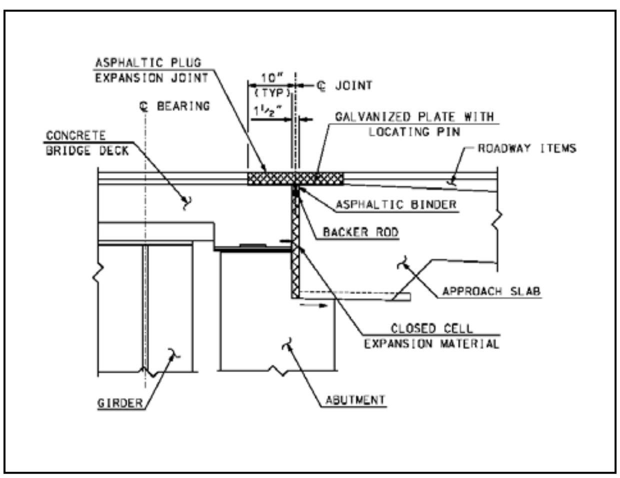
A list of approved proprietary expansion joints is listed in the NHDOT Qualified Product List (QPL) located at http://www.nh.gov/dot/org/projectdevelopment/materials/research/products.htm under Section 559 Asphaltic Plug Expansion Joint; Section 560 Prefabricated Compression Seal Expansion Joint; and Section 561 Prefabricated Expansion Joint. When designing an expansion joint, the designer shall use the most current proprietary joint information from the manufacturer's web site.

When the total longitudinal movement is ≤ ¼", no expansion joint is required. An asphaltic plug for crack control shall be placed on both ends of the bridge. The asphaltic plug for crack control shall also be placed on the fixed end of all bridges. See Appendix 7.4-B1 for details of the asphaltic plug for crack control.

A. Asphaltic Plug Expansion Joint

Asphaltic plug joints consist of flexible polymer modified asphalt (PMA) installed within a blockout over a steel plate with locating pin and backer rod. The steel plate spans across the expansion gap to retain the PMA during its installation. Application guidelines must be carefully followed to assure successful performance. Many limitations are placed on this type of joint because past performance has shown that the PMA tends to creep, migrating out of the blockouts. The limitations for the asphaltic plug joint are listed in Appendix 7.4-A2 and details are shown on Figure 7.4.2-1 and on Appendix 7.4-B2. The asphaltic plug expansion joint can be used when the total longitudinal movement is > ¼" and ≤ ¾" *and* if the limitations noted in Appendix 7.4-A2 are met.



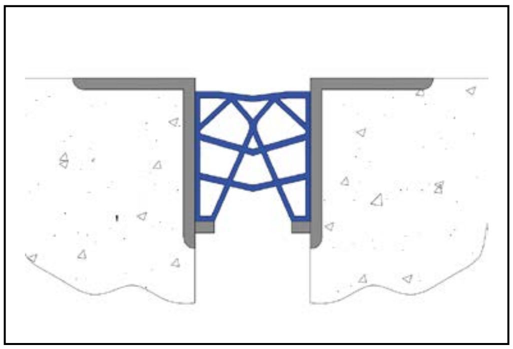


Asphaltic Plug Expansion Joint

Figure 7.4.2-1

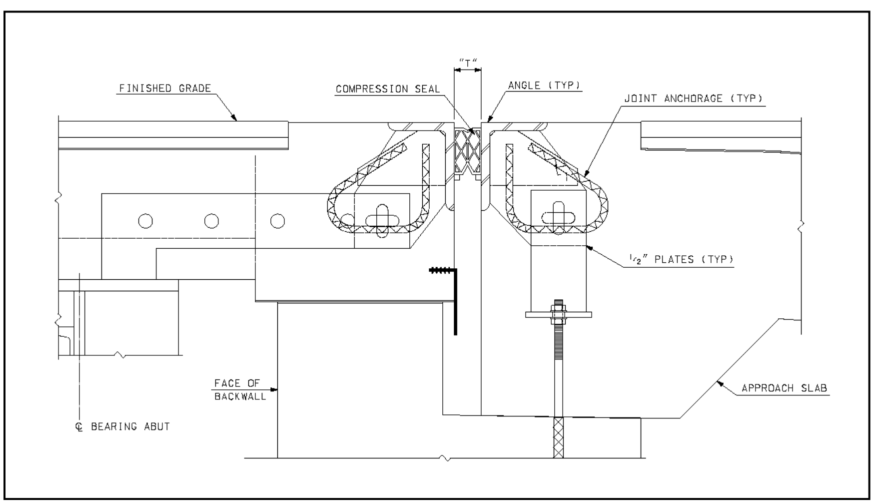
B. Compression Seal Expansion Joint

Compression seal expansion joints are continuous preformed elastomeric sections with extruded internal web systems and are held in place by mobilizing friction against adjacent vertical faces of angles embedded into the concrete deck on each side of the expansion joint gap. They must be sized and installed to always be in a state of compression. If the skew of the expansion joint is greater than 30°, a compression seal shall not be used. The retainer bars (stop bars) serve as a ledge to prevent the seal from being forced down through the joint. The limitations for compression seals are listed in Appendix 7.4-A3 and the details are shown below on Figure 7.4.2-2 & 3 and Appendix 7.4-B3. The compression seal expansion joint can be used when the total longitudinal movement is ≤ 2” *and* if the limitations noted in Appendix 7.4-A3 are met. It is preferred that the compression seal expansion joint be used when possible (instead of the strip seal), due to less maintenance required.



Compression Seal Expansion Joint

Figure 7.4.2-2

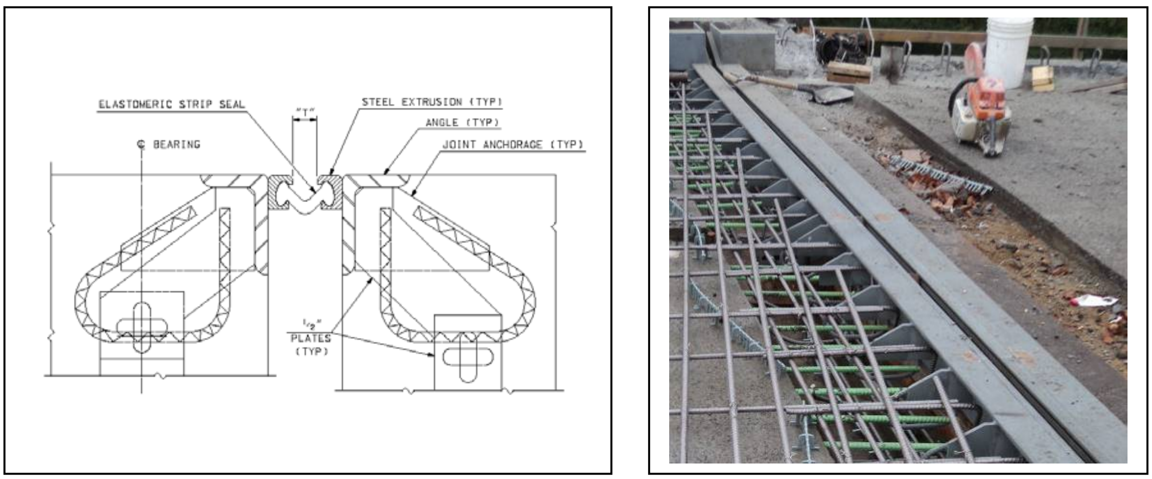


Compression Seal Expansion Joint Behind Backwall

Figure 7.4.2-3

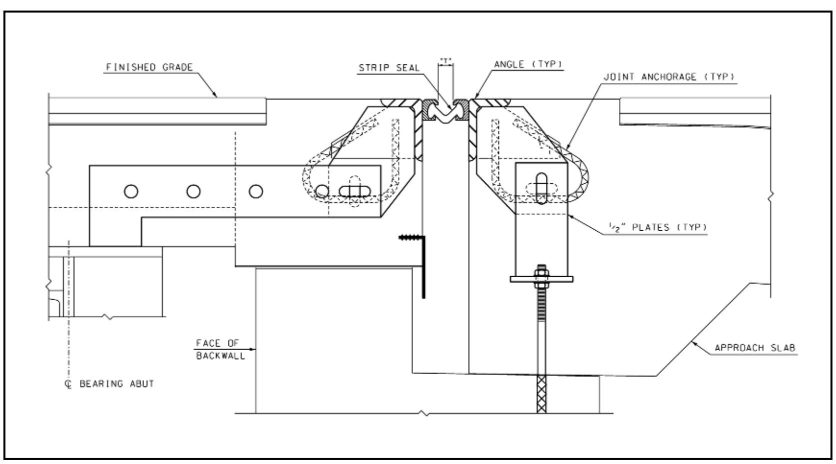
C. Strip Seal Expansion Joint

Strip seal expansion joints consists of a preformed elastomeric gland mechanically locked into steel edge rails (extrusions) welded to angles embedded into the concrete deck on each side of an expansion joint gap. Provide cover plates on sidewalks, medians and pedestrian bridges to cover the opening. If the strip seal joint has a skew between 32° and 42° left ahead (either direction on the interstate), *or* near this range, communication shall be made with the Bridge Design Chief, Bureau of Bridge Maintenance and the District Engineer on whether a plow protection plate shall be placed on the expansion joint. See Appendix 7.4-A8 for standard dimensions of the plow protection plate design. The limitations for strip seals are listed in Appendix 7.4-A4 and the details are shown below on Figure 7.4.2-4, 5 & 6 and on Appendix 7.4-B4 & B8. The strip seal expansion joint can be used when the total longitudinal movement is ≤ 4" *and* if the limitations noted in Appendix 7.4-A4 are met.



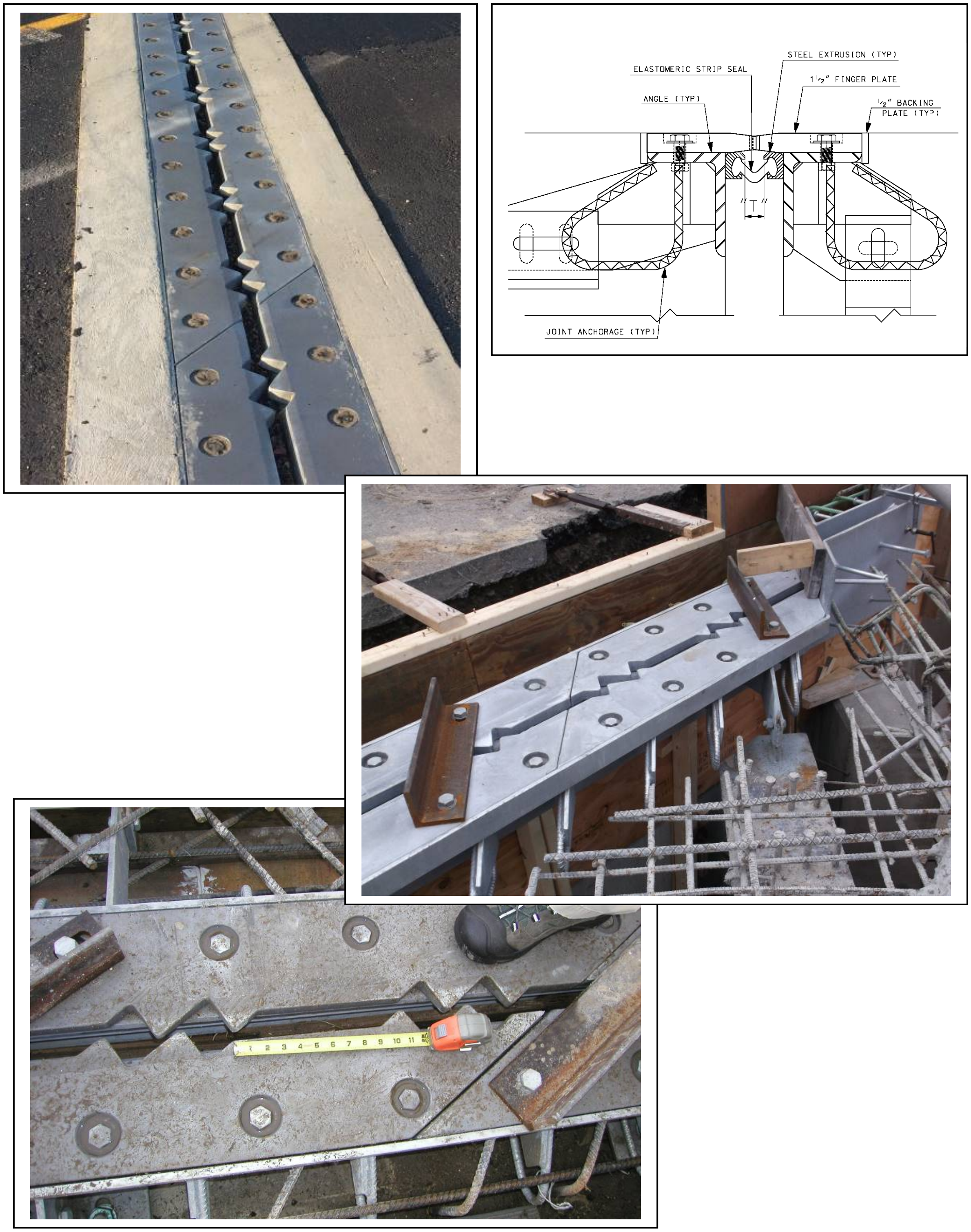
Strip Seal Expansion Joint

Figure 7.4.2-4



Strip Seal Expansion Joint
Behind Backwall

Figure 7.4.2-5

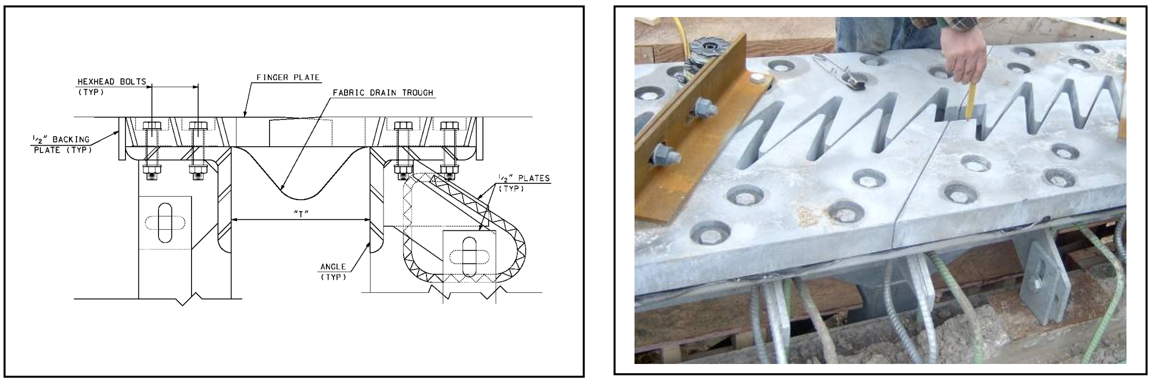


Strip Seal Expansion Joint with Plow Protection Plate

Figure 7.4.2-6

D. Finger Expansion Joint

Finger expansion joints are fabricated from steel plates and are installed in cantilevered configurations across expansion joint openings. The steel fingers must be designed to support traffic loads with sufficient stiffness to preclude excessive vibration. In addition to longitudinal movement, finger joints must also accommodate any rotations or differential vertical deflection across the joint. Since finger joints do not provide an effective seal against water infiltration, a fabric drain trough is installed beneath the finger joint to catch and redirect runoff water to downspouts. NHDOT's current finger joint limitations and design have evolved through the years with input from the Bureau of Maintenance, to take into account the difficulty of accessing the trough for maintenance and trying to remove the material that builds up in the trough. No plow protection plate is required for finger joints. The limitations for finger joints are listed in Appendix 7.4-A5 and the details are shown on Figure 7.4.2-7 and on Appendix 7.4-B5 & B6.



Finger Expansion Joint

Figure 7.4.2-7

E. Modular Expansion Joint

Modular expansion joints are complex, expensive, structural systems designed to provide watertight wheel load transfer across expansion joint openings. Modular expansion joints comprise a series of steel center beams oriented parallel to the expansion joint axis. Elastomeric strip seals attach to adjacent center beams, preventing infiltration of water and debris. The center beams are supported on support bars, which span in the primary direction of anticipated movement. The support bars are supported on sliding bearings mounted within support boxes. Polytetrafluoroethylene (PTFE) on stainless steel interfaces between elastomeric support bearings and support bars facilitate the unimpeded translation of the support bars as the expansion gap opens and closes. The support boxes rest on either cast-in-place concrete or grout pads installed into a preformed block out.

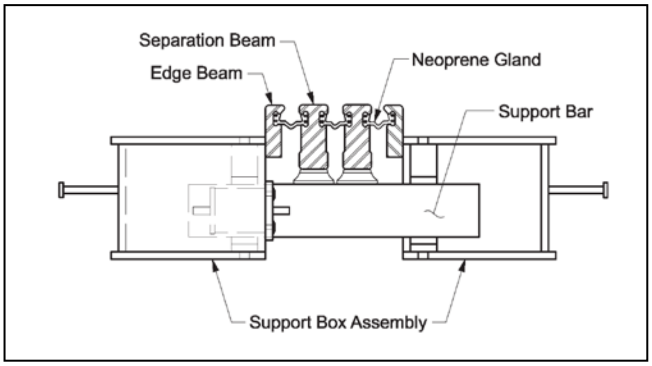
Modular expansion joints can be classified as either single support bar systems or multiple support bar systems. In multiple support bar systems, a separate support bar supports each center beam. In the more complex single support bar system, one support bar supports all center beams at each support location. This design concept requires that each center beam be free to translate along the longitudinal axis of the support bar as the expansion gap varies. This is accomplished by attaching steel yokes to the underside of the center beams. The yoke engages the support bar to facilitate load transfer. Precompressed elastomeric springs and PTFE on stainless steel interfaces between the underside of each center beam and the top of the support bar and between the bottom of the support bar and bottom of the yoke support each center beam and allow it to translate along the longitudinal axis of the support bar. Single-support bar systems have not meet AASHTO required manufacturer testing. Therefore, only multiple-support bar systems are allowed and shall have a full-penetration welded connection between the center beams and support bars.

The highly repetitive nature of axle loads predisposes modular expansion joint components and connections to fatigue susceptibility, particularly at center beam to support bar connections and center beam field splices. Bolted connections of center beams to support bar have demonstrated poor fatigue endurance. Welded connections are preferred, but must be carefully designed, fatigue tested, fabricated, and inspected to assure satisfactory fatigue resistance. NHDOT current specification for modular expansion joints includes stringent fatigue based design criteria for modular expansion joints. This specification also specifies criteria for manufacturing, shipping, storing, and installing modular expansion joints.

Modular expansion joints may need to be shipped and/or installed in two or more pieces and subsequently spliced together in order to accommodate project staging and/or practical shipping constraints. Splicing generally occurs after concrete is cast into the block outs. The center beams are elements that must be connected. These field connections are either welded, bolted, or a hybrid combination of both.

Center beam field splices have historically been the “weak link” of modular expansion joints because of their high fatigue susceptibility and their tendency to initiate progressive zipper-type failure. The reduced level of quality control achievable with a field operation in regard to a shop operation contributes to this susceptibility.

The limitations for modular expansion joints are listed in Appendix 7.4-A6 and the details are shown on Figure 7.4.2-8 &9 and Appendix 7.4-B7. The use of a modular joint shall be approved by the Bridge Design Chief.



Modular Expansion Joint

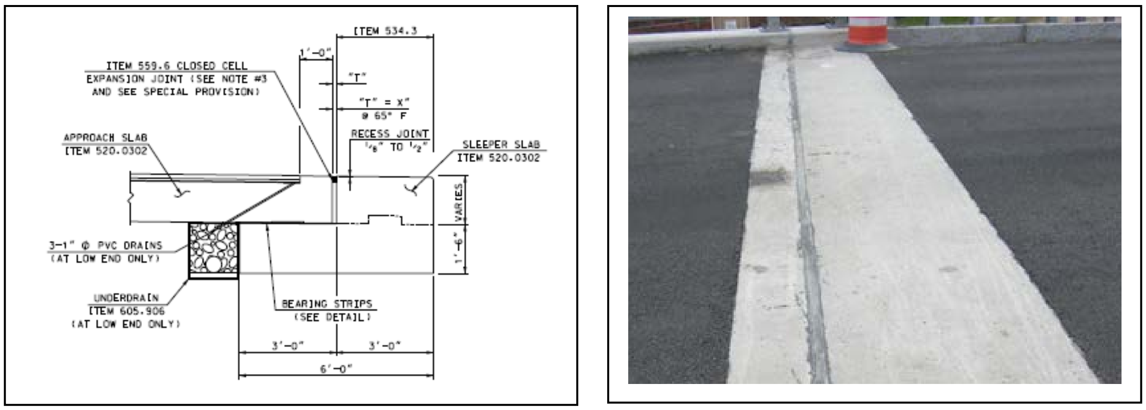
Figure 7.4.2-8

Modular Expansion Joint

Figure 7.4.2-9

F. Preformed Closed Cell Expansion Joint

Preformed closed cell expansion joints are a preformed, low-density impermeable closed cell, cross-linked, nitrogen blown, EVA polyethylene copolymer or polyethylene (XLPE) material with a UV stabilizer that is bonded into place with an epoxy adhesive that is typically used with integral bridges. Manufactures of this product state the expansion joint is capable of accommodating movements of 60% compression, 30% tension, and 120% shear and provides sizing charts for this movement. However, the product has failed in tension on previous projects and shall *only* be designed for compression. The designer shall size the closed cell as shown in the design example Appendix 7.4-A7 and note the size of two different manufacturers listed in the special provision. The limitations are listed in Appendix 7.4-A7 and the details are shown below on Figure 7.4.2-10 and Chapter 6, Appendix 6.4-B2. The preformed closed cell expansion joint can be used when the total longitudinal movement is ≤ 1-in. (steel girder); ≤ 3/4-in. (concrete girder) *and* if the limitations noted in Appendix 7.4-A7 are met.



Preformed Closed Cell Expansion Joint

Figure 7.4.2-10

7.4.3 Design Criteria

Expansion joints and their supports shall be designed to withstand force effects and movements according to *AASHTO LRFD 14.5.1-2* as noted and considering the following:

- Creep
- Construction tolerances
- Temperature range
- Bearing type and direction of allowed movements
- Skew
- External restraints
- Seismic movements
- Snow plowing operations

With respect to seismic movements, it is assumed that some expansion joint damage may occur, that this damage is tolerable and that it will be subsequently repaired. In cases where seismic isolation bearings are used, the expansion joints must accommodate seismic movements in order to allow the isolation bearings to function properly.

A. Shrinkage Effects (SH)

Accurate calculation of shrinkage as a function of time requires that average ambient humidity, volume-to-surface ratios, and curing methods be taken in consideration as summarized in *AASHTO LRFD Article 5.4.2.3*. See Chapter 4, Section 4.3.7, Superimposed Deformation Loads for calculating the design displacement due to shrinkage.

B. Thermal Effects (TU)

Variation in the superstructure average temperature produces elongation or shortening. Therefore, thermal movement range is calculated using the maximum and minimum anticipated bridge superstructure average temperatures anticipated during the structure's lifetime. See Chapter 4, Section 4.3.7, Superimposed Deformation Loads for calculating the thermal movement.

The expansion length is measured along the centerline of the bridge and the length is normal to the joint opening for structures with a zero skew. The length of superstructure affecting the movement at one of its joints shall be the length from the joint being considered to the structure's neutral point.

Expansion joint openings need to be checked for the temperature drop from the normal construction installation temperature (65° F for compression and strip seals, 45° F for finger joints), shrinkage, *and* the total closing movement due to temperature rise from the installation temperature.

Most expansion joint devices are installed in pre-formed concrete blockouts some time after the completion of the bridge deck. The expansion joint device must be cast into its respective blockout with a gap setting corresponding to the ambient superstructure average temperature at the time the blockouts are filled with concrete. In order to accomplish this, expansion device gap settings must be specified on the contract drawings as a function of superstructure ambient average temperature. Generally, these settings are specified in the temperature adjustment table for temperatures of: 20° F; 35° F; 50° F; 65° F; 80° F; and 95° F.

