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16. Abstract

Integral-abutment bridges, which do not contain expansion joints, provide a very attractive alternative to the more traditional, stub-abutment bridges that have expansion joints. Jointless bridges have lower construction and maintenance costs than those costs for bridges with expansion joints. The integral connection between the abutment, bridge girders, and piles introduces additional strains and corresponding stresses in the bridge members as a result of thermal expansion and contraction of the bridge superstructure. Experience of bridge engineers from many state departments of transportation who design and construct integral-abutment bridges indicate that these bridges are performing well.

The objectives of this research program were to evaluate the state-of-art for the design of prestressed-concrete (PC), integral-abutment bridges; to validate the assumptions that are incorporated in the current-design procedures for these types of bridges when they are subjected to thermal-loading conditions; and, as appropriate, to revise and improve the current-design procedures for this type of a bridge, as that design relates to the thermally-induced displacements of the abutments and the thermally-induced forces in the abutments and abutment piles.

Two, skewed, PC girder, integral-abutment bridges in the State of Iowa were instrumented over a two-year period to measure structural behavior. Longitudinal and transverse displacements and rotation of the integral abutments, strains in the steel piles and in the PC girders, and temperature distributions were recorded throughout the monitoring period for both bridges. The coefficient of thermal expansion and contraction for the concrete in core specimens that were taken from 20 bridge decks and from several PC girders was experimentally measured at the 100%-dry and 100%-saturated conditions. The longitudinal displacements of the integral abutments correlated well with the recorded change in the bridge temperature. Total, longitudinal, pile strains exceeded the minimum, specified, yield strain of the steel for both bridges. Longitudinal strains in the PC girders were well within acceptable limits. The experimental data were used to calibrate and refine finite-element models of both bridges. Discrepancies were not fully explained for the differences between the predicted and measured, thermal expansion of the bridge and vertical rotations of the integral abutments.

Recommendations for the design of integral-abutment bridges with PC girders and steel piles were advanced, including equations and procedures for the design-temperature range, vertical-temperature gradients in the bridge superstructure, longitudinal displacements of the integral abutments, concrete creep and concrete-shrinkage effects, and coefficients of thermal expansion and contraction for the concrete. Software was presented to estimate the transverse movement of skewed, integral-abutment bridges. Approximate methods were outlined to analyze the abutment pile cap and backwall and to check their designs. Ductility demands placed on the abutment piles during thermal movements were compared to the ductility capacity for the piles when they are subjected to biaxial, cyclic, and reversed loading conditions. Some of the design recommendations were illustrated by examples.

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