

**NDOT STRUCTURES MANUAL
REVISION 2019-3
March 2019**

Revision Summary

Page(s)	Manual Subsection	Description
13-3	13.1.2.2.3	Add provision for the reduction of dead load skew factors for post-tensioned box girders.
13-10	13.3.1	Add requirement clarifying that all bridges shall be analyzed and detailed in accordance with Seismic Zone 3 and 4 requirements. Add provision for the use of the AASHTO Guide Specifications for LRFD Seismic Bridge Design. Add revised column overstrength moment resistance factor.

Revisions indicated by underscored text.

13.1.2.2.3 Skewed Bridges

Simplified analyses using the specified distribution factors of LRFD Article 4.6.2.2 can be used for skewed bridges provided that adjustments are made.

The bending moment in the longitudinal direction in a skewed bridge is generally smaller than the bending moment in a rectilinear bridge of the same span. NDOT currently does not take advantage of the reduction in load distribution factors for moment in longitudinal girders on skewed supports.

Torsional moments exist about the longitudinal axis in skewed bridges due to gravity loads (both dead and live load). These moments increase the reactions and shear forces at the obtuse corners compared to the acute corners.

The potential exists for reactions to become very small or negative at acute corners, and should be avoided whenever possible during design. This can be achieved in post-tensioned bridges by the appropriate choice of the prestressing forces and the tendon profiles. The bridge designer should account for the higher reactions at the obtuse corners in the design of bearings and the supporting elements.

The skew correction factors for shear of LRFD Table 4.6.2.2.3c-1 shall be used to adjust the live load shears and reactions in skewed bridges. Figure 13.1-B shall be used to adjust the dead load shears and reactions. For shear design, the factors are assumed to vary linearly from the maximum value at the support to unity at midspan. The dead load skew factors from Figure 13.1-B may be reduced for post-tensioned box girders based on methods approved by the Chief Structures Engineer.

Curved bridges with supports skewed off of the radial direction by relatively large skew angles should be analyzed using a refined analysis; see Section 13.2.

13.3.1 General

The objective of seismic analysis is to assess the force and deformation demands and capacities on the structural system and its individual components. Equivalent static analysis (ESA) and linear elastic dynamic analysis (EDA) are the appropriate analytical tools for estimating the displacement demands for Ordinary Standard bridges. Inelastic static analysis (ISA) is the appropriate analytical tool to establish the displacement capacities for Ordinary Standard bridges.

All bridges shall be analyzed and designed in accordance with the criteria for Seismic Zones 3 and 4. Bridges may be analyzed and designed in accordance with AASHTO Guide Specifications for LRFD Seismic Bridge Design. If the *Seismic Guide Specification* is used, bridges shall be analyzed and designed in accordance with the criteria for SDC C or D. If the *Seismic Guide Specification* is not used, the column moment overstrength resistance factor shall be 1.4, since it is applied to the nominal moment that is calculated based on the specified minimum material strengths.