C. Load Factor γ_{TU}, for Force Effect due to Uniform Temperature, TU

A load factor γ_{TU} of 1.2 *(AASHTO Table 3.4.1-1)* shall be applied when calculating the movement due to temperature change for sizing all expansion joints, *except* for the asphaltic plug joint. The exception for the asphaltic plug joint is because the joint does not require sizing and it is designed for only a small movement.

The load factor γ_{TU} shall *not* be applied when determining the joint widths for the adjustment temperature table. See design examples in Appendix 7.4-A2 through A7.

D. Foundation Movement Effects

Typical construction requires backfilling abutments up to bridge seat elevations prior to construction of the deck slab. Therefore, abutment tip does *not* need to be considered in sizing the expansion joint as stated in *AASHTO Section 14.5*. However, if construction of the bridge is such that abutment tip should be considered in sizing joints, then abutment tip may be estimated as follows unless more accurate information is available:

M_{tip} = Movement due to abutment tip
= ¼" abutment tip for 10 ft. of abutment height

7.4.4 Bridge Movements and Fixity

To determine movements for joints (and bearings), the point of fixity must be established for the bridge. The point of fixity is the neutral point on the bridge that does not move horizontally as the bridge experiences force effects and movement.

Because the movement restriction imposed by a bearing must be compatible with the movements allowed by the adjacent expansion joint, expansion joints and bearings must be designed interdependently and in conjunction with the anticipated behavior of the overall structure.

The longitudinal stiffness is a function of the interaction between pier stiffnesses, bearing types and joint locations. The following shall be considered when determining bridge fixity and longitudinal stiffness:

- For single span structures, the low end of the bridge should be a fixed bearing. This is done to prevent the bridge from creeping downhill and to minimize the amount of water passing over the joint.
- Expansion joints located over bridge piers should be avoided.
- Minimize the number of expansion joints.
- For very wide bridges, horizontally curved bridges, and bridges with large skews, the impacts of transverse movement and forces shall be considered.
- For highly skewed bridges, a 3-D analysis shall be performed to determine the thermal movement of the bridge, the orientation and type of bearings, and the transverse and longitudinal translation the expansion joint shall be designed for.
- Expansion bearings should be compatible with movements of the expansion joint.
- The subsurface conditions play a factor in the distribution of horizontal loads (e.g. braking force or expansion bearing friction force) to the substructure and foundation.
- The number and location of expansion joints is determined based on a maximum joint opening at the ends of the bridge.
- Tall flexible piers deflect.

7.4.5 Review of Shop Drawings and Recording

Shop drawings should be reviewed for conformance with the provisions of Section 105 of the *NHDOT Standard Specifications for Road and Bridge Construction* and for general conformity with the contract plans and proposal. See Chapter 1, Section 1.3.6 for additional shop drawing review procedures.

The following is a guide for checking expansion joint shop drawings:

- ❑ Items should be checked for *general conformity* against the contract plans, proposal, addenda, special provisions and standard specifications.
- ❑ Material specifications.
- ❑ Size and type of seal, members and fasteners.
- ❑ Dimensions shown on contract plans.
- ❑ Finish (surface finish, galvanizing, painting, etc.).
- ❑ Weld size, type, and procedures.
- ❑ Anchorage assembly.

- ❑ Adequacy of details.
- ❑ Fabrication (welding and assembly procedures).
- ❑ Phase construction assembly.
- ❑ Cut and weld connection of the angles and plates at the crown or break-in-slope.

The designer shall input the seal size and type that was shown on the shop drawings, into the Bureau of Bridge Design Data Base, Bridge Particulars. This will record the expansion joint seal size and type for any future replacement by Bridge Maintenance.

7.4.6 Reinforcement Detailing at Expansion Joints

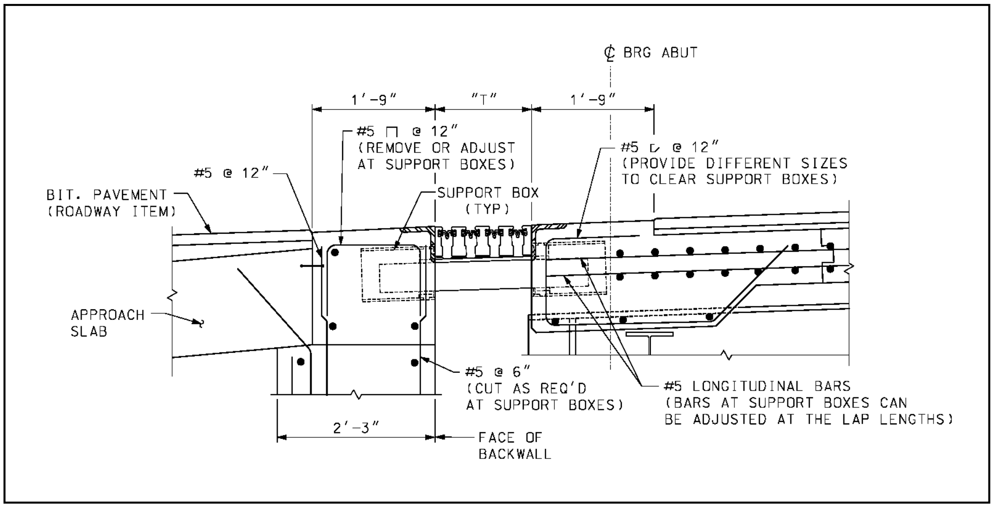
Reinforcement in the deck, backwall, and approach slab can conflict with the installation of prefabricated expansion joints, especially when the bridge is skewed. The designer shall detail the reinforcement to avoid possible conflicts with the joint anchors and support boxes. The prefabricated expansion joint shop plans shall also be reviewed for any possible conflicts prior to construction of the backwall, approach slab and deck blockout.

The following shall be included in detailing the bridge reinforcement near prefabricated compression, strip, finger, and modular expansion joints (See Figure 7.4.6-1, 2 & 3):

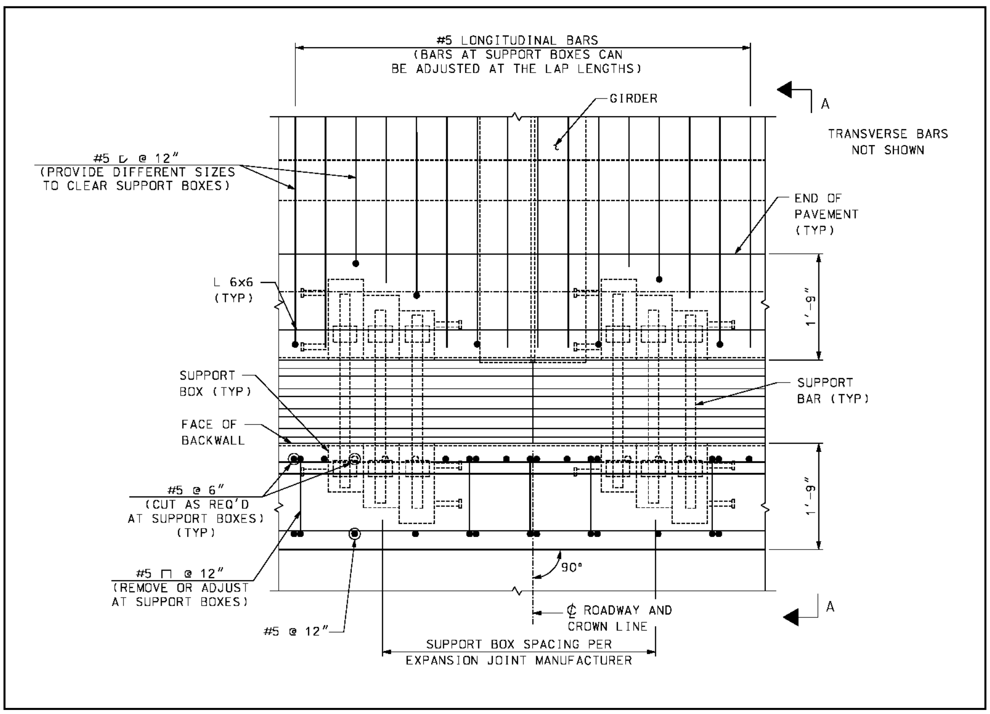
- ❑ All plan details located at the expansion joint shall show an assumed outline of the proposed joint including the anchors and support boxes.
- ❑ With the expansion joint outline in the detail, the designer shall layout the reinforcing to avoid possible conflicts with the joint.
- ❑ The following notes is located on the Reinforcement Notes:

  "Deck reinforcing layout shown is based on an assumed expansion joint design. Deck reinforcement may require adjustment in the field during the installation based on details shown on the approved expansion joint shop drawings." (i.e., the deck and approach slab haunch hoop bars and longitudinal bars may be moved to avoid the expansion joint anchors.)
- ❑ If the bridge is skewed and the deck reinforcing is detailed normal (perpendicular) to the centerline of the roadway, the deck reinforcing (longitudinal and transverse) shall be dimensioned 6"± from the end of the deck, unless the design requires otherwise.

See Figure 7.4.6-1 for example of detailing reinforcement near a prefabricated modular expansion joint.



Section A-A



Modular Expansion Joint
Example of Reinforcing Detailing

Figure 7.4.6-1

Modular Expansion Joint Reinforcing

Figure 7.4.6-2

Finger Expansion Joint Reinforcing

Figure 7.4.6-3

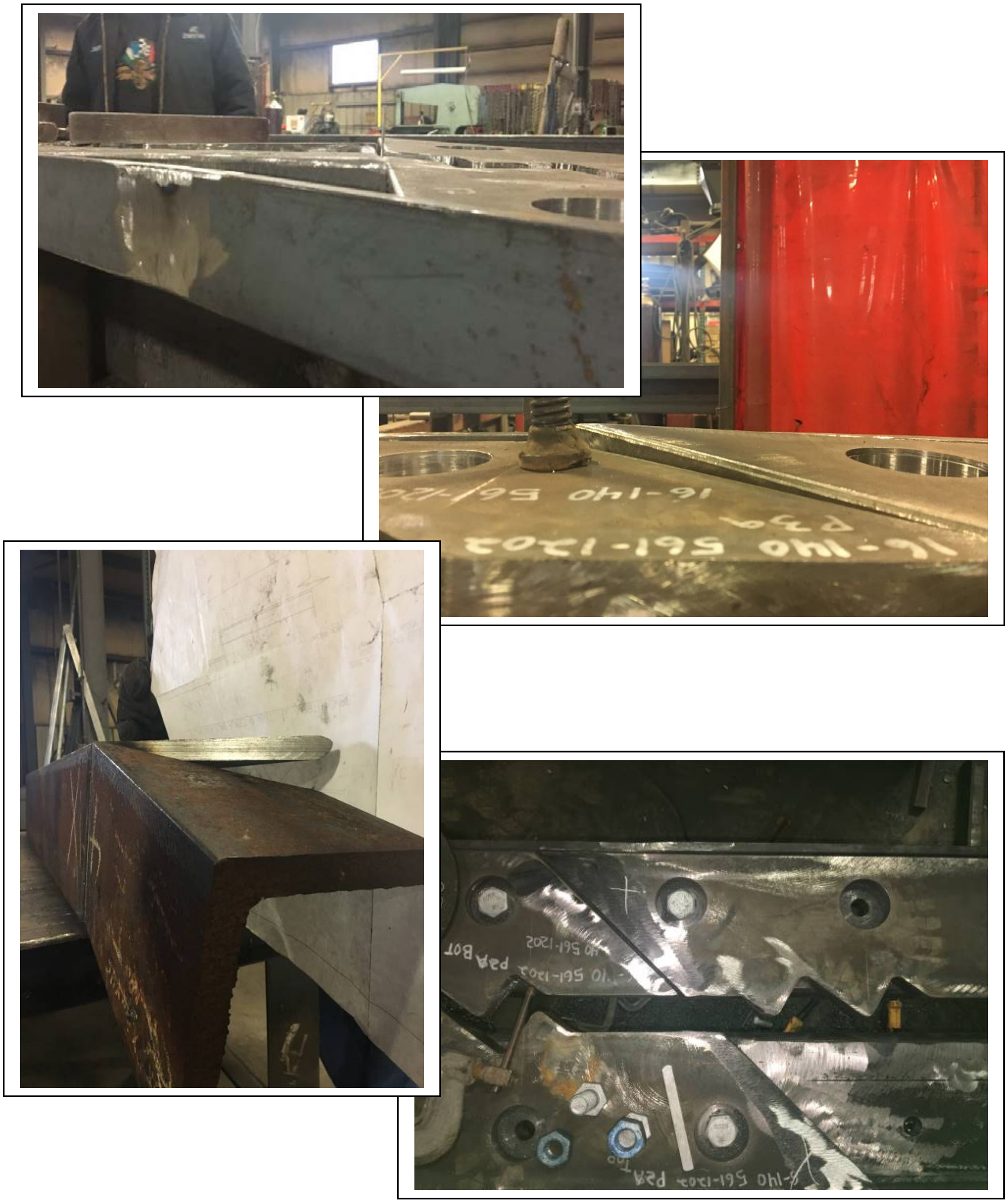
7.4.7 Angle/Plate Connection Fabrication Detailing at all Breaks-in-Slope

There have been issues with fabrication of armored expansion joints due to bridge geometry. Typically, a Fabricator would bend the angles of the expansion joints to match the bridge profile and cross-slope. However, if the bridge has a large skew, the angles cannot be bent to the geometry. Additionally, the top of the angles need to be flat if a plow plate is attached on top. Therefore, the designer needs to check the geometry at all breaks-in-slope and if needed, detail on the contract plans showing how the armored expansion joint shall be fabricated.

All armored expansion joints with a skew shall be reviewed and detailed as follows:

- Designers shall review the geometry of the expansion joint angles and plates at the break-in-slope or crown. Depending on the skew angle, cross-slope, and profile, the top flanges of the angles may not match when cut and welded together at the break. The vertical (front) legs of the angles need to line up in order for the extrusions/stop bars to remain in the same plane which causes the top legs to not line up.
- Plates, ¾-in. or 1-in. thick for both the horizontal and vertical, can be welded to the angle at the break-in-slope/crown and the plates continue to the curb line. Use a plate size that matches the angle thickness. The intent is to keep the vertical leg of the angle and plates straight and perpendicular to the profile so the strip or compression seal can be installed. The top plate can be angled to match the profile along the skew. Using two plates allows welding at an angle greater than or lesser than 90°.
- The details shall show how the angle is to be cut and the plates welded to the angle.
- If a plow plate or finger joint plate is attached on top, details of the plates shall show the spacing of the teeth and bolt hole locations.
- The additional connection details only need to be included if the expansion joint angle would not be able to be bent by the Fabricator due to the geometry. This is for locations at the break-in-slope and break-in-shoulder. If the expansion joint has a 6 x 4 angle with a small skew, the designer should check the dimension change at the crown and/or break-in-slope. If there is too much of a difference to be made by bending in the shop, then ¾-in. plates shall be shown and a connection detail drawn. Depending on the geometry, a 3-D drawing may be needed to determine the difference in dimensions at the break.
- If the expansion joint has phasing joints, the designer shall check the geometry if the location is near a crown or break-in-slope.
- See Appendix 7.4-B13 for details to be put on the contract plans, if applicable.
- See Appendix 7.4-B13 for a sample project explaining the geometry of why the welded plates are required to meet the grade and profile due to the skew.
- When reviewing the shop plans, the designer shall confirm the Fabricator is constructing the armoring as noted on the plans. Communicate with the Fabricator if the shop plans do not follow the contract plans.

An example of where an expansion joint fabrication problem occurred is the Concord-Pembroke 40405 project. The expansion joint was a strip seal with a plow plate on top with a 4.5% cross-slope, shoulder grade break, and a 45 degree skew. The angles were cut and welded along the break line but the geometry did not allow the plow plate to sit flat as intended. The corner of the plow plate stuck up ½-inch. The contract plans did not have angle/plate connection details for at the break. The Fabricator placed shims and ground down the plate as best as they could to match the geometry. Pictures of the expansion joint fabrication are shown in Figure 7.4.7-1.



Expansion Joint with Plow Plate Fabrication Issues
(Concord-Pembroke 40405)

Figure 7.4.7-1

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New Hampshire DOT Department of Transportation

Bridge Design Manual

Chapter 7- Appendix A

January 2015 – v 2.0

(Revised November 2018)

THE STATE OF NEW HAMPSHIRE ★ DEPARTMENT OF TRANSPORTATION ★

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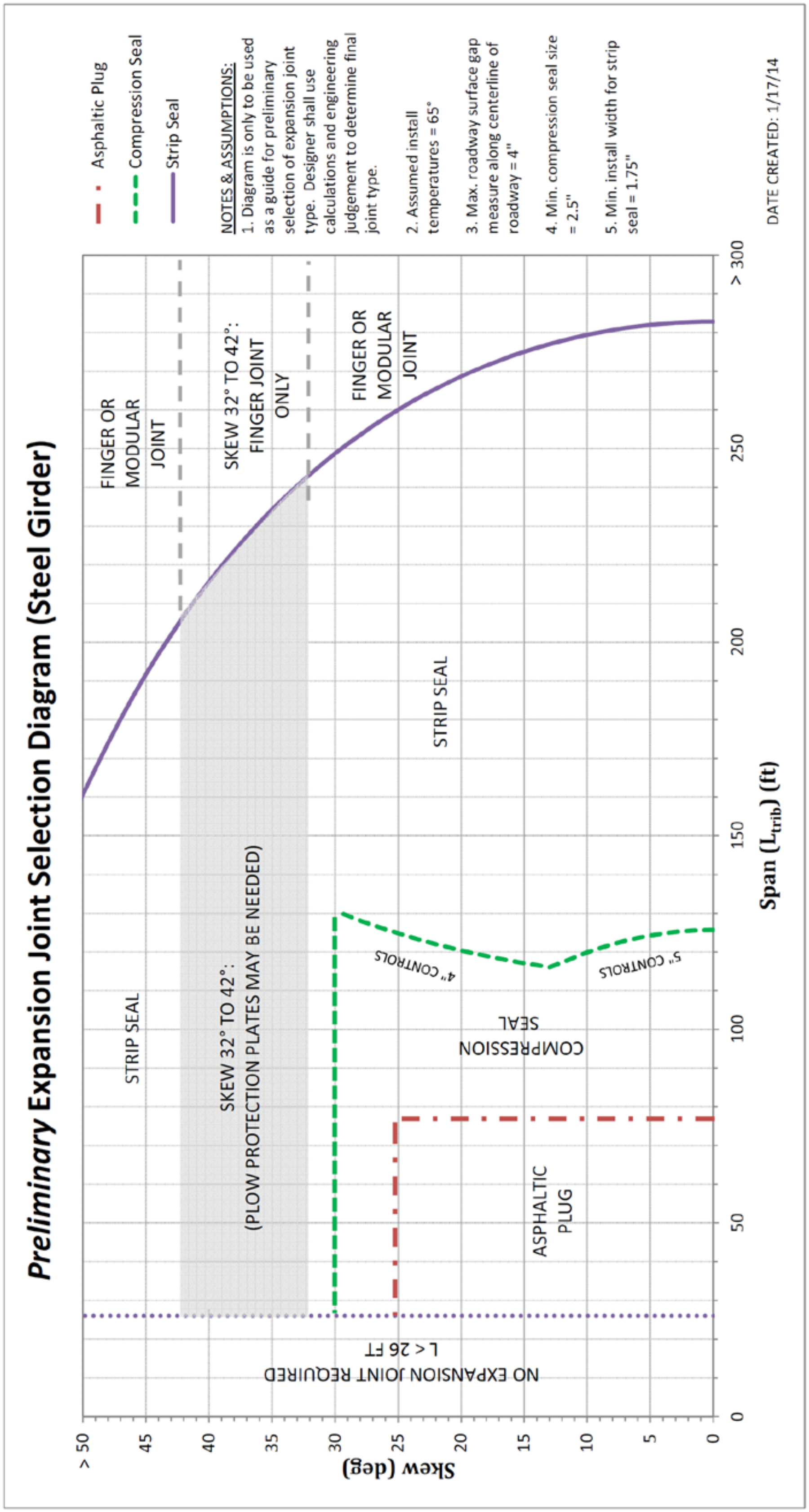
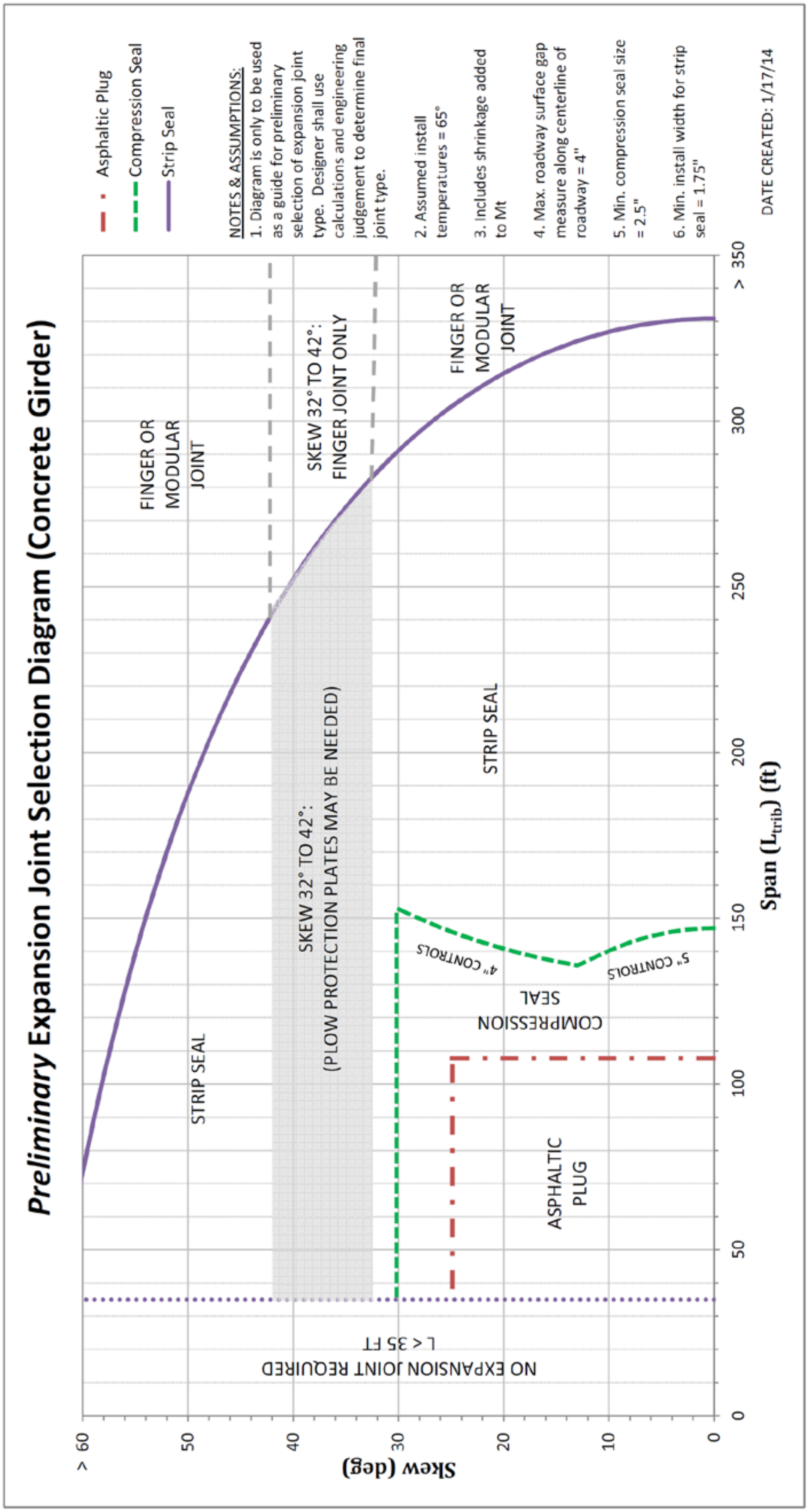


Note: Use asphaltic plug for crack control on all fixed ends and expansion ends with $L_{trib} \leq 26$ ft.



Note: Use asphaltic plug for crack control on all fixed ends and expansion ends with $L_{trib} \leq 35$ ft.

