A Constructible Bridge Bent Designed to Re-center after an Earthquake.

John Stanton

Marc Eberhard, Travis Thonstad, Jeffrey Schaefer,
Bryan Kennedy

Dept. of Civil and Environmental Engineering
University of Washington

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Acknowledgments

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- Pacific Earthquake Engineering Research Center
- Washington State DOT
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Conventional Bridge Bent

- Cast-in-place concrete construction

Conventional Bridge Bent

- Slow to construct

Conventional Bridge Bent

- Susceptible to seismic damage

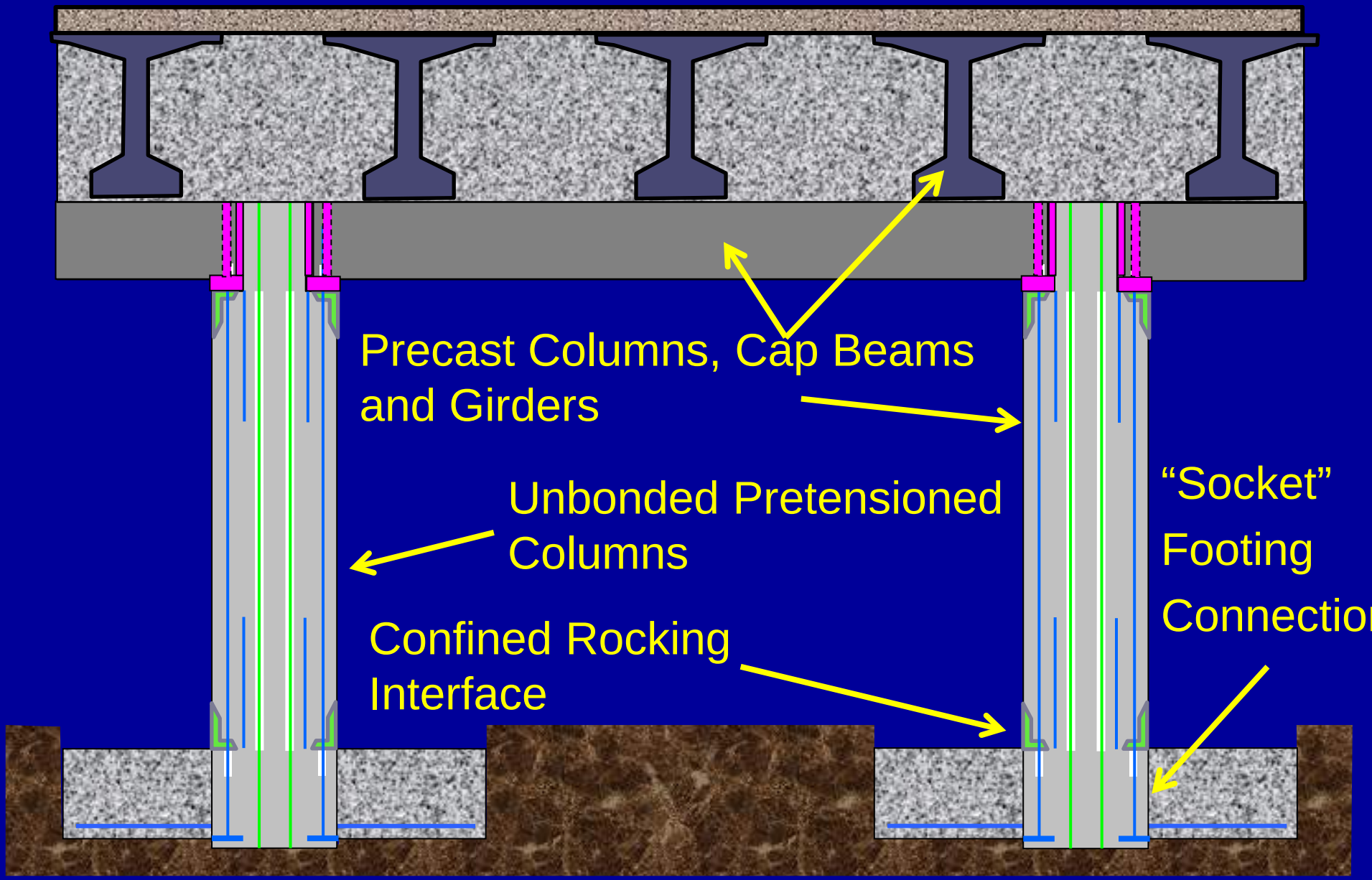
Conventional Bridge Bent

- Post-earthquake residual displacements

Proposed Improvements

- Accelerate Construction
  - Use precast components
  - (Connections are critical)
- Reduce column damage
  - Use rocking column approach
  - Columns rock as rigid bodies
  - Damage significantly reduced
- Minimize residual displacements
  - Use unbonded prestressing

Proposed Strategy



Accelerated Construction

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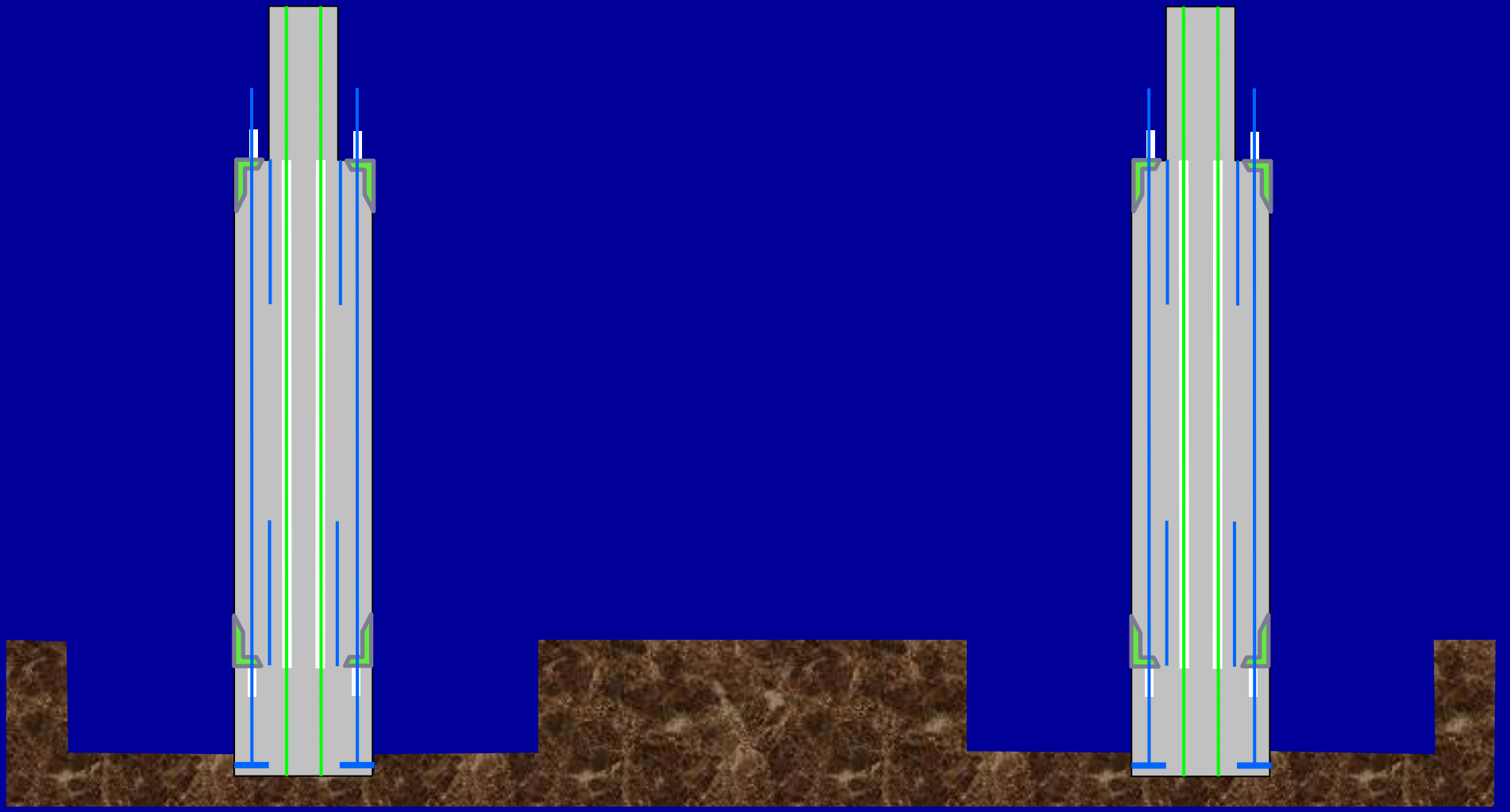

