Emerging Alternatives for ABC in High Seismic Zones

Seismic Performance of Bridge Column-to-Shaft Pin Connections for Application in Accelerated Bridge Construction

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Presentation outline

WHY?

- Pinned connections to improve seismic performance
- Proposed ABC method
- Current practice and design criteria

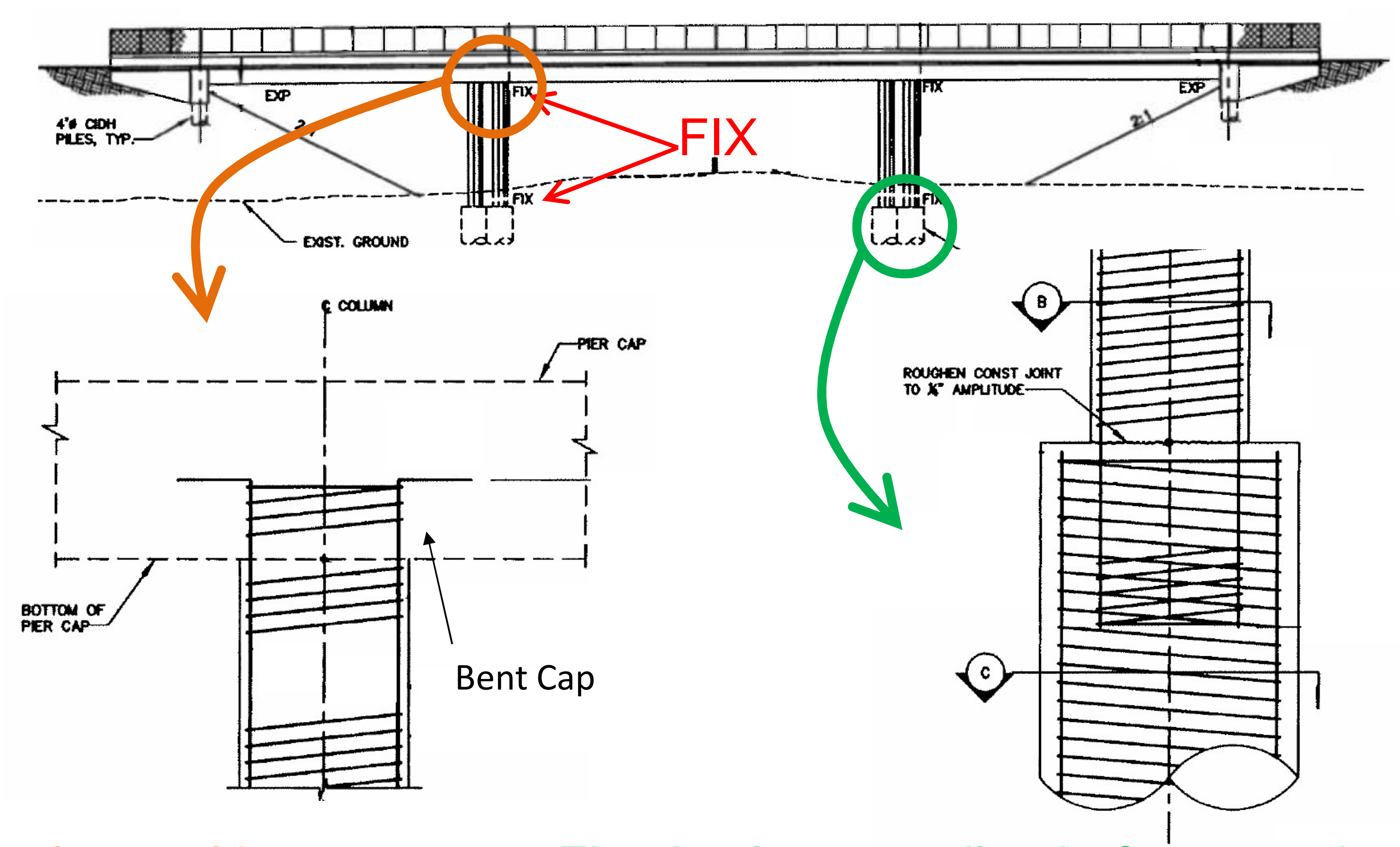
HOW?

- Experimental studies
- Analytical studies
- Parametric studies

WHAT?