Asphaltic Plug Expansion Joint Limitations

An asphaltic plug expansion joint may be used with the following limitations (See Appendix 7.4-B2 for Asphaltic plug expansion joint details):

- 1/4” < total movement of expansion joint measured along center line of bridge (expansion and contraction) ≤ 3/4”.
- Do *not* apply the load factor γ_{TU} of 1.2 when calculating the movement due to temperature change.
- Skew of joint ≤ 25°
- Do not use at stop and start traffic locations (such as intersections).
- Do not use on a 3-lane (same direction) highway, unless approved by the Bridge Design Chief.
- Do not use on a 2-lane (same direction) highway with an ADT ≥ 15,000, unless approved by the Bridge Design Chief.
- Do not use on a 2-lane (opposite direction) highway with an ADT ≥ 15,000 unless approved by the Bridge Design Chief.
- Each project on a 2-lane (opposite direction) highway with an 8,000 ≤ ADT ≤ 15,000, shall be reviewed by the Bridge Design Chief *and* the Bureau of Bridge Maintenance for the traffic control required for any future repair work.
- Each project on a 2-lane (opposite direction) highway with an ADT < 8,000, shall take into account if traffic control is feasible for any future repair of the plug joint, as approved by the Bridge Design Chief.
- Minimum joint installation depth = 2” (measured from top of deck to top of pavement).
- Standard joint width = 20”
- Maximum gradient at joint location = 4%

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Compression Seal Expansion Joint Limitations

A compression seal expansion joint may be used with the following limitations (See Appendix 7.4-B3 for a compression seal joint detail. See p 7.4-A3-3 for design notations and p. 7.4-A3-4 & 9 for design examples):

- 1/4" < total movement of expansion joint measured along center line of bridge (expansion and contraction) ≤ 2.0".
- Skew of joint ≤ 30°
  - ⇒ This is different than *AASHTO 14.5.6.6* recommendation skew of joint < 20°.
  - ⇒ Limitation chosen after review of Maine DOT's compression seal testing. See Maine DOT Bridge Design Guide located at: http://www.maine.gov/mdot/bdg/docs/bpdg/Complete2003BDGwithUpdatesto2017.pdf - Chapter 4, Deck Joints and Expansion Devices
  - ⇒ The compression seal loses its ability to absorb "racking" movement with larger skews.
- It is preferred the compression seal expansion joint is used when possible (instead of the strip seal), due to less maintenance required.
- No splices of the seal shall be allowed.
- Nominal uncompressed width of seal (W) shall be: 2.5"≤ W ≤ 5" for deck joints (*AASHTO 14.5.6.6)* (Bureau of Bridge Maintenance feels a seal larger than 5" does not perform well.) W < 2.5" can be used for sleeper slabs.
- Maximum roadway surface gap (measured along center line of bridge) ≤ 4.0" *(AASHTO 14.5.3.2).*
- W = nominal uncompressed width of seal
  - ⇒ Max. joint opening = 0.85W
  - ⇒ Min. joint opening = 0.40W
  - ⇒ Max. shear displacement (racking) = 0.20W
- The expansion gap should be set so the compression seal can be replaced over a reasonably wide range of construction temperatures. Show the gap width on plans as a function of the superstructure temperature.
- The typical construction installation temperature is 65°F.
- For skewed joints:
  - ⇒ Bridge deck movement must be separated into components perpendicular and parallel to the joint axis (See design example).
- Concrete blockouts are required for the installation of a compression seal expansion joint.
- Anchorage of the compression seal expansion joint to the backwall and deck, between the curb lines, shall be made using a loop rebar and shall be spaced at 1'-0" maximum. Brush curb and sidewalk anchorage shall be made of stud anchors and shall be spaced at 1'-6" maximum. The anchorage reinforcement shall extend into the backwall or curb reinforcement cage for proper anchorage.
- Stop bars shall be continuously welded (top and bottom) to prevent rust forming behind the bars.

- Minimum joint openings that are ≤ 1-in. shall use ⅜ x ⅜-in. stop bars. The ½ x ½-in. stop bars would close onto each other at the minimum joint opening.

Compression Seal Joint Dimension Table

Uncompressed					
Seal Width "W"	**Seal Height**	**Min. Joint Width**	**Max. Joint Width**	**Min. Install Width**	**Min. Joint Depth**
2 ½	2 ½	1 ⅛ ±	2 ⅞	1 ½	3 ½ ±
3	3 ¼ ±	1 ⅜ ±	2 ½	1 ¾ ±	4 ¼ ±
3 ½	3 ½	1 ½ ±	3	2 ¼ ±	4 ½
4	4	1 ¾ ±	3 ⅜ ±	2 ½ ±	5 ⅝ ±
5	5	1 ⅞ ±	4 ¼	3	6 ¼ ±

Note: This table shows approximate values for both Watson-Bowman seal (WA series) and D.S. Brown seal (CV & CA series). The fabricator's websites should be viewed for the current and exact dimensions. The minimum install width is 0.6*Seal Width for D.S. Brown (given by email from the representative on 8/2012).

Stop Bar Distance Table for Compression Seal Joint

(Note the distance on the expansion joint contract plan.)

Seal Name	Nominal Seal Size (W x H) (in)	Depth to Stop Bar (in)
WA-200 CV-2000	2 x 2 2 x 2	2 ⅝
WA-225 CV-2250	2.25 x 2.25 2.25 x 2.25	3
WA-250 CV-2502	2.5 x 2.5 2.5 x 2.5	3 ½
WA-300 CV-3000	3 x 3 3 x 3.25	4 ¼
WA-350 CV-3500	3.5 x 3.5 3.5 x 3.5	4 ½
WA-400 CV-4000	4 x 4 4 x 4	5
CA-4500	4.5 x 4.5	5 ½
WA-500 CA-5001	5 x 5 5 x 5	6

Expansion Joint Design Notations

$M_{t(unfactored)}$ = Movement due to temperature (inches)
= $\alpha \cdot L_{trib} \cdot \Delta T \cdot$ (12 in./1ft.)

- ΔT = bridge superstructure average temperature range as a function of bridge type and location
  = 80° F (0° F to $^{+}$80° F) for concrete bridges
  = 125° F ($^{-}$20° F to $^{+}$105° F) for steel bridges
- L_{trib} = tributary length of the structure subject to expansion or contraction
- α = Coefficient of thermal expansion
  = 0.0000060 in./in./°F for concrete
  = 0.0000065 in./in./°F for steel

M_s = Movement due to shrinkage after construction (inches) (concrete beams)
= $\beta \cdot \mu \cdot L_{trib}$

- β = shrinkage coefficient for reinforced concrete, 0.0002
- μ = factor accounting for restraining effect imposed by superstructure elements installed before the concrete slab is cast
  = 0.5 for precast prestressed concrete girders
  = 0.8 for concrete box girders and T-beams
  = 1.0 for concrete flat slabs

M_p = Movement parallel to joint (inches)

M_n = Movement normal to joint (inches)

γ_{TU} = Load factor for force effect due to uniform temperature, 1.2

θ = Skew angle

"T" = Joint opening normal to joint for the installation chart (inches)

A = Joint opening normal to joint

W = Nominal uncompressed width of expansion seal (inches)

W_{min} = Minimum expansion width (inches)

W_{max} = Maximum expansion width (inches)

$W_{install}$ = Expansion width at installation (inches)

T_{min} = Minimum superstructure temperature
= (0° for concrete bridges, $^{-}$20° F for steel bridges)

T_{max} = Maximum superstructure temperature
= ($^{+}$80° F for concrete bridges, $^{+}$105° F for steel bridges)

$T_{install}$ = Minimum installation superstructure temperature
= $^{+}$65° F (all bridges)

Compression Seal Joint Design Example (1)

Design Procedure

A. Movement Calculations

$M_t = (\alpha)(L_{trib})(\Delta T)(\gamma_{TU})(12''/')$

$M_s = (\beta)(\mu)(L_{trib})(12''/')$ (= 0 for steel bridges)

$M_{t\ longitudinal} = (M_t + M_s)$

$M_{t\ normal} = M_t \cos\theta$

$M_{s\ normal} = M_s \cos\theta$ (= 0 for steel bridges)

$M_p = (M_t + M_s)\sin\theta$

$M_n = (M_t + M_s)\cos\theta$

$\Delta T_{ratio\ min} = (T_{install} - T_{min})/(\Delta T)$

$\Delta T_{ratio\ max} = (T_{max} - T_{install})/(\Delta T)$

B. Selection of Seal Width (largest W value)

1. Max. joint opening = 0.85W
   Min. joint opening = 0.40W
   Hence, (0.85W – 0.40W) = 0.45W for total movement
   $M_n = 0.45W$
   Algebraic manipulation and solving for W yields:

   $W \geq M_n / 0.45$

2. Max. shear displacement = 0.20W
   $M_p = 0.20W$
   Algebraic manipulation and solving for W yields:

   $W \geq M_p / 0.20$

3. $W_{max} = W_{install} + [(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}] < 0.85W$
   Assume $W_{install} = 0.6W$
   Algebraic manipulation and solving for W yields:
   $W_{max} = 0.6W + [(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}] < 0.85W$
   Rearranging yields:

   $W \geq 4\ [(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}]$

$\Rightarrow$ Choose a seal size from manufacturer's chart

<u>Compression Seal Joint Design Example (1) (cont.)</u>

C. Check Joint Opening for Install, Max. and Min. Temperatures

1. Install Temp. (65° F):

   $A_{install}$ = manufacturer's min. install width

   ⇒ Set $A_{install}$

2. Min. Temp. :

   $A_{max} = A_{install} + [(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}] \leq$ manufacturer's maximum opening

3. Max. Temp.:

   $A_{min} = A_{install} - (\Delta T_{ratio\ max} \cdot M_{t\ normal}) \geq$ manufacturer's minimum opening

4. Min. Opening between *stop bars*:

   $A_{min\ stop\ bars} = A_{min} - (2 \cdot 0.5\text{" stop bar width}) > 0\text{"}$

5. $A_{max\ longitudinal} \leq 4\text{"}$ (*AASHTO 14.5.3.2)*

   $A_{max\ longitudinal} = A_{max}/\cos\theta$

⇒ Confirm two different manufacturer seals (same size) meet all requirements.

⇒ The designer shall use judgment if $T_{install}$ needs to be adjusted in order to get a certain size seal to work. However, the designer needs to be aware at what the install temperature will mostly be (i.e. summer construction). If the designer decides the seal needs to be installed at a temperature lower than 65° F, the $T_{install\ min.}$ needs to be noted on the plan and approved by the Design Chief.

D. Calculate Temperature Adjustment Table

Calculate $M_{15°\ normal}$ *without* load factor, γ_{TU}

Design Example (1)

- **Steel girder**
- Total expansion length = 70'
- Skew angle = 27°
- Expansion joint at one abutment
- Value of Constants:

  $\theta = 27°$

  $\alpha = 0.0000065$ in./in./°F

  $L_{trib} = 70'$

  $\Delta T = 125°$ F (-20° F to $^{+}$105° F)

  $T_{install} = 65°$ F

  $\gamma_{TU} = 1.2$

A. Movement Calculations

$M_t = (\alpha)(L_{trib})(\Delta T)(\gamma_{TU})$

$= (0.0000065\text{ in./in./°F})(70')(125°\text{ F})(1.2)(12\text{"/'})$

$= 0.82\text{"}$

Compression Seal Joint Design Example (1) (cont.)

$M_{t\ normal} = M_t \cos\theta$
$= (0.82")\cos 27°$
$= 0.73"$

$M_s = 0$

$M_n = (M_t + M_s)\cos\theta$
$= (0.82" + 0)\cos 27°$
$= 0.73"$

$M_p = (M_t + M_s)\sin\theta$
$= (0.82" + 0")\sin 27°$
$= 0.37"$

$\Delta T_{ratio\ min} = (T_{install} - T_{min})/(\Delta T)$
$= (65° F – (-20°F)/(125° F)$
$= 0.680$

$\Delta T_{ratio\ max} = (T_{max} - T_{install})/(\Delta T)$
$= (105° F – 65° F)/(125° F)$
$= 0.320$

$M_{t\ longitudinal} = (M_t + M_s) = 0.82" \leq 2"$ (max. movement)
$\theta = 27° \leq 30°$
$\Rightarrow$ **OK**

B. Selection of Seal Width (largest W value)

1. $W \geq M_n /0.45 = 0.73"/0.45 =$ 1.62"
2. $W \geq M_p /0.20 = 0.37"/0.20 =$ 1.85"
3. $W \geq 4\,[(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}]$ ← governs
   $\geq 4\,[(0.680 \cdot 0.73") + 0] = 1.99"$

$\Rightarrow$ Try a 2.5" seal (Min. seal width per limitations.)

Joint Type	Joint Opening		Minimum Install	Nominal Width
	Minimum	Max		
WA-250	1.0"	2.125"	1.50"	2.5"
CV-2502	1.13"	2.13"	1.50"	2.5"

C. Check Joint Opening for Install, Max. and Min. Temperatures

1. Install Temp. (65° F):

$A_{install}$ = manufacturer's min. install width
= 1.5"

$\Rightarrow$ Set $A_{install} = 1.5"$

2. Min. Temp. :

$A_{max} = A_{install} + [(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}] \leq$ manufacturer's maximum opening

$A_{max} = 1.5" + [(0.680 \cdot 0.73") + 0]$
$= 2.0" < 2.13"$ **O.K.**

Compression Seal Joint Design Example (1) (cont.)

3. Max. Temp. :

$A_{min} = A_{install} - (\Delta T_{ratio\ max} \cdot M_{t\ normal}) \geq$ manufacturer's min. opening

$A_{min} = 1.50" - (0.320 \cdot 0.73")$

$= 1.27" > 1.0"$ (WA-250) **O.K.**

$> 1.13"$ (CV-2502) **O.K.**

4. Min. Opening between *stop bars*:

$A_{min\ stop\ bars} = A_{min} - (2 \cdot 0.5"$ stop bar width$) > 0"$

$= 1.27" - (2 \cdot 0.5") = 0.27" > 0"$ **O.K.**

5. $A_{max\ longitudinal} \leq 4"$ (*AASHTO 14.5.3.2)*

$A_{max\ longitudinal} = A_{max}/\cos\theta$

$A_{max\ longitudinal} = 2.0/\cos27° = 2.24" \leq 4"$ **O.K.**

$\Rightarrow$ **Use: 2. 5" compression seal (WA-250 or CV-2502)**

D. Calculate Temperature Adjustment Table

$\Rightarrow$ Note: Calculate $M_{15°\ nomral}$ *without* load factor, γ_{TU}

$M_{15°\ normal} = (\alpha)(L_{trib})(15°)(12"/')\cos27°$

$= (0.0000065$ in./in./°F$)(70')(15°F)(12"/')\cos27°$

$= 0.073"$

"T" at 20° F = $A_{install} + (3)(M_{15°\ normal}) = 1.719"$

35° F = $A_{install} + (2)(M_{15°\ normal}) = 1.646"$

50° F = $A_{install} + (1)(M_{15°\ normal}) = 1.573"$

65° F = $A_{install}$ = 1.5"

80° F = $A_{install} - (1)(M_{15°\ normal}) = 1.427"$

95° F = $A_{install} - (2)(M_{15°\ normal}) = 1.354"$

Temperature Adjustment Table	
Temperature	**"T"**
20° F	1 3/4"
35° F	1 5/8"
50° F	1 9/16"
65° F	1 1/2"
80° F	1 7/16"
95° F	1 3/8"

Compression Seal Joint Design Example (1) (cont.)

Note on Plans:

1. Minimum width "T" for seal installation = 1 1/2" (Approx. 65° F or less).
2. The compression seal has been designed for a total factored movement of 0.82". This design includes movement due to temperature, skew, shrinkage and minimum installation. The Contractor shall use compression seal *WA-250 by Watson Bowman Acme* or *CV-2502 by D.S. Brown Co.*
3. Values in the Temperature Adjustment Table are for adjusting the expansion joint assembly immediately prior to pouring the concrete blockouts.

Compression Seal Joint Design Example (2)

Design Example (2)

- **Precast prestressed girder**
- Total expansion length = 135'
- Skew angle = 15°
- Expansion joint at one abutment
- Value of Constants:

  $\theta = 15°$
  $\alpha = 0.0000060$ in./in./°F
  $\beta = 0.0002$
  $\mu = 0.5$
  $L_{trib} = 135'$
  $\Delta T = 80°$ F (0° F to $^{+}80°$ F)
  $T_{install} = 65°$ F
  $\gamma_{TU} = 1.2$

A. Movement Calculations

$M_t = (\alpha)(L_{trib})(\Delta T)(\gamma_{TU})$
$= (0.0000060 \text{ in./in./°F})(135')(80° \text{ F})(1.2)(12''/')$
$= 0.93''$

$M_{t\ normal} = M_t \cos\theta$
$= (0.93'')\cos 15°$
$= 0.90''$

$\Delta T_{ratio\ min} = (T_{install} - T_{min})/(\Delta T)$
$= (65° \text{ F} - 0° \text{F})/(80° \text{ F})$
$= 0.8125$

$M_s = (\beta)(\mu)(L_{trib})$
$= (0.0002)(0.5)(135')(12''/')$
$= 0.16''$

$\Delta T_{ratio\ max} = (T_{max} - T_{install})/(\Delta T)$
$= (80° \text{ F} - 65° \text{ F})/(80° \text{ F})$
$= 0.1875$

$M_{s\ normal} = M_s \cos\theta$
$= (0.16'')\cos 15°$
$= 0.16''$

$M_n = (M_t + M_s)\cos\theta$
$= (0.93'' + 0.16'')\cos 15°$
$= 1.05''$

$M_p = (M_t + M_s)\sin\theta$
$= (0.93'' + 0.16'')\sin 15°$
$= 0.28''$

$M_{t\ longitudinal} = (M_t + M_s) = 1.09'' \leq 2''$ (max. movement for compression seal)

$\theta = 15° \leq 30°$

$\Rightarrow$ **OK**

Compression Seal Joint Design Example (2) (cont.)

B. Selection of Seal Width (largest W value)

1. $W \geq M_n / 0.45 = 1.05''/0.45 =$ 2.33”
2. $W \geq M_p / 0.20 = 0.28''/0.20 =$ 1.40”

governs → 3. $W \geq 4\,[(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}]$
$\geq 4\,[(0.8125 \cdot 0.90'') + 0.16''] = 3.56''$

⇒ Try a 4” seal

Joint Type	Joint Opening		Minimum Install	Nominal Width
	Minimum	Max		
WA-400	1.625”	3.40”	2.5”	4.0”
CV-4000	1.750”	3.40”	2.4”	4.0”

C. Check Joint Opening for Install, Max. and Min. Temperatures

1. Install Temp. (65° F):

$A_{install}$ = manufacturer’s min. install width
= 2.5”

⇒ Set $A_{install} = 2.5''$

2. Min. Temp. :

$A_{max} = A_{install} + [(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}] \leq$ manufacturer’s maximum opening

$A_{max} = 2.5'' + [(0.8125 \cdot 0.90'') + 0.16'']$
$= 3.39'' < 3.40''$ **O.K.**

3. Max. Temp. :

$A_{min} = A_{install} - (\Delta T_{ratio\ max} \cdot M_{t\ normal}) \geq$ manufacturer’s min. opening

$A_{min} = 2.5'' - (0.1875 \cdot 0.90'')$
$= 2.33'' > 1.625''$ (WA-400) **O.K.**
$> 1.75''$ (CV-4000) **O.K.**

4. Min. Opening between *stop bars*:

$A_{min\ stop\ bars} = A_{min} - (2 \cdot 0.5''$ stop bar width$) > 0''$
$= 2.33'' - (2 \cdot 0.5'') = 1.33''$ **O.K.** (stop bars will not close together)

5. $A_{max\ longitudinal} \leq 4''$ (*AASHTO 14.5.6.6)*

$A_{max\ longitudinal} = A_{max} / \cos\theta$
$A_{max\ longitudinal} = 3.39/\cos 15° = 3.51'' \leq 4''$ **O.K.**

⇒ **Use: 4” compression seal (WA-400 or CV-4000)**

Compression Seal Joint Design Example (2) (cont.)

D. Calculate Temperature Adjustment Table

⇒ Note: Calculate $M_{15° \text{ normal}}$ *without* load factor, γ_{TU}

$M_{15° \text{ normal}}$ = (α)(L_{trib})(15°)(12"/')cos15°
= (0.0000060 in./in./°F)(135')(15° F)(12"/')cos15°
= 0.141"

"T" at 20° F = $A_{install}$ + (3)($M_{15° \text{ normal}}$) = 2.92"
35° F = $A_{install}$ + (2)($M_{15° \text{ normal}}$) = 2.78"
50° F = $A_{install}$ + (1)($M_{15° \text{ normal}}$) = 2.64"
65° F = $A_{install}$ = 2.5"
80° F = $A_{install}$ - (1)($M_{15° \text{ normal}}$) = 2.36"
95° F = $A_{install}$ - (2)($M_{15° \text{ normal}}$) = 2.22"

Temperature Adjustment Table	
Temperature	**"T"**
20° F	2 15/16"
35° F	2 3/4"
50° F	2 5/8"
65° F	2 1/2"
80° F	2 3/8"
95° F	2 1/4"

Note on Plans:

1. Minimum width for seal installation "T" = 2 1/2" (Approx. 65° F or less).
2. The compression seal has been designed for a total factored movement of 1.09". This design includes movement due to temperature, skew, shrinkage and minimum installation. The Contractor shall use compression seal *WA-400 by Watson Bowman Acme* or *CV-4000 by D.S. Brown Co.*
3. Values in the Temperature Adjustment Table are for adjusting the expansion joint assembly immediately prior to pouring the concrete blockouts.

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Strip Seal Expansion Joint Limitations

A strip seal joint may be used with the following limitations (See Appendix 7.4-B4 for a strip seal joint detail. See p. 7.4-A4-2 for design notations and p 7.4-A4-3 & 6 for design examples):

- Total movement of expansion joint measured along center line of bridge (expansion and contraction) ≤ 4.0”
- Use 4” seal only (Two manufacturers are required per FHWA. At time of publication, D.S. Brown only makes a 4” seal). If need a 5” seal, a special provision is required since it will be a proprietary item.
- No splices of the seal shall be allowed.
- The complete full width units shall be shipped to the project site.
- Maximum roadway surface gap (measured along center line of bridge) ≤ 4.0” *(AASHTO 14.5.3.2).*
- Minimum joint opening at installation of seal shall not be less than 1.5” normal to joint for Watson Bowman Acme. Minimum joint opening at installation of seal shall not be less than 1.75” normal to joint for D.S. Brown Co. (per email from D.S. Brown representative)
  - ⇒ For starters, check that the joint opening is at least 1.75” for 65°F (typical construction installation temperature). If a larger seal size is required, then try 1.75” installation joint opening at 60°F.
- The minimum joint opening at total temperature expansion (measured from the inside of the steel edge members that holds the gland) shall not be less than 0.5” or the manufacturer’s minimum opening (whichever is greater).
- Bridges on horizontal curve or skews over 30° must accommodate “racking” or transverse movements per NHDOT:
  - ♦ 30° < skew ≤ 45°:
    - ⇒ Limit “racking” movement to 60% of seals rated capacity (total movement parallel to the joint ÷ 0.60)
  - ♦ Skews > 45°:
    - ⇒ Limit “racking” movement to 50% of seals rated capacity (total movement parallel to joint ÷ 0.50)
- For skews between 32° and 42° left ahead (either direction on Interstate), communication shall be made with the Bridge Design Chief, Bureau of Bridge Maintenance and the District Engineer on whether a plow protection plate should be placed on the expansion joint. The use of a plow plate will be decided on a project to project basis. (See Appendix 7.4-B8 for the Plow Protection Plate Sample Plan).
- Concrete block-outs are required for the installation of a strip seal expansion joint.
- Anchorage of the strip seal expansion joint to the backwall and deck, between the curb lines, shall be made using loop rebar and shall be spaced at 1’-0” maximum. Brush curb and sidewalk anchorage shall be made of stud anchors and shall be spaced at 1’-6” maximum. The anchorage reinforcement shall extend into the backwall or curb reinforcement cage for proper anchorage.

