14.7.5.3.4—Stability of Elastomeric Bearings

Replace Article 14.7.5.3.4:

~~Bearings shall be investigated for instability at the service limit load combinations specified in the Table 3.4.1-1.~~

~~Bearings satisfying Eq. 14.7.5.3.4-1 shall be considered stable, and no further investigation of stability is required.~~

$$\cancel{2A \le B} \quad \text{(14.7.5.3.4-1)}$$

~~in which:~~

$$\cancel{A = \frac{1.92\frac{h_{rt}}{L}}{\sqrt{1+\frac{2.0L}{W}}}} \quad \text{(14.7.5.3.4-2)}$$

$$\cancel{B = \frac{2.67}{(S_i + 2.0)(1+\frac{L}{4.0W})}} \quad \text{(14.7.5.3.4-3)}$$

~~where:~~

~~G = shear modulus of the elastomer (ksi)~~

~~h_{rt} = total elastomer thickness (in.)~~

~~L = plan dimension of the bearing perpendicular to the axis of rotation under consideration (generally parallel to the global longitudinal bridge axis) (in.)~~

~~S_i = shape factor of the i^{th} internal layer of an elastomeric bearing.~~

~~W = plan dimension of the bearing parallel to the axis of rotation under consideration (generally parallel to the global transverse bridge axis) (in.)~~

~~For a rectangular bearing where L is greater than W, stability shall be investigated by interchanging L and W in Eqs. 14.7.5.3.4-2 and 14.7.5.3.4-3.~~

~~For circular bearings, stability may be investigated by using the equations for a square bearing with W=L=0.8L).~~

~~For rectangular bearings not satisfying Eq. 14.7.5.3.4-1, the stress due to the total load shall satisfy Eq. 14.7.5.3.4-4 or 14.7.5.3.4-5.~~

- ~~If the bridge deck is free to translate horizontally:~~

$$\cancel{\sigma_s \le \frac{GS_i}{2A-B}} \quad \text{(14.7.5.3.4-4)}$$

C14.7.5.3.4

Replace Article C14.7.5.3.4:

~~The average compressive stress is limited to half the predicted buckling stress. The latter is calculated using the buckling theory developed by Gent, modified to account for changes in geometry during compression, and calibrated against experimental results (Gent, 1964; Stanton at al., 1990). This provision will permit taller bearings and reduced shear forces compared to those permitted under previous editions of the AASHTO Standard Specifications.~~

~~Eq. 14.7.5.3.4-4 corresponds to buckling in a sideway mode and is relevant for bridges in which the deck is not rigidly fixed against horizontal translation at any point. This may be the case in many bridges for transverse perpendicular to the longitudinal axis. If one point on the bridge is fixed against horizontal movement, the sideway buckling mode is not possible, and Eq. 14.7.5.3.4-5 should be used. This freedom to move horizontally should be distinguished from the question of whether the bearing is subject to shear deformations relevant to Articles 14.7.5.3.2 and 14.7.5.3.3. In a bridge that is fixed at one end, the bearings at the other end will be subjected to impose shear deformation but will not be free to translate in the sense relevant to buckling due to the restraint at the opposite end of the bridge.~~

~~A negative or infinite limit from Eq. 14.7.5.3.4. 5 indicates that the bearing is stable and is not dependent on σ_s.~~

~~If the value $A-b \le 0$, the bearing is stable and is not dependent on σ_s.~~

<u>Equation (14.7.5.3.4-3) presumes that the bridge is not rigidly fixed against horizontal translation in the longitudinal direction. Buckling in the transverse bridge direction is not considered because either the direction is restrained, or if not, longitudinal buckling dominates due to the placement of bearings with the long dimension perpendicular to the bridge longitudinal axis. In any case, the designer should check buckling for the governing scenario.</u>

- ~~If the bridge deck is fixed against horizontal translation:~~

$$\cancel{\sigma_s \leq \frac{GS_i}{A-B}} \qquad \cancel{(14.7.5.3.4\text{-}5)}$$

Bearings shall be investigated for instability at the strength limit load combinations specified in the Table 3.4.1-1.

The critical buckling load at strength limit displacement ($\Delta_S = \Delta_{Sst} + \Delta_{Scy}$) is given by

$$P'_{cr_s} = P_{cr_s}\frac{A_r}{A} \qquad (14.7.5.3.4\text{-}1)$$

with

$$A_r = B(L - \Delta_S) \qquad (14.7.5.3.4\text{-}2)$$

and for rectangular bearings is

$$P'_{cr_s} = 0.680\frac{GBL^2(L-\Delta_S)}{(1+L/B)tT_r} \qquad (14.7.5.3.4\text{-}3)$$

A bearing design may be considered acceptable for buckling if

$$\frac{P'_{cr_s}}{(\gamma_{DC}P_{DC} + \gamma_{DW}P_{DW}) + \gamma_L(P_{Lst} + P_{Lcy})} \geq 2.0 \qquad (14.7.5.3.4\text{-}4)$$

where:

A = bonded rubber area of elastomeric bearing (in^2.)
A_r = reduced bonded rubber area of elastomeric bearing (in^2.)
B = long plan dimension of rectangular bearing (in.)
G = shear modulus of rubber (psi)
L = short plan dimension of rectangular bearing (in.)
P_{cr_s} = critical load in un-deformed configuration (kip)
P'_{cr_s} = critical load in deformed configuration (kip)

P_{DC} = dead load (kip)
P_{DW} = wearing surfaces and utilities load (kip)
P_{Lst} = static component of live load (kip)
P_{Lcy} = cyclic component of live load (kip)
t = rubber layer thickness (in.)
T_r = total rubber thickness (in.)
γ_{DC} = load factor for dead load
γ_{DW} = load factor for wearing surfaces and utilities loads
γ_L = load factor is either HL-93 or Permit truck load
Δ_S = non-seismic lateral displacement (in.)
Δ_{Sst} = static component of non-seismic lateral displacement (in.)
Δ_{Scy} = cyclic component of non-seismic lateral displacement (in.)

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14.10 –REFERENCES

Add to References:

Constantinou, M.C., Kalpakidis, I., Filiatrault, A. and Ecker Lay, R.A. (2011), "LRFD-Based Analysis and Design Procedures for Bridge Bearings and Seismic Isolators", *Report No. MCEER-11-0004*, Multidisciplinary Center for Earthquake Engineering Research, Buffalo, NY

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