DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Column Base Pipe Pins for Accelerated Bridge Construction

New pipe pin connections speed up construction and reduce the size of bridge foundations

Seismic

JANUARY 2015

Project Title:
Experimental and Analytical Seismic Studies of Bridge Piers with Innovative Pipe Pin Column-Footing Connections and Precast Cap Beams

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WHAT IS THE NEED?

Prefabricated bridge elements, such as columns and bent cap beams, expedite bridge construction. Connecting the prefabricated elements to the rest of the bridge is critical to resisting traffic and earthquake loads. However, the connections used for bridges in low seismic zones do not always have sufficient ductility and strength to withstand a seismic event. Cost-effective, practical, and reliable bridge connections must be designed for California's bridges.

Caltrans bridge engineers had developed pipe pins for connections at the top of columns for conventional, cast-in-place bridge construction. Previous studies showed that the pipe pins can be adapted for Accelerated Bridge Construction, but they cannot be used at the bottom of columns. The bottom of the column can experience uplift force under horizontal loading, which must be resisted without inducing flexural strength at the pin, because the connection would no longer be "moment-free."

WHAT WAS OUR GOAL?

The goal was to design, test, and analyze two types of column connections to reduce the moment transfer between structural elements: pipe pin connections for the base of precast or cast-in-place bridge columns to the footing, and pocket connections for the top of precast columns to the cap beam.

WHAT DID WE DO?

Caltrans, in partnership with the University of Nevada, Reno Large Scale Structural Laboratory, tested a large-scale two-column bent model under simulated earthquake loading. The model was composed of a precast concrete pedestal, a precast engineered cementitious composite (ECC)-concrete column, a cast-in-place reinforced concrete column, a precast cap beam, and two single footings. The columns were connected to the footing and cap beam using pipe pin and pocket connections, respectively. The researchers subjected the pins to direct tension to investigate the failure mode and determine their ultimate tensile capacity.

The researchers also designed new pocket connections, which are constructed by leaving an opening in the cap beam and placing a prefabricated column in the pocket followed by grouting, because they can be an efficient way of connecting the bridge pieces. When properly designed and constructed, these connections provide strong seismic joints that can resist demanding earthquakes. To keep bridges operational even after strong earthquakes, the team investigated using concrete with special fibers to enhance seismic resistance.

The team calibrated analytical models using experimental data and then used them to simulate the effect of earthquakes on various pipe pin designs. Results of the parametric studies, along with the experimental observations, led to an accurate method to estimate seismic loads and designing pipe pins.

WHAT WAS THE OUTCOME?

The research designed a proof-tested, reliable pipe pin design for column footing connections. Pocket connections were refined and made ready for real-world application in California bridges. Using concrete with special fibers demonstrated that earthquake damage can be minimized. The precast ECC-concrete column demonstrated that this material can reduce repair costs after strong earthquakes.

WHAT IS THE BENEFIT?

The precast cap beam incorporating the proposed pocket connections meets Caltrans design requirements for strong earthquakes. The connection can be used in both conventional and prefabricated bridge construction.
The proposed base pipe pin connection decreases the size of the foundation compared to fixed base connections, which significantly reduces bridge costs.

LEARN MORE

To view the complete report:
http://wolfweb.unr.edu/homepage/saiidi/caltrans/basepins.html

IMAGES

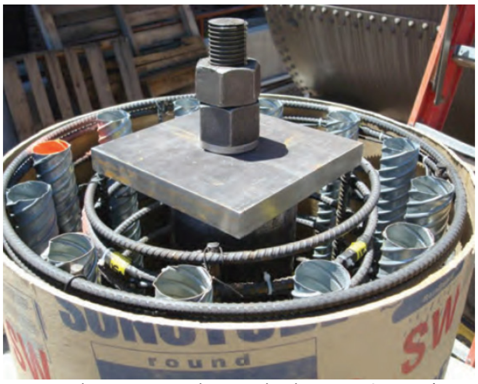
Figure 1: Pipe pin in pedestal


Figure 2: Pedestal with pipe pin connection at base