Expansion Joint Design Notations

$M_{t(unfactored)}$ = Movement due to temperature (inches)
= $\alpha \cdot L_{trib} \cdot \Delta T \cdot$ (12 in./1ft.)

ΔT = bridge superstructure average temperature range as a function of bridge type and location
= 80° F (0° F to $^{+}$80° F) for concrete bridges
= 125° F ($^{-}$20° F to $^{+}$105° F) for steel bridges

L_{trib} = tributary length of the structure subject to expansion or contraction

α = Coefficient of thermal expansion
= 0.0000060 in./in./°F for concrete
= 0.0000065 in./in./°F for steel

M_s = Movement due to shrinkage after construction (inches) (concrete beams)
= $\beta \cdot \mu \cdot L_{trib}$

β = shrinkage coefficient for reinforced concrete, 0.0002

μ = factor accounting for restraining effect imposed by superstructure elements installed before the concrete slab is cast
= 0.5 for precast prestressed concrete girders
= 0.8 for concrete box girders and T-beams
= 1.0 for concrete flat slabs

M_p = Movement parallel to joint (inches)

M_n = Movement normal to joint (inches)

γ_{TU} = Load factor for force effect due to uniform temperature, 1.2

θ = Skew angle

"T" = Joint opening normal to joint for the installation chart (inches)

A = Joint opening normal to joint

W = Nominal uncompressed width of expansion seal (inches)

W_{min} = Minimum expansion width (inches)

W_{max} = Maximum expansion width (inches)

$W_{install}$ = Expansion width at installation (inches)

T_{min} = Minimum superstructure temperature
= (0° for concrete bridges, $^{-}$20° F for steel bridges)

T_{max} = Maximum superstructure temperature
= ($^{+}$80° F for concrete bridges, $^{+}$105° F for steel bridges)

$T_{install}$ = Minimum installation superstructure temperature
= $^{+}$65° F (all bridges)

Strip Seal Joint Design Example (1)

Design Procedure

A. Movement Calculations

$M_t = (\alpha)(L_{trib})\ (\Delta T)(\gamma_{TU})(12''/')$
$M_s = (\beta)(\mu)(L_{trib})(12''/')$ (= 0 for steel bridges)
$M_{t\ longitudinal} = (M_t + M_s)$
$M_{t\ normal} = M_t \cos\theta$
$M_{s\ normal} = M_s \cos\theta$ (= 0 for steel bridges)
$M_p = (M_t + M_s)\sin\theta$
$\Delta T_{ratio\ min} = (T_{install} - T_{min})/(\Delta T)$
$\Delta T_{ratio\ max} = (T_{max} - T_{install})/(\Delta T)$

B. Select seal width from largest W or A value:

1. Install Temp. (65° F):

   $A_{install}$ = manufacturer's min. install width
   ⇒ Set $A_{install}$

2. $W \geq M_{t\ longitudinal}$
   $W \geq A_{max} = A_{install} + [(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}] \leq$ manufacturer's maximum opening
   $W \geq M_p \div$ % of seals rated capacity due to racking

3. Check Max. Temp.:

   Min. construction gap width A = 0.5" (NHDOT)
   $A_{min} = A_{install} - (\Delta T_{ratio\ max} \cdot M_{t\ normal}) \geq$ manufacturer's min. opening
   $\geq$ 0.5" (NHDOT)

4. Check Max. Opening:

   $A_{max\ longitudinal} \leq 4''$ (*AASHTO 14.5.3.2)*
   $A_{max\ longitudinal} = A_{max} \div \cos\theta$

⇒ Confirm two different manufacturer seals (same size) meet all requirements.

C. Calculate Temperature Adjustment Table

Calculate $M_{15^\circ\ normal}$ *without* load factor, γ_{TU}

Design Example (1)

- **Steel girder**
- Total expansion length = 275'
- Skew angle = 0°
- Expansion joint at one abutment
- Value of Constants:

$\theta = 0^\circ$	ΔT=125° F (-20° F to $^+$105° F)
α = 0.0000065 in./in./°F	L_{trib} = 275'
$T_{install}$ = 65° F	γ_{TU} = 1.2

Strip Seal Joint Design Example (1) (cont.)

A. Movement Calculations

$M_t = (\alpha)(L_{trib})(\Delta T)(\gamma_{TU})$
$= (0.0000065 \text{ in./in./°F})(275')(125° \text{ F})(1.2)(12''/')$
$= 3.22''$

$M_s = 0$

$M_{t\ normal} = M_t \cos\theta$
$= (3.22'')\cos 0°$
$= 3.22''$

$M_{t\ longitudinal} = (M_t + M_s) = 3.22'' \leq 4''$ (max. movement for strip seal)

$\Rightarrow$ **OK to use strip seal**

$\Delta T_{ratio\ min} = (T_{install} - T_{min})/(\Delta T)$
$= [65° \text{ F} - (-20° \text{ F})] / (125° \text{ F})$
$= 0.680$

$\Delta T_{ratio\ max} = (T_{max} - T_{install})/(\Delta T)$
$= (105° \text{ F} - 65° \text{ F}) / (125° \text{ F})$
$= 0.320$

B. Selection of Seal Width

Joint Type	Movement		Minimum Install	Nominal Width
	Minimum	Max		
SE-400	0”	4”	1.5”	4.0”
A2R-400	0.5”	4.5”	1.75”	4.0”

1. Install Temp. (65° F):

$A_{install}$ = manufacturer’s min. install width
$A_{install} \geq 1.5''$ (SE-400)
$\geq 1.75''$ (A2R-400)

$\Rightarrow$ Set $A_{install} = 1.75''$

2. Min. Temp. :

$A_{max} = A_{install} + [(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}] \leq$ manufacturer’s maximum opening
$= 1.75'' + [(0.680 \cdot 3.22'') + 0'']$
$= 3.94'' \leq 4''$ (SE-400) **O.K.**
$\leq 4.5''$ (A2R-400) **O.K.**

Strip Seal Joint Design Example (1) (cont.)

3. Max. Temp. :

$A_{min} = A_{install} - [(\Delta T_{ratio\ max} \cdot M_{t\ normal})] \geq$ manufacturer's min. opening ≥ 0.5" (NHDOT)

$= 1.75" - [(0.320 \cdot 3.22")]$

$= 0.71" \geq 0"$ (SE-400) **O.K.**

$\geq 0.5"$ (A2R-400) **O.K.**

$\geq 0.5"$ (NHDOT) **O.K.**

4. Check Max. Opening:

$A_{max\ longitudinal} \leq 4"$ (*AASHTO 14.5.3.2)*

$A_{max\ longitudinal} = A_{max} \div \cos\theta = 3.94" \div \cos 0° = 3.94" \leq 4"$ **O.K.**

⇒ **Use: 4" strip seal (SE-400 or A2R-400)**

C. Calculate Temperature Adjustment Table

Calculate $M_{15°\ normal}$ *without* load factor, γ_{TU}

$M_{15°\ normal} = (\alpha)(L_{trib})(15°)\cos\theta$

$= (0.0000065$ in./in./°F$)(275' \cdot 12"/')(15°$ F$) \cos 0°$

$= 0.322"$

"T" at 20° F = $A_{install} + (3)(M_{15°\ normal}) = 2.72"$

35° F = $A_{install} + (2)(M_{15°\ normal}) = 2.39"$

50° F = $A_{install} + (1)(M_{15°\ normal}) = 2.07"$

65° F = $A_{install} = 1.75"$

80° F = $A_{install} - (1)(M_{15°\ normal}) = 1.43"$

95° F = $A_{install} - (2)(M_{15°\ normal}) = 1.11"$

Temperature Adjustment Table	
Temperature	**"T"**
20° F	2 3/4"
35° F	2 3/8"
50° F	2 1/16"
65° F	1 3/4"
80° F	1 7/16"
95° F	1 1/8"

<u>Notes on Plan:</u>

1. Minimum width for seal installation "T" = 1 3/4" (Approx. 65° F or less).
2. The strip seal has been designed for a total factored movement of 3.22". This design includes movement due to temperature, skew, and minimum installation. The Contractor shall use strip seal *SE-400 by Watson Bowman Acme* or *A2R-400 by D.S. Brown Co.*
3. Values in the Temperature Adjustment Table are for adjusting the expansion joint assembly immediately prior to pouring the concrete blockouts.

Strip Seal Joint Design Example (2)

Design Example (2)

- **Steel girder**
- Total expansion length = 250'
- Skew angle = 45°
- Expansion joint at one abutment
- Value of Constants:

$\theta = 45°$

$\alpha = 0.0000065$ in./in./°F

$L_{trib} = 250'$

$\Delta T = 125°$ F (-20° F to $^{+}$105° F)

$T_{install} = 65°$ F

$\gamma_{TU} = 1.2$

A. Movement Calculations

$M_t = (\alpha)(L_{trib})(\Delta T)(\gamma_{TU})(12''/')$
$= (0.0000065\text{ in./in./°F})(250')(125°\text{ F})(1.2)(12''/')$
$= 2.93''$

$M_s = 0$

$M_{t\ normal} = M_t \cos\theta$
$= (2.93'')\cos 45°$
$= 2.07''$

$M_p = (M_t + M_s)\sin\theta$
$= (2.93'' + 0'')\sin 45°$
$= 2.07''$

$M_{t\ longitudinal} = (M_t + M_s) = 2.93'' \leq 4''$ (max. movement for strip seal)

$\Rightarrow$ **OK to use strip seal**

$\Delta T_{ratio\ min} = (T_{install} - T_{min})/(\Delta T)$
$= [65°\text{ F} - (-20°\text{ F})]/(125°\text{ F})$
$= 0.680$

$\Delta T_{ratio\ max} = (T_{max} - T_{install})/(\Delta T)$
$= (105°\text{ F} - 65°\text{ F})/(125°\text{ F})$
$= 0.320$

Strip Seal Joint Design Example (2) (cont.)

B. Selection of Seal Width (largest W or A value)

- Install Temp. (65° F):

  $A_{install}$ ≥ manufacturer's min. install width
  ≥ 1.5" (SE-400)
  ≥ 1.75" (A2R-400)

  ⇒ Set $A_{install}$ = 1.75"

Joint Type	Movement		Minimum Install	Nominal Width
	Minimum	Max		
SE-400	0"	4"	1.5"	4.0"
A2R-400	0.5"	4.5"	1.75"	4.0"

- 30° < skew ≤ 45°:
  ⇒ Limit "racking" movement to 60% of seals rated capacity (total movement parallel to the joint ÷ 0.60)

- Select seal width from largest W or A value:

  1. W ≥ $M_{t\ longitudinal}$
     ≥ 2.93"

  2. $A_{max} = A_{install} + [(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}]$ ≤ manufacturer's maximum opening
     = 1.75" + [(0.680 · 2.07") + 0"]
     = 3.16" ≤ 4" (SE-400) **O.K.**
     ≤ 4.5" (A2R-400) **O.K.**

  governs ⟶ 3. W ≥ $M_p \div 0.6$
     ≥ 2.07" ÷ 0.6
     ≥ 3.45"

- Check Max. Temp:

  $A_{min} = A_{install} - [(\Delta T_{ratio\ max} \cdot M_{t\ normal})]$ ≥ manufacturer's min. opening
  ≥ 0.5" (NHDOT)
  = 1.75" - [(0.320 · 2.07")]
  = 1.08" ≥ 0" (SE-400) **O.K.**
  ≥ 0.5" (A2R-400) **O.K.**
  ≥ 0.5" (NHDOT) **O.K.**

- Check Max. Opening:

  $A_{max\ longitudinal}$ ≤ 4" (*AASHTO 14.5.3.2)*
  $A_{max\ longitudinal} = A_{max} \div \cos\theta$ = 3.16" ÷ cos 45° = 4.47" > 4" **N.G.**

⇒ **Need to use a finger expansion joint.**

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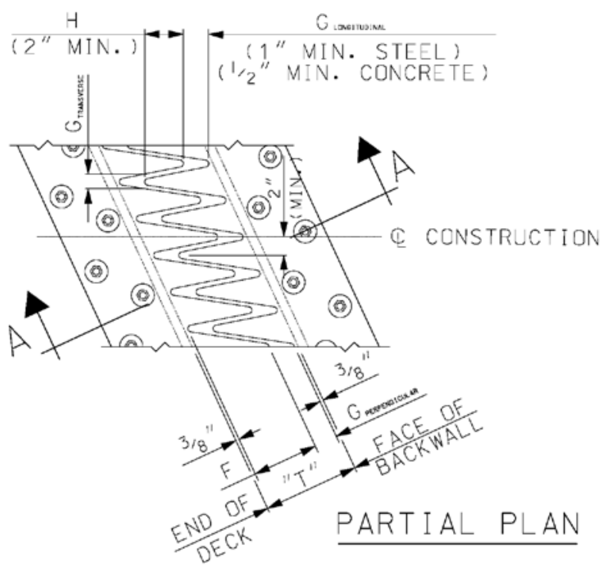
Finger Expansion Joint Limitations

A finger expansion joint may be used with the following limitations (See Appendix 7.4-B5 for a finger joint sample plan as a guide) (See p 7.4-A5-3 for design notations and p. 7.4-A5-4 for design example):

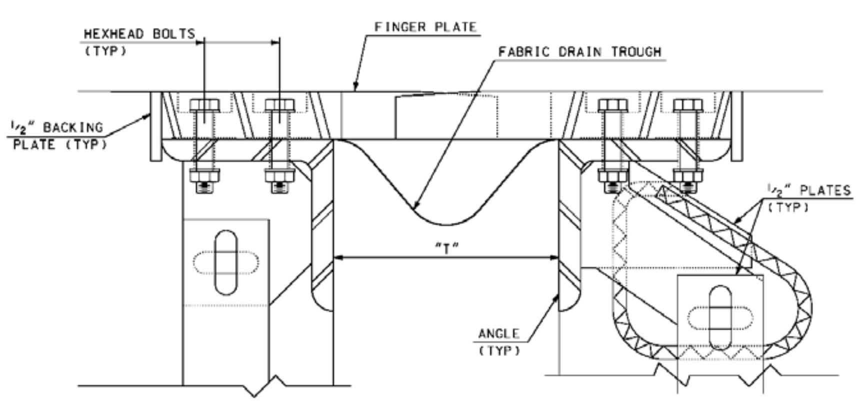
- Typically used for total movement of expansion joint > 4" measured along the center line of the bridge (expansion and contraction). May be required if a strip seal cannot be used.
- The finger joint plates requirements:
  - ⇒ Minimum joint opening (at max. design temperature) in the longitudinal direction between fingers shall be 1" for steel beams. For concrete beams the minimum joint opening may be less to account for creep and shrinkage. *(AASHTO 14.5.3.2)*
  - ⇒ Maximum joint opening (at min. design temperature) in the transverse direction between fingers shall not exceed 2" when the maximum longitudinal opening in the direction of traffic exceeds 8". *(AASHTO 14.5.3.2)*
  - ⇒ Maximum joint opening (at min. design temperature) in the transverse direction between fingers shall not exceed 3" when the maximum longitudinal opening in the direction of traffic is 8" or less. *(AASHTO 14.5.3.2)*
  - ⇒ Minimum finger overlap shall be 2" in the longitudinal direction at maximum joint opening (at minimum design temperature).
  - ⇒ Parallel to the profile grade, follow the cross-slope
  - ⇒ Set 1/8" lower than the proposed finished roadway grade.
  - ⇒ Minimum 2 ¼" thickness.
  - ⇒ Minimum 2" center-to-center of finger.
  - ⇒ No outside vertical curb plate cover on exterior (Need to keep exterior joint opening for maintenance.) Still use vertical plate at curb line.
  - ⇒ As a minimum, cuts (breaks) in plate should be at the downspouts, crown line and painted travel lane lines.
- Drain trough design requirements:
  - ⇒ 3-ply performed fabric material conforming to NHDOT Standard Specification for Road & Bridge Construction, Section 561.
  - ⇒ Slope 1" per foot *(AASHTO 14.5.6.3)*, ½" per foot min. *(Br. Maintenance)*
  - ⇒ Start with a minimum drain trough depth of 4" (6" preferred).
  - ⇒ No more than 50 ft. without a downspout.
  - ⇒ No kinks.
  - ⇒ The fabric shall be cut during shop pre-assembly from one piece.
  - ⇒ For phase construction, the fabric shall be shall be cut during shop pre-assembly and supplied in lengths with 1'-0" overlap at crown line and phase construction joints.

Finger Joint Limitations (cont.)

- ⇒ Design in sections to provide constructability and maintenance access. Provide cuts in the trough for hoppers and at the profile grade line with 1'-0" overlap.
- Downspout design requirements:
  - ⇒ As many downspouts as possible
  - ⇒ Size 6" x 6" minimum, 8" x 8" preferred by Bridge Maintenance
  - ⇒ Avoid sharp bends
  - ⇒ Install cleanouts at angle changes
  - ⇒ Do not encase in concrete
- The Designer shall determine and specify the joint settings as noted on the temperature adjustment table.
- If bicycle traffic will be crossing the finger joint, the Bridge Design Chief shall be consulted on what type of protection to provide.



PARTIAL PLAN



SECTION A-A

Expansion Joint Design Notations

$M_{t(unfactored)}$ = Movement due to temperature (inches)
= $\alpha \cdot L_{trib} \cdot \Delta T \cdot$ (12 in./1ft.)

ΔT = bridge superstructure average temperature range as a function of bridge type and location
= 80° F (0° F to $^+$80° F) for concrete bridges
= 125° F ($^-$20° F to $^+$105° F) for steel bridges

L_{trib} = tributary length of the structure subject to expansion or contraction

α = Coefficient of thermal expansion
= 0.0000060 in./in./°F for concrete
= 0.0000065 in./in./°F for steel

M_s = Movement due to shrinkage after construction (inches) (concrete beams)
= $\beta \cdot \mu \cdot L_{trib}$

β = shrinkage coefficient for reinforced concrete, 0.0002

μ = factor accounting for restraining effect imposed by superstructure elements installed before the concrete slab is cast
= 0.5 for precast prestressed concrete girders
= 0.8 for concrete box girders and T-beams
= 1.0 for concrete flat slabs

M_p = Movement parallel to joint (inches)

M_n = Movement normal to joint (inches)

γ_{TU} = Load factor for force effect due to uniform temperature, 1.2

θ = Skew angle

"T" = Joint opening normal to joint for the installation chart (inches)

F = Finger length

$G_{longitudinal}$ = Longitudinal opening between fingers

H_{min} = Minimum finger overlap in the longitudinal direction

H_{max} = Maximum finger overlap in the longitudinal direction

T_{min} = Minimum superstructure temperature
= (0° for concrete bridges, $^-$20° F for steel bridges)

T_{max} = Maximum superstructure temperature
= ($^+$80° F for concrete bridges, $^+$105° F for steel bridges)

Finger Joint Design Example

I. Design Procedure

A. Movement Calculations

$M_t = (\alpha)(L_{trib})(\Delta T)(\gamma_{TU})(12''/')$

$M_s = (\beta)(\mu)(L_{trib})(12''/')$ (= 0 for steel bridges)

$M_{t\ longitudinal} = (M_t + M_s)$

$G_{longitudinal}$ = Longitudinal opening between fingers
= 1" min. for steel beams
= ½" min. for concrete beams

$G_{transverse} < 3''$, when $G_{longitudinal} \leq 8''$ (*AASHTO 14.5.3.2)*
$< 2''$, when $G_{longitudinal} > 8''$ (*AASHTO 14.5.3.2)*

$H_{min} = 2''$ (minimum finger overlap in the longitudinal direction, NHDOT)

F = Finger length

B. Check Joint Opening "T" for Maximum Temperature

⇒ Min. longitudinal joint opening between fingers ($G_{longitudinal}$) at max. design temperature

"T"$_{min}$ = 3/8" space + $G_{perpendicular}$ + F + 3/8" space
⇒ Set "T"$_{min}$

C. Check Finger Overlap Length (H) for Max. and Min. Temperatures

1. Max. Temp. :
$H_{max} = [F/\cos\theta] - G_{longitudinal\ MIN}$

2. Min. Temp.:
$H_{min} = H_{max} - M_{t\ longitudinal} \geq 2''$

D. Calculate Temperature Adjustment Table

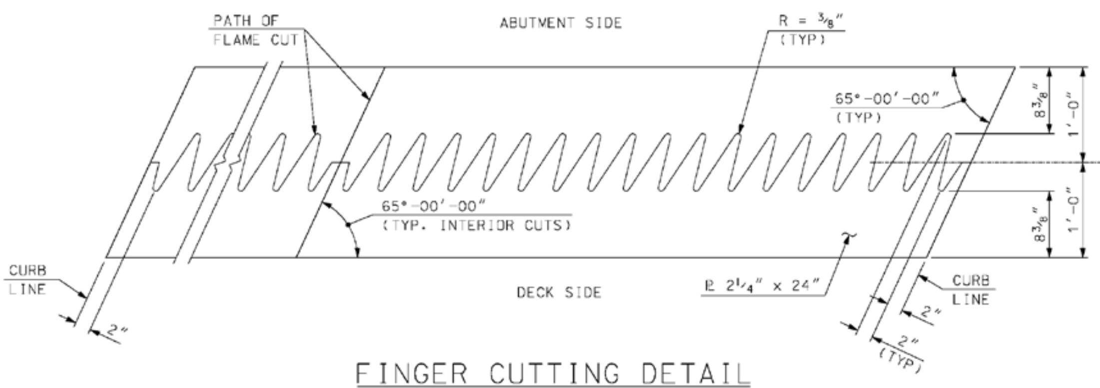
Calculate $M_{15^\circ\ normal}$ *without* load factor, γ_{TU}

Finger Joint Design Example (cont.)

II. Design Example

- **Steel girder**
- Total expansion length = 360'
- Skew angle = 25°
- Expansion joint at one abutment
- Value of Constants:

  $\theta = 25°$
  $\alpha = 0.0000065$ in./in./°F
  $L_{trib} = 360'$
  $\Delta T = 125°$ F (-20° F to $^{+}105°$ F)
  $\gamma_{TU} = 1.2$
  F = 7.25" (measured normal to the joint)
  $G_{longitudinal\ MIN} = 1"$



FINGER CUTTING DETAIL

A. Movement Calculations

$M_t = (\alpha)(L_{trib})(\Delta T)(\gamma_{TU})(12"/')$
$= (0.0000065 \text{ in./in./°F})(360')(125° \text{ F})(1.2)(12"/')$
$= 4.21"$

$M_s = 0$

$M_{t\ longitudinal} = (M_t + M_s) = 4.21"$

Finger Joint Design Example (cont.)

