

## EXPANSION JOINTS

### NOTATIONS

$\theta$  = Skew angle.

$\alpha$  = Coefficient of thermal expansion  
           0.0000060/°F for concrete  
           0.0000065/°F for steel

$\beta$  = Shrinkage Coefficient for reinforced concrete on new construction, 0.0003.  
       For rehabilitation projects, assume all shrinkage has occurred and use a value of 0.0.

$\gamma_{TU}$  = Load factor due to temperature on new construction designed using LRFD, 1.20.  
       For rehabilitation projects not designed using LRFD, consider using a value of 1.0.

$\mu$  = Factor accounting for the restraining effect imposed by superstructure elements installed before the concrete slab is cast.  
       1.0 for flat slabs  
       0.8 for cast-in-place box girders and t-beams  
       0.5 for prestressed girders  
       0.25 for deck bulb-tee girders (no cast-in-place slab)  
       0.0 for steel girder bridges

$T_c$  = Structure temperature during construction of joint opening.

$L$  = Length of structure contributing to expansion or contraction of the joint (feet).

$W$  = Nominal uncompressed width of expansion seal (inches)

$A$  = Joint opening normal to joint at the time of deck placement (inches).

$K$  = Temperature drop below the installation temperature divided by temperature range.  
       Assume installation temperature equals 60°F

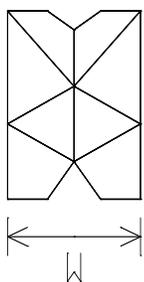
$M_t$  = Movement due to temperature (inches).

$M_s$  = Movement due to shrinkage after construction (inches)

$M_p$  = Movement parallel to joint (inches).

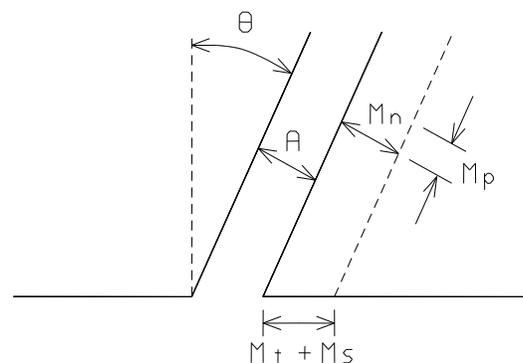
$M_n$  = Movement normal to joint (inches).

### JOINT SEAL



(uncompressed width)

### JOINT PLAN VIEW



## SELECTION CRITERIA FOR COMPRESSION SEALS

### Design Limitations

- A. Total anticipated movement of the expansion joint,  $M_t + M_s$ , should not exceed 2". When the nominal seal width computed by the following procedure exceeds 2", a joint system with greater movement capacity is required.
- B. The maximum joint opening shall not be greater than 0.85W. The minimum joint opening shall not be less than 0.40W. The minimum joint opening at installation of the seal shall not be less than 0.60W.
- C. The skew angle should not exceed 30°.
- D. Temperature Range
  - Concrete structures..... 0° to 80°F
  - Steel structures..... -30° to 120°F

### Design Procedure

- A. Movement Calculations
  - 1. Calculate the joint opening movement due to temperature drop from the installation temperature and shrinkage.  
 $M_t = 12 * L * \alpha * (\text{Installation Temp} - \text{Minimum Temp}) * Y_{TU}$   
 $M_s = 12 * L * \beta * \mu$
  - 2. Calculate the total closing movement due to temperature rise from the installation temperature.  
 $M_t = 12 * L * \alpha * (\text{Maximum Temp} - \text{Installation Temp}) * Y_{TU}$
  - 3. The total movement along the centerline of bridge is equal to (1) + (2).  
Movement parallel to joint  $M_p = (M_t + M_s) \sin \theta$   
Movement normal to joint  $M_n = (M_t + M_s) \cos \theta$
- B. Selection of Seal Width
  - 1. The maximum joint opening is equal to the minimum installation opening plus the movement due to temperature drop and shrinkage, therefore:  
 $0.85W = 0.60W + (\cos \theta)(KM_t + M_s)$ , or  
 $W = 4(\cos \theta)(KM_t + M_s)$
  - 2. The seal width to accommodate  $M_p$ :  
 $W = M_p \div 0.22$
  - 3. The seal width to accommodate  $M_n$ :  
 $W = M_n \div 0.45$
  - 4. The nominal seal width, W, shall be the largest of the values calculated in steps 1 thru 3 above.
- C. Select manufacturer's seal style and check for minimum gap and maximum gap normal to joint. The maximum gap along centerline of bridge at maximum movement shall not exceed 4" in accordance with AASHTO Article 14.5.3.2.
- D. Adjustment in joint opening for a 10°F change in temperature.

