Socket Connections for Rapid Construction of Bridge Bents with Spread Footings.

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Acknowledgments

- Federal Highway Administration
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- Washington State DOT
- TransNow Center
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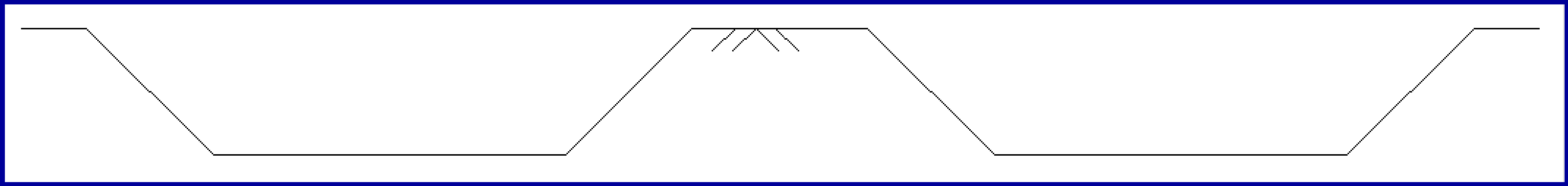
Conventional Bridge Bent

- Slow to construct

Background

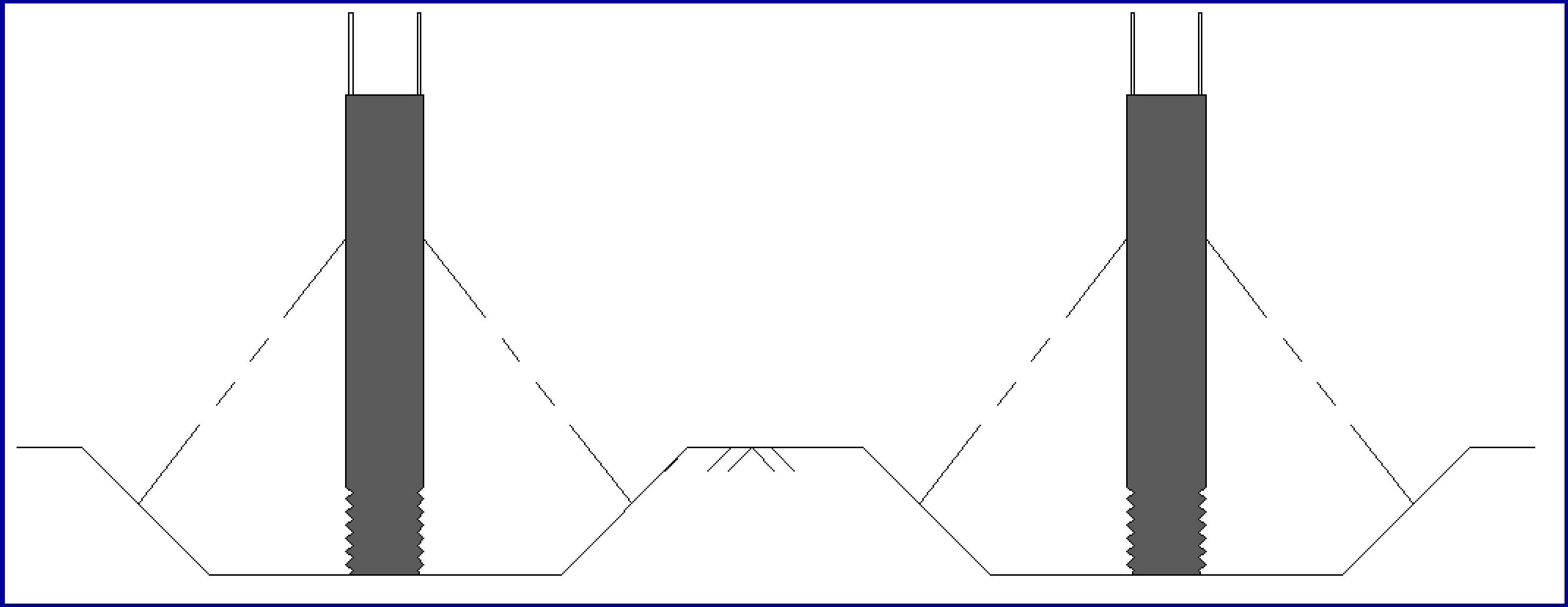
- Have developed a family of connections
- Mix and match to suit conditions
  - Large bars in grouted ducts (column to cap beam)
  - Socket connections (column to footing)