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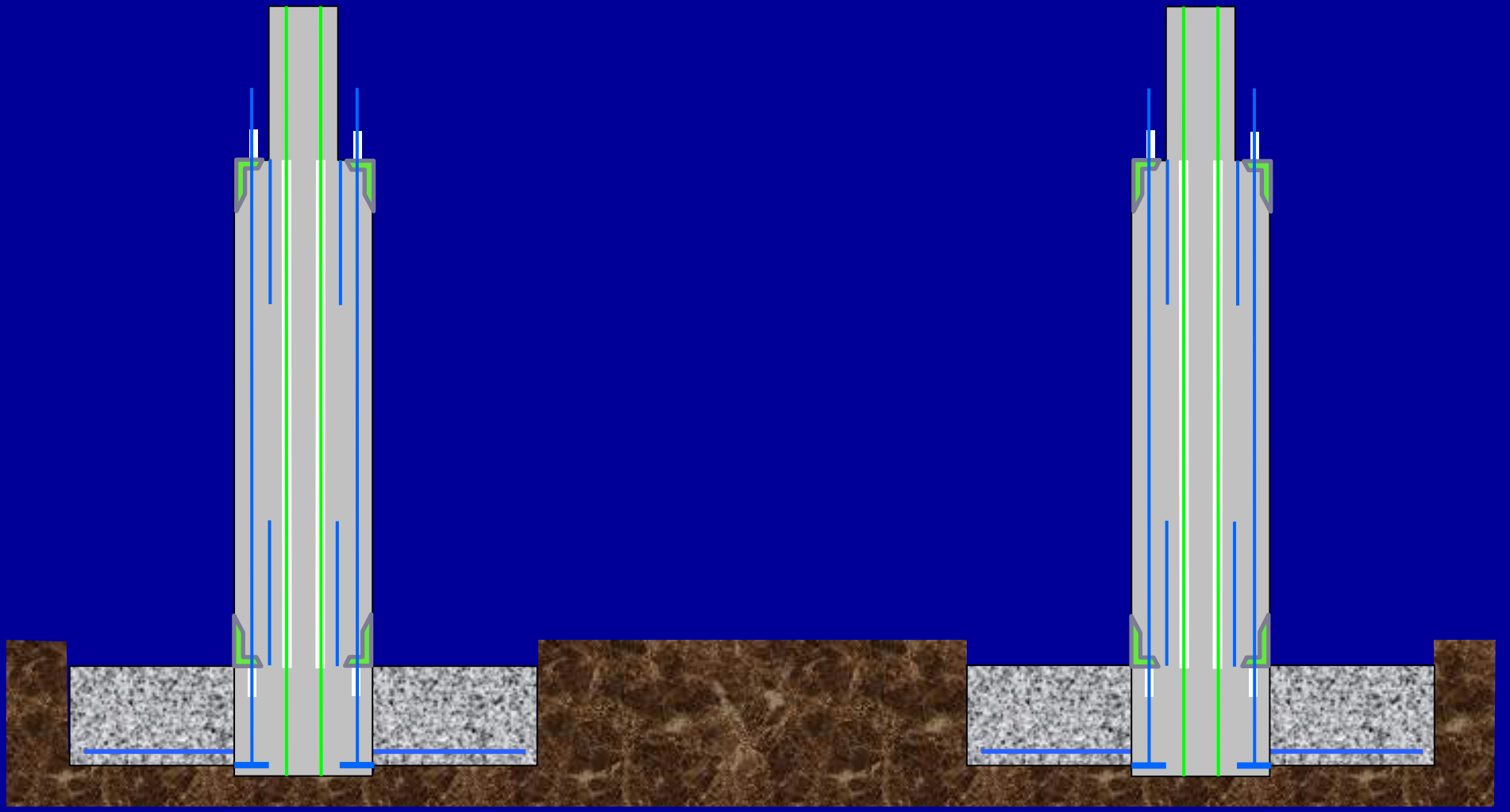

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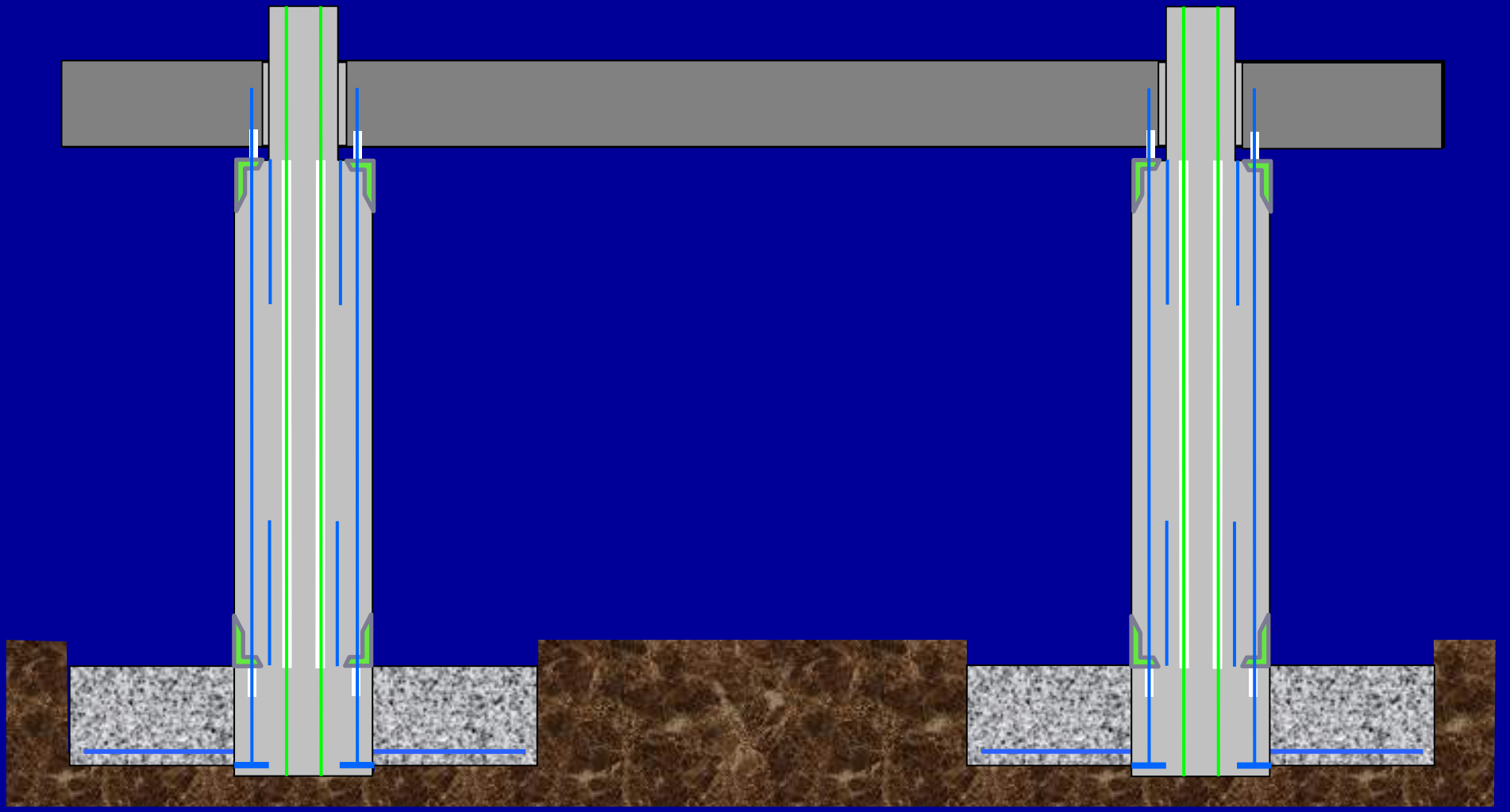

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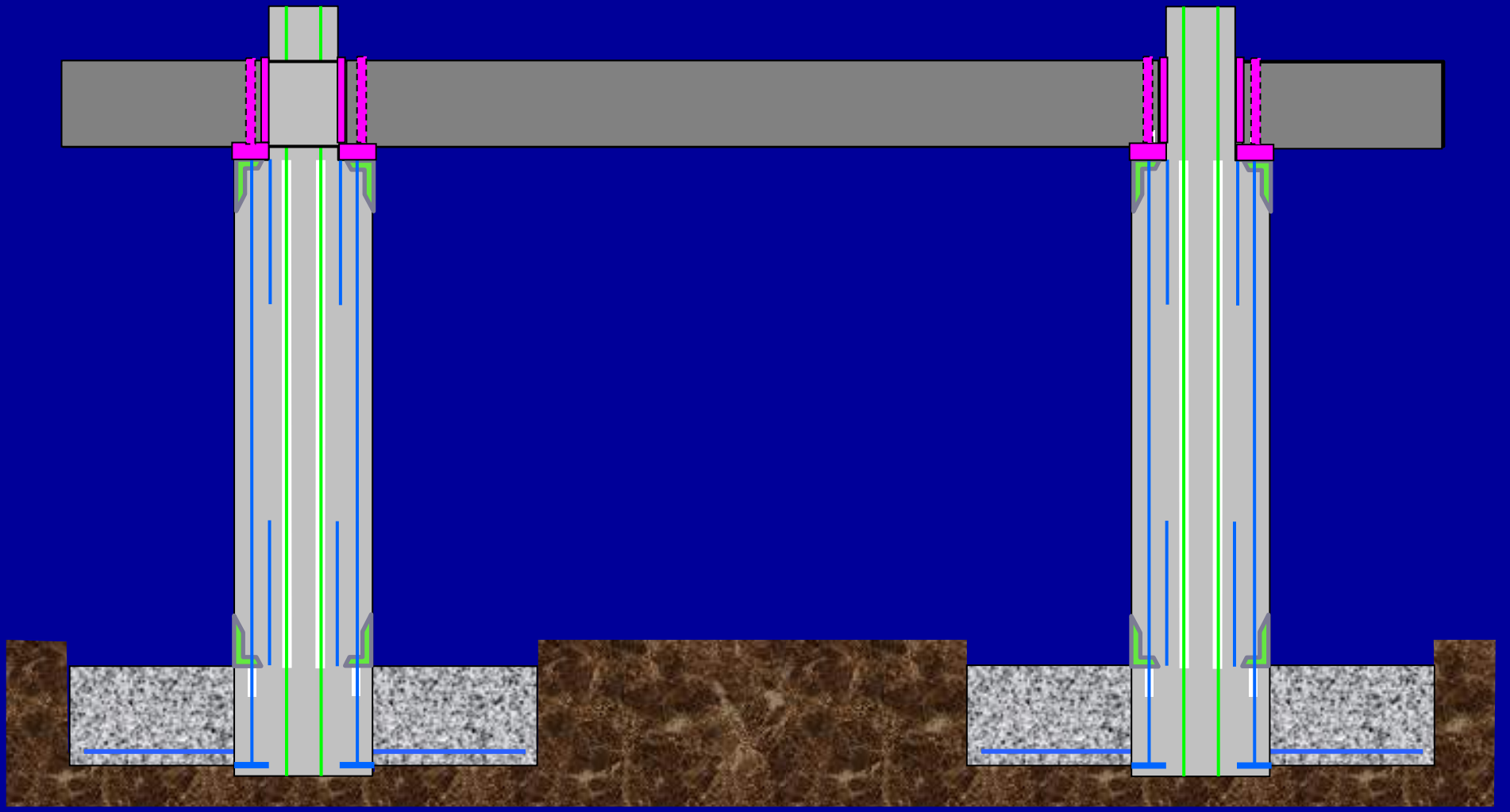