- Recommendations
- Conclusions

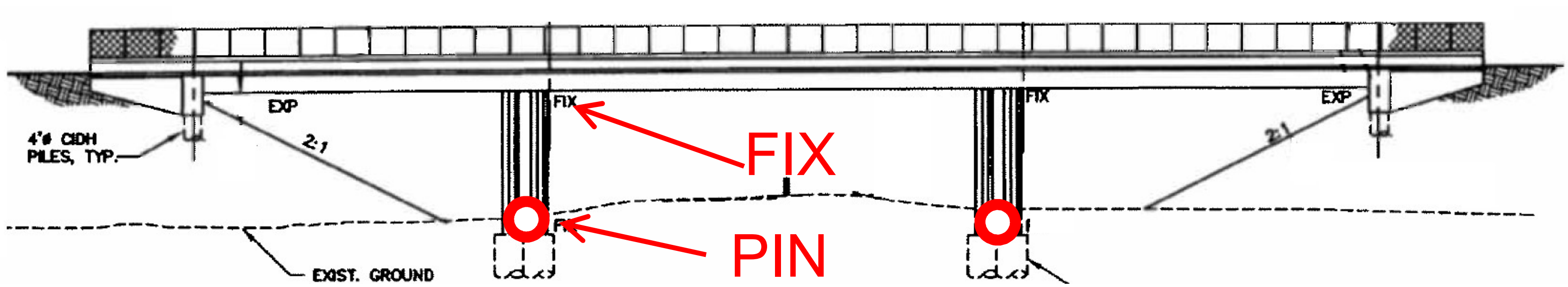
Typical integral bridge system



Integral bent cap

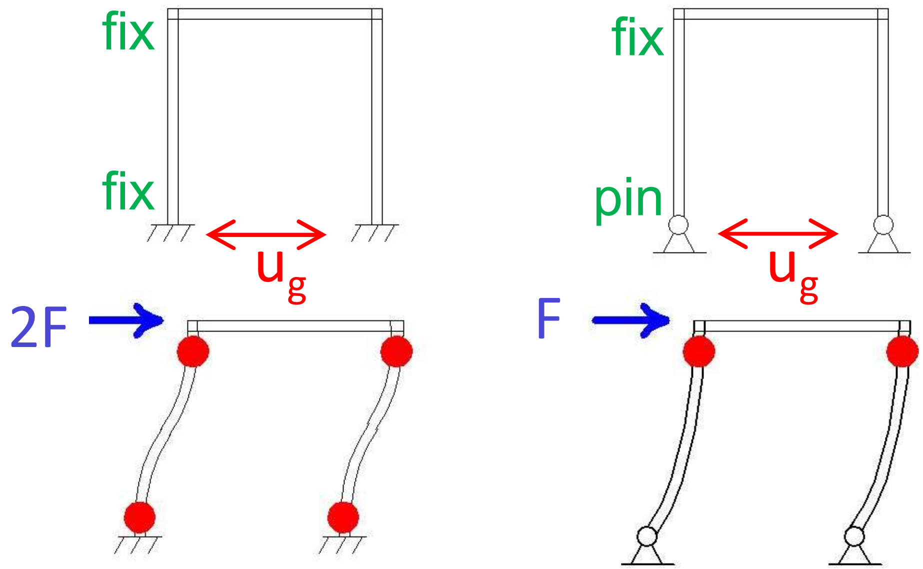
Fixed column to pile-shaft connection

Typical integral bridge system

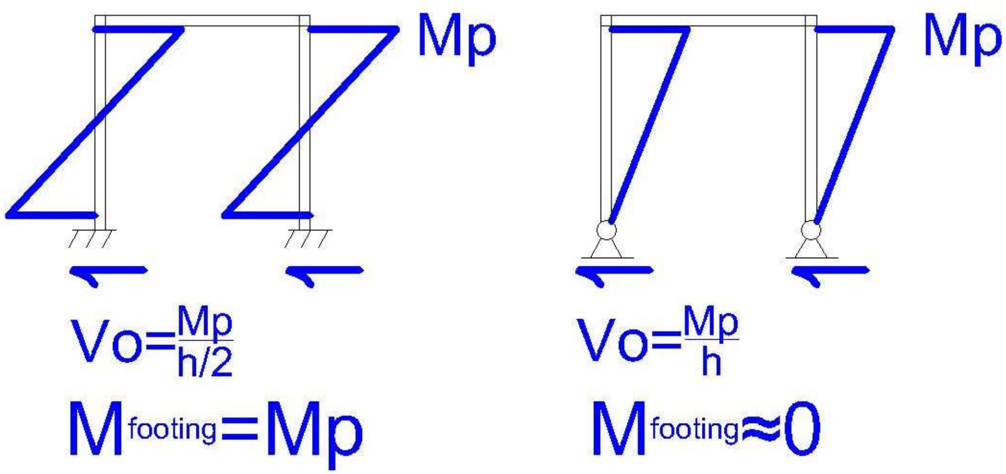


How use of pins at the bottom of columns would help performance and economy of bridge?