Construction Procedure



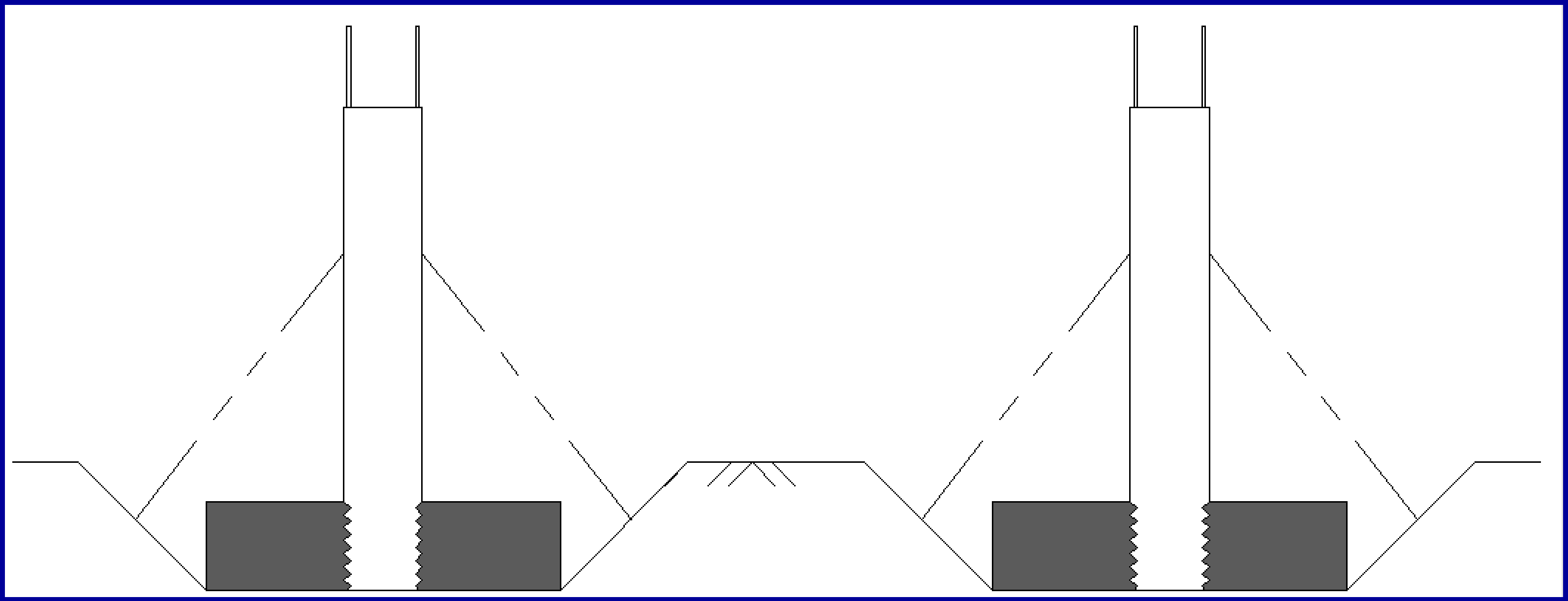
1) Excavate footing.

Construction Procedure



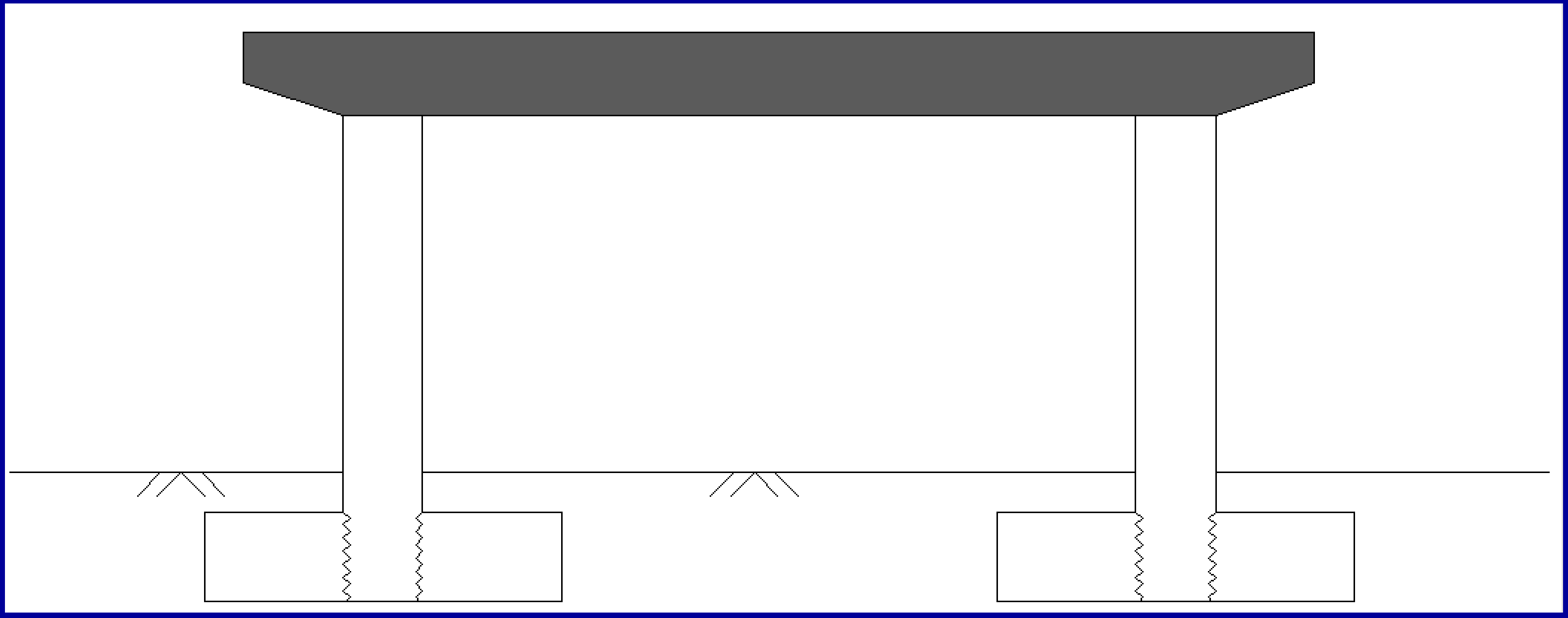
2) Position and brace precast column.

