DRISI
Caltrans Division of Research, Innovation and System Information

Research Results

Seismic

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Project Title:
Concrete-Filled Tube Pier Connections for Accelerated Bridge Construction

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Designing Concrete- Filled Tube Column-to-Cap Connections

New column connections facilitate accelerated bridge construction in high seismic locations

WHAT IS THE NEED?

Concrete-filled tubes (CFT) are composite structural elements that provide strength and stiffness. The steel tube serves as formwork and reinforcement to the concrete fill, negating the need for reinforcing cages, elaborate shoring, and temporary formwork. CFTs are an efficient alternative to conventional reinforced-concrete construction, facilitating accelerated bridge construction (ABC) and reducing material and labor costs. Despite their structural advantages, the use of CFTs has been limited in seismic regions due a lack of practical connection details, large-scale testing, and design equations.

WHAT WAS OUR GOAL?

The goal was to develop CFT column-to-cap beam connections capable of sustaining cyclic, nonlinear deformation demands while minimizing damage and degradation to facilitate ABC in seismic regions.

WHAT DID WE DO?

Caltrans, in partnership with the University of Washington Department of Civil and Environment Engineering, tested new CFT column-to-cap beam connections using a monotonically increasing cyclic loading protocol. The three proposed connection types included embedded CFT, welded dowel, and embedded dowel. For the facilitation of ABC, all connection types used a grouted detail with a single void cast into a precast beam.

For the embedded CFT connection, an annular flange was welded to the top of the steel tube to provide anchorage and transfer stress to the concrete and reinforcing in the cap beam. The CFT component controls the strength and ductility.

The welded dowel connection used a series of vertical-headed reinforcing bars welded to the inside of the tube and developed into the cap beam. The reinforcement ratio of the longitudinal bars, which extend from the column into the cap beam, controls the strength while the confinement controls the ductility.

The embedded dowel connection consisted of a more traditional reinforced concrete dowel connection, with both transverse and longitudinal reinforcing extended from the CFT column into the cap beam as a short inner cage. The reinforcing ratio and moment arm of the longitudinal reinforcing controlled the strength, and local confinement controlled the ductility. Construction of this connection would require a friction collar to temporarily support the cap beam.

WHAT WAS THE OUTCOME?

All specimens exhibited sufficient strength and ductility while limiting damage to the cap beam for both the longitudinal and transverse directions. The overall behavior emulated cast-in-place construction. Some damage states and failure modes observed during testing include the following.

Embedded CFT connection—Tube buckling observed at 3.5% drift, but no strength degradation. Tube tearing initiated at 7.5%. The test was stopped at 9% drift as tube tearing propagated around the base of the column. Traditional columns typically achieve 8% to 10% drift in such tests.

Welded dowel connection—The specimen was tested cyclically to 9% drift with no strength degradation or bar buckling. A monotonic push was conducted to 12% drift with no influence on strength. Very limited cap beam damage observed.

Embedded dowel connection—The specimen was cycled to 8.75% drift with no strength degradation. At 9% drift, reinforcing bars at the extreme fibers fractured. The remainder of the reinforcing bars fractured in subsequent cycles. The test was stopped at 12% drift. Very limited cap beam damage observed.

WHAT IS THE BENEFIT?

CFTs are not widely used in bridge construction in the United States because of the lack of practical, economical, and standardized seismic connection details with design procedures. The experimental results from this research were used to develop a preliminary design equation in AASHTO LRFD format for CFT column-to-cap connections that perform well under seismic conditions. Using these prefabricated bridge elements can expedite construction, decrease overall costs, and minimize the impact on traffic.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2015/CA15-2417_FinalReport.pdf

IMAGES

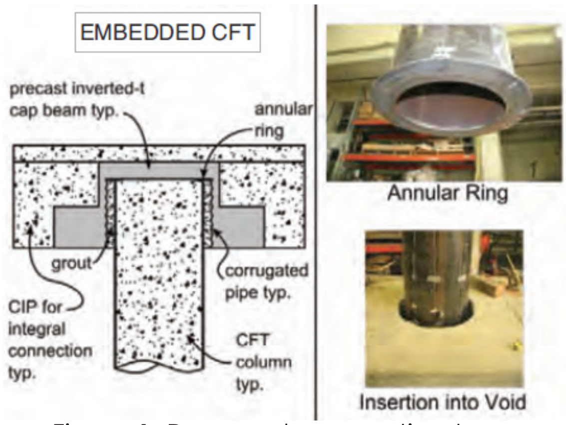

Figure 1: Proposed connection types