Investigation of Frame Piers under Temperature, Shrinkage, and Creep Effects

Cole Shurbert-Hetzel
Graduate Research Assistant, Iowa State University, colesh@iastate.edu

Behrouz Shafei
Assistant Professor, Iowa State University, shafei@iastate.edu

Katelyn Freeseman
Associate Director, Iowa State University, kfreese@iastate.edu

Frame piers are a type of bridge pier composed of multiple columns supporting a cap beam. This type of pier is often the most efficient and economic choice when piers do not need to be placed in water or designed for vehicular collisions. However, frame piers become increasingly susceptible to forces caused by temperature and shrinkage effects as the length of the pier increases. This is particularly a problem in bridges with wide decks or high skew. Many factors need to be considered when designing for these forces in long frames, such as the age of the structures, the rate of creep and shrinkage, and the nonlinear behavior concrete. Due to the difficulty in accurately determining the forces, designers may overdesign a pier for these forces and diminish the benefits of frame piers. Through a holistic finite element analysis and field monitoring of newly constructed frame pier bridges, this study investigates forces caused by temperature and shrinkage in frame piers. Field data is collected from bridges that are instrumented with vibrating wire strain gauges embedded in the frame piers. The sensors record the strain in the rebar and the temperature of the sensor itself every hour. The temperature data is used to create a temperature time history, which is applied to a finite element model. The strain data is used to validate the finite element analysis model. A shrinkage program is developed to run concurrently with finite element analyses to accurately model time dependent shrinkage and creep of the concrete. The finite element models are validated with collected field data and data from available concrete shrinkage and creep databases. Various geometries, temperature fields, and ages of the piers are simulated using the validated model. The most susceptible frame pier geometries are identified. Design guidelines and limits for frame pier design are recommended as the outcome of this investigation.

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