B. Check Joint Opening "T" for Maximum Temperature

⇒ Min. longitudinal joint opening between fingers ($G_{longitudinal}$) at max. design temperature = 105° F

$$"T"_{min} = 3/8" \text{ space} + G_{longitudinal\ MIN}(\cos\theta) + F + 3/8" \text{ space}$$
$$= 3/8" + 1"(\cos 25°) + 7.25" + 3/8"$$
$$= 8.91"$$

⇒ Set $"T"_{min} = 9"$

$$G_{longitudinal\ MIN\ PROVIDED} = ("T"_{min} - 2(\text{space}) - F) \div \cos\theta$$
$$= (9 - 2(3/8") - 7.25) \div \cos 25°$$
$$= 1.103" > 1"$$ **O.K**

C. Check Finger Overlap Length (H) for Max. and Min. Temperatures

1. Max. Temp. (105° F):

$$H_{max} = [F \div \cos\theta] - G_{longitudinal\ MIN\ PROVIDED}$$
$$= [7.25" \div \cos(25°)] - 1.103"$$
$$= 6.90"$$

2. Min. Temp. (-20° F):

$$H_{min} = H_{max} - M_{t\ longitudinal} \geq 2"$$
$$= 6.90" - 4.21" = 2.69" \geq 2"$$ **O.K.**

D. Calculate Temperature Adjustment Table

Calculate $M_{15°\ normal}$ *without* load factor, γ_{TU}

$$M_{15°\ normal} = (\alpha)(L_{trib})(15°)(12"/')\cos\theta$$
$$= (0.0000065 \text{ in./in./°F})(360')(15° \text{ F})(12"/')\cos(25°)$$
$$= 0.382"$$

"T" at -20° F = $"T"_{min} + (8.33)(M_{15°\ normal})$ = 12.17"
0° F = $"T"_{min} + (7)(M_{15°\ normal})$ = 11.67"
15° F = $"T"_{min} + (6)(M_{15°\ normal})$ = 11.29"
30° F = $"T"_{min} + (5)(M_{15°\ normal})$ = 10.91"
45° F = $"T"_{min} + (4)(M_{15°\ normal})$ = 10.5"
60° F = $"T"_{min} + (3)(M_{15°\ normal})$ = 10.15"
75° F = $"T"_{min} + (2)(M_{15°\ normal})$ = 9.76"
90° F = $"T"_{min} + (1)(M_{15°\ normal})$ = 9.38"
105° F = $"T"_{min}$ = 9"

Temperature Adjustment Table			
Temperature	**"T"**	**Temperature**	**"T"**
15° F	11 1/4"	60° F	10 1/8"
30° F	10 15/16""	75° F	9 3/4"
45° F	10 1/2"	90° F	9 3/8"

Modular Expansion Joint Limitations

A modular expansion joint may be used with the following limitations (See Appendix 7.4-B7 for a modular joint detail. See p 7.4-A6-2 for design notations and p. 7.4-A6-3 for design example):

- > 4" total movement of expansion joint measured along the center line of the bridge (expansion and contraction).
- 32° > Skew of joint > 42° (outside typical snowplow angle).
- The use of a modular expansion joint shall be approved by the Design Chief.
- No splices of the seal shall be allowed.
- The complete full width units shall be shipped to the project site except for phase construction projects.
- Maximum movement of 3" per each seal element *(AASHTO 14.5.3.2-2).*
- The minimum seal opening at total temperature expansion (measured from the inside of the steel edge members that holds the gland) shall not be less than 0.5".
- Minimum joint opening at installation of seal shall not be less than 1.75" normal to joint (Required for D.S. Brown Co. strip steals).
- Concrete block-outs are required for the installation of the modular joint.
- Anchorage of the modular joint to the backwall and deck, between the curb lines, shall be made using loop rebar and shall be spaced at 1'-0" maximum. Brush curb and sidewalk anchorage shall be made of stud anchors and shall be spaced at 1'-6" maximum. The anchorage reinforcement shall extend into the backwall or curb reinforcement cage for proper anchorage.
- See Sample Project Notes for notes to be placed on the plans.
- Maximum gap between center beams and/or edge beams shall be 3" at the fully opened position. *(AASHTO 14.5.6.9.6)*
- Support boxes and bars shall be designed by the Manufacturer utilizing multiple support bar systems and full-penetration welded connection between the center beams and support bars. No single-suppport bar with yoke (stirrup) will be allowed.
- The modular joint plans shall show multiple-support bars on the plan view.

Expansion Joint Design Notations

$M_{t(unfactored)}$ = Movement due to temperature (inches)
= $\alpha \cdot L_{trib} \cdot \Delta T \cdot$ (12 in./1ft.)

ΔT = bridge superstructure average temperature range as a function of bridge type and location
= 80° F (0° F to $^{+}$80° F) for concrete bridges
= 125° F ($^{-}$20° F to $^{+}$105° F) for steel bridges

L_{trib} = tributary length of the structure subject to expansion or contraction

α = Coefficient of thermal expansion
= 0.0000060 in./in./°F for concrete
= 0.0000065 in./in./°F for steel

M_s = Movement due to shrinkage after construction (inches) (concrete beams)
= $\beta \cdot \mu \cdot L_{trib}$

β = shrinkage coefficient for reinforced concrete, 0.0002

μ = factor accounting for restraining effect imposed by superstructure elements installed before the concrete slab is cast
= 0.5 for precast prestressed concrete girders
= 0.8 for concrete box girders and T-beams
= 1.0 for concrete flat slabs

M_p = Movement parallel to joint (inches)

M_n = Movement normal to joint (inches)

γ_{TU} = Load factor for force effect due to uniform temperature, 1.2

θ = Skew angle

"T" = Joint gap opening normal to joint between steel angles (inches)

T_{min} = Minimum superstructure temperature
= (0° for concrete bridges, $^{-}$20° F for steel bridges)

T_{max} = Maximum superstructure temperature
= ($^{+}$80° F for concrete bridges, $^{+}$105° F for steel bridges)

$T_{install}$ = Minimum installation superstructure temperature
= $^{+}$65° F (all bridges)

Modular Bridge Joint System Design Example

I. Design Procedure

A. Movement Calculations

$M_t = (\alpha)(L_{trib})\ (\Delta T)(\gamma_{TU})(12''/')$

$M_s = (\beta)(\mu)(L_{trib})(12''/')$ (= 0 for steel bridges)

$M_{t\ longitudinal} = (M_t + M_s)$

$M_{t\ normal} = M_t \cos\theta$

$M_{s\ normal} = M_s \cos\theta$

$M_p = (M_t + M_s)\sin\theta$

$\Delta T_{ratio\ min} = (T_{install}\text{-}T_{min})/(\Delta T)$

$\Delta T_{ratio\ max} = (T_{max}\text{-}T_{install})/(\Delta T)$

$M_{normal\ open} = (\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}$

$M_{normal\ close} = (\Delta T_{ratio\ max} \cdot M_{t\ normal})$

$MR = M_{normal\ open} + M_{normal\ close}$

B. Selection of Joint Size

The total factored movement range, MR should be a multiple of 3”

⇒ Confirm two different manufacturer MBJS can be used.

C. Calculate Expansion Joint Gap,“T”

Expansion joint gap is the distance measured face to face of steel angles (L 6x6x3/4)

- Calculate *without* load factor, γ_{TU}
- Minimum seal joint opening = 0.5” (NHDOT)

D. Calculate adjustment in opening for non-factored 15°F change in temperature.

Modular Bridge Joint System Design Example (cont.)

II. Design Example

- **Steel girder**
- Total expansion length = 1640’
- Skew angle = 15°
- Expansion joint at both abutments
- Point of no movement for temperature is at the center of the bridge
- Value of Constants:

$\theta = 15°$

$\alpha = 0.0000065$ in./in./°F

$L_{trib} = 1640' \div 2 = 820'$

$\Delta T = 125°$ F (-20° F to $^{+}105°$ F)

$T_{install} = 65°$ F

$\gamma_{TU} = 1.2$

A. Movement Calculations

$M_t = (\alpha)(L_{trib})(\Delta T)(\gamma_{TU})(12''/')$
$= (0.0000065 \text{ in./in./°F})(820')(125° \text{ F})(1.2)(12''/')$
$= 9.59''$

$M_{t\ normal} = M_t \cos\theta$
$= (9.59'')\cos 15°$
$= 9.26''$

$M_s = 0$

$M_p = (M_t + M_s)\sin\theta$
$= (9.59'' + 0'')\sin 15°$
$= 2.48''$

$M_{t\ longitudinal} = (M_t + M_s) = 9.59'' > 4''$

$\Rightarrow$ **OK to use modular joint**

$\Delta T_{ratio\ min} = (T_{install} - T_{min})/(\Delta T)$
$= [65° \text{ F} - (-20° \text{ F})]/(125° \text{ F})$
$= 0.680$

$\Delta T_{ratio\ max} = (T_{max} - T_{install})/(\Delta T)$
$= (105° \text{ F} - 65° \text{ F})/(125° \text{ F})$
$= 0.320$

$M_{normal\ close} = (\Delta T_{ratio\ max} \cdot M_{t\ normal})$
$= (0.320 \cdot 9.26'')$
$= 2.96''$

Modular Bridge Joint System Design Example (cont.)

$M_{normal\ open} = (\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}$
$= (0.680 \cdot 9.26") + 0"$
$= 6.30"$

$MR = M_{normal\ close} + M_{normal\ open}$
$= 2.96" + 6.30"$
$= 9.26"$

B. Selection of Joint Size

The total factored movement range, MR should be a multiple of 3”

MR = 9.26”

⇒ **Use a 12” movement range joint.**

C. Calculate Expansion Joint Gap, “T”

Expansion gap is the distance measured face to face of steel angles (L 6x6x3/4)

- Minimum seal joint opening = 0.5” (NHDOT)
- Minimum seal install opening = 1.75” (Appendix 7.4-A4)
- Maximum seal joint opening = 3” (AASHTO)
- Assume center beam top flange width = 2.5”
- Assume edge beam top flange width = 1.25”
- Install Temp. = 65° F ±

1. Number of strip seals = (12”MR ÷ 3”) = 4 strip seals
2. Number of center beams = (4 strip seals - 1) = 3 center beams
3. $A_{min\ gap\ 105°F}$ = (3 center beams)(2.5” top flange width) + (4 strips seals)(0.5”) + (2 edge beams)(1.25”)
   = 12”
4. $A_{max\ gap\ -20°F}$ = (3 center beams)(2.5” top flange width) + (4 strips seals)(3.0”) + (2 edge beams)(1.25”)
   = 22”
5. $A_{install\ gap\ 65°F}$ = (3 center beams)(2.5” top flange width) + (4 strips seals)(1.75”) + (2 edge beams)(1.25”)
   = 17”
6. Check $A_{gap\ -20°F}$:

   $A_{install\ gap\ 65°F} + M_{normal\ open\ (65°F\ to\ -20°F)} = 17" + 6.30"$
   $= 23.3" > 22"$ **N.G.**

Modular Bridge Joint System Design Example (cont.)

⇒ **Try 5 strip seals:**

1. Number of strip seals = 5 strip seals
2. Number of center beams = (5 strip seals - 1) = 4 center beams
3. $A_{min\ gap\ 105°F}$ = (4 center beams)(2.5" top flange width) + (5 strips seals)(0.5") + (2 edge beams)(1.25")
   = 15"
4. $A_{max\ gap\ -20°F}$ = (4 center beams)(2.5" top flange width) + (5 strips seals)(3.0") + (2 edge beams)(1.25")
   = 27.5"
5. $A_{install\ gap\ 65°F}$ = (4 center beams)(2.5" top flange width) + (5 strips seals)(1.75") + (2 edge beams)(1.25")
   = 21.25"
6. Check $A_{gap\ -20°F}$:
   $A_{install\ gap\ 65°F} + M_{normal\ open\ (65°F\ to\ -20°F)}$ = 21.25" + 6.30"
   = 27.55" ≅ 27.5" **O.K.**
7. Check $A_{gap\ 105°F}$:
   $A_{gap\ 105°F} + M_{normal\ close\ (65°F\ to\ 105°F)}$ = 21.25" – 2.96"
   = 18.29" > 15" **O.K.**

⇒ **Use 5 strip seals**

♦ Calculate *without* load factor, γ_{TU}

D. $A_{15°F}$ = $(\alpha)(L_{trib})(15°)(12"/')\cos\theta$
= (0.0000065 in./in./°F)(820')(15° F)(12"/') cos15°
= 0.93"

⇒ Adjustment in opening for a non-factored 15° F change in temperature = 15/16"

Note on Plans:

See Sample Project Notes

Preformed Closed Cell Expansion Joint Limitations

A preformed closed cell expansion joint may be used with the following limitations. See p. 7.4-A7-3 for design notations and p. 7.4-A7-4 for design examples):

- 1/4” < total movement of expansion joint measured normal to the joint (expansion, contraction and shrinkage) ≤ 1” (steel girder); ≤ 3/4” (concrete girder).
- Skew of joint ≤ 20°
  ⇒ Typically used with sleeper slab of integral abutments. Skew limit of integral abutments is ≤ 20°.
- The preformed closed cell expansion joint shall always be in compression (i.e., the nominal width shall be greater than the calculated maximum joint opening).
- Maximum roadway surface gap (measured along center line of bridge) ≤ 4.0” *(AASHTO LRFD14.5.3.2).*
- The closed cell size and manufacturer’s names shall be noted on the plans. A minimum of two manufacturers shall be noted.
- A temperature setting chart and notes shall be shown on the plans.
- See Special Provision Item 559.6, Preformed Closed Cell Expansion Joint System (F) for additional information.
- See Chapter 6, Appendix 6.4-B2 for sleeper slab details.

Note: The following tables show values for closed cell expansion joint seals Watson-Bowman Evazote UV and Polyset Ply-Seal XE Beige. The maximum normal movement (temperature and shrinkage) is noted with the corresponding seal size that will remain in compression for the design temperature range.

Closed Cell Sizing Chart (Steel Girder):

$M_{t\ normal}$ (max)	Joint Type	Nominal Width (in.)	Joint Opening (in.)	
			Minimum	Install
1"	UV 3.4375	3.4375	1.38	2.75
	XE #3.5	3.5	1.4	2.75
7/8"	UV 3.1250	3.1250	1.25	2.50
	XE #3.25	3.25	1.3	2.50
3/4"	UV 2.8125	2.8125	1.12	2.25
	XE #3.0	3.0	1.2	2.25
5/8"	UV 2.5000	2.5	1.0	2.0
	XE #2.75	2.75	1.1	2.0
1/2"	UV 1.875	1.875	0.75	1.5
	XE #2.0	2.0	0.8	1.5
3/8"	UV 1.5625	1.5625	0.63	1.25
	XE #1.63	1.625	0.6	1.25

Closed Cell Sizing Chart (Concrete Girder):

$M_{t\ normal}$ (max)	Joint Type	Nominal Width (in.)	Joint Opening (in.)	
			Minimum	Install
3/4"	UV 3.7500	3.7500	1.5	3.0
	XE #4.0	4.0	1.6	3.0
5/8"	UV 3.4375	3.4375	1.38	2.75
	XE #3.5	3.5	1.4	2.75
1/2"	UV 2.8125	2.8125	1.12	2.25
	XE #3.0	3.0	1.2	2.25
3/8"	UV 2.1875	2.1875	0.88	1.75
	XE #2.38	2.375	0.9	1.75

Expansion Joint Design Notations

$M_{t(unfactored)}$ = Movement due to temperature (inches)
= $\alpha \cdot L_{trib} \cdot \Delta T \cdot$ (12 in./1ft.)

ΔT = bridge superstructure average temperature range as a function of bridge type and location
= 80° F (0° F to $^+$80° F) for concrete bridges
= 125° F ($^-$20° F to $^+$105° F) for steel bridges

L_{trib} = tributary length of the structure subject to expansion or contraction

α = Coefficient of thermal expansion
= 0.0000060 in./in./°F for concrete
= 0.0000065 in./in./°F for steel

M_s = Movement due to shrinkage after construction (inches) (concrete beams)
= $\beta \cdot \mu \cdot L_{trib}$

β = shrinkage coefficient for reinforced concrete, 0.0002

μ = factor accounting for restraining effect imposed by superstructure elements installed before the concrete slab is cast
= 0.5 for precast prestressed concrete girders
= 0.8 for concrete box girders and T-beams
= 1.0 for concrete flat slabs

M_p = Movement parallel to joint (inches)

M_n = Movement normal to joint (inches)

γ_{TU} = Load factor for force effect due to uniform temperature, 1.2

θ = Skew angle

"T" = Joint opening normal to joint for the installation chart (inches)

A = Joint opening normal to joint

W = Nominal uncompressed width of expansion seal (inches)

W_{min} = Minimum expansion width (inches)

W_{max} = Maximum expansion width (inches)

$W_{install}$ = Expansion width at installation (inches)

T_{min} = Minimum superstructure temperature
= (0° for concrete bridges, $^-$20° F for steel bridges)

T_{max} = Maximum superstructure temperature
= ($^+$80° F for concrete bridges, $^+$105° F for steel bridges)

$T_{install}$ = Minimum installation superstructure temperature
= $^+$65° F (all bridges)

Closed Cell Expansion Joint Design Example

Design Procedure

A. Movement Calculations

$M_t = (\alpha)(L_{trib})(\Delta T)(\gamma_{TU})(12''/')$

$M_s = (\beta)(\mu)(L_{trib})(12''/')$ (= 0 for steel bridges)

$M_{t\ longitudinal} = (M_t + M_s)$

$M_{t\ normal} = M_t \cos\theta$

$M_{s\ normal} = M_s \cos\theta$ (= 0 for steel bridges)

$M_p = (M_t + M_s)\sin\theta$

$M_n = (M_t + M_s)\cos\theta$

$\Delta T_{ratio\ min} = (T_{install} - T_{min})/(\Delta T)$

$\Delta T_{ratio\ max} = (T_{max} - T_{install})/(\Delta T)$

B. Select Size from Manufacturer’s chart.

C. Check Joint Opening for Install, Max. and Min. Temperatures

1. Install Temp. (65° F):

   $A_{install}$ = manufacturer’s min. install width

   $\Rightarrow$ Set $A_{install}$

2. Min. Temp. :

   $A_{max} = A_{install} + [(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}] \leq$ nominal width

3. Max. Temp.:

   $A_{min} = A_{install} - (\Delta T_{ratio\ max} \cdot M_{t\ normal}) \geq$ manufacturer’s minimum opening

$\Rightarrow$ Confirm two different manufacturer seals (same install dimension) meet all requirements.

$\Rightarrow$ The designer shall use judgment if $T_{install}$ needs to be adjusted in order to get a certain size seal to work. However, the designer needs to be aware what the install temperature will most likely be (i.e. summer construction). If the designer decides the seal needs to be installed at a temperature lower than 65° F, the $T_{install}$ needs to be noted on the plan and approved by the Design Chief.

D. Calculate Temperature Adjustment Table

Calculate $M_{15°\ normal}$ *without* load factor, γ_{TU}

Closed Cell Expansion Joint Design Example (cont.)

Design Example

- **Steel girder**
- L_{trib} = 170’ ÷ 2 expansion joints = 85’
- Skew angle = 0°
- Expansion joint at both sleeper slabs on each approach.
- Value of Constants:

$\theta = 0°$
$\alpha = 0.0000065$ in./in./°F
$L_{trib} = 85'$
$\Delta T = 125°$ F (-20° F to $^{+}105°$ F)
$T_{install} = 65°$ F
$\gamma_{TU} = 1.2$

A. Movement Calculations

$M_t = (\alpha)(L_{trib})(\Delta T)(\gamma_{TU})$
$= (0.0000065 \text{ in./in./°F})(85')(125° \text{ F})(1.2)(12''/')$
$= 1.0''$

$M_{t\ normal} = M_t \cos\theta$
$= (1.0'')\cos 0°$
$= 1.0''$

$\Delta T_{ratio\ min} = (T_{install} - T_{min})/(\Delta T)$
$= (65° \text{ F} - (-20° \text{F}))/(125° \text{ F})$
$= 0.680$

$M_s = 0$

$\Delta T_{ratio\ max} = (T_{max} - T_{install})/(\Delta T)$
$= (105° \text{ F} - 65° \text{ F})/(125° \text{ F})$
$= 0.320$

$M_n = (M_t + M_s)\cos\theta$
$= (1.0'' + 0)\cos 0°$
$= 1.0''$

$M_p = (M_t + M_s)\sin\theta$
$= (1.0'' + 0'')\sin 0°$
$= 0''$

$M_{t\ longitudinal} = (M_t + M_s) = 1.0''$

$M_{total\ normal} = (M_{t\ normal} + M_{s\ normal}) = 1.0'' \leq 1''$ (max. movement)

$\theta = 0° \leq 20°$

$\Rightarrow$ **OK**

Closed Cell Expansion Joint Design Example (cont.)

B. Select Size from Manufacturer's Chart.

Joint Type	Nominal Width (in.)	Joint Opening (in.)	
		Minimum	Install
UV 3.4375	3.4375	1.38	2.75
XE #3.5	3.5	1.4	2.75

C. Check Joint Opening for Install, Max. and Min. Temperatures

1. Install Temp. (65° F):

$A_{install}$ = manufacturer's min. install width
= 2.75"

⇒ Set $A_{install}$ = 2.75"

2. Min. Temp. :

$A_{max} = A_{install} + [(\Delta T_{ratio\ min} \cdot M_{t\ normal}) + M_{s\ normal}] \leq$ nominal width

A_{max} = 2.75" + [(0.680 · 1.0") + 0]
= 3.43" < 3.4375" in compression **O.K.**
< 3.5"
≤ 4.0" (*AASHTO LRFD 14.5.3.2)*

3. Max. Temp. :

$A_{min} = A_{install} - (\Delta T_{ratio\ max} \cdot M_{t\ normal}) \geq$ manufacturer's min. opening
A_{min} = 2.75" – (0.320· 1.0")
= 2.43" > 1.38" **O.K.**
> 1.4" **O.K.**

⇒ **Use: Watson-Bowman UV 3.4375** ***or***
Ply-Seal XE Beige #3.5

D. Calculate Temperature Adjustment Table

⇒ Note: Calculate $M_{15°\ normal}$ *without* load factor, γ_{TU}

$M_{15°\ normal}$ = (α)(L_{trib})(15°)(12"/')cos0°
= (0.0000065 in./in./°F)(85')(15°F)(12"/')cos0°
= 0.10"

Closed Cell Expansion Joint Design Example (cont.)

"T" at 20° F = $A_{install}$ + (3)($M_{15° \text{ normal}}$) = 3.05"
35° F = $A_{install}$ + (2)($M_{15° \text{ normal}}$) = 2.95"
50° F = $A_{install}$ + (1)($M_{15° \text{ normal}}$) = 2.85"
65° F = $A_{install}$ = 2.75"
80° F = $A_{install}$ - (1)($M_{15° \text{ normal}}$) = 2.65"
95° F = $A_{install}$ - (2)($M_{15° \text{ normal}}$) = 2.55"

Temperature Adjustment Table	
Temperature	**"T"**
20° F	3 1/16"
35° F	2 15/16"
50° F	2 7/8"
65° F	2 3/4"
80° F	2 5/8"
95° F	2 9/16"

Notes on Plans (Sample):

1. Item 559.6, Preformed Closed Cell Expansion Joint System (F) includes closed cell expansion material and joint adhesive as noted in the special provision.
2. Minimum width "T" for closed cell installation = 2 3/4" (Approx. 65° F or less).
3. The Contractor shall use closed cell *Wabo Evazote UV 3.4375 by Watson Bowman Acme* or *Ply-Seal XE Beige #3.5 by Polyset Co.* The closed cell expansion material has been designed to stay in compression. This design includes movement due to temperature, skew, shrinkage, and minimum installation.
4. Values in the Temperature Adjustment Table are for adjusting the expansion joint assembly immediately prior to pouring the concrete blockouts.
5. The joint opening "T" may be formed with other closed cell expansion material noted on the QPL under Item 559 E. The material listed on the QPL is different than Item 559.6. If the material listed on the QPL is used for forming, the material can stay in the joint. *However,* the thickness of the form material must be the dimension "T" of the joint opening for the ambient temperature at the time of the concrete pour, and a portion removed to the depth of the expansion joint material after the concrete sets.
6. Do not use extruded polystrene (XPS) rigid foam noted on the QPL under Item 520 M for forming the joint opening "T" *unless* it can be completely removed from the joint opening. This material does not compress and expand.

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Plow Protection Plate Standard Design Data

If an expansion joint has a skew between 32° and 42° left ahead (either direction on the interstate) or near this range *or* the joint opening (inside extrusions) is greater than 4-in. in the longitudinal direction [*AASHTO LRFD 4.5.3.2*], communication shall be made with the Bridge Design Chief, Bureau of Bridge Maintenance, and the District Engineer on whether a plow protection plate should be placed on the expansion joint. The use of a plow plate will be decided on a project to project basis.

Plow protection plates are to be placed on top of strip seal expansion joint angles. Compression seals can only be used for skews less than 30°; therefore a plow protection plate is not needed.

There is no standard plan of plow protection plates since the dimensions and details are different with each bridge, similar to a finger joint. However, there are some standard dimensions and details that are to be used so the fingers and distance between the fingers are the same.

See Appendix 7.4-A8 for sample plans of a plow protection plate and at:
http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/sampleplans/index.htm

Details are located at:
http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/bridgedetails/index.htm

The following standard design data shall be used for each plow protection plate:

- 9 ¼-in. spacing of the bolts
- 2 ½-in. dia. x ¾-in. recessed hole with 15/16-in. dia. hole through plate
- 1 ½-in. thick plate
- 8 ¼-in. finger plate width
- 9 ¼-in. length straight cut between fingers along plate
- 3/8-in. radius of the fingers
- 1-in. finger height
- 2 ½-in. from center of bolt to edge of plate
- Taper fingers ¼-in. top and bottom
- Use backing plates
- Fit as many 6’-2” length plates as geometry allows
- Use 6x8 angles for strip seal armoring
- May require offset between plates to center fingers throughout range of movement.