Construction Procedure



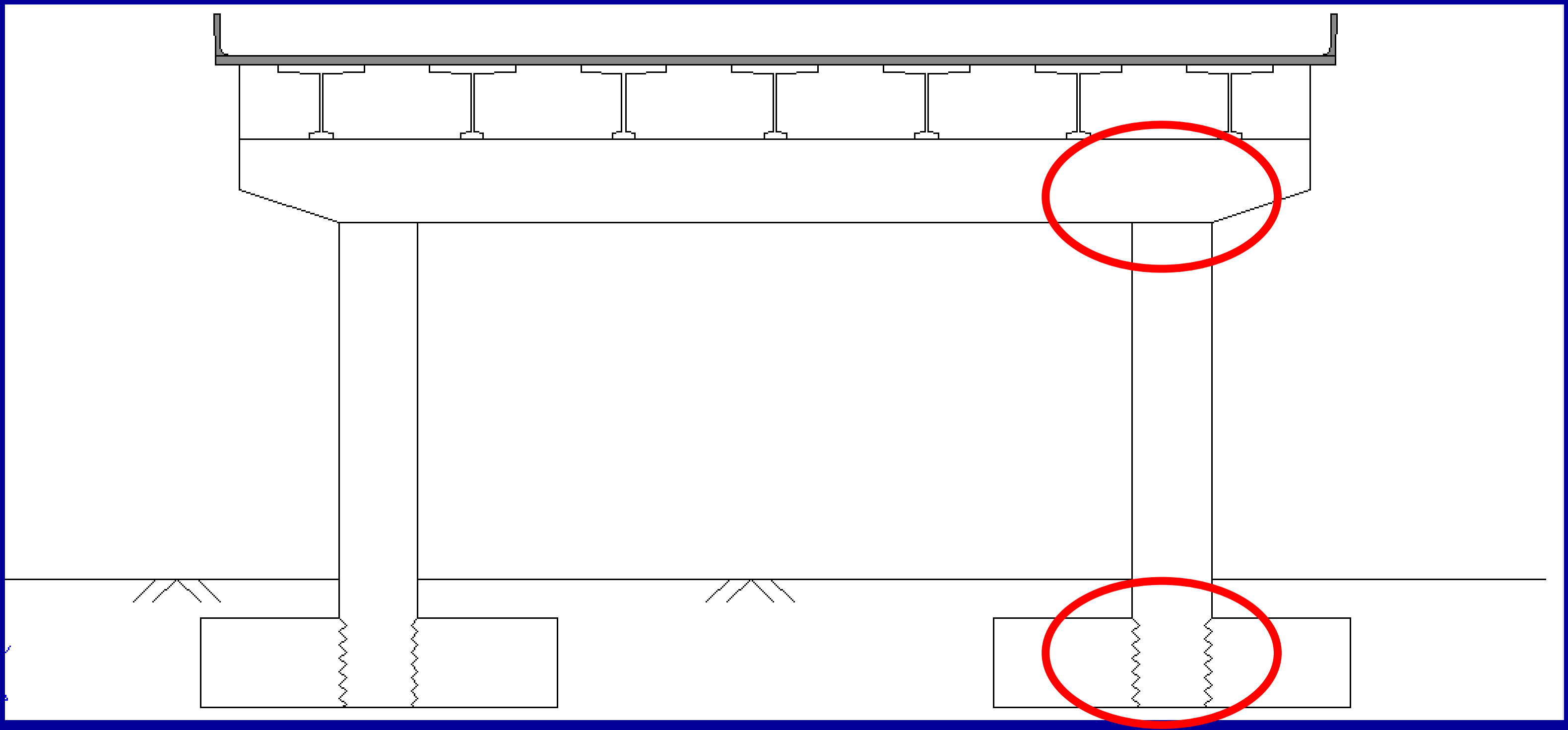
3) Place footing reinforcement and cast.