Advantages of pinned connections



Collapse limit state mechanism

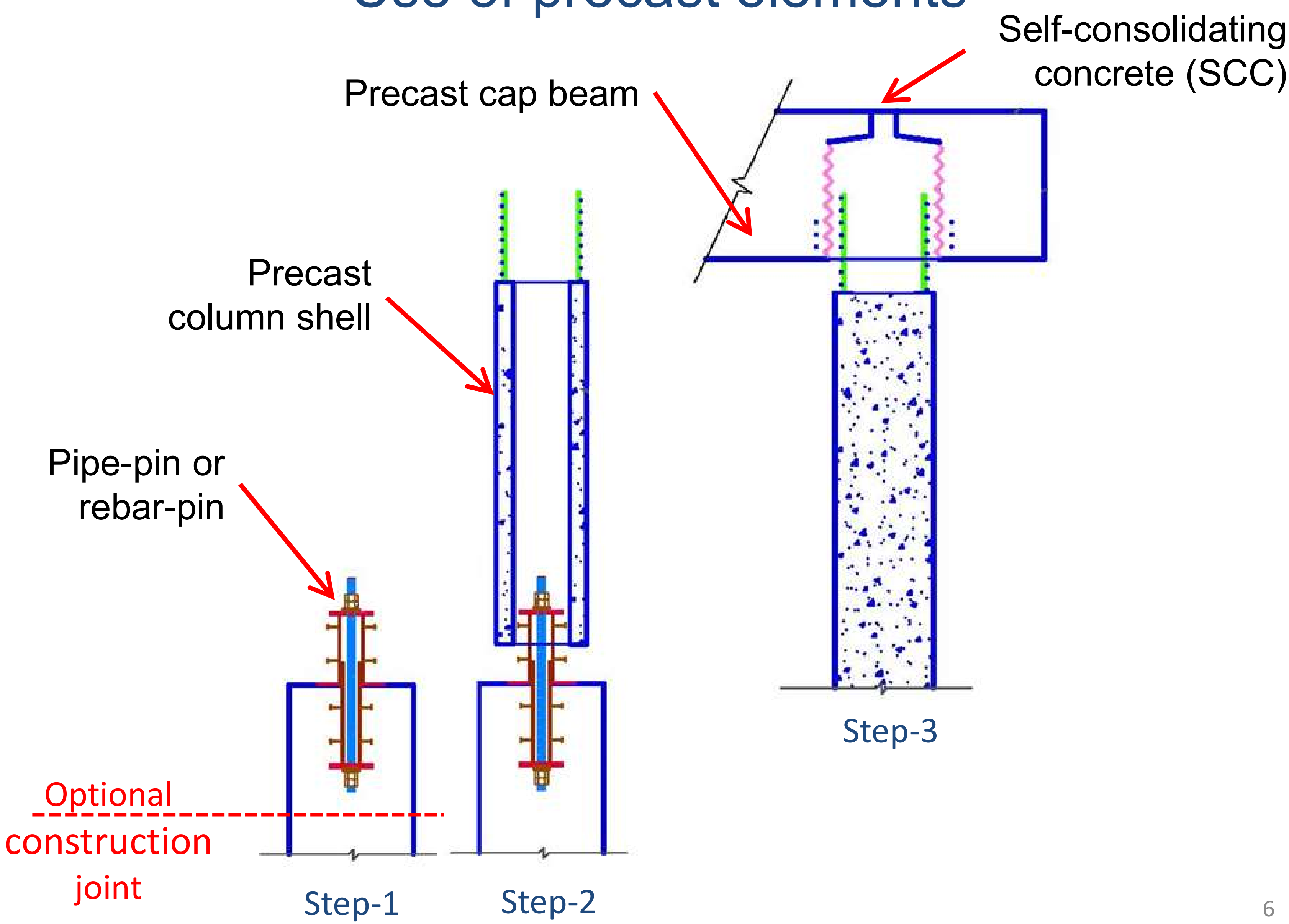


Reduce foundation **force and moment**

Reduce **size** of foundation

Reduce **cost**

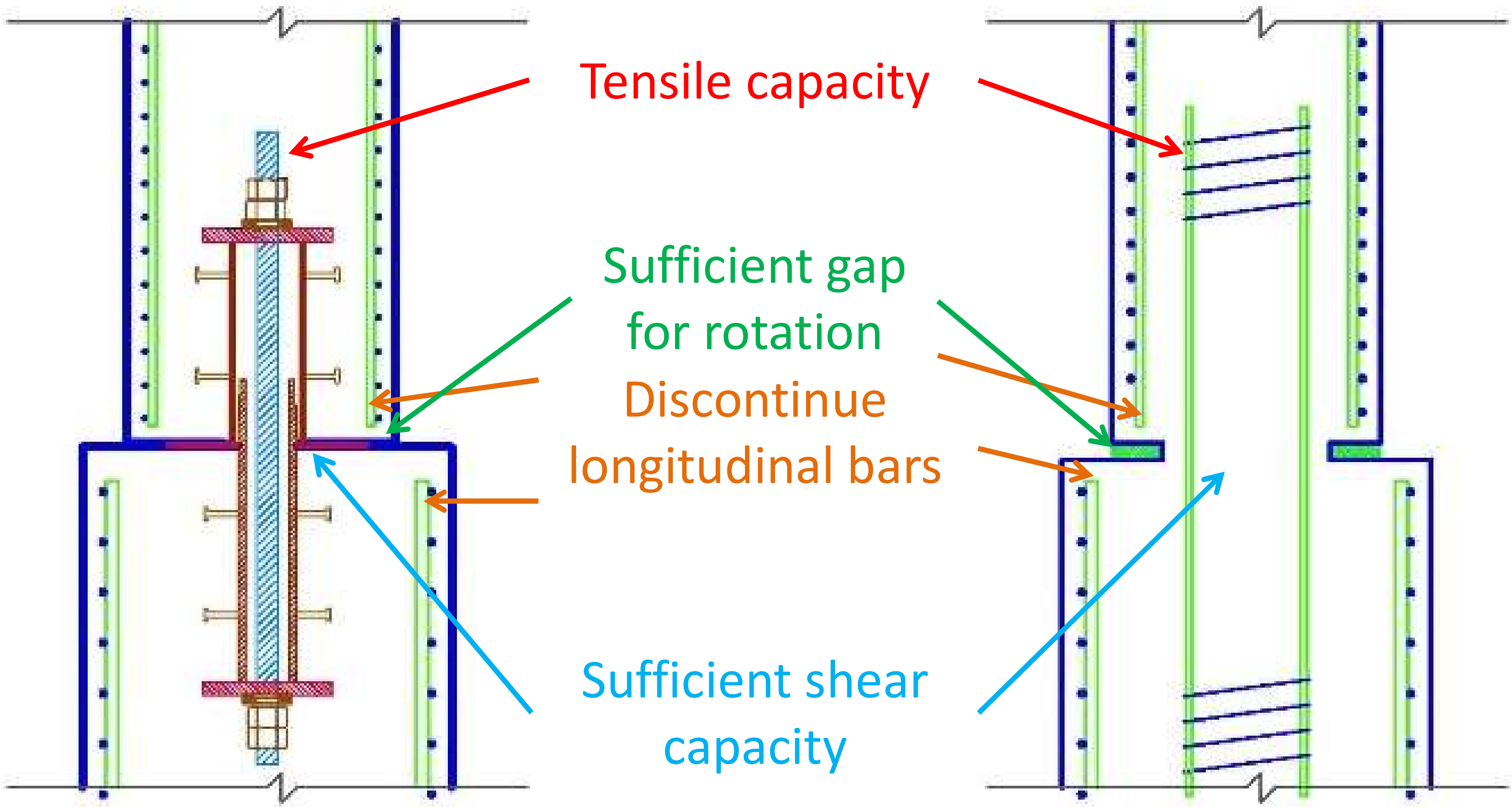
Use of precast elements



General detail of pins used in this study

Two pinned connections were investigated in this study

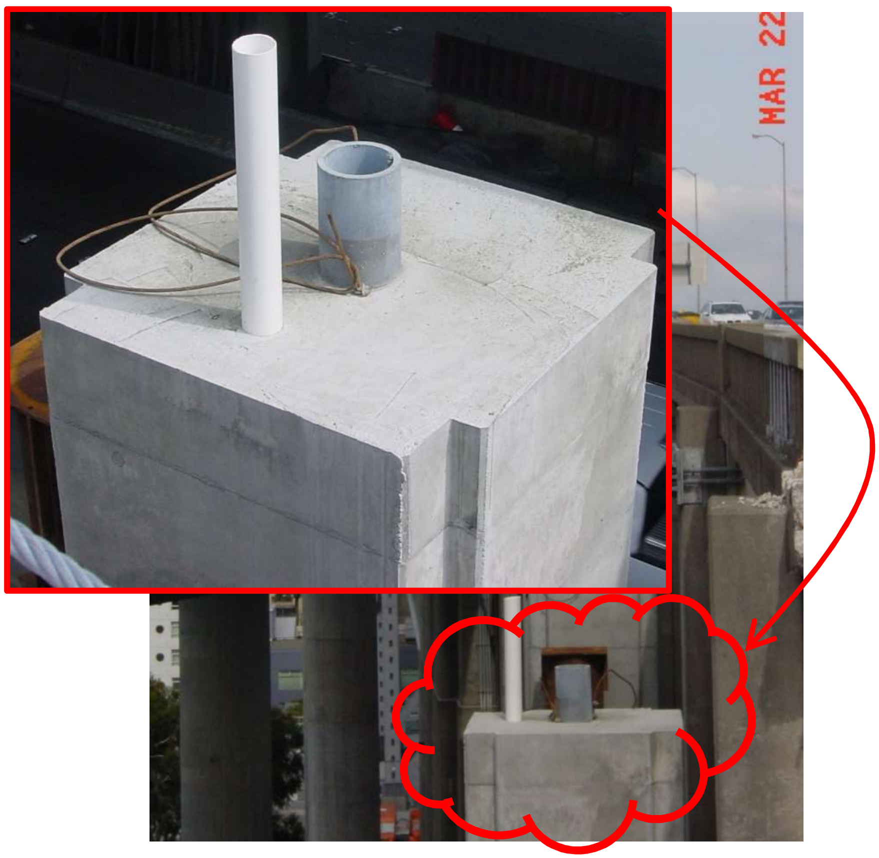
Pipe-Pin Rebar-Pin



Pipe engagement Friction + Dowel

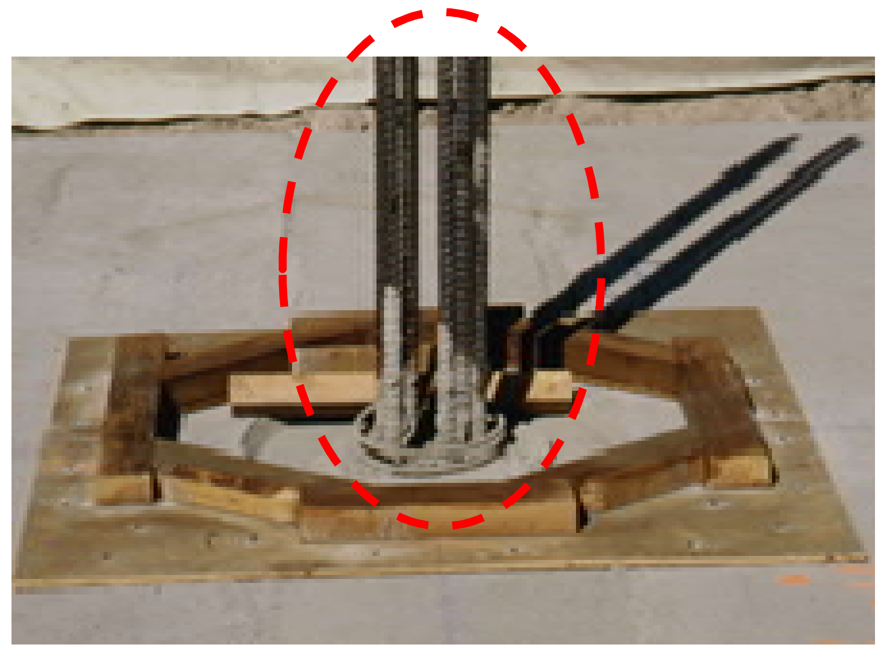
RC “pinned” connections in practice since 1880