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EXPANSION TABLE

(*Including* **γTU**, Load factor for force effect due to uniform temperature):

STEEL: $M_t = (\Delta T)*(\alpha)*(L)*(\gamma TU)$

$\Delta T = 125°$ (-20°F to +105°F) (NHDOT Bridge Design Manual, Chap. 7, Sec. 7.4)

$\alpha = 6.5 \times 10^{-6}$ IN/IN/°F (AASHTO 6.4.1)

$\gamma TU = 1.2$ (AASHTO 3.4.1-1)

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
1	0.01	26	0.30	51	0.60	76	0.89
2	0.02	27	0.32	52	0.61	77	0.90
3	0.04	28	0.33	53	0.62	78	0.91
4	0.05	29	0.34	54	0.63	79	0.92
5	0.06	30	0.35	55	0.64	80	0.94
6	0.07	31	0.36	56	0.66	81	0.95
7	0.08	32	0.37	57	0.67	82	0.96
8	0.09	33	0.39	58	0.68	83	0.97
9	0.11	34	0.40	59	0.69	84	0.98
10	0.12	35	0.41	60	0.70	85	0.99
11	0.13	36	0.42	61	0.71	86	1.01
12	0.14	37	0.43	62	0.73	87	1.02
13	0.15	38	0.44	63	0.74	88	1.03
14	0.16	39	0.46	64	0.75	89	1.04
15	0.18	40	0.47	65	0.76	90	1.05
16	0.19	41	0.48	66	0.77	91	1.06
17	0.20	42	0.49	67	0.78	92	1.08
18	0.21	43	0.50	68	0.80	93	1.09
19	0.22	44	0.51	69	0.81	94	1.10
20	0.23	45	0.53	70	0.82	95	1.11
21	0.25	46	0.54	71	0.83	96	1.12
22	0.26	47	0.55	72	0.84	97	1.13
23	0.27	48	0.56	73	0.85	98	1.15
24	0.28	49	0.57	74	0.87	99	1.16
25	0.29	50	0.59	75	0.88	100	1.17

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
101	1.18	126	1.47	151	1.77	176	2.06
102	1.19	127	1.49	152	1.78	177	2.07
103	1.21	128	1.50	153	1.79	178	2.08
104	1.22	129	1.51	154	1.80	179	2.09
105	1.23	130	1.52	155	1.81	180	2.11
106	1.24	131	1.53	156	1.83	181	2.12
107	1.25	132	1.54	157	1.84	182	2.13
108	1.26	133	1.56	158	1.85	183	2.14
109	1.28	134	1.57	159	1.86	184	2.15
110	1.29	135	1.58	160	1.87	185	2.16
111	1.30	136	1.59	161	1.88	186	2.18
112	1.31	137	1.60	162	1.90	187	2.19
113	1.32	138	1.61	163	1.91	188	2.20
114	1.33	139	1.63	164	1.92	189	2.21
115	1.35	140	1.64	165	1.93	190	2.22
116	1.36	141	1.65	166	1.94	191	2.23
117	1.37	142	1.66	167	1.95	192	2.25
118	1.38	143	1.67	168	1.97	193	2.26
119	1.39	144	1.68	169	1.98	194	2.27
120	1.40	145	1.70	170	1.99	195	2.28
121	1.42	146	1.71	171	2.00	196	2.29
122	1.43	147	1.72	172	2.01	197	2.30
123	1.44	148	1.73	173	2.02	198	2.32
124	1.45	149	1.74	174	2.04	199	2.33
125	1.46	150	1.76	175	2.05	200	2.34

EXPANSION TABLE

(*Including* **γTU**, Load factor for force effect due to uniform temperature):

STEEL: $M_t = (\Delta T)*(\alpha)*(L)*(\gamma TU)$

$\Delta T = 125°$ **(-20°F to +105°F)** (NHDOT Bridge Design Manual, Chap. 7, Sec. 7.4)

$\alpha = 6.5 \times 10^{-6}$ IN/IN/°F (AASHTO 6.4.1)

$\gamma TU = 1.2$ (AASHTO 3.4.1-1)

SPAN LENGTH (FT)	M_t (IN)
201	2.35
202	2.36
203	2.38
204	2.39
205	2.40
206	2.41
207	2.42
208	2.43
209	2.45
210	2.46
211	2.47
212	2.48
213	2.49
214	2.50
215	2.52
216	2.53
217	2.54
218	2.55
219	2.56
220	2.57
221	2.59
222	2.60
223	2.61
224	2.62
225	2.63

SPAN LENGTH (FT)	M_t (IN)
226	2.64
227	2.66
228	2.67
229	2.68
230	2.69
231	2.70
232	2.71
233	2.73
234	2.74
235	2.75
236	2.76
237	2.77
238	2.78
239	2.80
240	2.81
241	2.82
242	2.83
243	2.84
244	2.85
245	2.87
246	2.88
247	2.89
248	2.90
249	2.91
250	2.93

SPAN LENGTH (FT)	M_t (IN)
251	2.94
252	2.95
253	2.96
254	2.97
255	2.98
256	3.00
257	3.01
258	3.02
259	3.03
260	3.04
261	3.05
262	3.07
263	3.08
264	3.09
265	3.10
266	3.11
267	3.12
268	3.14
269	3.15
270	3.16
271	3.17
272	3.18
273	3.19
274	3.21
275	3.22

SPAN LENGTH (FT)	M_t (IN)
276	3.23
277	3.24
278	3.25
279	3.26
280	3.28
281	3.29
282	3.30
283	3.31
284	3.32
285	3.33
286	3.35
287	3.36
288	3.37
289	3.38
290	3.39
291	3.40
292	3.42
293	3.43
294	3.44
295	3.45
296	3.46
297	3.47
298	3.49
299	3.50
300	3.51

SPAN LENGTH (FT)	M_t (IN)
301	3.52
302	3.53
303	3.55
304	3.56
305	3.57
306	3.58
307	3.59
308	3.60
309	3.62
310	3.63
311	3.64
312	3.65
313	3.66
314	3.67
315	3.69
316	3.70
317	3.71
318	3.72
319	3.73
320	3.74
321	3.76
322	3.77
323	3.78
324	3.79
325	3.80

SPAN LENGTH (FT)	M_t (IN)
326	3.81
327	3.83
328	3.84
329	3.85
330	3.86
331	3.87
332	3.88
333	3.90
334	3.91
335	3.92
336	3.93
337	3.94
338	3.95
339	3.97
340	3.98
341	3.99
342	4.00
343	4.01
344	4.02
345	4.04
346	4.05
347	4.06
348	4.07
349	4.08
350	4.10

SPAN LENGTH (FT)	M_t (IN)
351	4.11
352	4.12
353	4.13
354	4.14
355	4.15
356	4.17
357	4.18
358	4.19
359	4.20
360	4.21
361	4.22
362	4.24
363	4.25
364	4.26
365	4.27
366	4.28
367	4.29
368	4.31
369	4.32
370	4.33
371	4.34
372	4.35
373	4.36
374	4.38
375	4.39

SPAN LENGTH (FT)	M_t (IN)
376	4.40
377	4.41
378	4.42
379	4.43
380	4.45
381	4.46
382	4.47
383	4.48
384	4.49
385	4.50
386	4.52
387	4.53
388	4.54
389	4.55
390	4.56
391	4.57
392	4.59
393	4.60
394	4.61
395	4.62
396	4.63
397	4.64
398	4.66
399	4.67
400	4.68

EXPANSION TABLE:

(*Without* **γTU**, Load factor):

STEEL: $M_t = (\Delta T)*(\alpha)*(L)$

$\Delta T = 125°$ **(-20°F to +105°F)** (NHDOT Bridge Design Manual, Chap. 7, Sec. 7.4)

$\alpha = 6.5 \times 10^{-6}$ IN/IN/°F (AASHTO 6.4.1)

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
1	0.01	26	0.25	51	0.50	76	0.74
2	0.02	27	0.26	52	0.51	77	0.75
3	0.03	28	0.27	53	0.52	78	0.76
4	0.04	29	0.28	54	0.53	79	0.77
5	0.05	30	0.29	55	0.54	80	0.78
6	0.06	31	0.30	56	0.55	81	0.79
7	0.07	32	0.31	57	0.56	82	0.80
8	0.08	33	0.32	58	0.57	83	0.81
9	0.09	34	0.33	59	0.58	84	0.82
10	0.10	35	0.34	60	0.59	85	0.83
11	0.11	36	0.35	61	0.59	86	0.84
12	0.12	37	0.36	62	0.60	87	0.85
13	0.13	38	0.37	63	0.61	88	0.86
14	0.14	39	0.38	64	0.62	89	0.87
15	0.15	40	0.39	65	0.63	90	0.88
16	0.16	41	0.40	66	0.64	91	0.89
17	0.17	42	0.41	67	0.65	92	0.90
18	0.18	43	0.42	68	0.66	93	0.91
19	0.19	44	0.43	69	0.67	94	0.92
20	0.20	45	0.44	70	0.68	95	0.93
21	0.20	46	0.45	71	0.69	96	0.94
22	0.21	47	0.46	72	0.70	97	0.95
23	0.22	48	0.47	73	0.71	98	0.96
24	0.23	49	0.48	74	0.72	99	0.97
25	0.24	50	0.49	75	0.73	100	0.98

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
101	0.98	126	1.23	151	1.47	176	1.72
102	0.99	127	1.24	152	1.48	177	1.73
103	1.00	128	1.25	153	1.49	178	1.74
104	1.01	129	1.26	154	1.50	179	1.75
105	1.02	130	1.27	155	1.51	180	1.76
106	1.03	131	1.28	156	1.52	181	1.76
107	1.04	132	1.29	157	1.53	182	1.77
108	1.05	133	1.30	158	1.54	183	1.78
109	1.06	134	1.31	159	1.55	184	1.79
110	1.07	135	1.32	160	1.56	185	1.80
111	1.08	136	1.33	161	1.57	186	1.81
112	1.09	137	1.34	162	1.58	187	1.82
113	1.10	138	1.35	163	1.59	188	1.83
114	1.11	139	1.36	164	1.60	189	1.84
115	1.12	140	1.37	165	1.61	190	1.85
116	1.13	141	1.37	166	1.62	191	1.86
117	1.14	142	1.38	167	1.63	192	1.87
118	1.15	143	1.39	168	1.64	193	1.88
119	1.16	144	1.40	169	1.65	194	1.89
120	1.17	145	1.41	170	1.66	195	1.90
121	1.18	146	1.42	171	1.67	196	1.91
122	1.19	147	1.43	172	1.68	197	1.92
123	1.20	148	1.44	173	1.69	198	1.93
124	1.21	149	1.45	174	1.70	199	1.94
125	1.22	150	1.46	175	1.71	200	1.95

EXPANSION TABLE:

(*Without* **γTU**, Load factor):

STEEL: $M_t = (\Delta T)*(\alpha)*(L)$

$\Delta T = 125°$ (-20°F to +105°F) (NHDOT Bridge Design Manual, Chap. 7, Sec. 7.4)

$\alpha = 6.5 \times 10^{-6}$ IN/IN/°F (AASHTO 6.4.1)

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
201	1.96	226	2.20	251	2.45	276	2.69
202	1.97	227	2.21	252	2.46	277	2.70
203	1.98	228	2.22	253	2.47	278	2.71
204	1.99	229	2.23	254	2.48	279	2.72
205	2.00	230	2.24	255	2.49	280	2.73
206	2.01	231	2.25	256	2.50	281	2.74
207	2.02	232	2.26	257	2.51	282	2.75
208	2.03	233	2.27	258	2.52	283	2.76
209	2.04	234	2.28	259	2.53	284	2.77
210	2.05	235	2.29	260	2.54	285	2.78
211	2.06	236	2.30	261	2.54	286	2.79
212	2.07	237	2.31	262	2.55	287	2.80
213	2.08	238	2.32	263	2.56	288	2.81
214	2.09	239	2.33	264	2.57	289	2.82
215	2.10	240	2.34	265	2.58	290	2.83
216	2.11	241	2.35	266	2.59	291	2.84
217	2.12	242	2.36	267	2.60	292	2.85
218	2.13	243	2.37	268	2.61	293	2.86
219	2.14	244	2.38	269	2.62	294	2.87
220	2.15	245	2.39	270	2.63	295	2.88
221	2.15	246	2.40	271	2.64	296	2.89
222	2.16	247	2.41	272	2.65	297	2.90
223	2.17	248	2.42	273	2.66	298	2.91
224	2.18	249	2.43	274	2.67	299	2.92
225	2.19	250	2.44	275	2.68	300	2.93

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
301	2.93	326	3.18	351	3.42	376	3.67
302	2.94	327	3.19	352	3.43	377	3.68
303	2.95	328	3.20	353	3.44	378	3.69
304	2.96	329	3.21	354	3.45	379	3.70
305	2.97	330	3.22	355	3.46	380	3.71
306	2.98	331	3.23	356	3.47	381	3.71
307	2.99	332	3.24	357	3.48	382	3.72
308	3.00	333	3.25	358	3.49	383	3.73
309	3.01	334	3.26	359	3.50	384	3.74
310	3.02	335	3.27	360	3.51	385	3.75
311	3.03	336	3.28	361	3.52	386	3.76
312	3.04	337	3.29	362	3.53	387	3.77
313	3.05	338	3.30	363	3.54	388	3.78
314	3.06	339	3.31	364	3.55	389	3.79
315	3.07	340	3.32	365	3.56	390	3.80
316	3.08	341	3.32	366	3.57	391	3.81
317	3.09	342	3.33	367	3.58	392	3.82
318	3.10	343	3.34	368	3.59	393	3.83
319	3.11	344	3.35	369	3.60	394	3.84
320	3.12	345	3.36	370	3.61	395	3.85
321	3.13	346	3.37	371	3.62	396	3.86
322	3.14	347	3.38	372	3.63	397	3.87
323	3.15	348	3.39	373	3.64	398	3.88
324	3.16	349	3.40	374	3.65	399	3.89
325	3.17	350	3.41	375	3.66	400	3.90

EXPANSION TABLE

(*Including* **γTU**, Load factor for force effect due to uniform temperature):

CONCRETE: $M_t = (\Delta T)*(\alpha)*(L)*(\gamma TU)$

$\Delta T = 80°$ **(0°F to +80°F)** (NHDOT Bridge Design Manual, Chap. 7, Sec. 7.4)

$\alpha = 6.0 \times 10^{-6}$ IN/IN/°F (AASHTO 5.4.2.2)

γTU = 1.2 (AASHTO 3.4.1-1)

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
1	0.01	26	0.18	51	0.35	76	0.53
2	0.01	27	0.19	52	0.36	77	0.53
3	0.02	28	0.19	53	0.37	78	0.54
4	0.03	29	0.20	54	0.37	79	0.55
5	0.03	30	0.21	55	0.38	80	0.55
6	0.04	31	0.21	56	0.39	81	0.56
7	0.05	32	0.22	57	0.39	82	0.57
8	0.06	33	0.23	58	0.40	83	0.57
9	0.06	34	0.24	59	0.41	84	0.58
10	0.07	35	0.24	60	0.41	85	0.59
11	0.08	36	0.25	61	0.42	86	0.59
12	0.08	37	0.26	62	0.43	87	0.60
13	0.09	38	0.26	63	0.44	88	0.61
14	0.10	39	0.27	64	0.44	89	0.62
15	0.10	40	0.28	65	0.45	90	0.62
16	0.11	41	0.28	66	0.46	91	0.63
17	0.12	42	0.29	67	0.46	92	0.64
18	0.12	43	0.30	68	0.47	93	0.64
19	0.13	44	0.30	69	0.48	94	0.65
20	0.14	45	0.31	70	0.48	95	0.66
21	0.15	46	0.32	71	0.49	96	0.66
22	0.15	47	0.32	72	0.50	97	0.67
23	0.16	48	0.33	73	0.50	98	0.68
24	0.17	49	0.34	74	0.51	99	0.68
25	0.17	50	0.35	75	0.52	100	0.69

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
101	0.70	126	0.87	151	1.04	176	1.22
102	0.71	127	0.88	152	1.05	177	1.22
103	0.71	128	0.88	153	1.06	178	1.23
104	0.72	129	0.89	154	1.06	179	1.24
105	0.73	130	0.90	155	1.07	180	1.24
106	0.73	131	0.91	156	1.08	181	1.25
107	0.74	132	0.91	157	1.09	182	1.26
108	0.75	133	0.92	158	1.09	183	1.26
109	0.75	134	0.93	159	1.10	184	1.27
110	0.76	135	0.93	160	1.11	185	1.28
111	0.77	136	0.94	161	1.11	186	1.29
112	0.77	137	0.95	162	1.12	187	1.29
113	0.78	138	0.95	163	1.13	188	1.30
114	0.79	139	0.96	164	1.13	189	1.31
115	0.79	140	0.97	165	1.14	190	1.31
116	0.80	141	0.97	166	1.15	191	1.32
117	0.81	142	0.98	167	1.15	192	1.33
118	0.82	143	0.99	168	1.16	193	1.33
119	0.82	144	1.00	169	1.17	194	1.34
120	0.83	145	1.00	170	1.18	195	1.35
121	0.84	146	1.01	171	1.18	196	1.35
122	0.84	147	1.02	172	1.19	197	1.36
123	0.85	148	1.02	173	1.20	198	1.37
124	0.86	149	1.03	174	1.20	199	1.38
125	0.86	150	1.04	175	1.21	200	1.38

EXPANSION TABLE

(*Including* **γTU**, Load factor for force effect due to uniform temperature):

CONCRETE: $M_t = (\Delta T)*(\alpha)*(L)*(\gamma TU)$

$\Delta T = 80°$ **(0°F to +80°F)** (NHDOT Bridge Design Manual, Chap. 7, Sec. 7.4)

$\alpha = 6.0 \times 10^{-6}$ IN/IN/°F (AASHTO 5.4.2.2)

γTU = 1.2 (AASHTO 3.4.1-1)

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
201	1.39	226	1.56	251	1.73	276	1.91
202	1.40	227	1.57	252	1.74	277	1.91
203	1.40	228	1.58	253	1.75	278	1.92
204	1.41	229	1.58	254	1.76	279	1.93
205	1.42	230	1.59	255	1.76	280	1.94
206	1.42	231	1.60	256	1.77	281	1.94
207	1.43	232	1.60	257	1.78	282	1.95
208	1.44	233	1.61	258	1.78	283	1.96
209	1.44	234	1.62	259	1.79	284	1.96
210	1.45	235	1.62	260	1.80	285	1.97
211	1.46	236	1.63	261	1.80	286	1.98
212	1.47	237	1.64	262	1.81	287	1.98
213	1.47	238	1.65	263	1.82	288	1.99
214	1.48	239	1.65	264	1.82	289	2.00
215	1.49	240	1.66	265	1.83	290	2.00
216	1.49	241	1.67	266	1.84	291	2.01
217	1.50	242	1.67	267	1.85	292	2.02
218	1.51	243	1.68	268	1.85	293	2.03
219	1.51	244	1.69	269	1.86	294	2.03
220	1.52	245	1.69	270	1.87	295	2.04
221	1.53	246	1.70	271	1.87	296	2.05
222	1.53	247	1.71	272	1.88	297	2.05
223	1.54	248	1.71	273	1.89	298	2.06
224	1.55	249	1.72	274	1.89	299	2.07
225	1.56	250	1.73	275	1.90	300	2.07

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
301	2.08	326	2.25	351	2.43	376	2.60
302	2.09	327	2.26	352	2.43	377	2.61
303	2.09	328	2.27	353	2.44	378	2.61
304	2.10	329	2.27	354	2.45	379	2.62
305	2.11	330	2.28	355	2.45	380	2.63
306	2.12	331	2.29	356	2.46	381	2.63
307	2.12	332	2.29	357	2.47	382	2.64
308	2.13	333	2.30	358	2.47	383	2.65
309	2.14	334	2.31	359	2.48	384	2.65
310	2.14	335	2.32	360	2.49	385	2.66
311	2.15	336	2.32	361	2.50	386	2.67
312	2.16	337	2.33	362	2.50	387	2.67
313	2.16	338	2.34	363	2.51	388	2.68
314	2.17	339	2.34	364	2.52	389	2.69
315	2.18	340	2.35	365	2.52	390	2.70
316	2.18	341	2.36	366	2.53	391	2.70
317	2.19	342	2.36	367	2.54	392	2.71
318	2.20	343	2.37	368	2.54	393	2.72
319	2.20	344	2.38	369	2.55	394	2.72
320	2.21	345	2.38	370	2.56	395	2.73
321	2.22	346	2.39	371	2.56	396	2.74
322	2.23	347	2.40	372	2.57	397	2.74
323	2.23	348	2.41	373	2.58	398	2.75
324	2.24	349	2.41	374	2.59	399	2.76
325	2.25	350	2.42	375	2.59	400	2.76

EXPANSION TABLE:

(*Without* **γTU**, Load factor):

CONCRETE: $M_t = (\Delta T)*(\alpha)*(L)$

$\Delta T = 80°$ **(0°F to +80°F)** (NHDOT Bridge Design Manual, Chap. 7, Sec. 7.4)

$\alpha = 6.0 \times 10^{-6}$ IN/IN/°F (AASHTO 5.4.2.2)

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
1	0.01	26	0.15	51	0.29	76	0.44
2	0.01	27	0.16	52	0.30	77	0.44
3	0.02	28	0.16	53	0.31	78	0.45
4	0.02	29	0.17	54	0.31	79	0.46
5	0.03	30	0.17	55	0.32	80	0.46
6	0.03	31	0.18	56	0.32	81	0.47
7	0.04	32	0.18	57	0.33	82	0.47
8	0.05	33	0.19	58	0.33	83	0.48
9	0.05	34	0.20	59	0.34	84	0.48
10	0.06	35	0.20	60	0.35	85	0.49
11	0.06	36	0.21	61	0.35	86	0.50
12	0.07	37	0.21	62	0.36	87	0.50
13	0.07	38	0.22	63	0.36	88	0.51
14	0.08	39	0.22	64	0.37	89	0.51
15	0.09	40	0.23	65	0.37	90	0.52
16	0.09	41	0.24	66	0.38	91	0.52
17	0.10	42	0.24	67	0.39	92	0.53
18	0.10	43	0.25	68	0.39	93	0.54
19	0.11	44	0.25	69	0.40	94	0.54
20	0.12	45	0.26	70	0.40	95	0.55
21	0.12	46	0.26	71	0.41	96	0.55
22	0.13	47	0.27	72	0.41	97	0.56
23	0.13	48	0.28	73	0.42	98	0.56
24	0.14	49	0.28	74	0.43	99	0.57
25	0.14	50	0.29	75	0.43	100	0.58

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
101	0.58	126	0.73	151	0.87	176	1.01
102	0.59	127	0.73	152	0.88	177	1.02
103	0.59	128	0.74	153	0.88	178	1.03
104	0.60	129	0.74	154	0.89	179	1.03
105	0.60	130	0.75	155	0.89	180	1.04
106	0.61	131	0.75	156	0.90	181	1.04
107	0.62	132	0.76	157	0.90	182	1.05
108	0.62	133	0.77	158	0.91	183	1.05
109	0.63	134	0.77	159	0.92	184	1.06
110	0.63	135	0.78	160	0.92	185	1.07
111	0.64	136	0.78	161	0.93	186	1.07
112	0.65	137	0.79	162	0.93	187	1.08
113	0.65	138	0.79	163	0.94	188	1.08
114	0.66	139	0.80	164	0.94	189	1.09
115	0.66	140	0.81	165	0.95	190	1.09
116	0.67	141	0.81	166	0.96	191	1.10
117	0.67	142	0.82	167	0.96	192	1.11
118	0.68	143	0.82	168	0.97	193	1.11
119	0.69	144	0.83	169	0.97	194	1.12
120	0.69	145	0.84	170	0.98	195	1.12
121	0.70	146	0.84	171	0.98	196	1.13
122	0.70	147	0.85	172	0.99	197	1.13
123	0.71	148	0.85	173	1.00	198	1.14
124	0.71	149	0.86	174	1.00	199	1.15
125	0.72	150	0.86	175	1.01	200	1.15