Construction Procedure



4) Set cap-beam, grout bars into ducts.

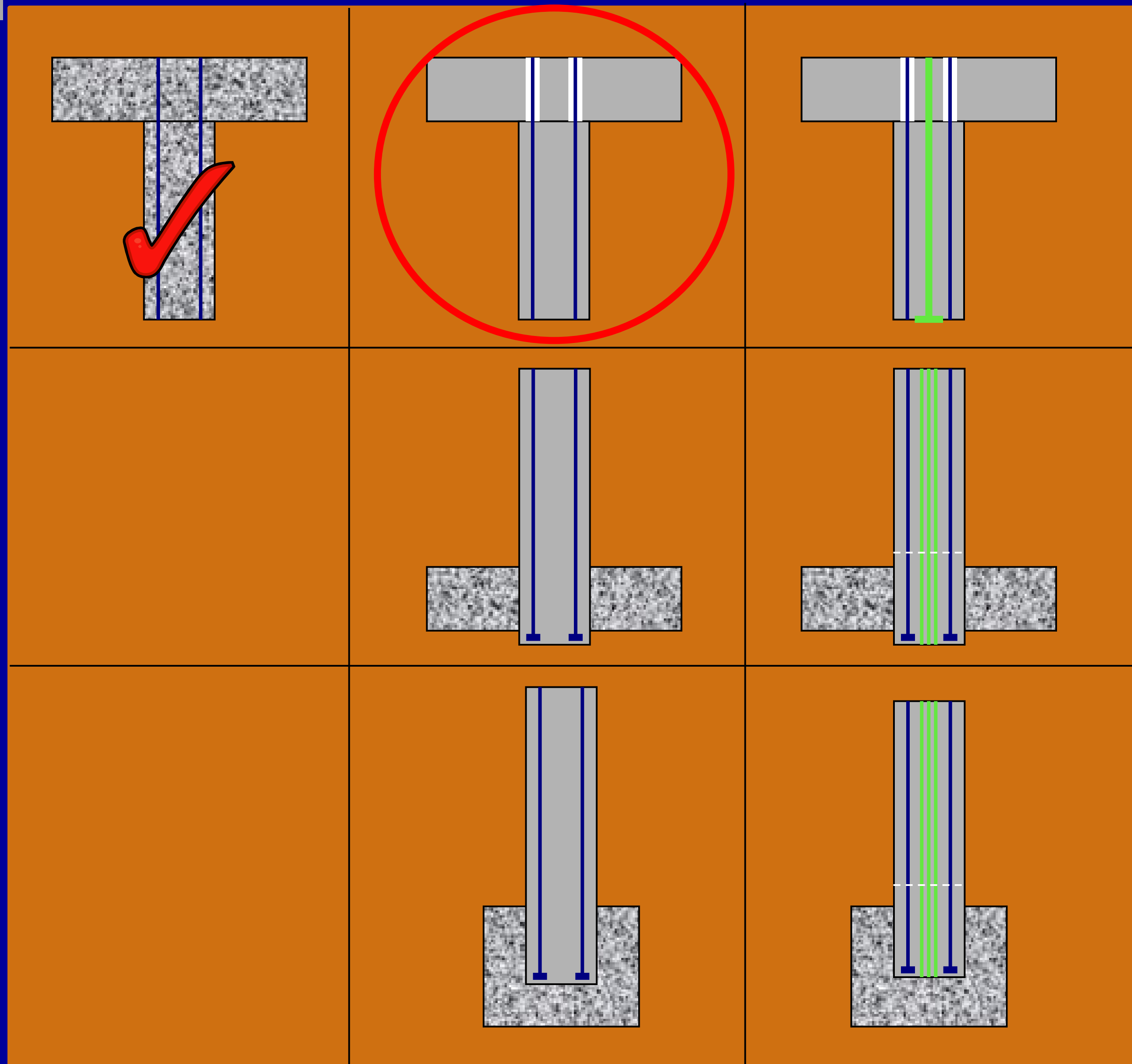
Construction Procedure



5) Place girders, diaphragms and deck.

