

UTC Project Information	
Project Title	MPC-478 – Long-Term Behavior of Precast Concrete Bridges
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Project Duration	September 30, 2013 to September 30, 2018
Brief Description of Research Project	<p>The inclusion of uniform temperature effects for bridges has traditionally been incorporated in design by allowing for expansion and contraction through the utilization of bearings and joints or deformations of the piers and abutments in the case of integral abutment construction. However, as a result of the growth in the multi-modal transportation system, more complex and longer-span bridges are now being constructed, requiring new material technologies and design methodologies. These modern bridges are increasing the necessity for accurate accounting of thermal effects to achieve the desired in-service performance. In general, temperature effects not only include these uniform changes but also changes in temperature gradients throughout the day. A vertical nonlinear temperature gradient over the height of the bridge cross section is caused by the relatively low thermal conductivity of the concrete deck and the variation of ambient temperature magnitudes with time. This nonlinear temperature gradient induces longitudinal stresses over the height of each of the girders across the width of the bridge that can lead to cracking and unacceptable service conditions if not taken into account properly.</p> <p>The magnitude of the temperature gradients that are produced over the height of a bridge structure depend mainly on geometry, location, orientation, bridge properties, environment and placement of any asphalt overlay. Imprecise thermal analysis of bridges has led to severe cracking and deterioration or even failure of structures (Priestley 1978; Moorty and Roeder 1990). To address these observed serviceability issues, engineers have at times, reduced the number of joints and designed monolithic, cast-in-place structures</p>

such as integral-abutment bridges. While eliminating the joints solves some serviceability problems, the thermal movement of these bridge types are restrained therefore proper detailing for the induced stresses are essential.

Several theoretical relationships based on one and two dimensional heat flow theory, solar radiation levels and daily air temperature distribution have been proposed to predict the changes in the nonlinear temperature distribution over a typical bridge cross section. Although the exact procedures for these proposed relationships vary, the consistent objective is to obtain a better estimate of the temperature profile and resulting stress distribution (Roeder 2003). Thepchatri and Johnson (1978) proposed a method to quantify temperature effects for various types of highway bridge cross sections including different environmental conditions by using finite-element analyses that incorporated heat flow and thermal relationships. The researchers validated their proposed methodology with measured data. Priestley et al. (1984) developed a thermal design procedure based on research conducted in New Zealand. The overall design philosophy consisted of three steps. First, the engineer obtained the predicted critical design gradient based on known local ambient characteristics. Second, a calculation of the corresponding stress levels based on simple statics induced in the bridge superstructure by the design thermal gradient was performed. Third, the influence of the thermally induced stresses for serviceability and ultimate load states was quantified. This procedure served as a basis for the development of the thermal design gradient that was eventually adopted in several design procedures.

Roeder (2003) proposed an alternative procedure to Priestley's Method for determining bridge design temperatures and thermal movements. For this research, 1,273 temperature measurements with an average time history of 70.7 years taken from different locations throughout the United States were utilized. This diverse data set resulted in the creation of bridge temperature design maps for initially steel girder bridges and subsequently concrete girder bridges throughout the continental 48 states. The AASHTO LRFD Specifications adopted this method in 2005. Other studies that have quantified the temperature effects on bridges include Emerson (1982), Branco and Mende (1993), Newhouse et al. (2008), Lee (2012) and Cai et al. (2012).

The research that has been performed is all based on limited sensor readings in the deck where the temperature gradient is the most severe. This research will result in a high-density array of data that not only quantifies changes in temperature vertically by also transversely across the bridge width.

Research Objectives:

	<p>The objective of this research is to compare measured temperature variations with predicted temperature variations in accordance to the AASHTO LRFD Specifications. Differences between the two sources will be quantified. In addition, the effect of temperature variations on prestressed concrete girder design will be summarized.</p>
<p>Describe Implementation of Research Outcomes (or why not implemented)</p> <p>Place Any Photos Here</p>	<p>This research project was focused on quantifying the prestress losses and temperature distribution of a precast, prestressed concrete girder bridge. It was observed that the measured elastic shortening losses were more accurately predicted with the high-strength modulus of elasticity equation. The long-term losses were conservative. It is believed that UDOT will start using the modulus of elasticity equation for high strength as recommended. Long-term losses will have to be made at the federal level. Hopefully with more data available, this change will be coming.</p>
<p>Impacts/Benefits of Implementation (actual, not anticipated)</p>	<p>Accurately predicting short-term losses is significant because not only does provide a more accurate long-term loss calculation but it also helps camber prediction, which is essential for serviceability. We found that using the high-strength equation for elastic modulus can improve percent errors of short-term losses from approximately 6 to 8%.</p>
<p>Web Links</p> <ul style="list-style-type: none"> • Reports • Project Website 	<p>https://www.ugpti.org/resources/reports/details.php?id=909</p>