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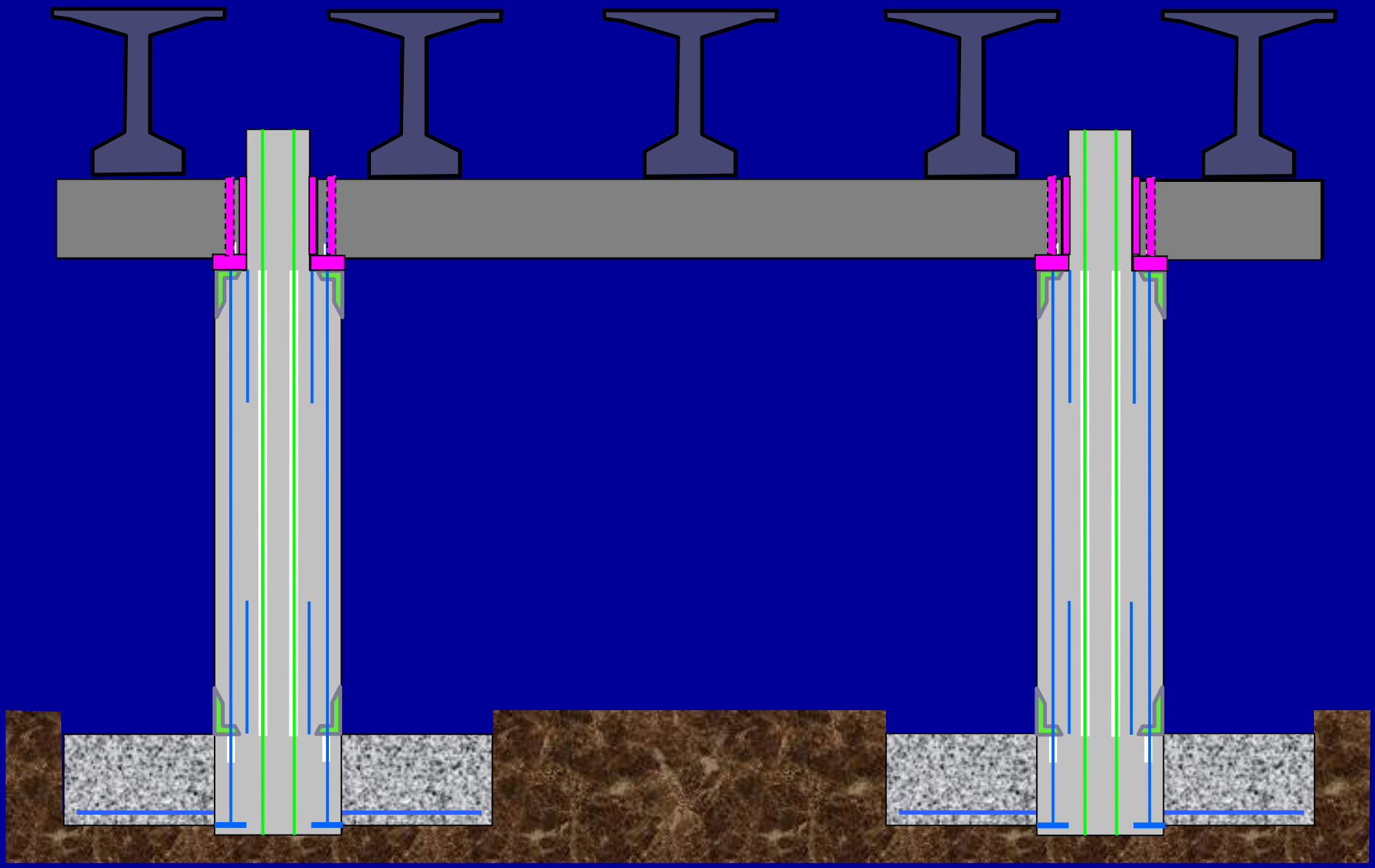

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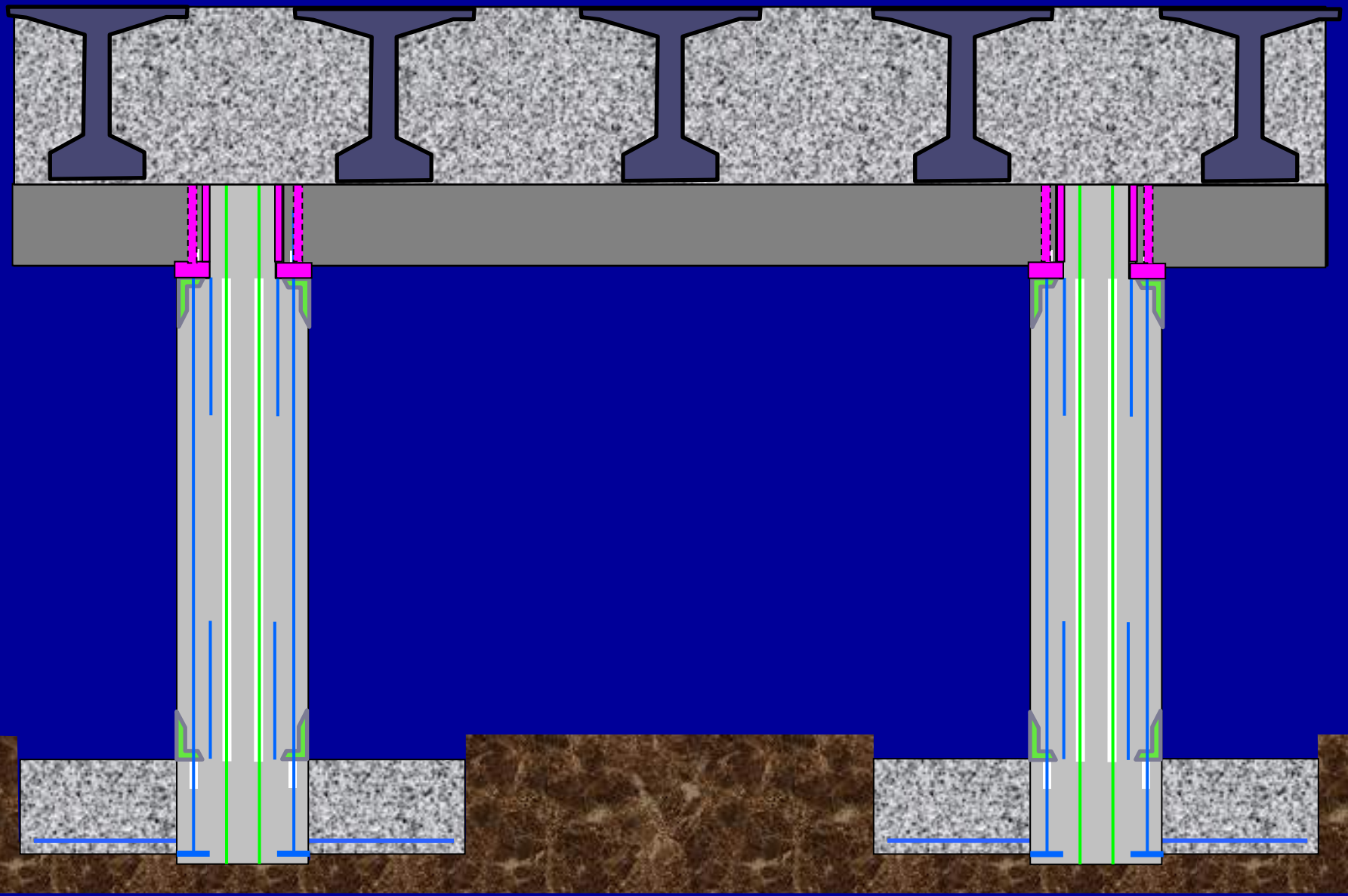