Pipe-pin



Rebar-pins

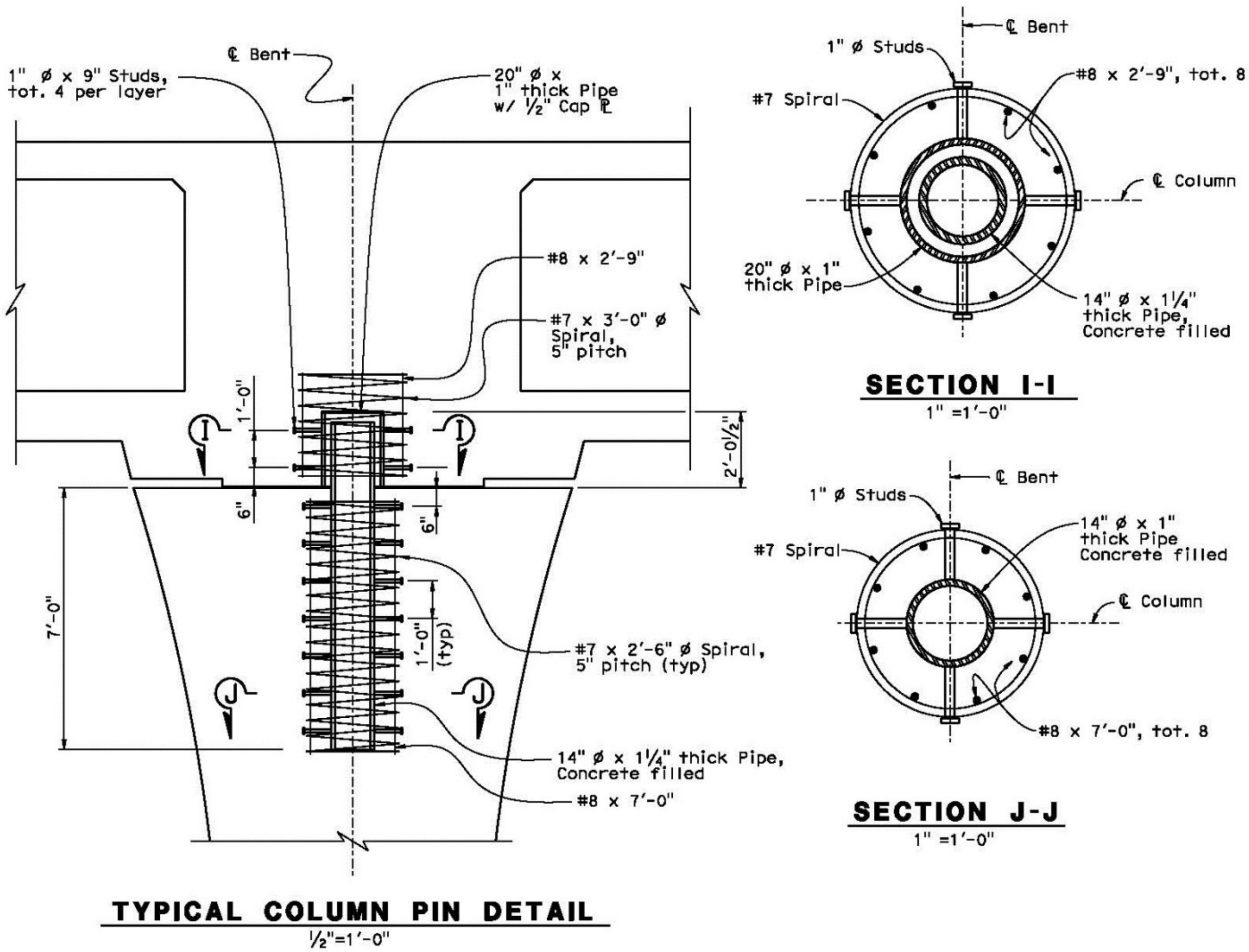
Or Two-way hinges



San Francisco Bay bridge Approach span (2006)