EXPANSION TABLE:

(*Without* **γTU**, Load factor):

CONCRETE: $M_t = (\Delta T)*(\alpha)*(L)$

$\Delta T = 80°$ **(0°F to +80°F)** (NHDOT Bridge Design Manual, Chap. 7, Sec. 7.4)

$\alpha = 6.0 \times 10^{-6}$ IN/IN/°F (AASHTO 5.4.2.2)

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
201	1.16	226	1.30	251	1.45	276	1.59
202	1.16	227	1.31	252	1.45	277	1.60
203	1.17	228	1.31	253	1.46	278	1.60
204	1.18	229	1.32	254	1.46	279	1.61
205	1.18	230	1.32	255	1.47	280	1.61
206	1.19	231	1.33	256	1.47	281	1.62
207	1.19	232	1.34	257	1.48	282	1.62
208	1.20	233	1.34	258	1.49	283	1.63
209	1.20	234	1.35	259	1.49	284	1.64
210	1.21	235	1.35	260	1.50	285	1.64
211	1.22	236	1.36	261	1.50	286	1.65
212	1.22	237	1.37	262	1.51	287	1.65
213	1.23	238	1.37	263	1.51	288	1.66
214	1.23	239	1.38	264	1.52	289	1.66
215	1.24	240	1.38	265	1.53	290	1.67
216	1.24	241	1.39	266	1.53	291	1.68
217	1.25	242	1.39	267	1.54	292	1.68
218	1.26	243	1.40	268	1.54	293	1.69
219	1.26	244	1.41	269	1.55	294	1.69
220	1.27	245	1.41	270	1.56	295	1.70
221	1.27	246	1.42	271	1.56	296	1.70
222	1.28	247	1.42	272	1.57	297	1.71
223	1.28	248	1.43	273	1.57	298	1.72
224	1.29	249	1.43	274	1.58	299	1.72
225	1.30	250	1.44	275	1.58	300	1.73

SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)	SPAN LENGTH (FT)	M_t (IN)
301	1.73	326	1.88	351	2.02	376	2.17
302	1.74	327	1.88	352	2.03	377	2.17
303	1.75	328	1.89	353	2.03	378	2.18
304	1.75	329	1.90	354	2.04	379	2.18
305	1.76	330	1.90	355	2.04	380	2.19
306	1.76	331	1.91	356	2.05	381	2.19
307	1.77	332	1.91	357	2.06	382	2.20
308	1.77	333	1.92	358	2.06	383	2.21
309	1.78	334	1.92	359	2.07	384	2.21
310	1.79	335	1.93	360	2.07	385	2.22
311	1.79	336	1.94	361	2.08	386	2.22
312	1.80	337	1.94	362	2.09	387	2.23
313	1.80	338	1.95	363	2.09	388	2.23
314	1.81	339	1.95	364	2.10	389	2.24
315	1.81	340	1.96	365	2.10	390	2.25
316	1.82	341	1.96	366	2.11	391	2.25
317	1.83	342	1.97	367	2.11	392	2.26
318	1.83	343	1.98	368	2.12	393	2.26
319	1.84	344	1.98	369	2.13	394	2.27
320	1.84	345	1.99	370	2.13	395	2.28
321	1.85	346	1.99	371	2.14	396	2.28
322	1.85	347	2.00	372	2.14	397	2.29
323	1.86	348	2.00	373	2.15	398	2.29
324	1.87	349	2.01	374	2.15	399	2.30
325	1.87	350	2.02	375	2.16	400	2.30

New Hampshire DOT
Department of Transportation

Bridge Design Manual

Chapter 7- Appendix B

January 2015 – v 2.0

(Revised August 2019)

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ASPHALTIC PLUG FOR CRACK CONTROL

The asphaltic plug for crack control details can be found at NHDOT Bridge Design Bridge Details web page:
http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/bridgedetails/index.htm

Scroll down to: Expansion Joints/Asphaltic Plug for Crack Control

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ASPHALTIC PLUG EXPANSION JOINT DETAILS

The asphaltic plug expansion joint details can be found at NHDOT Bridge Design Bridge Details web page:
http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/bridgedetails/index.htm

Scroll down to: Expansion Joints/Asphaltic Plug Expansion Joint Details

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COMPRESSION SEAL EXP. JOINT BRIDGE DETAIL

The compression seal expansion joint details can be found at NHDOT Bridge Design Bridge Details web page:
http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/bridgedetails/index.htm

Scroll down to: Expansion Joints/Compression Seal Expansion Joint Bridge Details

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STRIP SEAL EXPANSION BRIDGE JOINT DETAILS

The strip seal xpansion joint details can be found at NHDOT Bridge Design Bridge Details web page: http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/bridgedetails/index.htm

Scroll down to: Expansion Joints/Strip Seal Expansion Joint Details

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FINGER JOINT SAMPLE PLAN

The finger joint sample plan can be found at NHDOT Bridge Design Sample Plans web page:
https://www.nh.gov/dot/org/projectdevelopment/bridgedesign/sampleplans/index.htm

Scroll down to: Expansion Joints/Finger Joint

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FINGER JOINT PHASE CONSTRUCTION SAMPLE PLAN

The finger joint sample plan can be found at NHDOT Bridge Design Sample Plans web page:
https://www.nh.gov/dot/org/projectdevelopment/bridgedesign/sampleplans/index.htm

Scroll down to: Expansion Joints/Finger Joint

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MODULAR JOINT SAMPLE PLAN

The modular joint sample plan can be found at NHDOT Bridge Design Sample Plans web page:
https://www.nh.gov/dot/org/projectdevelopment/bridgedesign/sampleplans/index.htm

Scroll down to: Expansion Joints/Modular Joint

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PLOW PROTECTION PLATE SAMPLE PLAN

The plow protection plate sample plan can be found at NHDOT Bridge Design Sample Plans web page:
https://www.nh.gov/dot/org/projectdevelopment/bridgedesign/sampleplans/index.htm

Scroll down to: Expansion Joints/Plow Protection Plate

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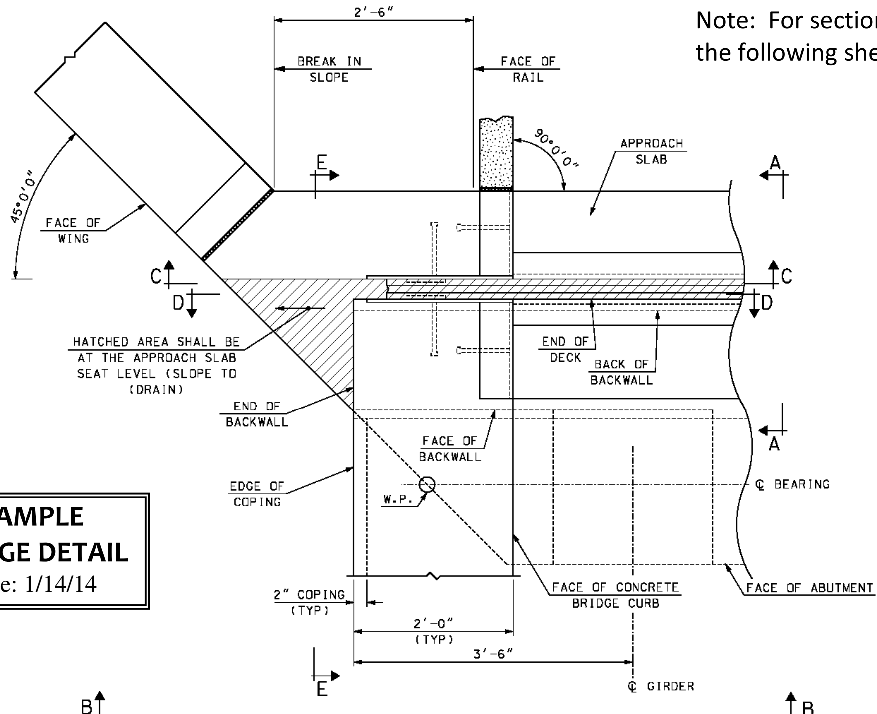
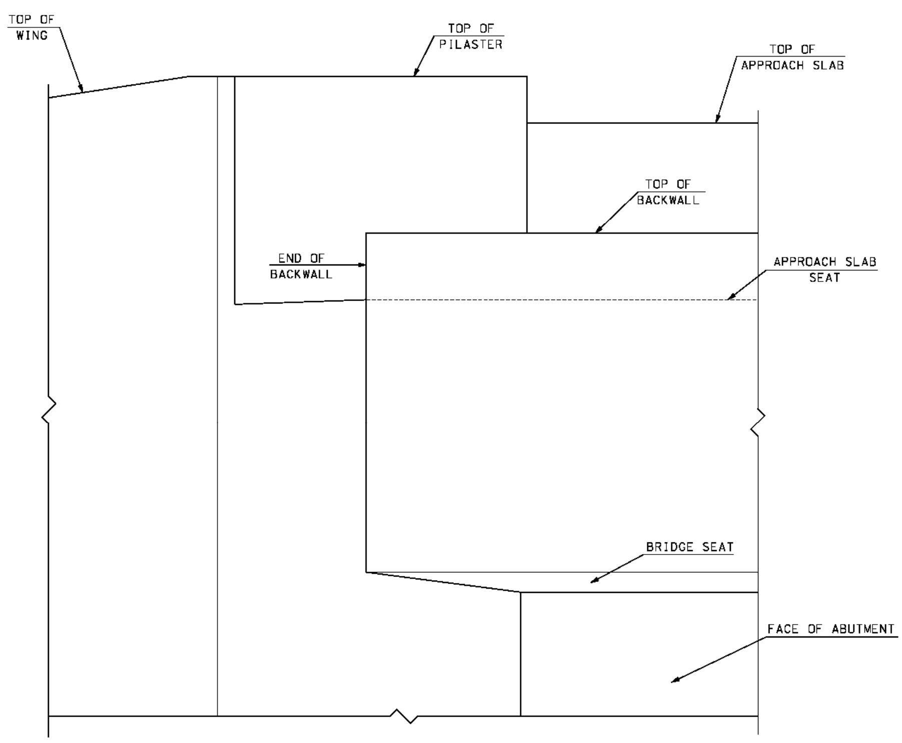
Note: For sections, see the following sheets.

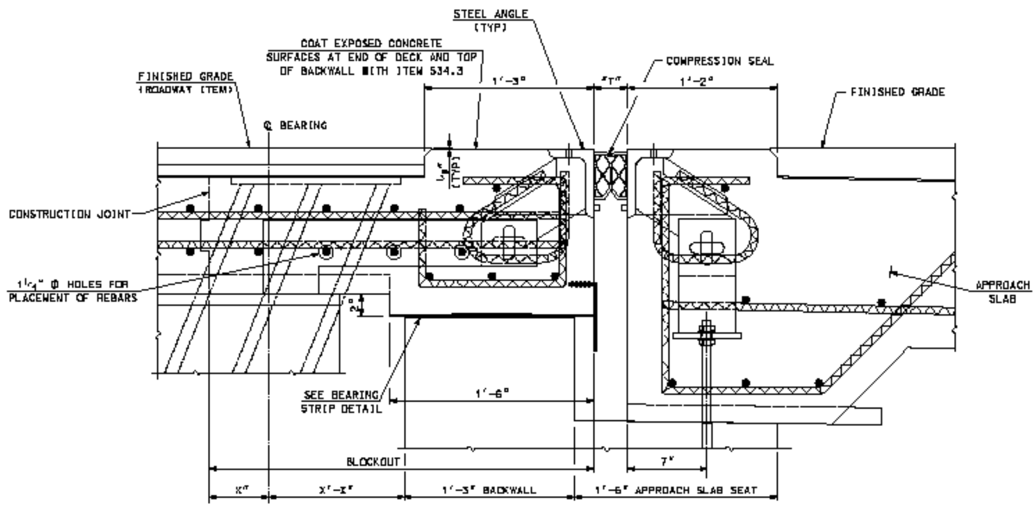
SAMPLE BRIDGE DETAIL
Date: 1/14/14



PLAN VIEW
(90° CROSSING)

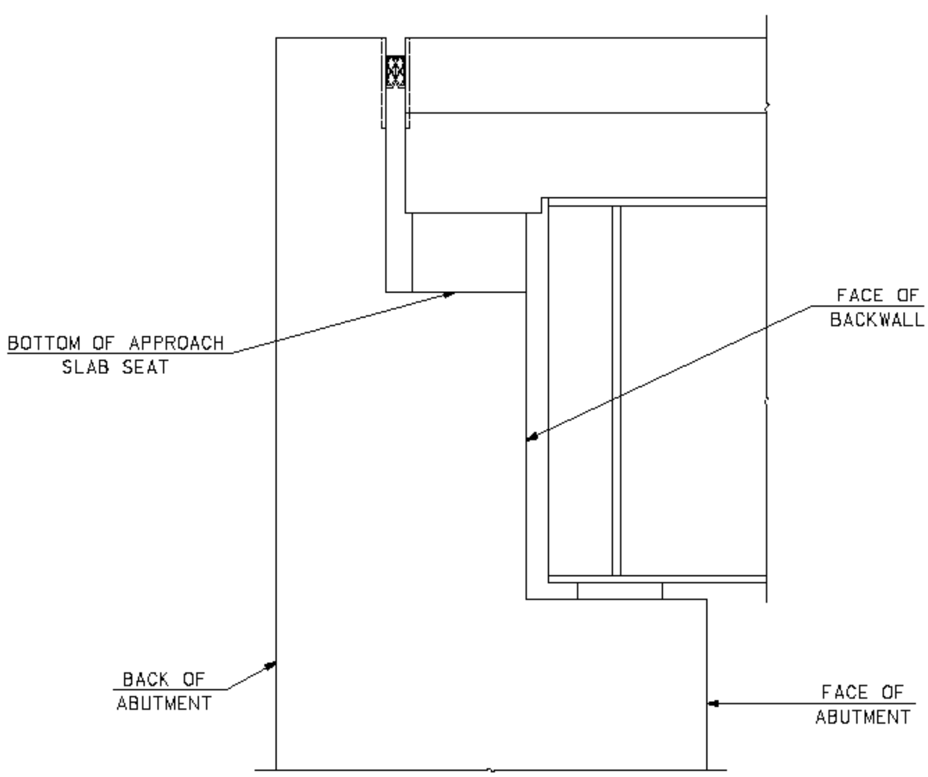


SECTION B-B
DECK NOT SHOWN FOR CLARITY

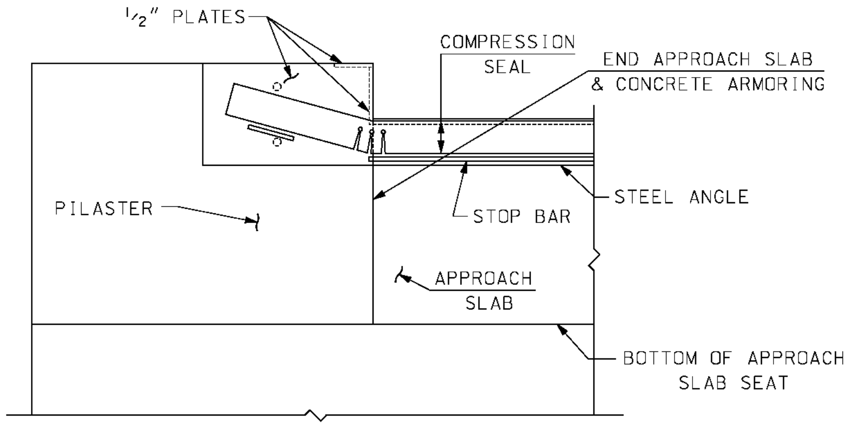


SECTION A-A

SAMPLE BRIDGE DETAIL
Date: 11/14/18

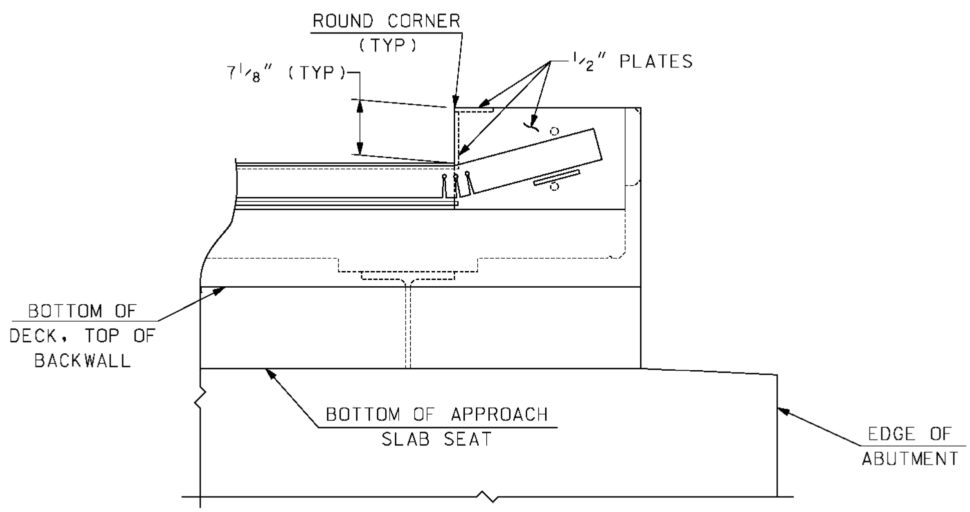


SECTION E-E

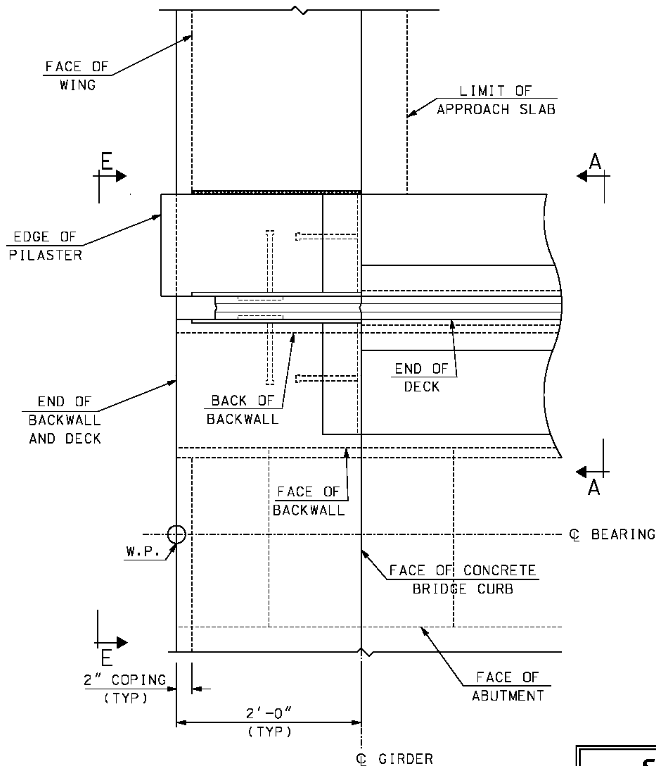


SECTION C-C

SAMPLE BRIDGE DETAIL
Date: 1/14/14

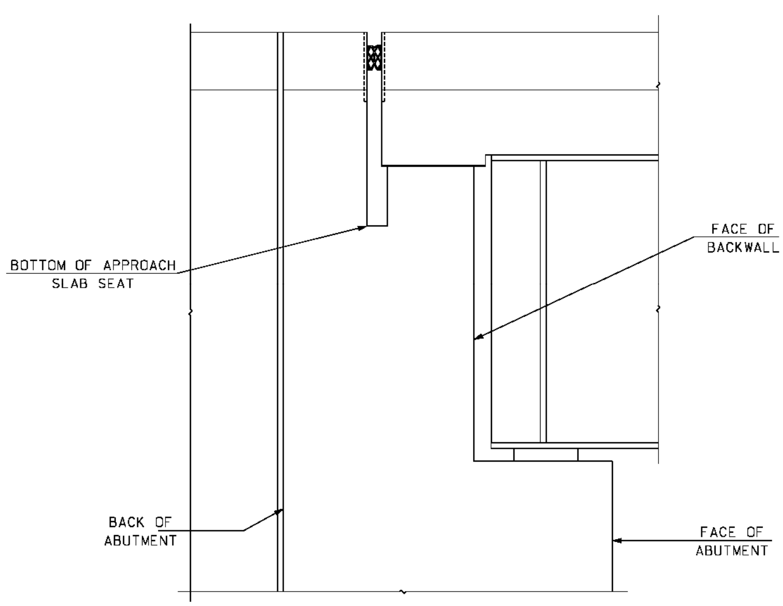


SECTION D-D



PLAN VIEW
(U-BACK WINGS)

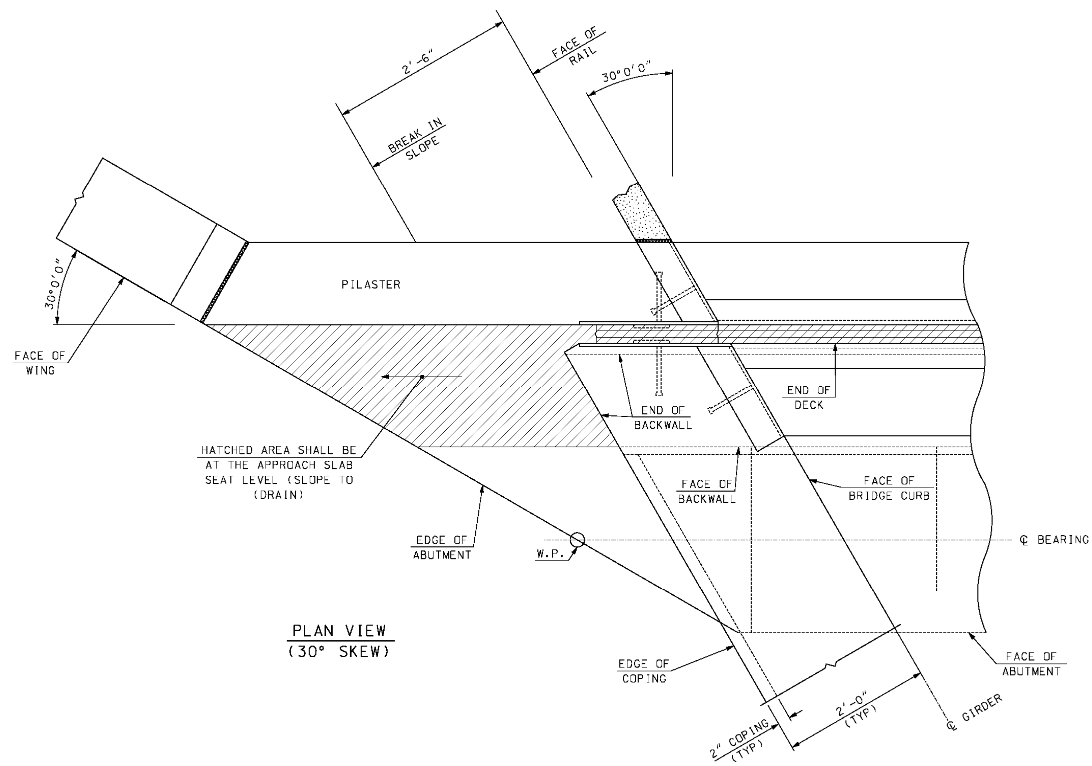
SAMPLE BRIDGE DETAIL
Date: 1/14/14



SECTION E-E

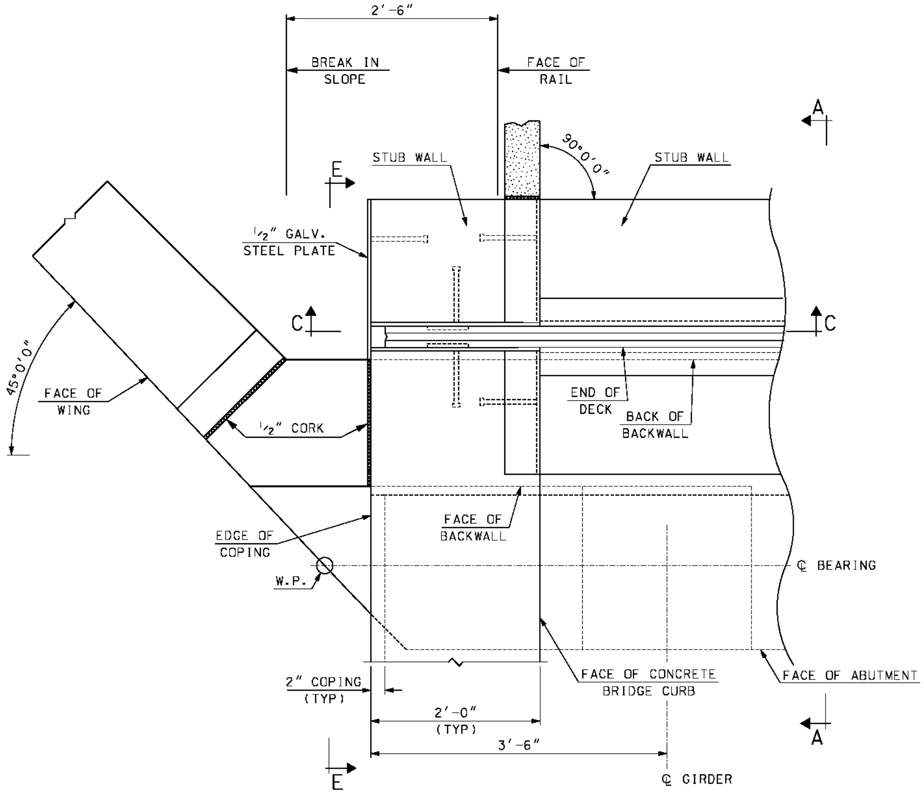
Note to Designer:

Locating the expansion joint behind the backwall may not provide the best geometry layout depending on the skew of the bridge and the angle of the wing. The expansion joint may need to be located in front of the backwall.



