DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Designing Cap Connections for Precast Girders

New girder-to-cap connections perform well under seismic conditions, facilitating accelerated bridge construction

Seismic

JANUARY 2016

Project Title:
Seismic Performance of Connections that Facilitate Accelerated Bridge Construction

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WHAT IS THE NEED?

One of the most common ways to incorporate accelerated bridge construction (ABC) methods is to use prefabricated elements. However, precast concrete connections to bent caps have at times experienced post-elastic damage when subjected to earthquake loading, largely due to the connections to the girders. To take advantage of the cost- and time-saving benefits of ABC methods in seismic regions, reliable connection details for precast concrete members must be developed.

WHAT WAS OUR GOAL?

TThe goal was to investigate the seismic response and overall moment capacity of a variety of precast concrete girder-to-cap connections for accelerated bridge construction in high seismic regions.

WHAT DID WE DO?

Caltrans, in partnership with Iowa State University, investigated connections for dapped-end I-shaped precast girders to inverted-tee cap beams and connections for precast bulb-tee girders to rectangular cap beams. The researchers evaluated six different girder-to-cap connection details. The team researched a grouted unstressed strand connection (GUSC) and a looped unstressed strand connection (LUSC) for joint regions between dapped-end I-shaped girders with end blocks and precast inverted-tee beams using a 50% scale test unit. The other four options, an extended strand bent with free end (ESBF), end platen (ESSP), extended strand lapped splice (ESLS), and extended strand mechanical splice (ESMS), were tested for connections between bulb tee girders with no end blocks

and rectangular cast-in-place cap beams, using 40% scale test units. In addition to the gravity load effects, the researchers subjected the test units to simulated horizontal and vertical seismic action to verify positive and negative moment resistance along with vertical shear resistance at the girder-to-cap beam interface.

WHAT WAS THE OUTCOME?

All the connection details demonstrated elastic super-structure behavior at shear and moment demands beyond the expected column plastic hinging when subjected to horizontal and 0.5g vertical seismic loadings. The successful response confirmed that the proposed details are viable, structurally sufficient ways to implement precast I-girders and bulb-tee girders in high seismic regions. If the precast I-girder or bulb-tee girder does not include an end block or dapped end at the girder-to-cap interface, additional cap beam or diaphragm stirrups need to be detailed to fit alongside the girder web and between the top and bottom girder flanges at the connection interface to prevent spalling. Because the shear friction generated by the dowel bars in the diaphragm is a critical part of the positive moment transfer mechanism, similar proportions as used in this project are recommended for the dowel bar locations in all girder-to-cap connections.

WHAT IS THE BENEFIT?

All the tested connection details provided seismically adequate integral connections, with each approach presenting different advantages and disadvantages. Having multiple options for precast girder-to-cap beam connections enables California designers to better implement ABC methods. Using unstressed portions of prestressing strands in the connection design, particularly those extended from prestressed girders, reduces costs and improves construction flexibility. The large-scale experimental validations confirmed that the connections can withstand seismic motion, eliminating the need for designing columns with more costly fixed supports at their base when using precast girders.

IMAGES

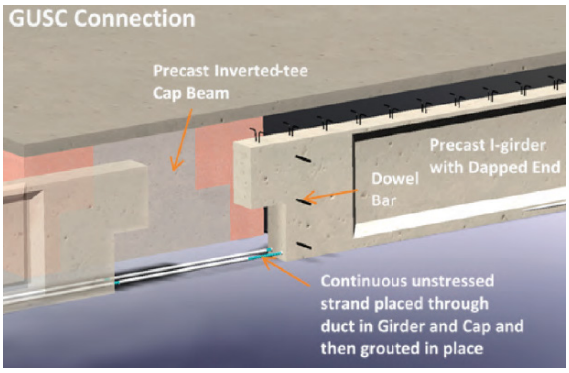

Figure 1: Grouted unstressed strand connection

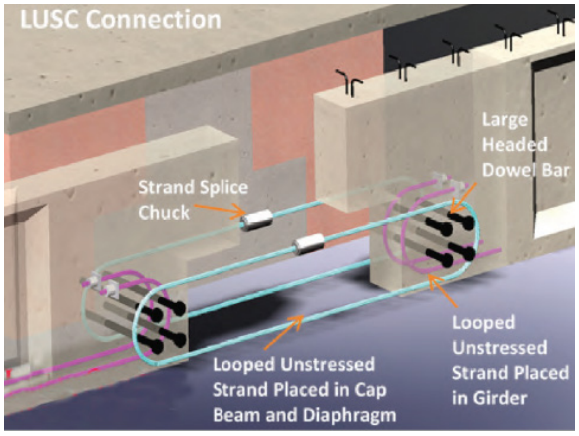

Figure 2: Looped unstressed strand connection

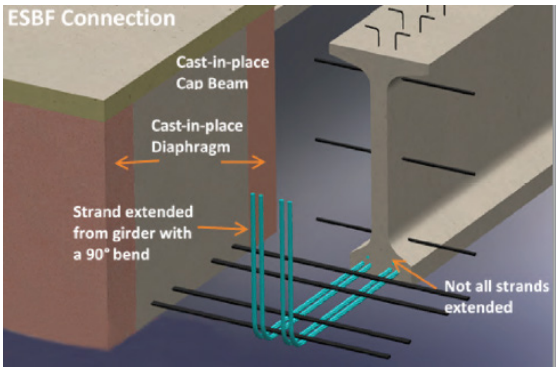

Figure : Extended strand bent with free end connection