



Caltrans Division of Research,  
Innovation and System Information

# Research



# Results

Seismic

## FEBRUARY 2015

**Project Title:**

Repair of Earthquake-Damaged Columns with Fractured Bars

**Task Number:** 2179

**Start Date:** June 13, 2011

**Completion Date:** March 31, 2014

**Task Manager:**

Peter Lee  
Research Contract Manager  
plee@dot.ca.gov

## Repairing Earthquake-Damaged Columns with Fractured Bars

Rebar couplers and fiber-reinforced polymer jackets provide a quick way to repair damaged columns

### WHAT IS THE NEED?

Reinforced concrete bridge columns undergo different levels of damage in an earthquake depending on the intensity of the ground shaking, type of earthquake, and the force or deformation demand on the individual members. Repairing earthquake-damaged reinforced concrete columns with fractured bars is especially challenging. Dependable and practical methods to repair columns with fractured reinforcement are needed to restore the functionality of the bridge as effectively and efficiently as possible.

### WHAT WAS OUR GOAL?

The goal was to develop methods to restore earthquake-damaged reinforced concrete bridge columns with fractured longitudinal bars to their original performance.

### WHAT DID WE DO?

Caltrans and the University of Nevada, Reno Center for Advanced Technology in Bridges and Infrastructure collaborated with the Missouri University of Science and Technology and the University of Houston to develop methods to restore damaged columns. The project tested three concrete bridge column specimens to failure using slow cyclic loading to produce fractured and buckled longitudinal bars. The researchers then repaired two columns by removing segments of the longitudinal bars in the plastic hinge region and replacing them by connecting new bar segments with undamaged longitudinal bars using mechanical bar couplers. The team tested two different types of bar couplers, both approved by Caltrans as ultimate splices. To install the new bar segments, the existing spiral reinforcement was removed but not replaced. After the concrete was replaced, a carbon fiber-reinforced polymer



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(CFRP) jacket was installed around the column to provide the function of the removed spirals. The researchers repaired the third column without repairing the longitudinal bars. Instead, CFRP strips and a CFRP jacket constructed with prefabricated laminates were installed on the column's surface and extended into pockets dug into the footing around the column base. The repaired columns were then tested to evaluate the effectiveness of each type of repair. The procedures and experimental results were documented.

### WHAT WAS THE OUTCOME?

The two columns repaired with mechanical bar couplers in the plastic hinge region did not sustain damage during the test, indicating that this method restores the column's strength and deformation capacity. Both types of couplers were effective. The column that was repaired with externally bonded prefabricated CFRP strips and jacket was also able to restore the column strength and deformation capacity without requiring replacement of the internal reinforcement.

### WHAT IS THE BENEFIT?

Bar couplers are currently not allowed in critical zones of bridge columns. This research shows that it is possible to successfully use mechanical bar couplers in the plastic hinge regions of columns and achieve a ductile response. In addition, the alternative prefabricated CFRP laminate system can be constructed quickly, saving valuable time in the repair process. This research expands the column repair options for Caltrans bridge engineers, especially for damaged columns with fractured bars.

### LEARN MORE

For more information about this project:  
<http://wolfweb.unr.edu/homepage/saiidi/caltrans/fractured.html>

### IMAGES



Figure 1: Concrete demolition in progress



Figure 2: Column R-Calt-1 with couplers and new replacement longitudinal bar segments in place