C5.8.3 Expansion joints

C5.8.3.1.2 Design information

Iowa State University research on strip seal performance [BDM 5.8.3.1.5] has indicated that the AASHTO Procedure A cold climate temperature range [AASHTO-LRFD 3.12.2.1] generally is correct for steel but unconservative for concrete superstructures. The research also showed that the thermal coefficient for steel superstructures (0.0000065/ ºF) in the AASHTO Standard Specifications [10.2.2] generally is correct, the Bureau shrinkage coefficient for concrete superstructures (0.0002 in/in) is reasonable but difficult to verify, and the thermal coefficient for concrete superstructures (0.000006/ ºF) in the AASHTO Standard Specifications [8.5.3] is conservative. Based on the research and long-term experience with expansion joints, the Bureau policy is to use the temperature ranges and coefficients in Table 5.8.3.1.2 to determine movements for deck expansion joints.

Iowa State University produced a 2019 research report regarding expansion limits of D.S. Brown seal types A2R-400 and A2R-XTRA with steel extrusion type SSA2. As a result of this research, BDM Tables 5.8.3.2.1-1 and 5.8.3.2.1-2 were updated for the A2R-400 seal in the July 2021 BDM release. The results for the A2R-XTRA were not included in the BDM release since the roadway surface gap for this 7.0-inch seal will greatly exceed the 4.0-inch single gap limit given in AASHTO-LRFD 14.5.3.2 (9^{th} edition).

C5.8.3.2 Strip seals

C5.8.3.2.1 Analysis and design

These two examples illustrate how to select and specify strip seals. Example 1 is for a steel bridge with characteristics that permit use of only one manufacturer's seal. Example 2 is for a concrete bridge with characteristics that permit use of alternate seals, as preferred by the Bureau.

Example 1

Given: steel bridge, 420 feet long, 210-foot expansion length, 30-degree skew

Make preliminary selection.
For 30-degree skew, Table 5.8.3.2.1-1 lists maximum expansion length of 260 feet for Wabo SE-300 and 345 feet for Wabo SE-400. D.S. Brown A2R-400 is not acceptable. Try Wabo SE-300.

Check allowable movement capacity parallel with centerline of roadway for Wabo SE-300.
$(\Delta L)_{thermal} = \alpha\ L\ \Delta T$ = (0.0000065)(210)(12)(150) = 2.46 inches
$(\Delta L)_{shrink}$ = k L = (0)(210)(12) = 0 inches
$(\Delta L)_{total}$ = 2.46 + 0 = 2.46 inches [< 3.5 inches from Table 5.8.3.2.1-2, OK]

Check long-term maximum joint opening. [Numerical subscripts refer to temperatures in degrees Fahrenheit. Shrinkage is zero and not shown.]
Try 1.5 inch at 90 °F joint setting for best installation options.
$Width_{-25} = Setting_{90} + (\Delta L)_{115}$ = 1.5 + (0.0000065)(210)(12)(115)(cos 30) = 3.13 inches [> 3 inches {minimum of seal size and (3.5)(cos 30) = 3.03 inches, Table 5.8.3.2.1-2}, NG]

Try 1.5 inch at 80 °F joint setting.
$Width_{-25} = Setting_{80} + (\Delta L)_{105}$ = 1.5 + (0.0000065)(210)(12)(105)(cos 30) = 2.99 inches [< 3 inches {minimum of seal size and (3.5)(cos 30) = 3.03 inches, Table 5.8.3.2.1-2}, OK]

Check short-term minimum joint opening.
$Width_{125} = Setting_{80} – (\Delta L)_{45}$ = 1.5 – (0.0000065)(210)(12)(45)(cos 30) = 0.86 inches [> 0 inches, Table 5.8.3.2.1-2, OK]

Determine joint settings for plans.
$Setting_{50} = Setting_{80} + (\Delta L)_{30}$ = 1.5 + (0.0000065)(210)(12)(30)(cos 30) = 1.93 inches

$(\Delta L)_{40} = \alpha\ L\ \Delta T$ = (0.0000065)(210)(12)(40)(cos 30) = 0.57 inches
$Setting_{10} = Setting_{50} + (\Delta L)_{40}$ = 1.93 + 0.57 = 2.50 inches
$Setting_{90} = Setting_{50} – (\Delta L)_{40}$ = 1.93 – 0.57 = 1.36 inches

Determine maximum gland installation temperature.
Maximum installation temperature is 80 °F from joint setting trial above.

Specify only one strip seal: Wabo SE-300 with joint settings of 1 3/8 inches at 90 °F, 1 15/16 inches at 50 °F, and 2 1/2 inches at 10 °F. Specify that maximum gland installation temperature is 80 °F.

(It would be conservative in this example to specify Wabo SE-400.)

Example 2

Given: Concrete bridge, 600 feet long, 300-foot expansion length, 10-degree skew

Make preliminary selection.
For 10-degree skew, Table 5.8.3.2.1-1 lists maximum expansion length of 375 feet for Wabo SE-400 and 300 feet for D.S. Brown A2R-400. Try Wabo SE-400, and then try D.S. Brown A2R-400.