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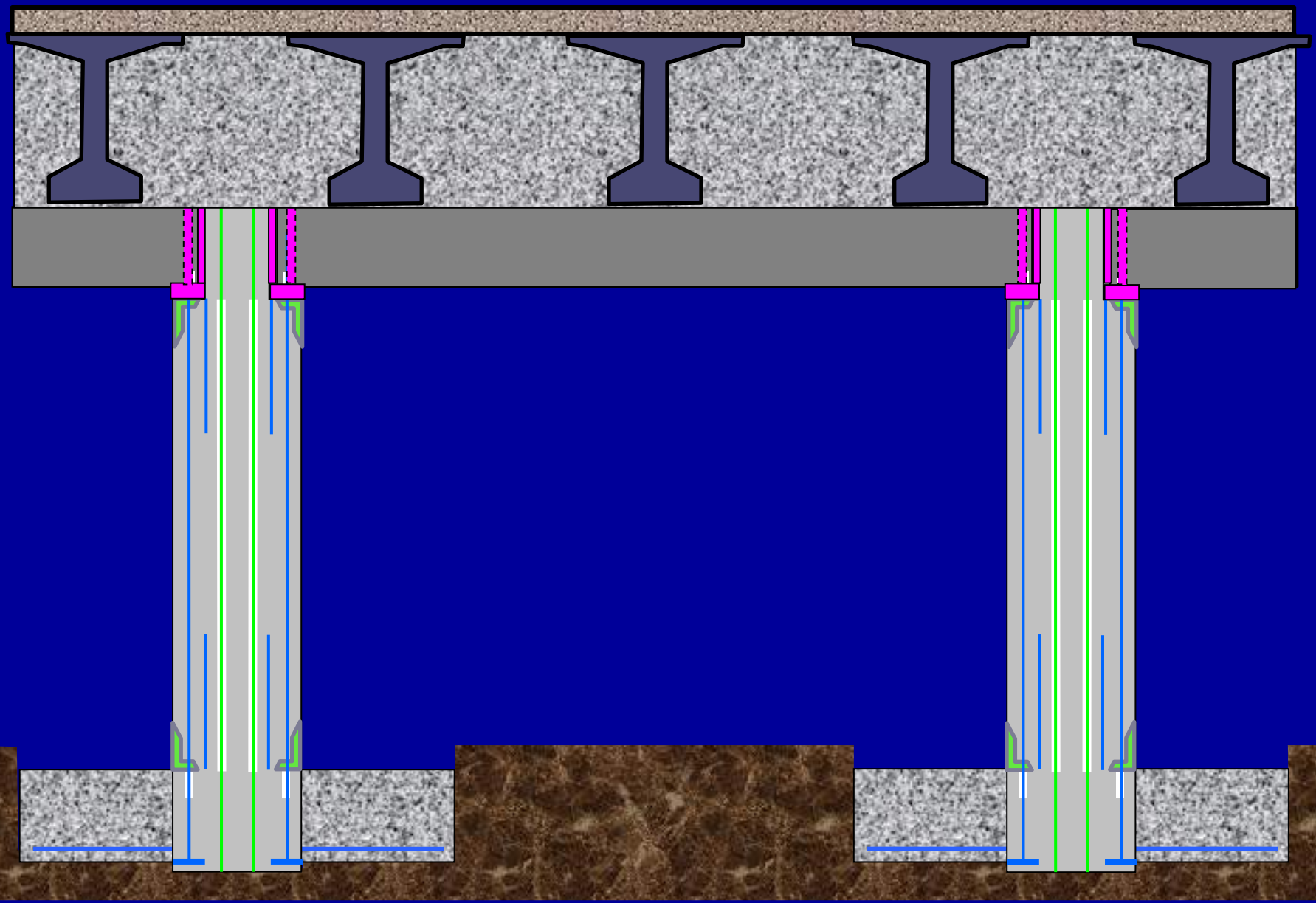


Field Deployment
(non-prestressed system)