## SELECTION CRITERIA FOR SILICONE SEALS

### Design Limitations

- A. Sealant designed to accommodate 100% tension and 50% compression.
- B. Use on rehabilitation projects.
- C. Temperature Range
  - Concrete structures..... 0° to 80°F
  - Steel structures..... -30° to 120°F

### Design Procedure

- A. Movement Calculations
  - 1.  $M_t = 12(L)(\alpha)(\text{temp range}) (Y_{TU})$
  - 2.  $M_s = 0$
  - 3.  $M_{\text{normal}} = (M_t + M_s)(\cos\theta)$
  - 4.  $M_{10F} = 12(L)(\alpha)(10^\circ F)$
- B. Expansion gap widths at assumed extreme installation temperatures
  - 1.  $G_{\text{min}} = G_{\text{exist}} + (T_{\text{normal}} - \text{Install}_{\text{min}})/10(M_{10F})$
  - 2.  $G_{\text{max}} = G_{\text{exist}} - \text{Install}_{\text{max}} - T_{\text{normal}}/10(M_{10F})$
- C. Check sealant capacity if installed at assumed minimum temperature
  - 1. Closing movement
    - $M_c = (T_{\text{max}} - \text{Install}_{\text{min}})/10(M_{10F})$
  - 2. Check 50% compression
    - $M_c/G_{\text{min}} < 0.50$
  - 3. Opening Movement
    - $M_o = (\text{Install}_{\text{min}} - T_{\text{min}})/10(M_{10F})$
  - 4. Check 100% tension
    - $M_o/G_{\text{min}} < 1.00$
- D. Check sealant capacity if installed at assumed maximum temperature
  - 1. Closing movement
    - $M_c = (T_{\text{max}} - \text{Install}_{\text{max}})/10(M_{10F})$
  - 2. Check 50% compression
    - $M_c/G_{\text{max}} < 0.50$
  - 3. Opening Movement
    - $M_o = (\text{Install}_{\text{max}} - T_{\text{min}})/10(M_{10F})$
  - 4. Check 100% tension
    - $M_o/G_{\text{max}} < 1.00$

## SELECTION CRITERIA FOR STRIP SEALS

### Design Limitations

- A. Total anticipated movement of the expansion joint should not exceed 4". When the nominal seal width computed by the following procedure exceeds 4", a joint system with greater movement capacity is required. The movement is measured along centerline of bridge.
- B. The minimum joint opening at installation of the seal shall not be less than 1.5" normal to the joint.
- C. Skewed joints are classified as follows:

<u>TYPE</u>	<u>SKEW ANGLE</u>
1	≤30°
2	>30° ≤ 45°
3	>45°

For skews greater than 45° also contact the manufacturer's representative for help in selecting both the joint type and size.

- D. Temperature Range
- Concrete structures..... 0° to 80°F  
Steel structures..... -30° to 120°F

### Design Procedure

- A. Movement Calculations
1. Calculate the joint opening movement due to temperature drop from the installation temperature and shrinkage.
- $$M_t = 12 * L * \alpha * (\text{Installation Temp} - \text{Minimum Temp}) * Y_{TU}$$
- $$M_s = 12 * L * \beta * \mu$$
2. a. Calculate the total closing movement due to temperature rise from the installation temperature.
- $$M_t = 12 * L * \alpha * (\text{Maximum Temp} - \text{Installation Temp}) * Y_{TU}$$
- b. Convert the 1.5" minimum installation width normal to the joint to a length along centerline of bridge.
- c. Use the larger value obtained from (a) or (b).
3. The total movement along the centerline of bridge is equal to (1) + (2).
- B. Joint Size
1. Type 1 Joints: The joint size required equals the total movement along the centerline of bridge.
2. Type 2 Joints: The joint size required equals the larger of:
- The total movement along the centerline of bridge,
  - The movement parallel to the joint centerline divided by 0.60.
3. Type 3 Joints: The joint size required equals the larger of:
- The total movement along the centerline of bridge,
  - The movement parallel to the joint centerline divided by 0.50.
- C. Select manufacturer's seal style and check for minimum gap and maximum gap normal to joint. The maximum gap along centerline of bridge at maximum movement shall not exceed 4" in accordance with AASHTO Article 14.5.3.2.
- D. Calculate the adjustment in joint opening for a 10°F change in temperature.