Check allowable movement capacity parallel with centerline of roadway for Wabo SE-400.
$(\Delta L)_{thermal} = \alpha\ L\ \Delta T$ = (0.000006)(300)(12)(100) = 2.16 inches
$(\Delta L)_{shrink} = k\ L$ = (0.0002)(300)(12) = 0.72 inches
$(\Delta L)_{total}$ = 2.16 + 0.72 = 2.88 inches [< 4.1 inches from Table 5.8.3.2.1-2, OK]

Check long-term maximum joint opening. [Numerical subscripts refer to temperatures in degrees Fahrenheit.]
Try 1.5 inch at 90 °F joint setting as best installation option.
$Width_0 = Setting_{90} + (\Delta L)_{90} + (\Delta L)_{shrink}$ = 1.5 + (0.000006)(300)(12)(90)(cos 10) + (0.72)(cos 10) = 4.12 inches [> 4 inches {minimum of seal size and (4.1)(cos 10) = 4.04 inches, Table 5.8.3.2.1-2}, NG]

Try 1.5 inch at 80 °F joint setting.
$Width_0 = Setting_{80} + (\Delta L)_{80} + (\Delta L)_{shrink}$ = 1.5 + (0.000006)(300)(12)(80)(cos 10) + (0.72)(cos 10) = 3.91 inches [< 4 inches {minimum of seal size and (4.1)(cos 10) = 4.04 inches, Table 5.8.3.2.1-2}, OK]

Check short-term minimum joint opening.
$Width_{100} = Setting_{80} – (\Delta L)_{20}$ = 1.5 – (0.000006)(300)(12)(20)(cos 10) = 1.07 inches [> 0 inches, Table 5.8.3.2.1-2, OK]

Determine joint settings for plans.
$Setting_{50} = Setting_{80} + (\Delta L)_{30}$ = 1.5 + (0.000006)(300)(12)(30)(cos 10) = 2.14 inches
$(\Delta L)_{40} = \alpha\ L\ \Delta T$ = (0.000006)(300)(12)(40)(cos 10) = 0.85 inches
$Setting_{10} = Setting_{50} + (\Delta L)_{40}$ = 2.14 + 0.85 = 2.99 inches
$Setting_{90} = Setting_{50} – (\Delta L)_{40}$ = 2.14 – 0.85 = 1.29 inches

Determine maximum gland installation temperature.
Maximum installation temperature is 80 °F from joint setting trial above.

Try D.S. Brown A2R-400.

Allowable movement capacity check will be the same as for the Wabo SE-400 seal.

Check long-term maximum joint opening.
Because Table 5.8.3.2.1-1 shows seal type to meet expansion length with no excess, try 2.0 inch at 60 °F joint setting.

$Width_0 = Setting_{60} + (\Delta L)_{60} + (\Delta L)_{shrink}$ = 2.0 + (0.000006)(300)(12)(60)(cos 10) + (0.72)(cos 10) = 3.99 inches [< 4 inches {minimum of seal size and (4.1)(cos 10) = 4.04 inches, Table 5.8.3.2.1-2, OK]

Check short-term minimum joint opening.
$Width_{100} = Setting_{60} – (\Delta L)_{40}$ = 2.0 – (0.000006)(300)(12)(40)(cos 10) = 1.15 inches [> 0.5 inches, Table 5.8.3.2.1-2, OK]

Determine joint settings for plans.
$Setting_{50} = Setting_{60} + (\Delta L)_{10}$ = 2.0 + (0.000006)(300)(12)(10)(cos 10) = 2.21 inches
$(\Delta L)_{40} = \alpha\ L\ \Delta T$ = (0.000006)(300)(12)(40)(cos 10) = 0.85 inches
$Setting_{10} = Setting_{50} + (\Delta L)_{40}$ = 2.21 + 0.85 = 3.06 inches
$Setting_{90} = Setting_{50} – (\Delta L)_{40}$ = 2.21 – 0.85 = 1.36 inches

Determine maximum gland installation temperature.
Maximum installation temperature is 60 °F from joint setting trial above.

Specify two, alternate strip seals:
- Wabo SE-400 with joint settings (to nearest 1/16 inch): 1 5/16 inch at 90 °F, 2 1/8 at 50 °F, and 3 inches at 10 °F and maximum gland installation temperature of 80 °F and
- D.S. Brown A2R-400 with joint settings (to nearest 1/16 inch): 1 3/8 inch at 90 °F, 2 3/16 at 50 °F, and 3 1/16 inches at 10 °F and maximum gland installation temperature of 60 °F.

C5.8.3.3 Finger joints

C5.8.3.3.1 Analysis and design

2011 ~ Minimum Opening and Temperature Settings for Finger Joints

During the 1990s the Bureau summarized and organized memos and Bureau practice for an Electronic Manual. The minimum finger joint opening of 0.5 inch for the Electronic Manual was taken from page 28-122, Through Highway Spans, Design, in Robert W. Abbett's *American Civil Engineering Practice*. Article 14.5.3.2 in the current AASHTO LRFD Specifications (2010 Interim) requires a minimum transverse deck joint opening of 1.0 inches for steel superstructures designed for the appropriate strength load combination but allows for a reduced opening for concrete superstructures. To more closely align with the AASHTO specifications the Bureau increased the minimum joint opening for steel superstructures but is neglecting the AASHTO load factor or Iowa setting factor because finger joints are required with this change to be installed with adjustment for the installation temperature. The designer is required to include on the plans the finger joint settings at 90, 50, and 10 degrees Fahrenheit.

C5.8.3.3.2 Detailing

2011 ~ Assembly of Finger Joints

In recent years finger joints have been fabricated with curb plates or barrier plate boxes shop welded to the ends of finger joint assemblies. During construction the attached plates and boxes must be cut loose so that the contractor can properly finish the deck. To improve constructability the curb plates and barrier plate boxes should not be shop attached but should be kept separate. After deck finishing the plates and boxes should be field welded in place and the galvanizing repaired using an approved method.

2011 ~ Elevation Adjustment for Finger Joints

The finger joint assembly will require elevation adjustment in the field. The +/- ½-inch minimum adjustment given in the manual may not be sufficient for the design haunch condition and, in that case, the designer will need to allow for more adjustment, either with a larger shim pack or by some other means. In unusual cases all of the design planning for elevation adjustment will not be adequate, and special field details will be necessary.