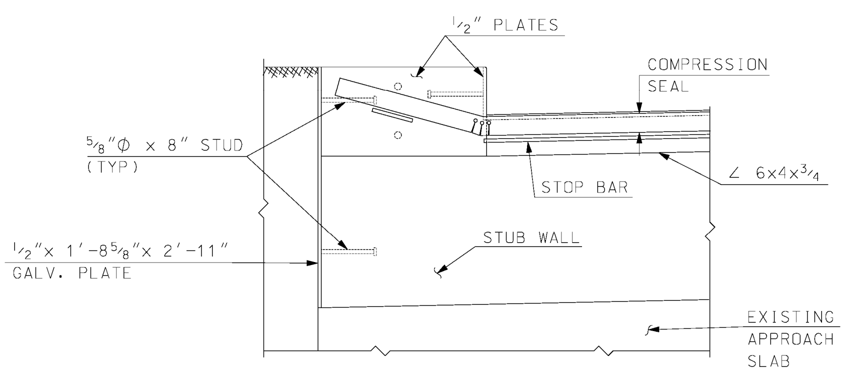
SAMPLE
BRIDGE DETAIL
Date: 1/14/14

Note: For sections, see the following sheets.

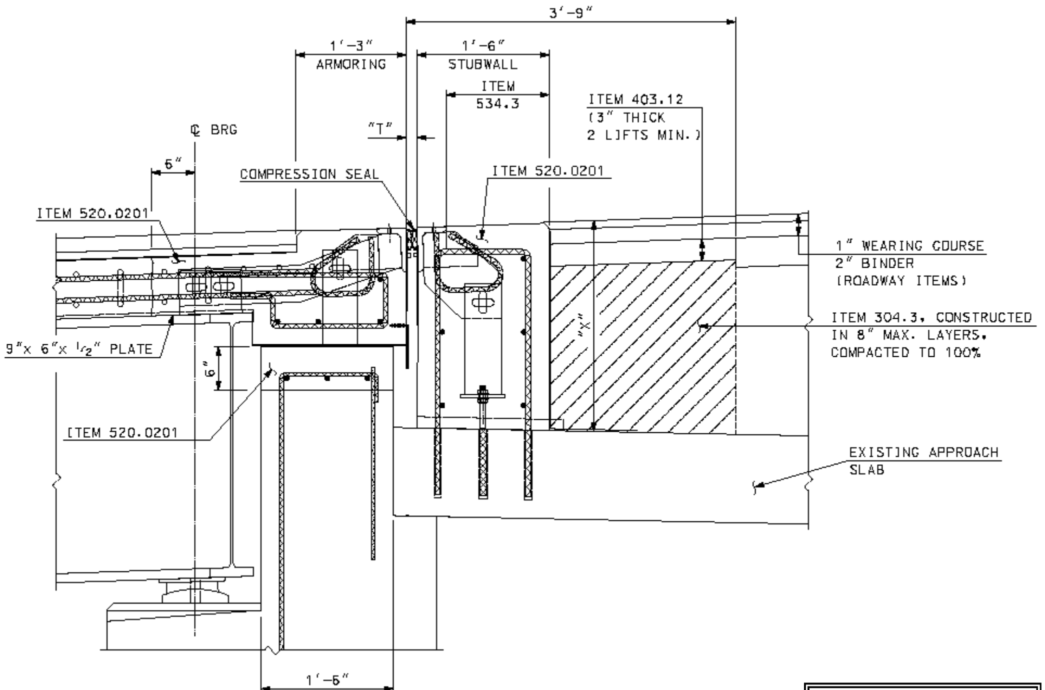


PLAN VIEW
(EXISTING BRIDGE:
JOINT REPLACEMENT-STUBWALL)

SAMPLE
BRIDGE DETAIL
Date: 1/14/14

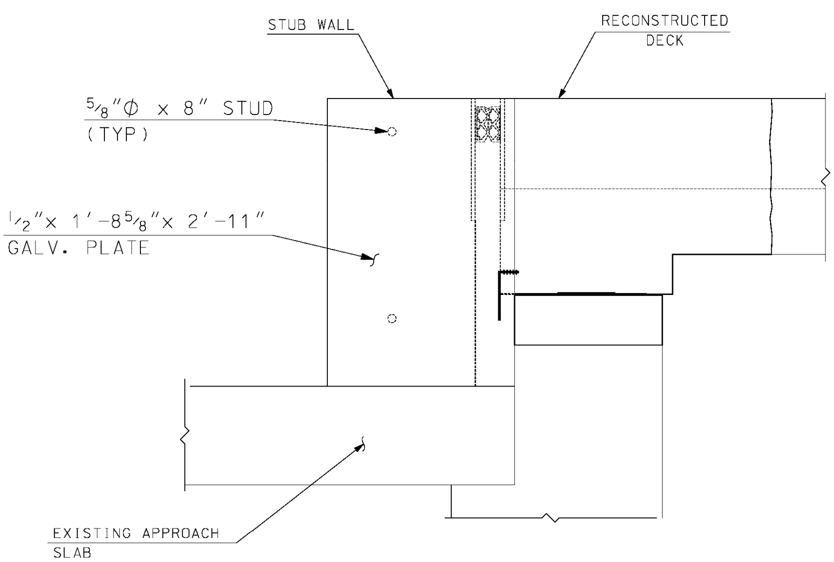


SECTION C-C



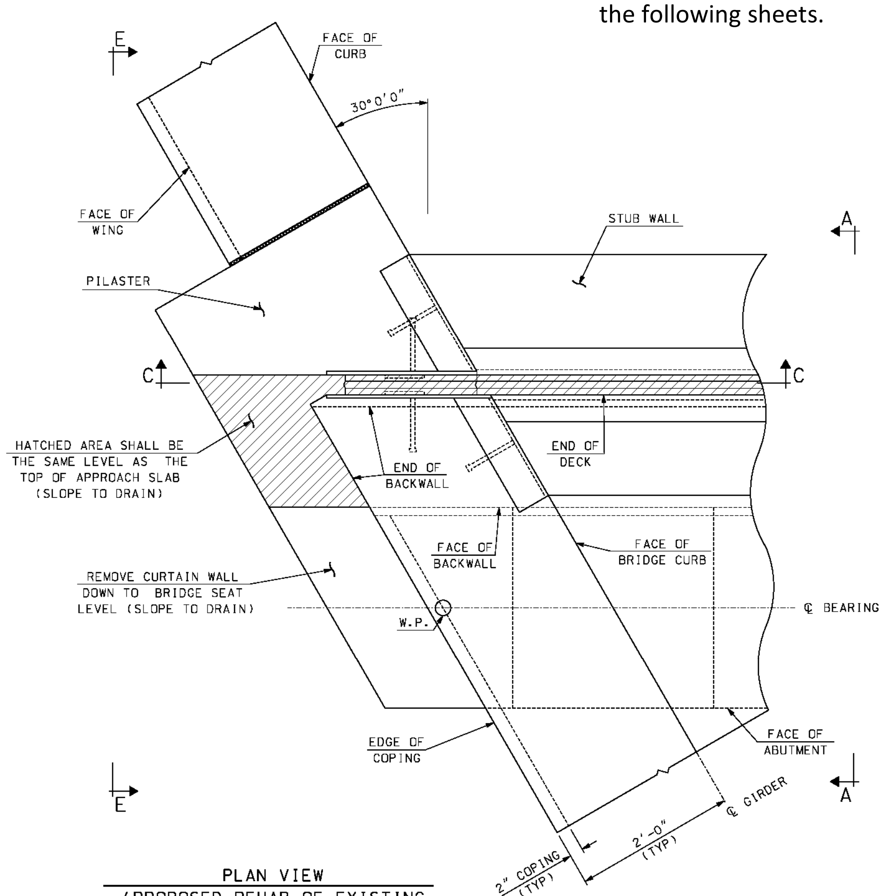
SECTION A-A RECONSTRUCTION

SAMPLE
BRIDGE DETAIL
Date: 11/14/18



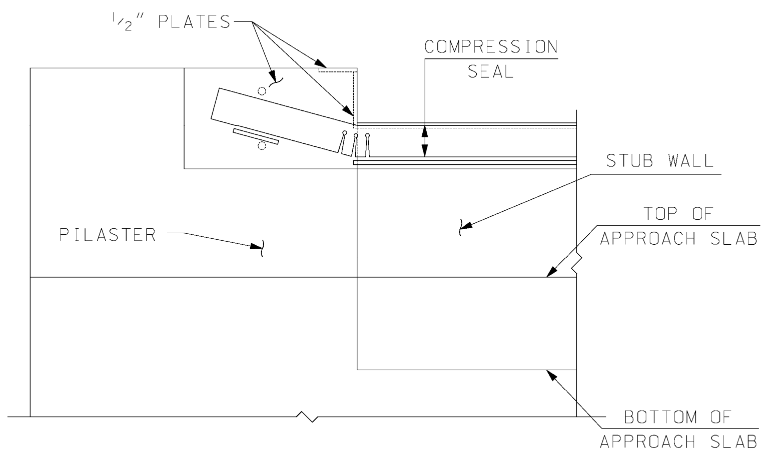
SECTION E-E

Note: For sections, see the following sheets.

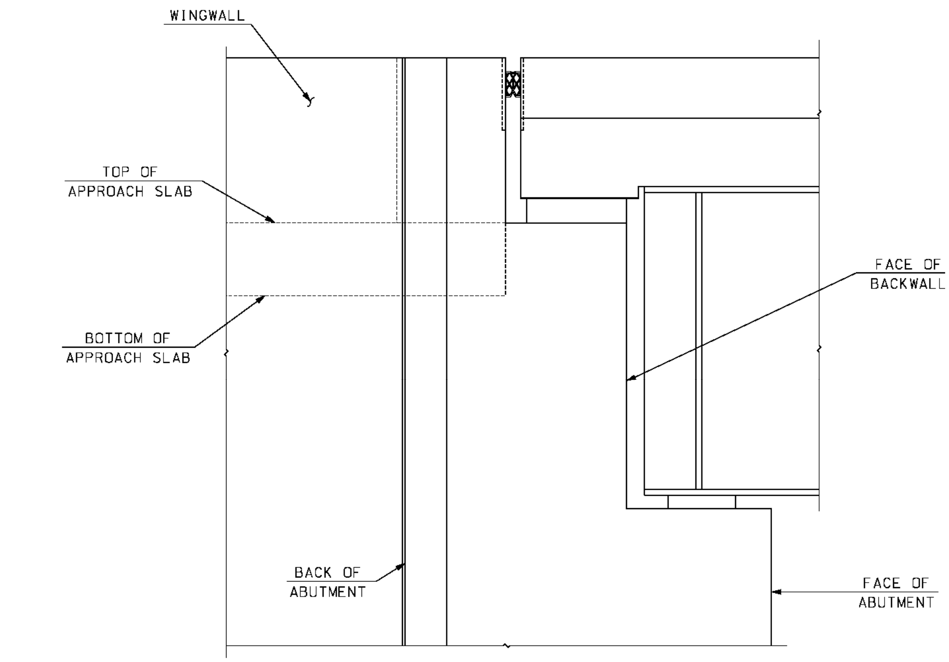


PLAN VIEW
(PROPOSED REHAB OF EXISTING BRIDGE: 30° SKEW, CURTAIN WALL, JOINT REPLACEMENT-STUBWALL)

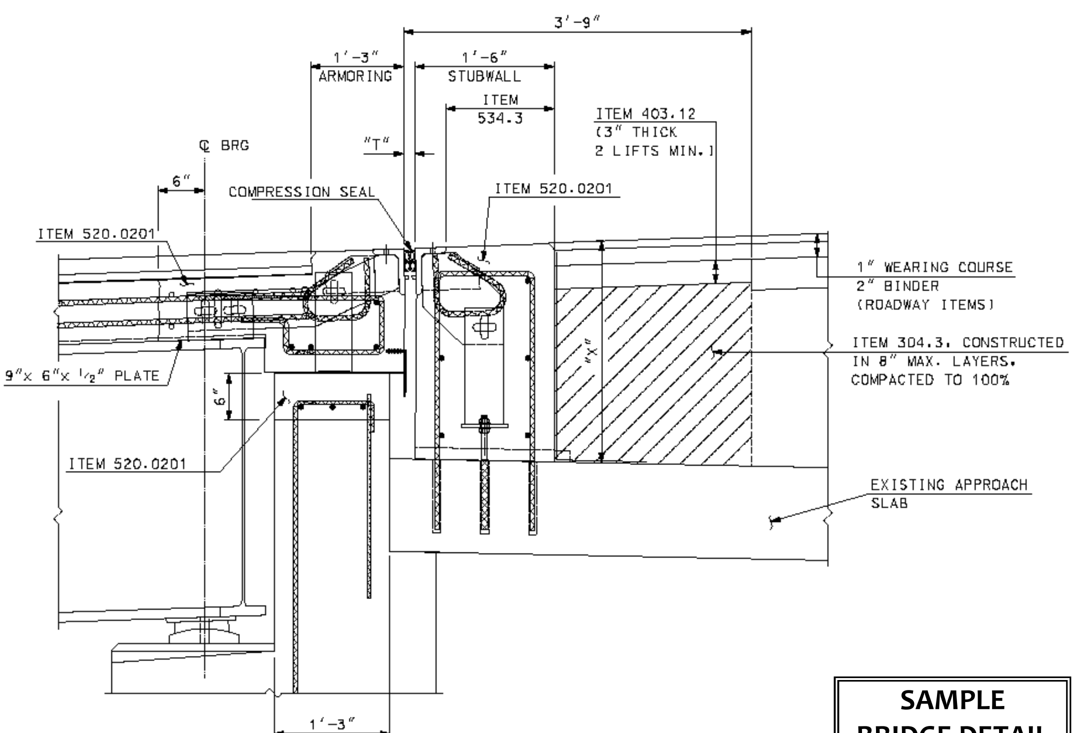
SAMPLE BRIDGE DETAIL
Date: 1/14/14



SECTION C-C



SECTION E-E



SECTION A-A RECONSTRUCTION

SAMPLE
BRIDGE DETAIL
Date: 11/14/18

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EXPANSION JOINT ANCHOR DETAILS

The expansion joint anchor details can be found at NHDOT Bridge Design Details web page:
http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/bridgedetails/index.htm

Scroll down to: Expansion Joints/Expansion Joint Anchor Details

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EXPANSION JOINT FIELD SPLICE WELD DETAILS

The expansion joint field splice weld details can be found at NHDOT Bridge Design Bridge Details web page:
http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/bridgedetails/index.htm

Scroll down to: Expansion Joints/Expansion Joint Field Splice Weld Details

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EXPANSION JOINT BACKING PLATE DETAILS

The expansion joint backing plate details can be found at NHDOT Bridge Design Bridge Details web page:
http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/bridgedetails/index.htm

Scroll down to: Expansion Joints/Expansion Joint Backing Plate Details

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EXPANSION JOINT PLATE/ANGLE CONNECTION DETAILS

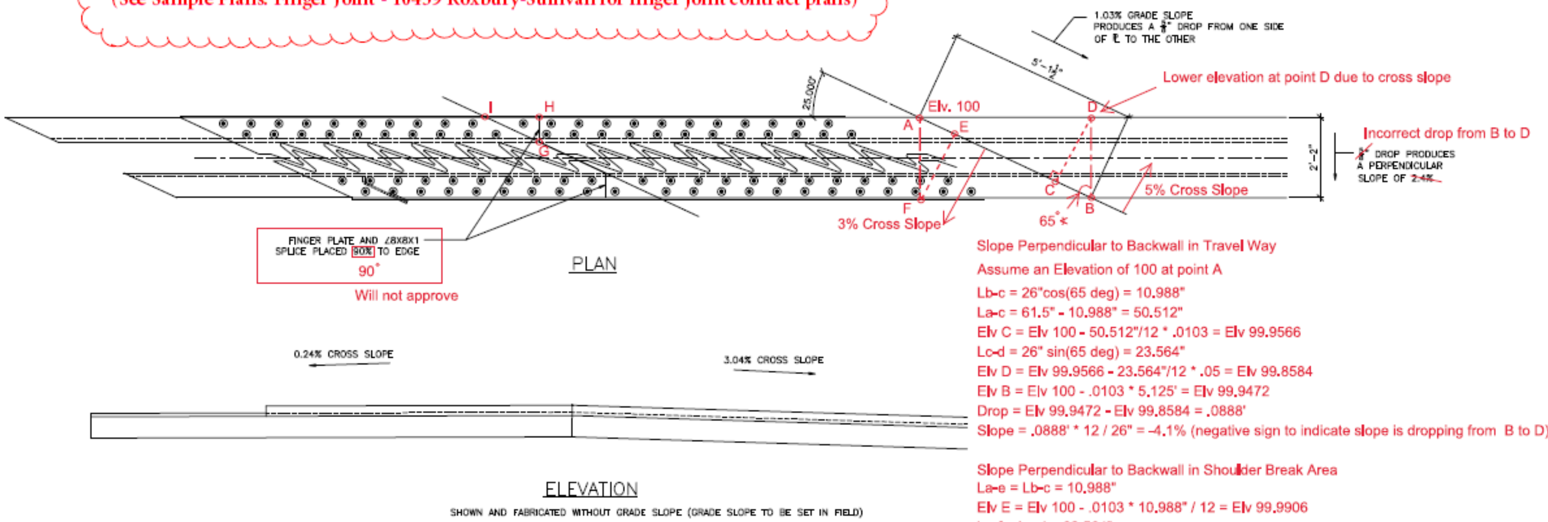
The plate/angle connection details can be found at NHDOT Bridge Design Bridge Details web page:
http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/bridgedetails/index.htm

Scroll down to: Expansion Joints/Expansion Joint Plate/Angle Connection Details

Note to Designer:

Details may need to be included for any armored joint. See Chapter 7, Section 7.4.7 for more information. See the following page for explanation of why angles are needed.

Explanation on why the profile, break-in-slope, and skew affect the plate cutting location.
(See Sample Plans: Finger Joint - 10439 Roxbury-Sullivan for finger joint contract plans)



Slope Perpendicular to Backwall in Travel Way
Assume an Elevation of 100 at point A
Lb-c = 26"cos(65 deg) = 10.988"
La-c = 61.5" - 10.988" = 50.512"
Elv C = Elv 100 - 50.512"/12 * .0103 = Elv 99.9566
Lc-d = 26" sin(65 deg) = 23.564"
Elv D = Elv 99.9566 - 23.564"/12 * .05 = Elv 99.8584
Elv B = Elv 100 - .0103 * 5.125' = Elv 99.9472
Drop = Elv 99.9472 - Elv 99.8584 = .0888'
Slope = .0888' * 12 / 26" = -4.1% (negative sign to indicate slope is dropping from B to D)

Slope Perpendicular to Backwall in Shoulder Break Area
La-e = Lb-c = 10.988"
Elv E = Elv 100 - .0103 * 10.988" / 12 = Elv 99.9906
Le-f = Lc-d = 23.564"
Elv F = Elv 99.9906 - .03 * 23.564" / 12 = Elv 99.9317
Drop = Elv 100 - Elv 99.9317 = .0683'
Slope = .0683' * 12 / 26" = 3.15%

Cross Slope Calculations
In Travel Way
La-d = 5.125' sin (65 deg) = 4.6448'
Slope = [Elv 100 - Elv 99.8584]/4.6448' = 3.05%

In Shoulder break
Lb-f = La-d = 4.6448'
Slope = [Elv 99.9472 - Elv 99.9317]/4.6448' = .33%

Notice from the calculations on the right for the slopes perpendicular to the back wall that the angles in the shoulder break are sloping up while the angles in the travel way are sloping down. If the angles are welded together at a 90 degree angle then as the angles are rotated to be flush with the deck in the travel way then two things will happen to the angles in the shoulder break. On the backwall side the angles will be rotated down and into the backwall when they need to rotate up and on the deck side the angles will be rotated up and out of the deck when the should be rotated down.

Calculation to determine how much the end of the angle will be recessed into the backwall or sticking out of the deck.

Assume point G Elevation = 100
Lg-h = 8"
Slope Perpendicular to backwall = -4.1%
Elv H = Elv 100 - 8"/12 *.041 = 99.9727
Cross slope of travelway angles from H to I = 3.05%
Elevation @ I if angle cut along shoulder break
Lh-i = 8"/tan(25 deg) = 17.1561"
Elv I = Elv 99.9727 + .0305 * 17.1561"/12 = 100.0163
Elevation @ I if angles cut 90 degrees to backwall.
Cross Slope of shoulder break angles from H to I = -.33%
Elv I = Elv 99.9727 - .0033 * 17.1561/12 = Elv 99.968

Elv Difference = Elv 100.0163 - Elv 99.968 = .0483' = .58"

Angle leg in shoulder area will be sticking out or into the concrete by .58" if cut at 90 degrees to backwall. Using the bent plate/angle connection detail as shown on bridge sheet 36 allows for the angles and plates to be cut along the crown line and match up without a misalignment at the top or having the leg stick in or out of the concrete.

ALL DIMENSIONS SHOWN ARE @ 65° F.

PAY ITEM: 561.3001

Roxbury-Sullivan 10439
NH Rte 9 over Otter Brook
Br. # 093/060

FINISH	GALVANIZED PER ASTM A123					
MATERIAL	ASTM A709 GRADE 50					
HOLES	15/16"Ø U.O.N.					
ELECTRODES						
WELDS	PER WPS					
SURFACE PREP						
		NO	DATE	DESCRIPTION	BY	
				REVISIONS		

EXPANSION JOINT SECTION A-A DRAWN ON PROFILE GRADE

The section A-A drawn on profile grade can be found at NHDOT Bridge Design Bridge Details web page:
http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/bridgedetails/index.htm

Scroll down to: Expansion Joints/Expansion Joint Section A-A Drawn on Profile Grade

Note to Designer:

Armored expansion joints on a profile grade are not being constructed correctly since the details are shown with a horizontal profile. This is especially important when a plow protection plate is placed on top of the expansion joint armoring. Therefore, all armored expansion joints on a profile grade shall be drawn showing the Section A-A along the profile, noting the location on the armoring where the profile grade shall be set. This detail shall replace the horizontal profile Section A-A that is shown on the corresponding expansion joint Detail Sheet.

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PLOW PROTECTION PLATE DETAILS

The plow protection plate details can be found at NHDOT Bridge Design Bridge Details web page: http://www.nh.gov/dot/org/projectdevelopment/bridgedesign/bridgedetails/index.htm

Scroll down to: Expansion Joints/Plow Protection Plate Details

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