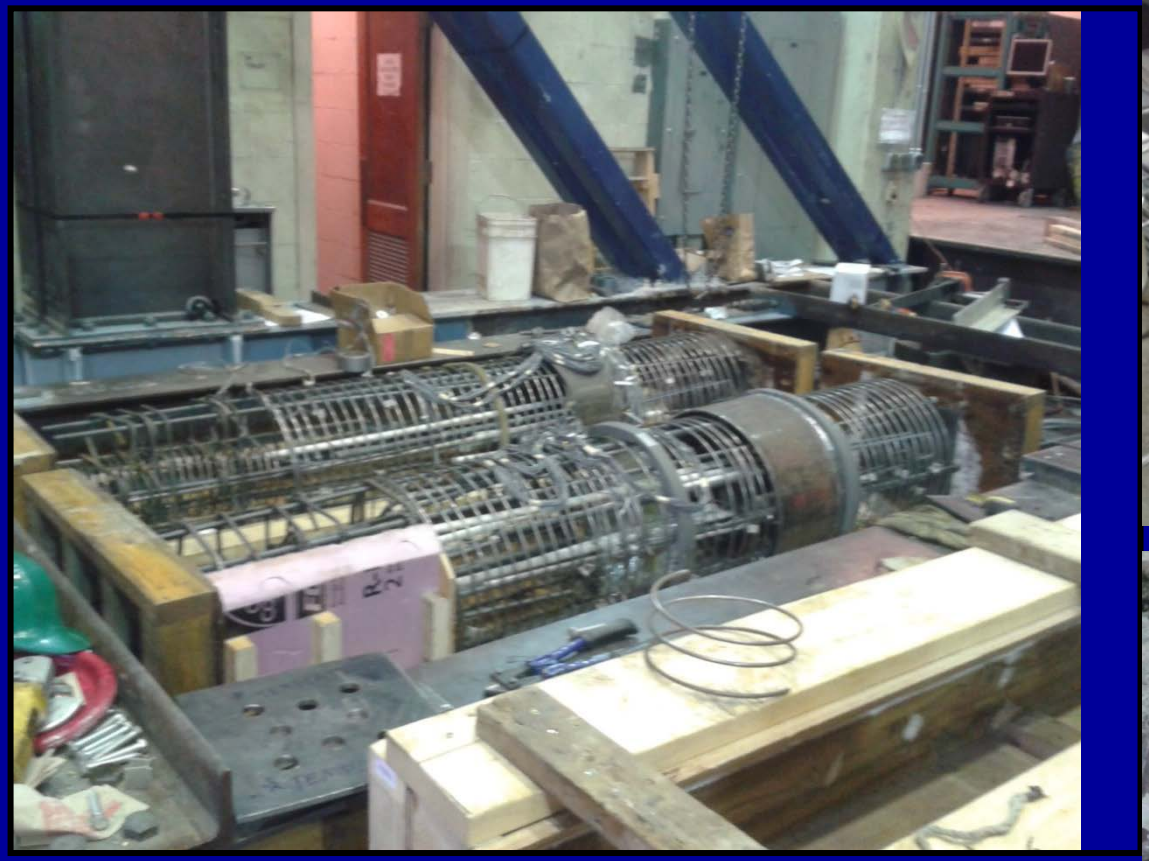
Socket Connection

Cap-Beam Connection

I5, Grand Mound Bridge Replacement Project, 2012

Earthquake Damage

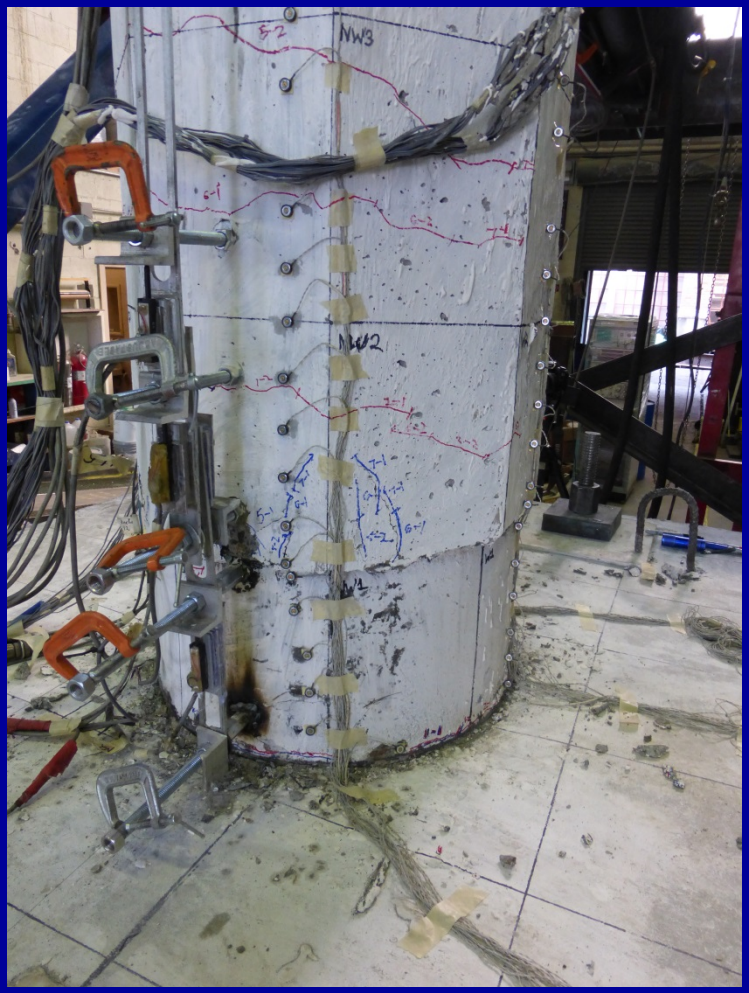
Sub-Assembly Tests

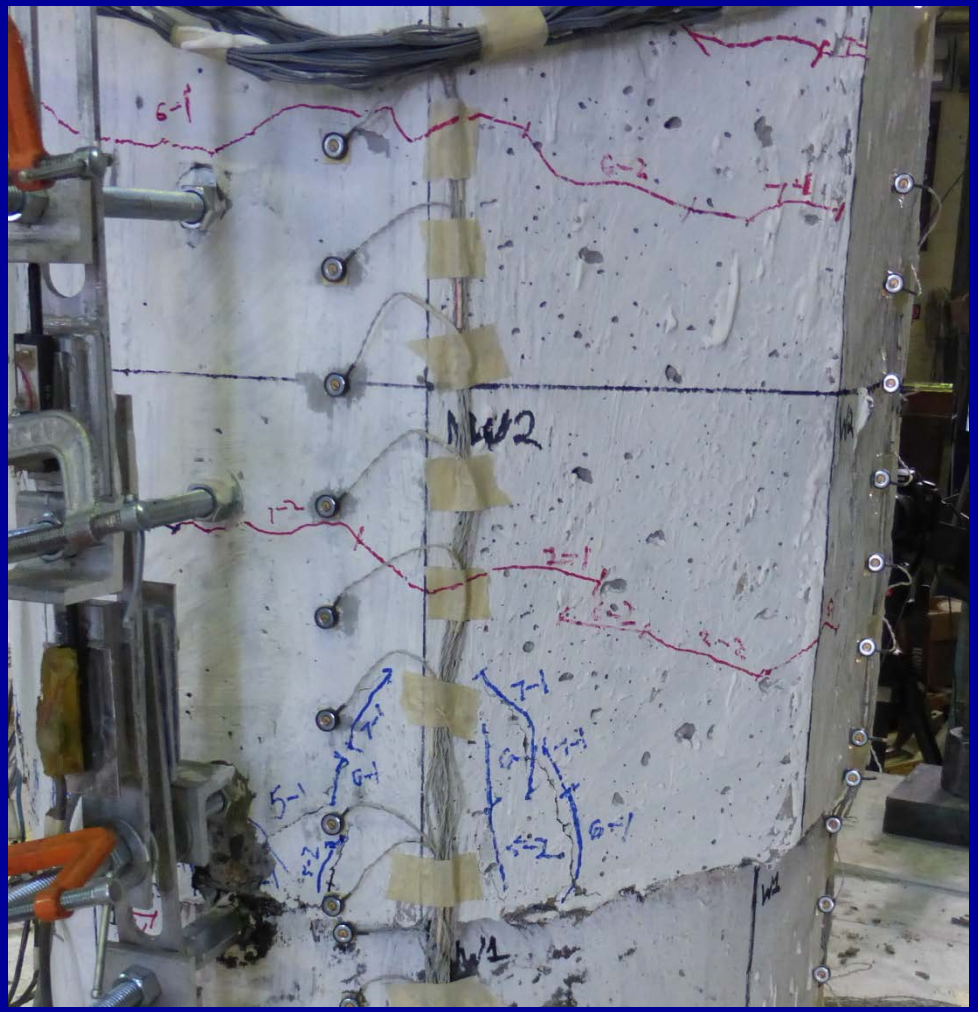


Sub-Assembly Tests

RC column after 10% drift

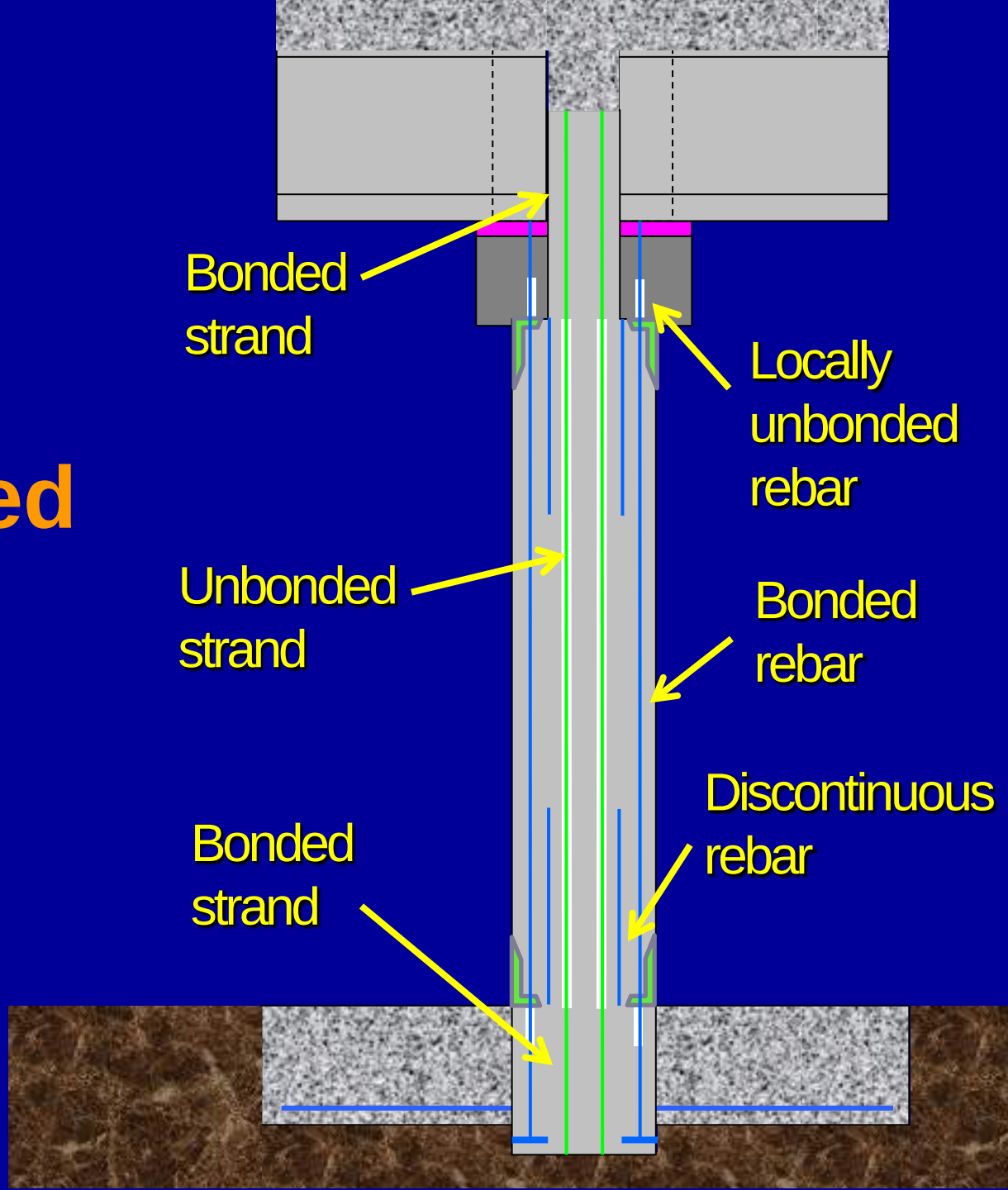
Rocking column after 10% drift



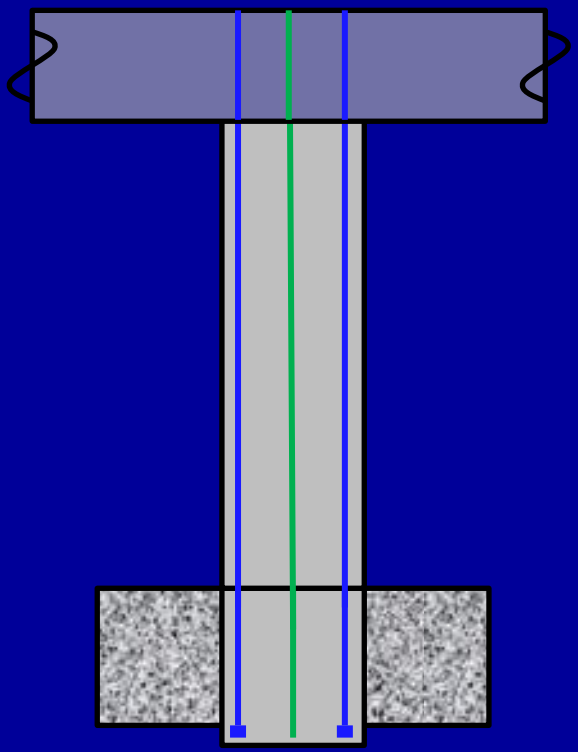


Post-Earthquake Residual Displacements

Precast, Pretensioned Column



Moment-Rotation Behavior

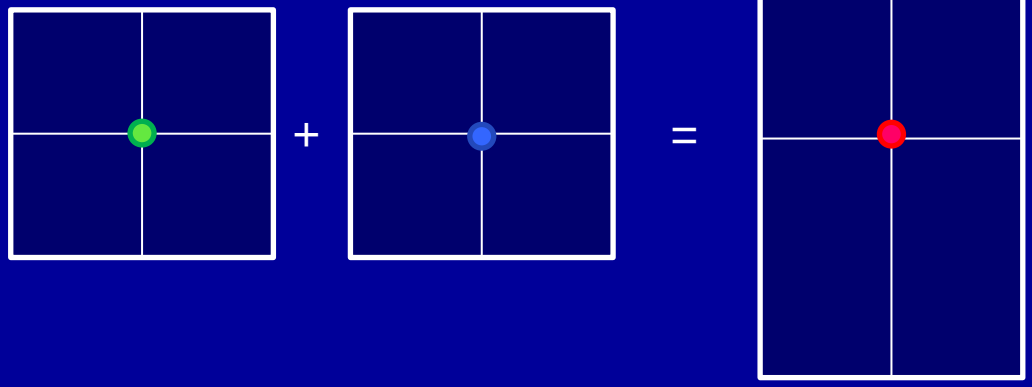


Moment-Rotation

Strand

Rebar

Total