Connection Details

	c.i.p. RC (ref)	Precast RC	Precast prestressed
Cap-beam to column			
Column to spread footing			
Column to drilled shaft			

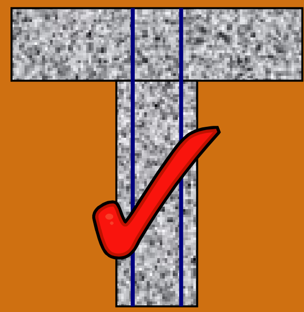
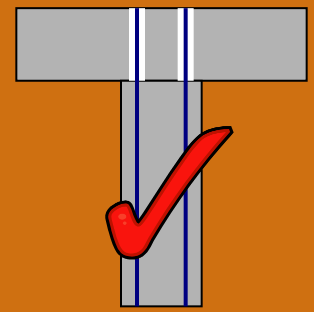
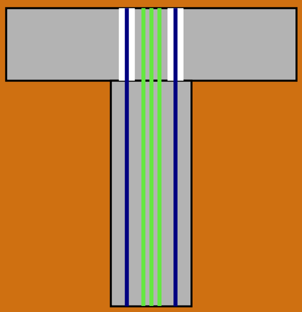
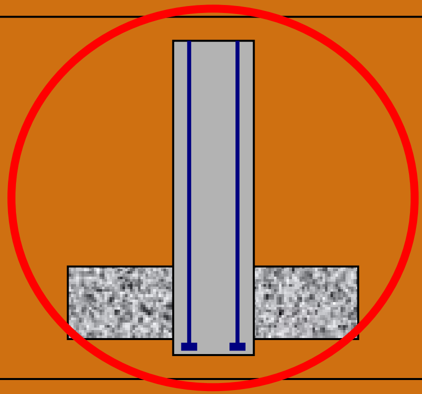
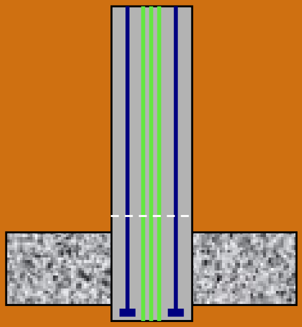
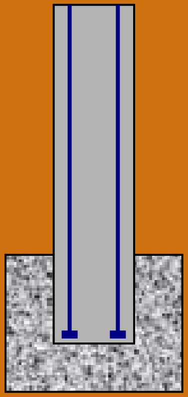
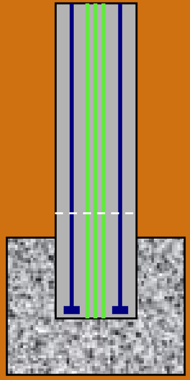


Cap-Beam Connection
Large bar in ducts

- Failure occurs in the column.

- Large-bar precast connection behaves the same as a cast-in-place connection.