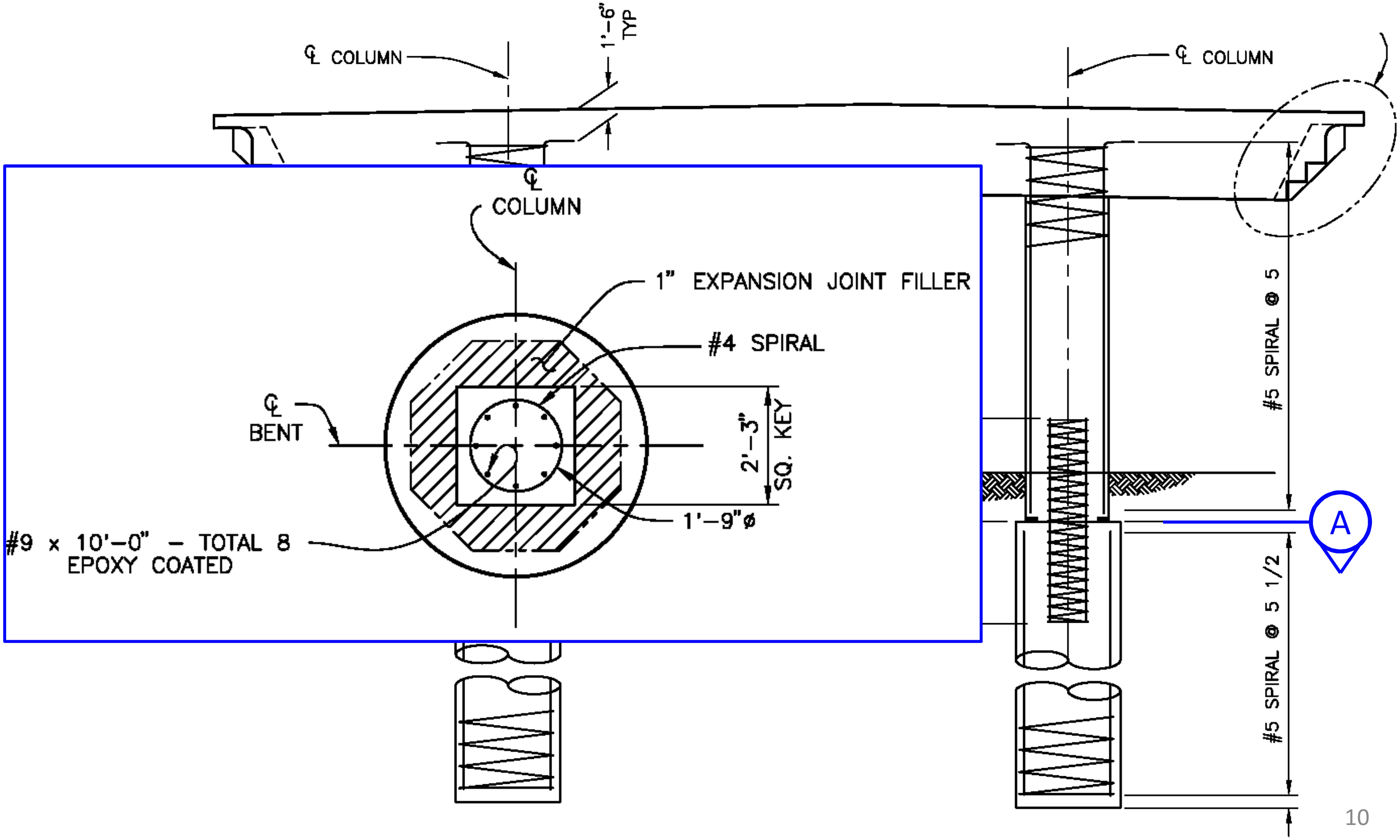
Pipe-pins in practice

Shyuler Heim Bridge, CA (2009)



Rebar-pins in practice

Replacement of Hollister (Bailey) Bridge, CA (2001)



Rebar-pin (column key) design criteria

At the time of specimens design, Caltrans SDC 1.6 (2010) was available:

7.6.7 Column Key Design

Column shear keys shall be designed for the axial and shear forces associated with the column's overstrength moment M_o^{col} including the effects of overturning. The key reinforcement shall be located as close to the center of the column as possible to minimize developing a force couple within the key reinforcement. Steel pipe sections may be used in lieu of reinforcing steel to relieve congestion and reduce the moment generated within the key. Any appreciable moment generated by the key steel should be considered in the footing design.

Caltrans SDC 1.6 does not discuss the followings:

	Practice	**Saiidi et al. (2009)**
Shear Capacity	Shear Friction Method μ=1.0	Shear Friction Method μ=0.45
Ductility	??	Based on column plastic hinge
Rotational Capacity	??	Larger than bent rotation
Tensile force transfer		No Experiment

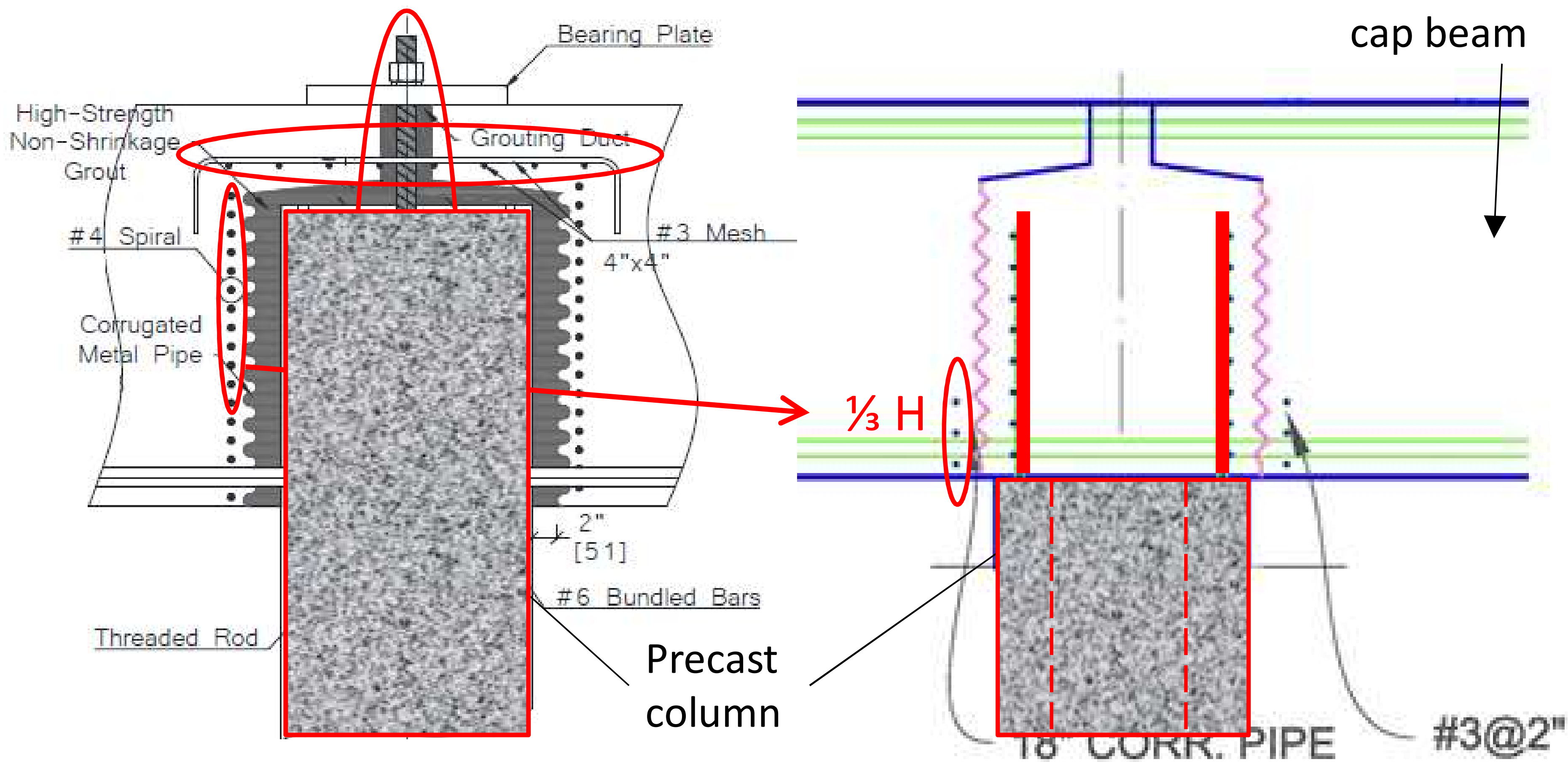
Design criteria for pipe-pins

- Caltrans SDC does not have requirements for pipe-pins despite their use.
- Recommendations by Zaghi and Saiidi (2010) was used.
- However, tensile force transfer mechanism was not studied.

