15-19 BRIDGES WITH SKEWED SUPPORTS

General

This memo provides recommendations for the design of bridges on straight alignments with support skews between 0 and 60 degrees and for concrete bridges on curved alignments with support skews between 0 and 45 degrees. For the purpose of this memo, a bridge on a curved alignment can be considered to be on a straight alignment as long as its curvature effects can be ignored according to AASHTO-LRFD 4.6.1.2.

For bridges on straight alignments with support skews exceeding 60 degrees and for curved concrete bridges with support skews exceeding 45 degrees, the designer should use a full three-dimensional (3D) model, such as a grillage or shell model, to more accurately capture true load distribution.

When determining the effect of skewed supports on bridges with curved alignments, the effect of both curvature and skew shall be included. Refer to AASHTO-LRFD 4.6.1.2 for consideration of curved alignment effects.

Background

Historically, bridges were typically designed using two-dimensional (2D) frame analysis and design software. A 2D frame model was created to analyze the bridge in the longitudinal direction, that is, the direction along the centerline of the bridge. Using reactions from the longitudinal 2D model, a 2D frame model for each bent was generated to analyze the bents in the transverse direction, that is, the direction parallel to the centerline of the bent. Bridge components were designed using results from the longitudinal model, the transverse model, or a combination of the two.

For the superstructure, it was assumed that support skew does not affect the distribution of loading response across the section with the exception of shear. In a skewed bridge, loads tend to distribute to the supports in a direction normal to the supports. This causes a greater proportion of the load to concentrate at the obtuse corners of the span and less at the acute corners. For concrete bridges, Bridge Design Aids 5-31 presented factors (developed from a 3D parametric study) to modify the girder shear demands obtained from a longitudinal 2D frame analysis.

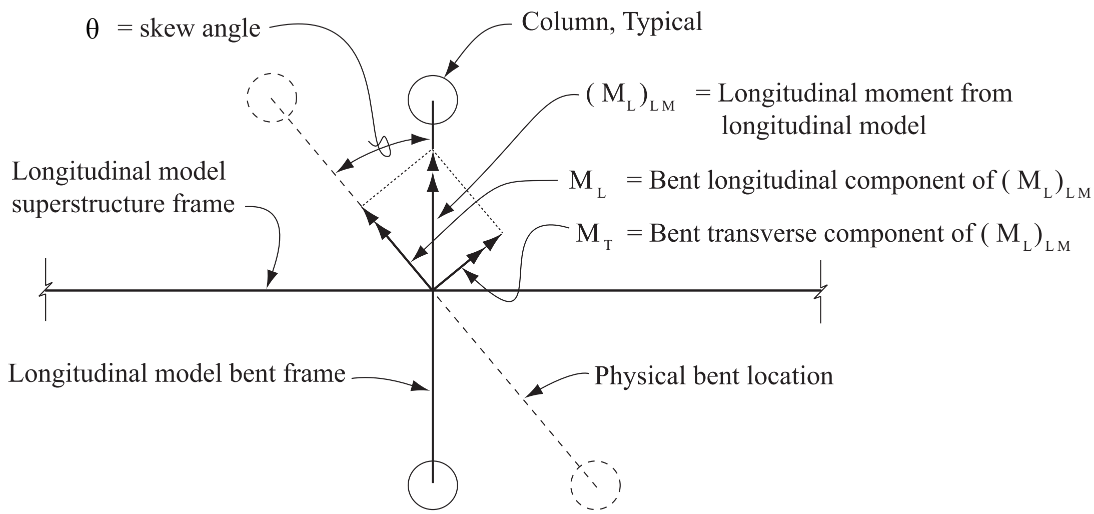
Design Tools

Some current longitudinal bridge design software tools such as CTBridge and CONBOX use models in which the superstructure is modeled as a single spine of frame elements supported on bents composed of frame elements. Like 2D frame models, these 3D spine models cannot capture any non-uniform transverse distribution of loading response across the superstructure section. Consequently, for superstructure shear design, the use of skew correction factors for obtuse girder regions is still required (AASHTO-LRFD 4.6.2.2.3c and CA Amendments 4.6.2.2.6).

When using 3D spine software programs like CTBridge and CONBOX, the designer has the option of assigning a skew angle between the superstructure spine and a support for the analytical model. However, it has been determined that if abutment, bent, or hinge supports are skewed relative to the superstructure spine, the longitudinal distribution of moment can change dramatically and unconservatively from that of the equivalent non-skewed spine model. The change in distribution is amplified for larger skews and is most significant when modeling unbalanced span geometries and when modeling simple supports as rollers and pins restrained against torsion. It has also been determined that if abutment, bent, or hinge supports are skewed relative to the superstructure spine, moments and torsions can be reported in the software output which, although accurate for the spine model itself, are not necessarily representative of actual structure demands. In addition, the demands generated for column design do not include full 3D effects from the longitudinal model and are, therefore, not necessarily more accurate than if one were to exclude the support skew in the model.

Design Recommendations

Based upon the above considerations, it is recommended that longitudinal models created in programs such as CTBridge and CONBOX exclude the physical skew at support locations for the analytical model. The design of the superstructure should not include the effects of skewed supports except that the use of skew correction factors for shear design at obtuse girder regions is required (AASHTO-LRFD 4.6.2.2.3c and CA Amendments 4.6.2.2.6). Physical skew shall, however, be considered in the geometry of transverse 2D bent models; and loads to the substructure from the longitudinal model shall be appropriately transformed into components consistent with the bent model for column design (see Figure 1).



M_L and M_T are transformed components of response from the longitudinal analysis and are to be added to the response from the bent analysis.

$M_L = (M_L)_{LM} \times \cos\theta$

$M_T = (M_L)_{LM} \times \sin\theta$

Other longitudinal force effects shall be transformed similarly.

Figure 1 Plan View of Longitudinal Model at Bent

References

Davis, Ray and Wallace, Mark, *Skew Parameter Studies*, Volumes 1 & 2, October 1976.

Original signed by Barton J. Newton

Barton J. Newton

State Bridge Engineer

Deputy Division Chief, Structure Policy & Innovation

Division of Engineering Services