## SELECTION CRITERIA FOR MODULAR JOINTS

### Design Limitations

- A. Maximum movement of 3" per each seal element.
- B. Maximum gap between adjacent center beams should be limited to 3".
- C. Temperature movements should be increased for the load factor of 1.20 for new construction.
- D. Temperature Range
  - Concrete structures..... 0° to 80°F
  - Steel structures..... -30° to 120°F
- E. The maximum gap along centerline of bridge at maximum movement shall not exceed 3" in accordance with AASHTO Article 14.5.3.2.

### Design Procedure

- A. Movement Calculations
  1. Calculate the joint opening movement due to temperature drop from the installation temperature and shrinkage.  
$$M_t = 12 * L * \alpha * (\text{Installation Temp} - \text{Minimum Temp}) * Y_{TU}$$
$$M_s = 12 * L * \beta * \mu$$
  2. Calculate the joint closing movement due to temperature rise from the installation temperature.  
$$M_t = 12 * L * \alpha * (\text{Maximum Temp} - \text{Installation Temp}) * Y_{TU}$$
  3. Total movement ( $M_t$ ) along centerline of bridge is the sum of (1) & (2).
  4. Total movement normal to joint is  $M_t(\cos\theta)$ .
- B. Joint Size
  1. Total movement range (MR) should be a multiple of 3" based upon A3.
- C. Installation Gaps
  1. Compute the minimum distance face-face of edge beams ( $G_{min}$ ).  
Number of seals (n) = MR/3  
Number of center beams = (n-1)  
w = Center beam top flange width  
g = Minimum gap per seal at full closure  
$$G_{min} = (n-1)(w) + (n)(g)$$
  2. Compute the maximum distance face-face of edge beams ( $G_{max}$ ).  
$$G_{max} = G_{min} + MR$$
  3. Compute gaps at different temperatures.
- D. Center Beam Spacing
  1. Check spacing between center beams at minimum temperature.  
$$G_{0F} = G_{60F} + \text{total opening movement}$$
$$\text{Spacing} = [G_{0F} - (n-1)(w)]/n$$
  2. Check spacing between center beams at 60°F for seal replacement.  
$$\text{Spacing} = [G_{60F} - (n-1)(w)]/n$$

**Revisions:**

- July 2009      Added definition of  $\mu$  on Page 1 and revised 0.8 factor to include c-i-p box girders & t-beams  
Added Selection Criteria for modular Joints  
Added Selection Criteria for silicone sealant joints
- March 2011    Changed coefficient of shrinkage for concrete  $\beta$  to 0.0003 to agree with the value used for bearing design.  
0.0003 is the average of the values in Article 5.4.3.2.1.  
Added temperature load factor of 1.20  
Deleted the 15% modular joint size increase due to adding the temperature load factor
- Feb 2012      Deleted shrinkage from rehabilitation projects.  
Deleted design examples.  
Added requirement that the maximum gap along centerline of bridge at maximum movement shall not exceed 4”  
in accordance with AASHTO Article 14.5.3.2
- July 2015      Added Restraining effect of 0.25 for deck bulb tees with no cast in place slab to account for the fact that most of  
the shrinkage has occurred by the time the expansion joint is installed in these types of bridges. The net effect is  
to reduce the shrinkage since there is no restraint.
- Added equations for calculating opening/closing movement and shrinkage movement to the Selection Criteria for  
Compression Seals, Strip Seals, and Modular Joints.
- Nov 2019      Corrected equation for modular joint installation gap in C. 1. From  $(n-1)*w + (n-1)*g$  to  $(n-1)*w + n*g$ .  
Changed the maximum gap along centerline from 3.5” to 3” to agree with the LRFD Specifications for modular  
joints.  
For modular joints, clarified that the 1.2 temperature factor is only used for new construction.