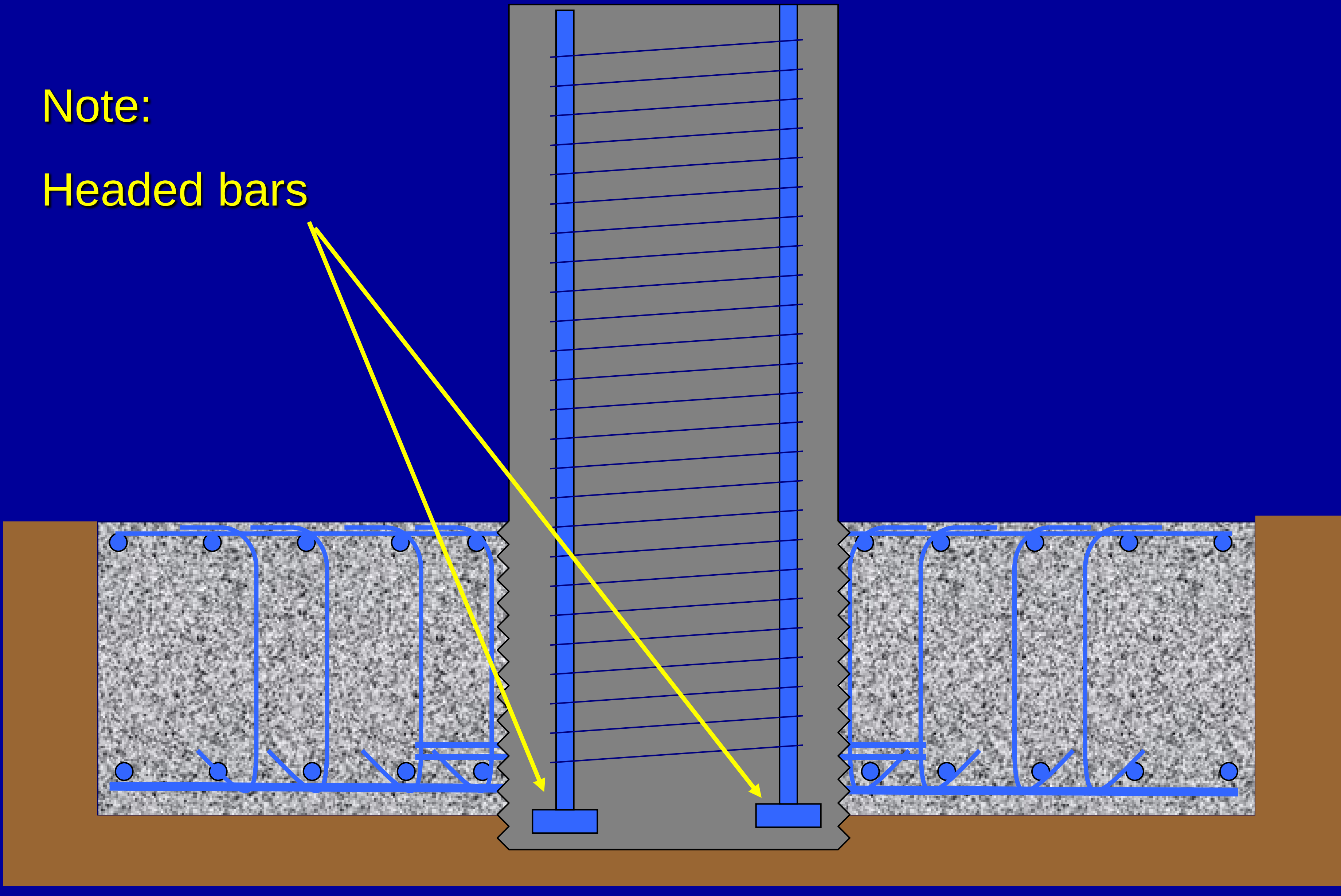
Connection Details

	c.i.p. RC (ref)	Precast RC	Precast prestressed
Cap-beam to column			
Column to spread footing			
Column to drilled shaft			

Footing Connection - Construction

Note:

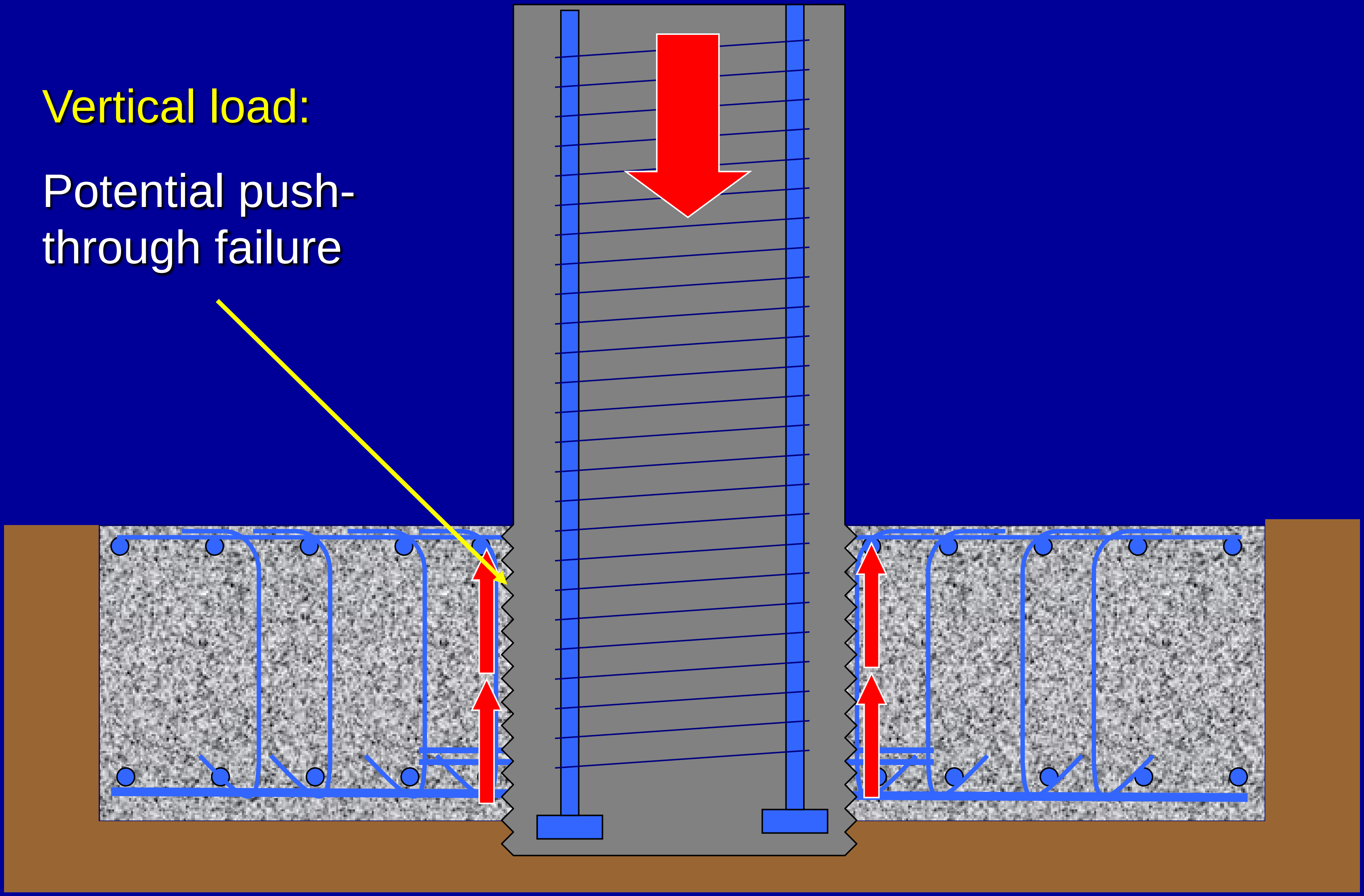
Headed bars



Footing Connection – Failure Modes

Vertical load:

