Development of Probabilistic Temperature Loadsfor a PC Bridge in Oklahoma

Jun HE
Associate professor
Changsha Univ. of Science and Technology, Hunan, China
frankhejun@gmail.com

Naiyu WANG
Assistant Professor
University of Oklahoma, Norman, USA
naiyu.wang@ou.edu

K.K. Muraleetharan
Professor
University of Oklahoma, Norman, USA
muralee@ou.edu

Summary

Temperature effects have always been considered to be one of the critical issues that affect the performance of traditional PC bridges. In order to develop an efficient temperature loading model for predicting bridge temperature-induced response, numerical and analytical studies were conducted on a PC girder bridge in Oklahoma. Firstly, a heat transfer model was established with hourly climate input data to estimate the temperature distribution and compared with monitoring counterparts. Secondly, probabilistic models of temperature loading were proposed based on environmental conditions from the 20-year climatic data and heat transfer analytical results. Finally, and the temperature loading values for a 75-year return period were determined and compared with recommended values in AASHTO LRFD(2012). The proposed temperature loading model can be referred to aid engineers in predicting the thermal behaviour of PC girders in Oklahoma.

Keywords: PC bridge; temperature loading; probability model; finite element analysis.

1. Introduction

Bridges are subject to daily, seasonally, and annually varying environmental thermal effects induced by solar radiation and surrounding air temperature. Uniform temperature effects, referring to the average temperature change along the cross section of a bridge, often induces expansion or contraction movements. Linearly or nonlinearly distributed temperature effects, with varying temperatures from the top to bottom surfaces of a bridge, often causes bending deflections. Any restraints to these deformations can induce thermal forces, potentially excessive stresses and cracks. To calculate temperature-induced responses and evaluate the thermal effects on bridge behaviour, the entire structural temperature distribution must be accurately known first. Early studies of temperature effects on concrete bridges in the 1950s and 1960s generally focused on one-dimensional (1D) heat flow in the vertical direction using experimental data or empirical formulas[1].These methods are basically 1D, can hardly capture the temperature variation and distribution of relatively complicated structures. Emanuel and Hulsey [2] built two-dimensional (2D) models and investigated the effects of weather data on the sectional temperature distribution within concrete-steel composite bridges. For PC bridges, several researchers examined the thermal effects including laboratory tests, field investigations and theoretical or numerical analyses[3-5]. Some laboratory experiments and field investigations have shown that changing temperature conditions may have a more significant effect on structural behaviour than those exerted by operational loads[6,7].

The AASHTOLRFD specification (2012)[8] provides provisions for uniform designing temperatures and temperature gradients. The transversal temperature difference is usually smaller than the vertical difference for most types of bridge, especially for concrete bridges [9], hence

https://doi.org/10.2749/222137816819259031
Distributed by structurae