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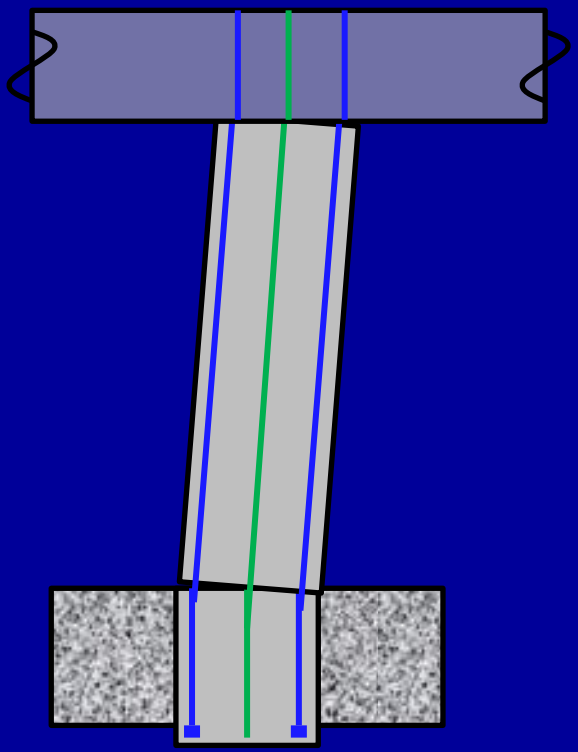

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Rebar

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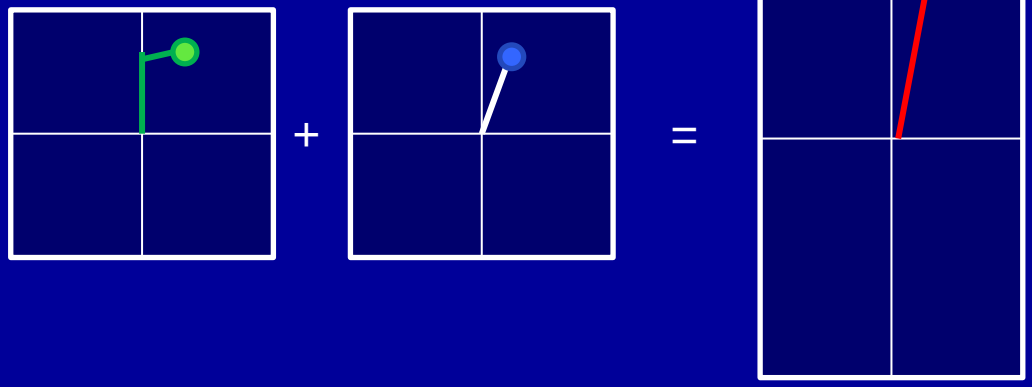
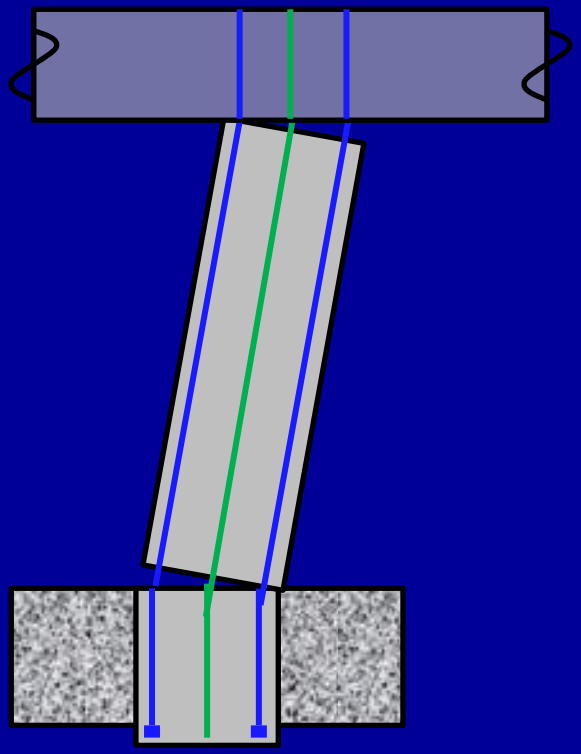


Moment-Rotation Behavior



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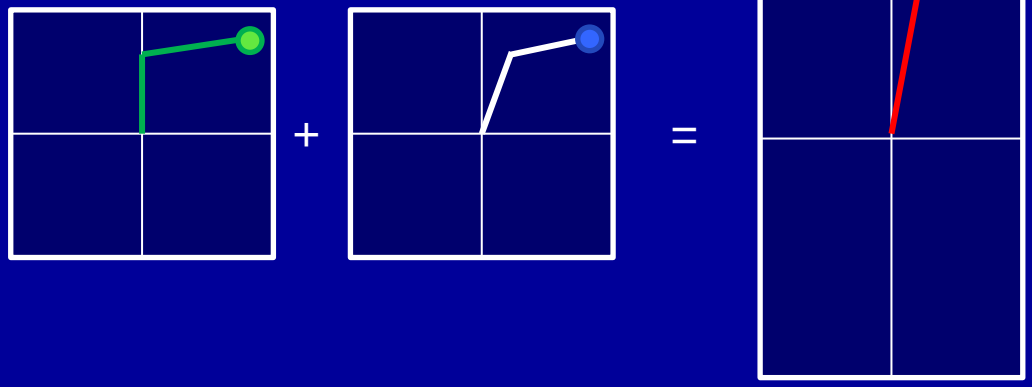

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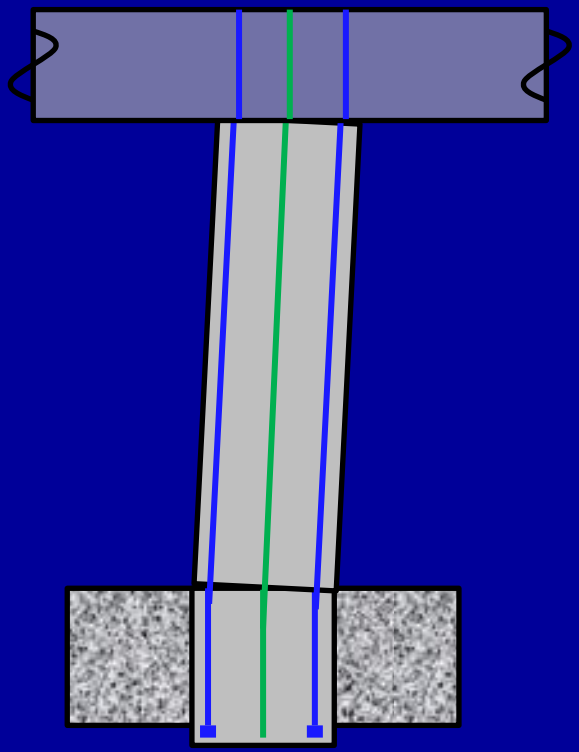

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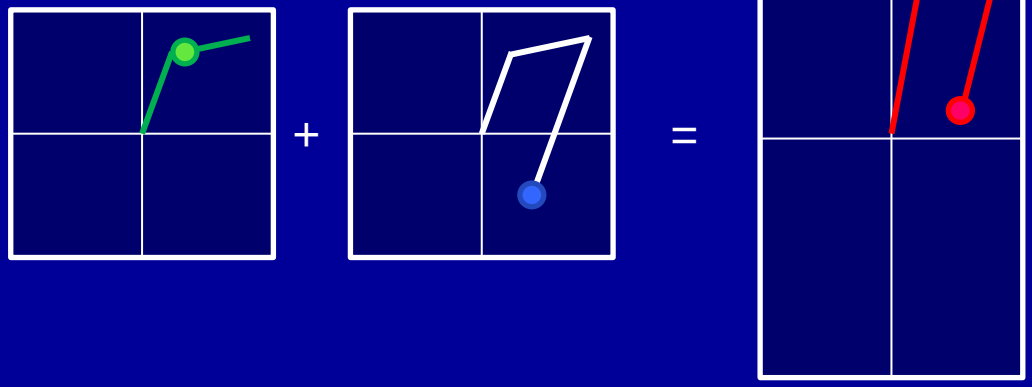