Pocket connection

Mehrsoroush and Saiidi (2014)

Proposed



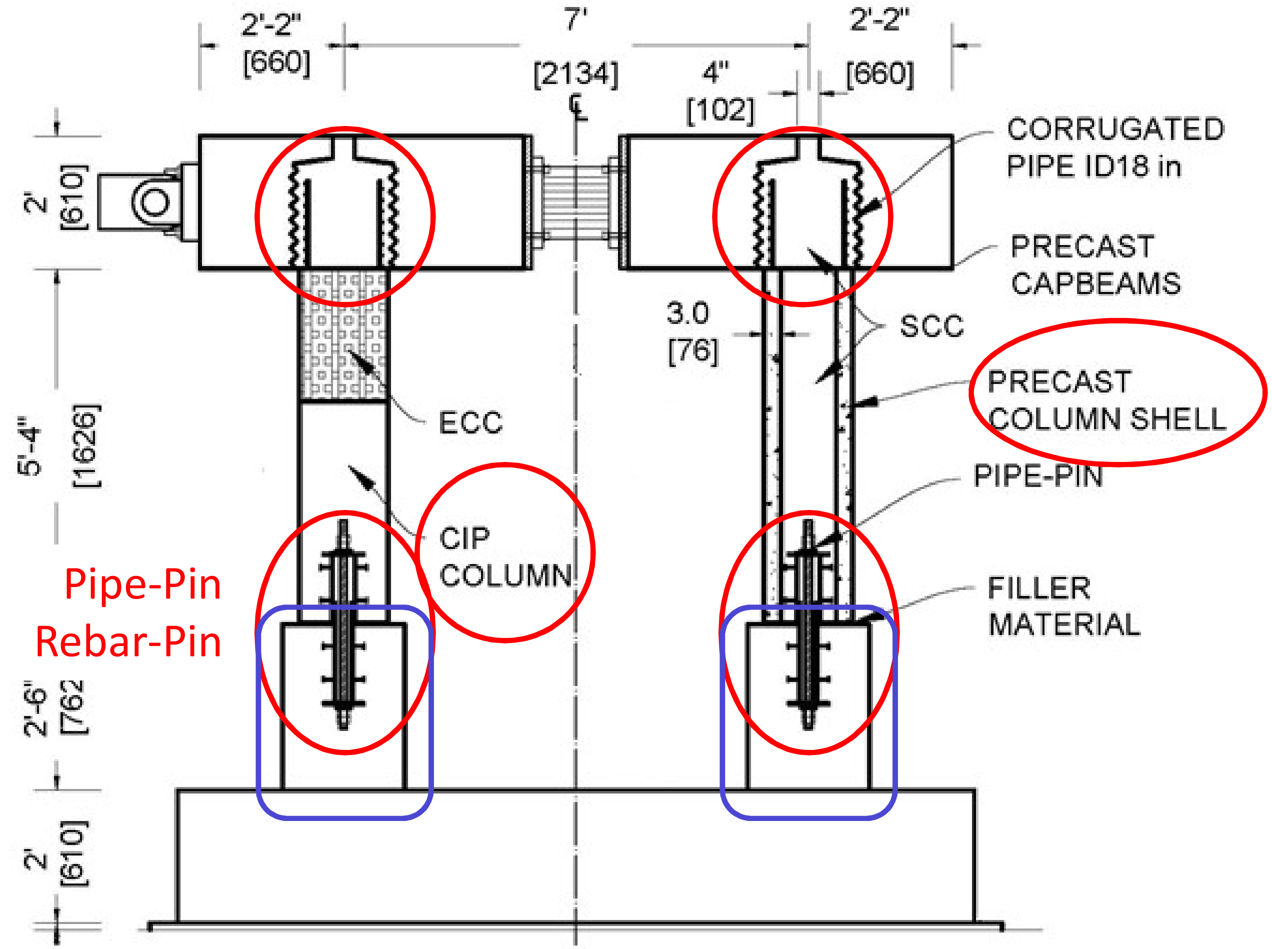
Gaps in literature and design guidelines

Tensile force transfer mechanism

and pile-shaft failure modes had not been studied in the previous researches on pinned connections.

Previous cap beam pocket connection (NCHRP12-74) were difficult to construct due to steel congestion.