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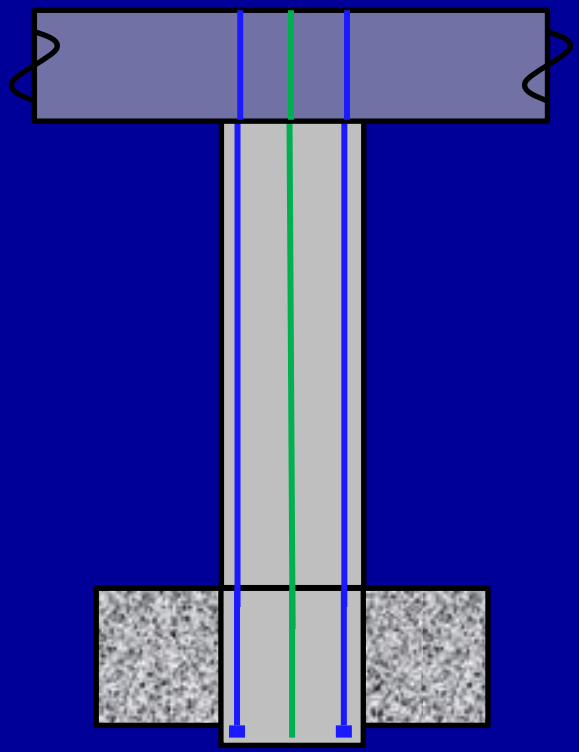

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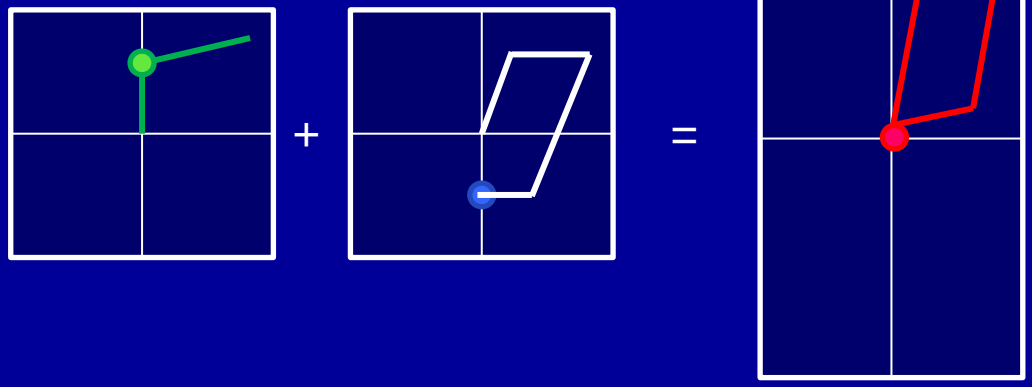
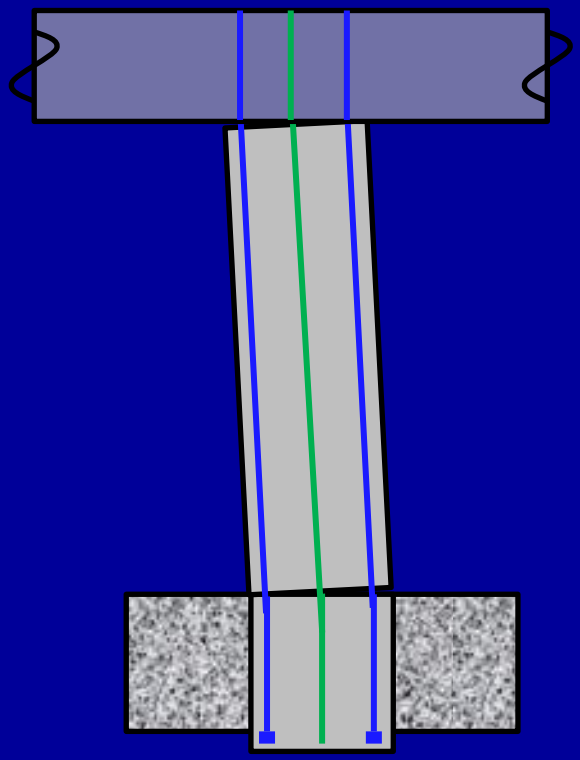


Moment-Rotation Behavior



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Rebar

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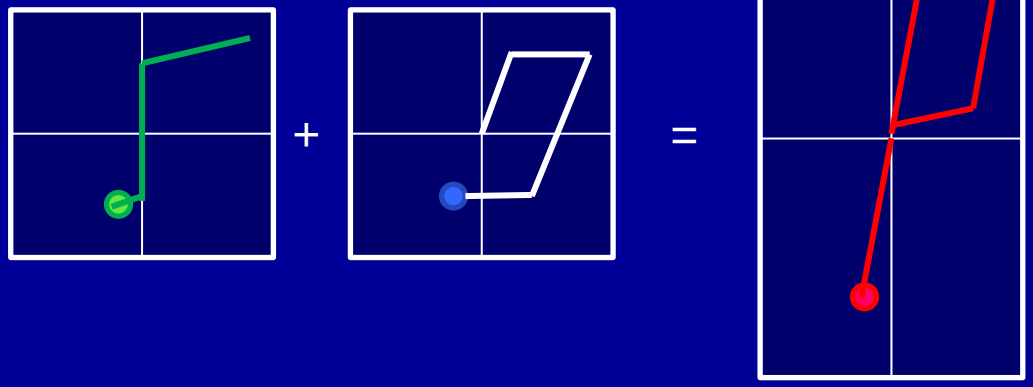

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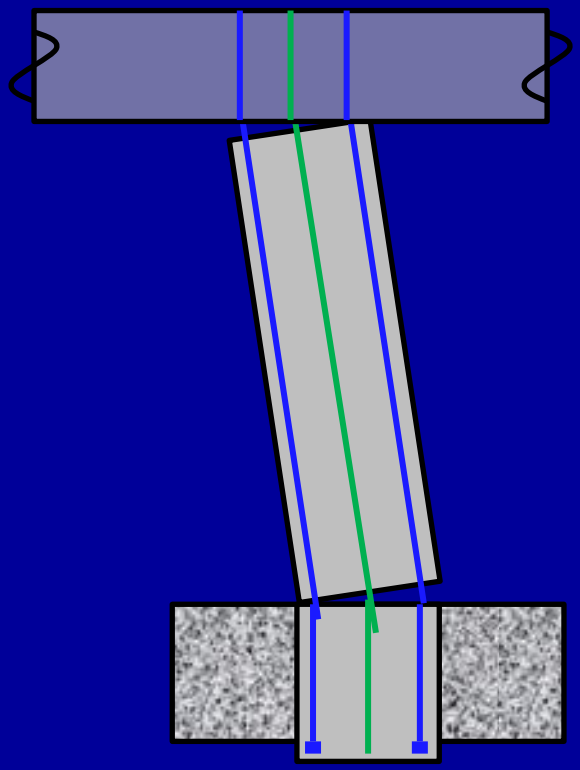

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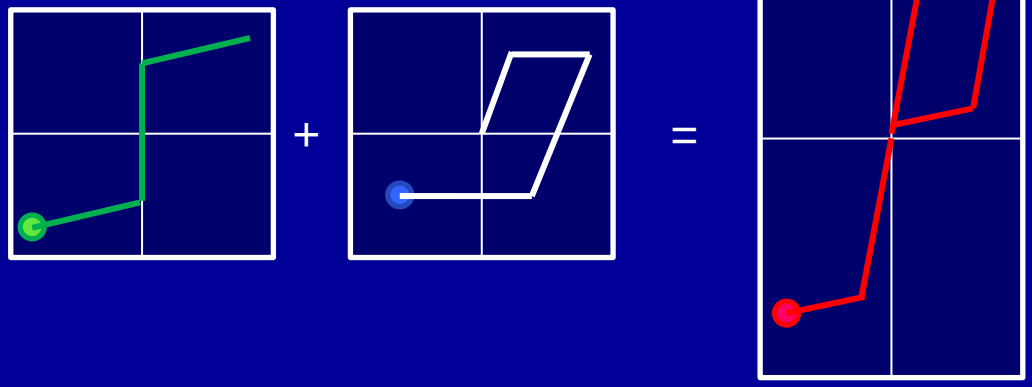

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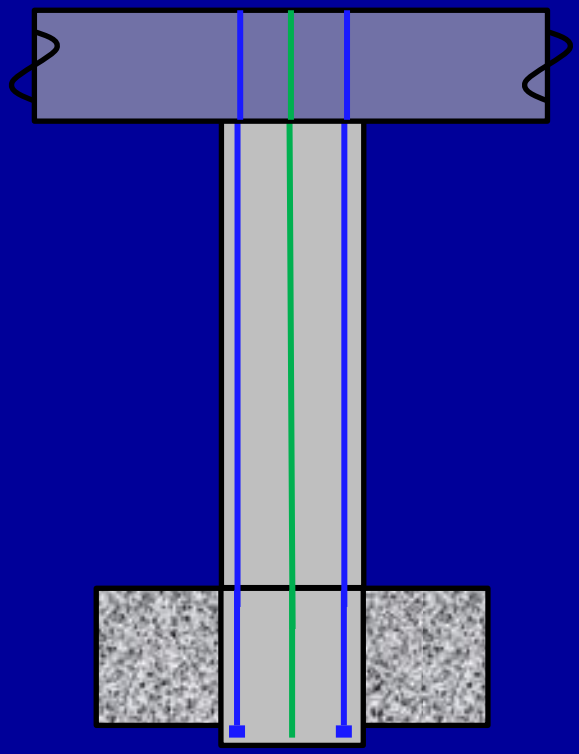

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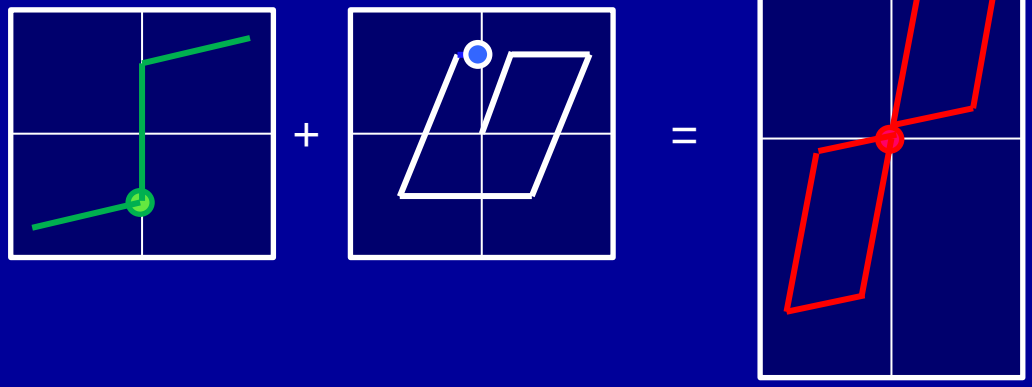
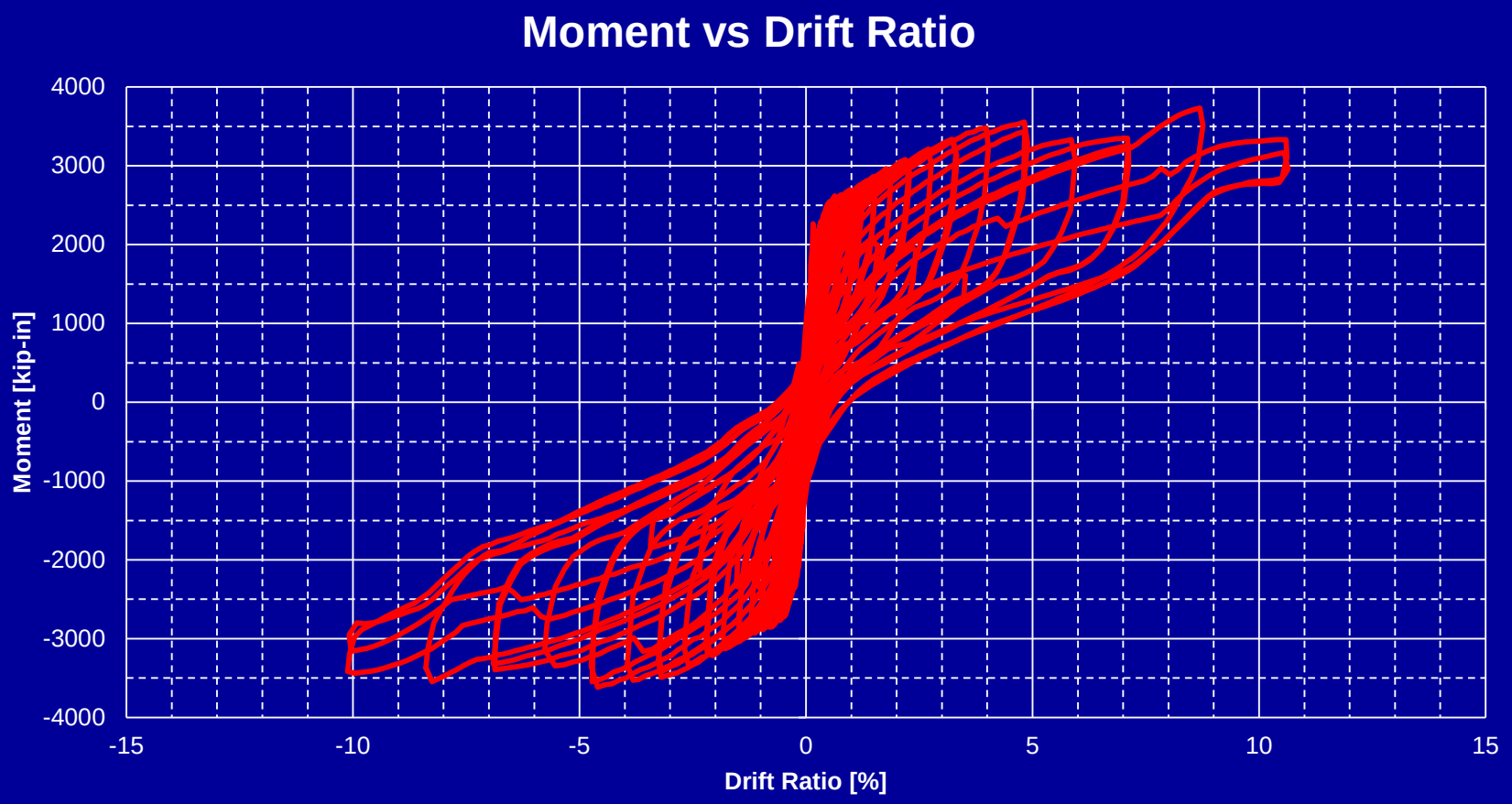


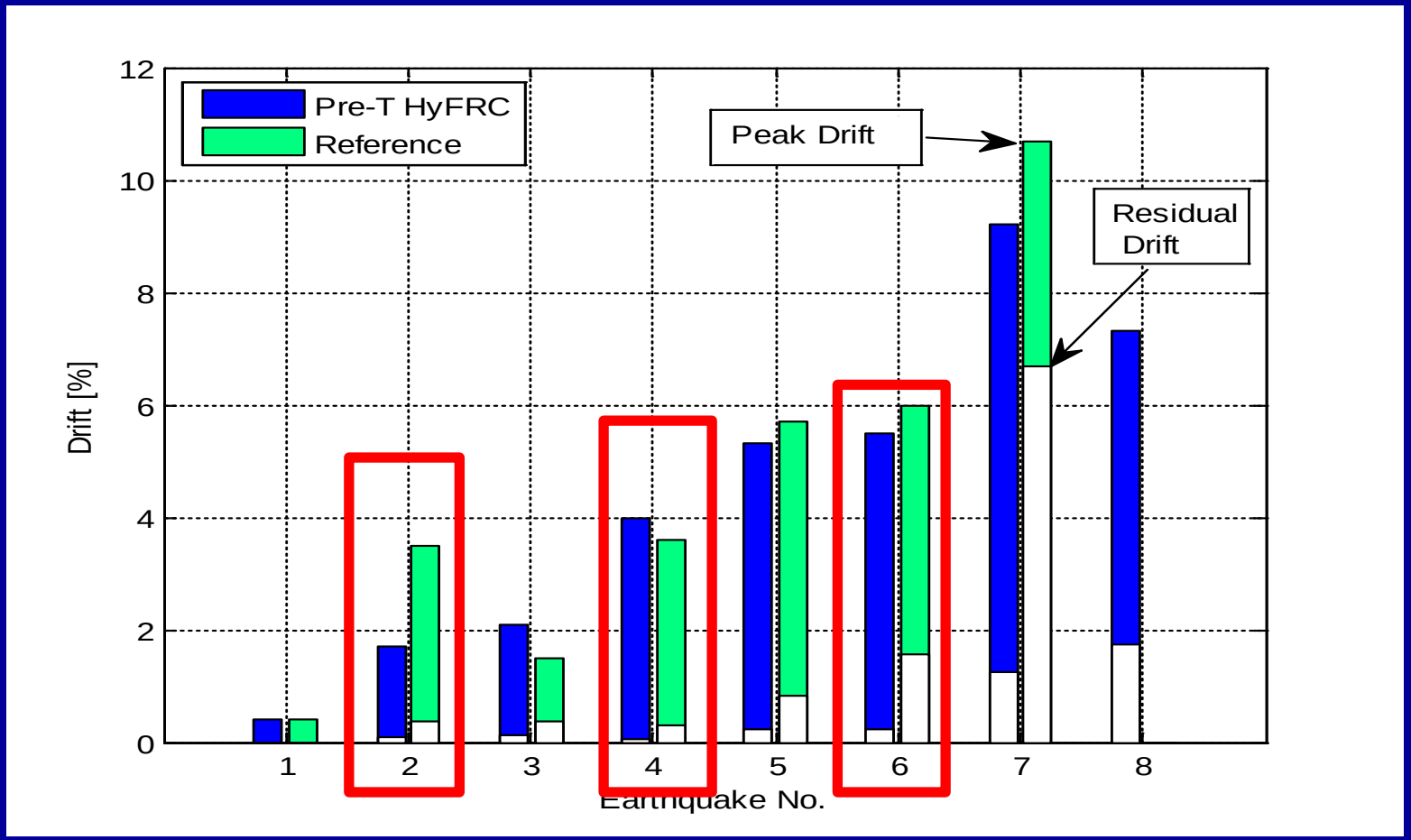
Quasi-static Test Results



Shaking table tests

(without steel confining tube at interface)

Shaking Table Test Results



- Peak drifts: about the same
- Residual drifts: smaller in Pre-T column.

Upcoming Tests

- Quasi-static test on top connection
  (UW, Sept 2013)

- Shaking table tests on 3-bent bridge
  (UNR NEES, Spring 2014)

Conclusions
Pre-tensioned bent system

- Accelerated Construction
  - Pre-tensioned bent system uses essentially the same connections as the precast (non-ps) system, which has been successfully implemented in the field.
- Seismic damage:
  - Negligible concrete damage even at 10% drift.
  - Rebar fracture at approx. 5% to 6% drift.
- Residual displacements:
  - Much smaller than with RC columns
  - Approx. $0.1\delta_{peak.}$

Thank You