Experimental study – Two Bents w/ pins

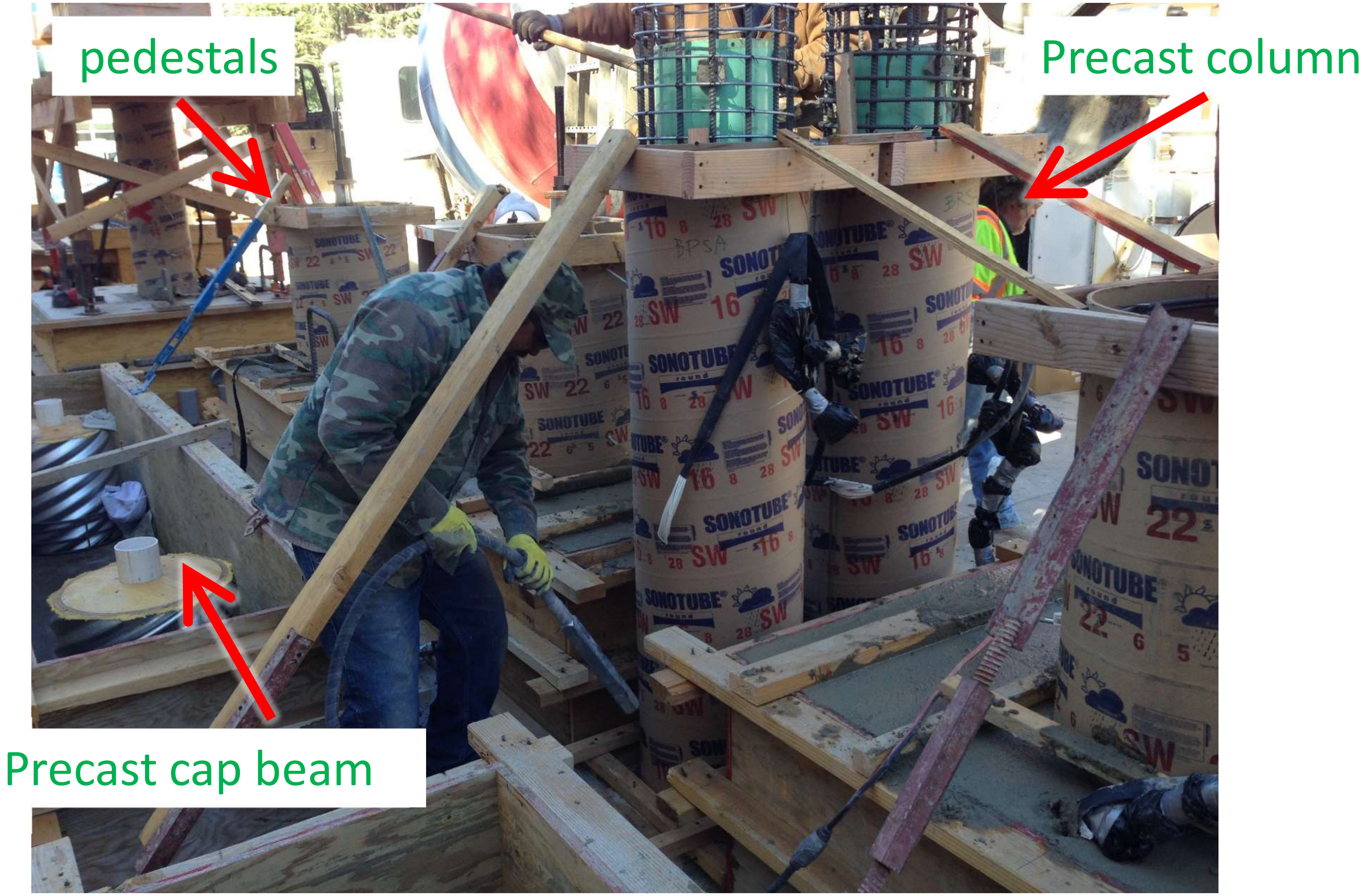


Pipe-pin for column to pile-shaft connection

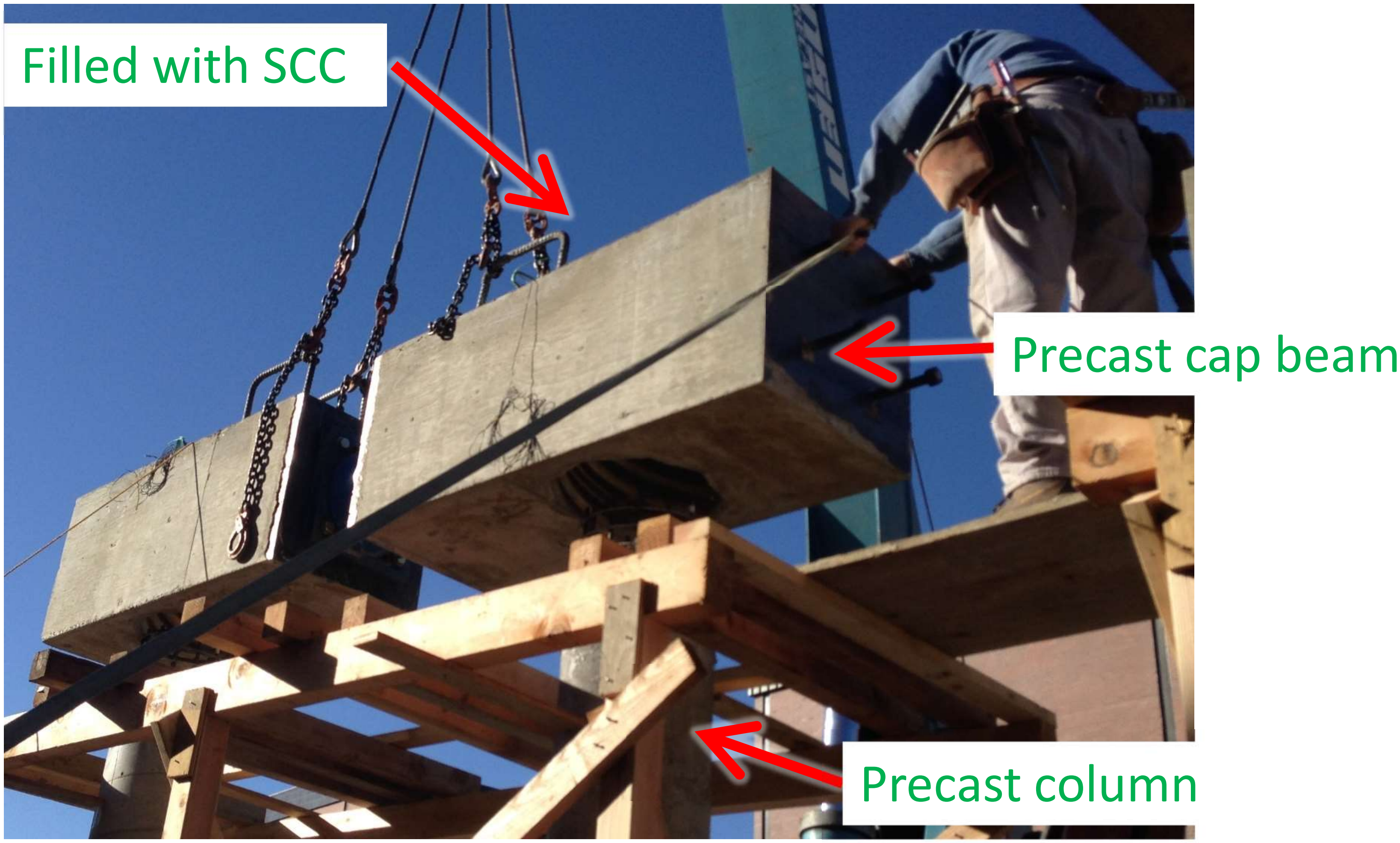
Connecting precast column to pile-shaft using pins

First, pile-shaft with pin embedded

Construction: precast elements

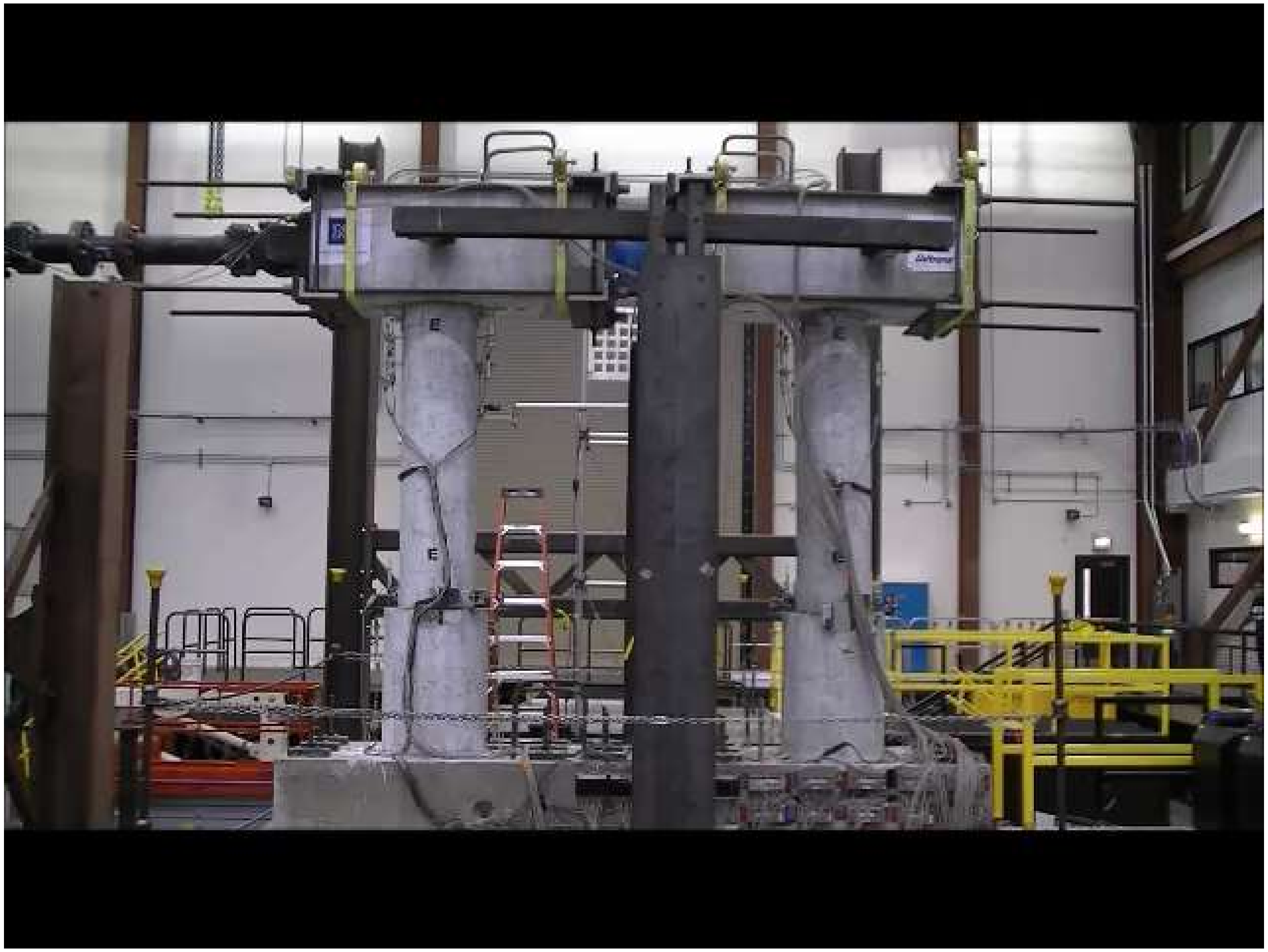


Connecting column to precast cap beam



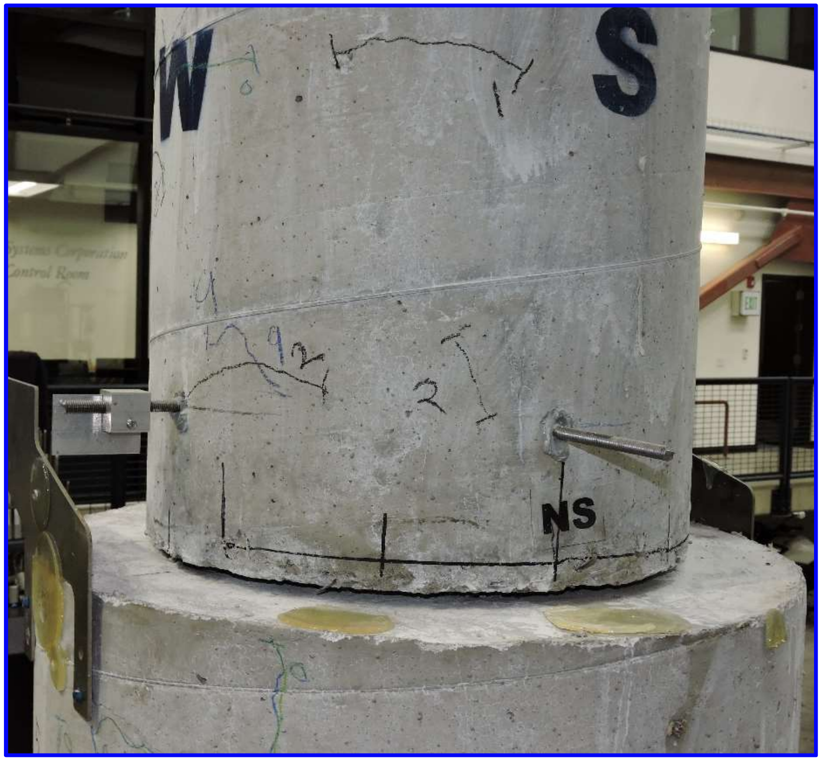
Bent w/ pipe-pin – Last run

$PGA = 2XPGA_{design\ earthquake}$



Comparison of pin damage in Piers

Pipe-Pin



Pipes did not yield
Minimal crack

Rebar-Pin

Longitudinal bars yielded
Flexural and shear cracks in the pin throat

Summary of experimental results

- Both bents were ductile.
- No difference was observed between precast and cast-in-place pins.
- Pocket connections were effective to form the plastic hinge in the columns.
- The precast cap beam remained elastic with no damage.

Three types of analysis for each bent

- **Numerical models** were verified by the test results.

- **Parametric studies** were developed to fill in knowledge gap that was not covered in the experimental and analytical studies

- The results were used to develop **design method**

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SEISMIC PERFORMANCE OF BRIDGE COLUMN-PILE-SHAFT PIN CONNECTIONS FOR APPLICATION IN ACCELERATED BRIDGE CONSTRUCTION

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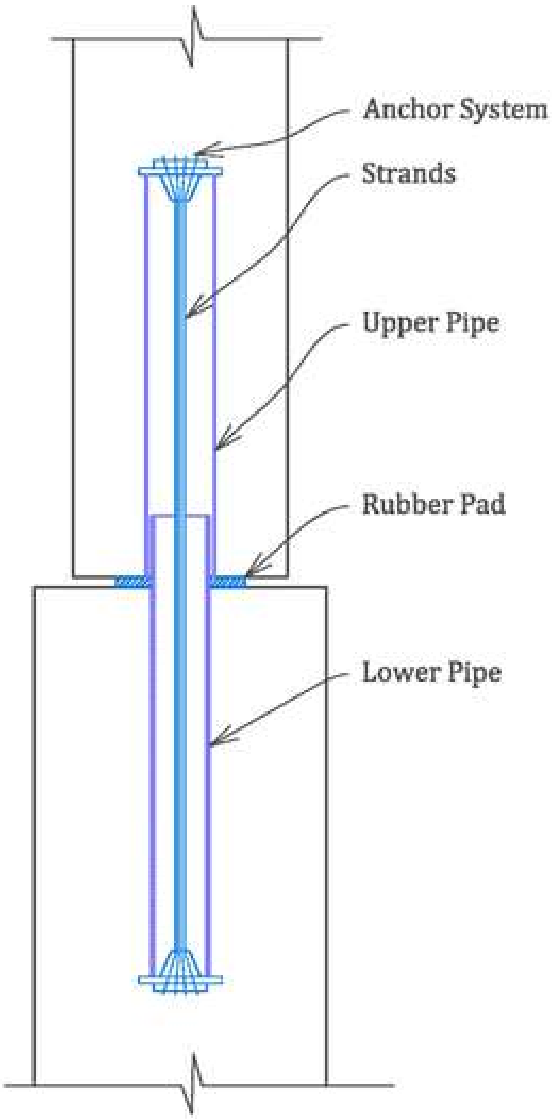
Recommendations to improve design

- The pin moments need to be included,
- Equations for pin moment and component force
- Shear capacity of a pins in pile-shaft
- Improved detailing recommendation



Conclusions

- **Pipe-pins** can be designed to remain entirely **elastic** when a strand is used for the tension member and may be treated as **capacity-protected** connections, whereas **rebar-pins** are expected to **yield**.

- Because **rebar-pins** undergo large **plastic deformations**, they should be designed as ductile elements.

- **Tension members** should be used in pipe-pins to maintain **global stability** of the bent under larger lateral displacements, even in cases that the dead load is sufficiently large to prevent uplift.

- The proposed detailing for **pocket connections** was efficient and safe.

Thanks