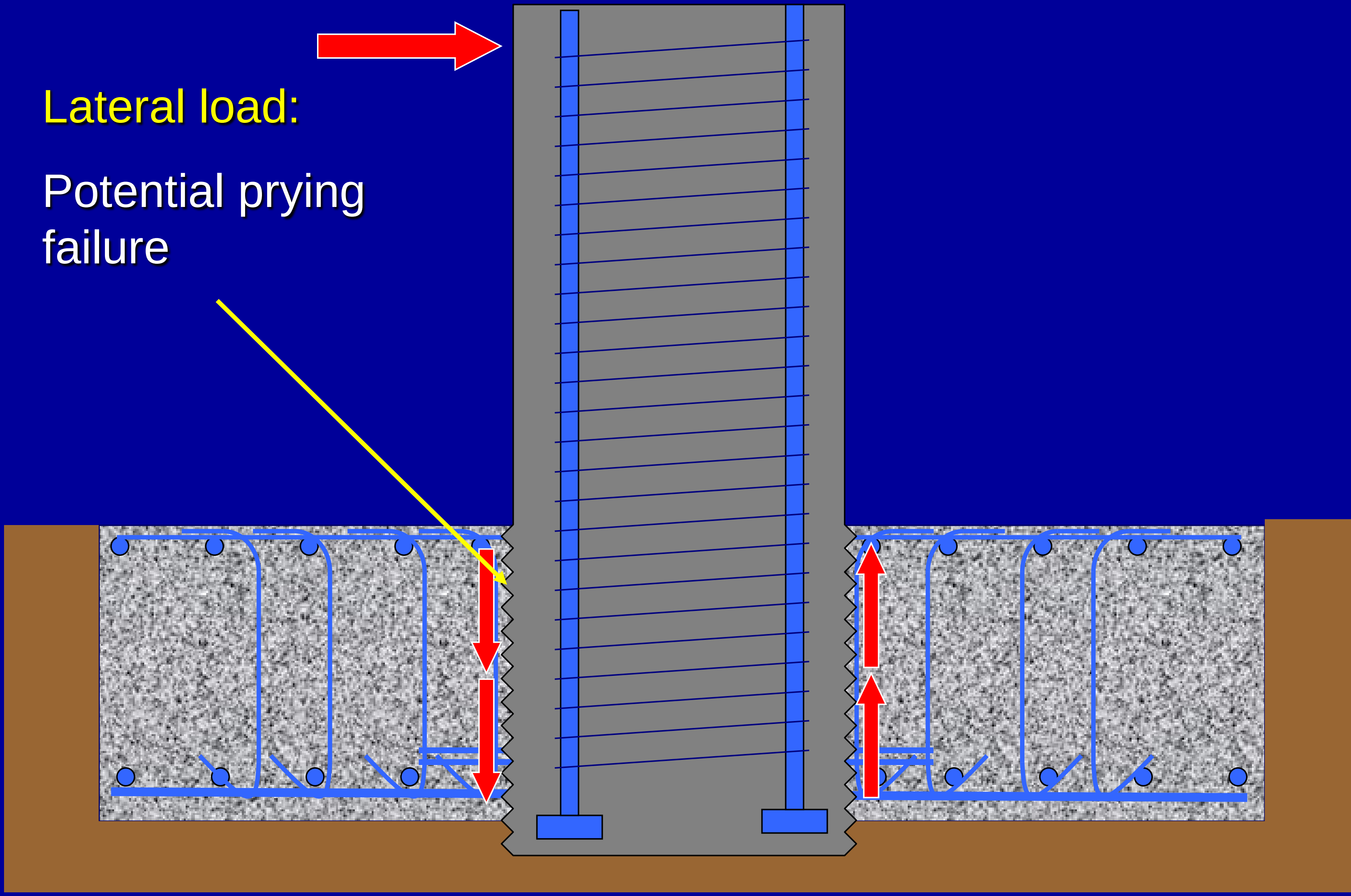
Potential push-through failure



Footing Connection

Lateral load:

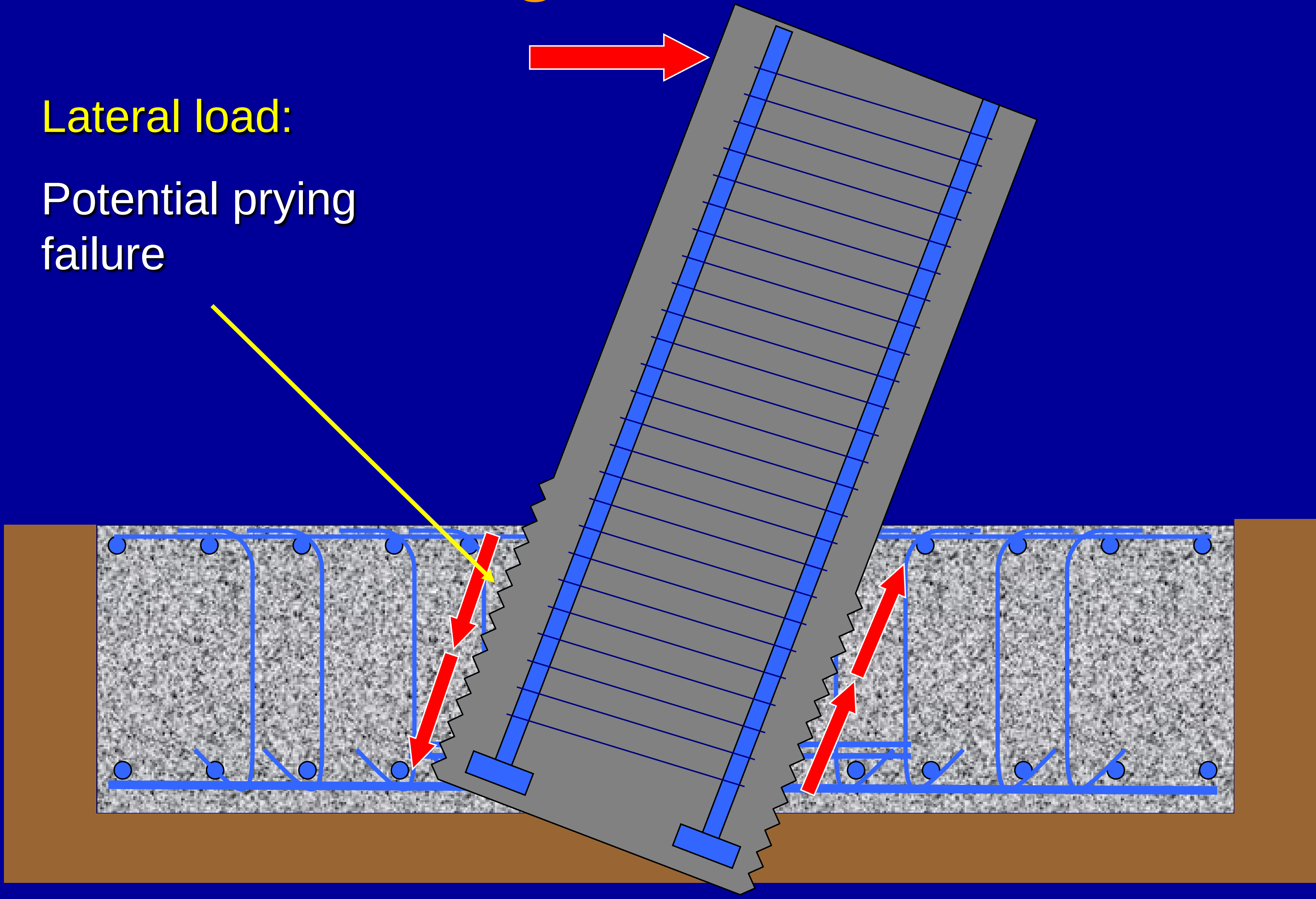
Potential prying failure



Footing Connection

Lateral load:

Potential prying failure

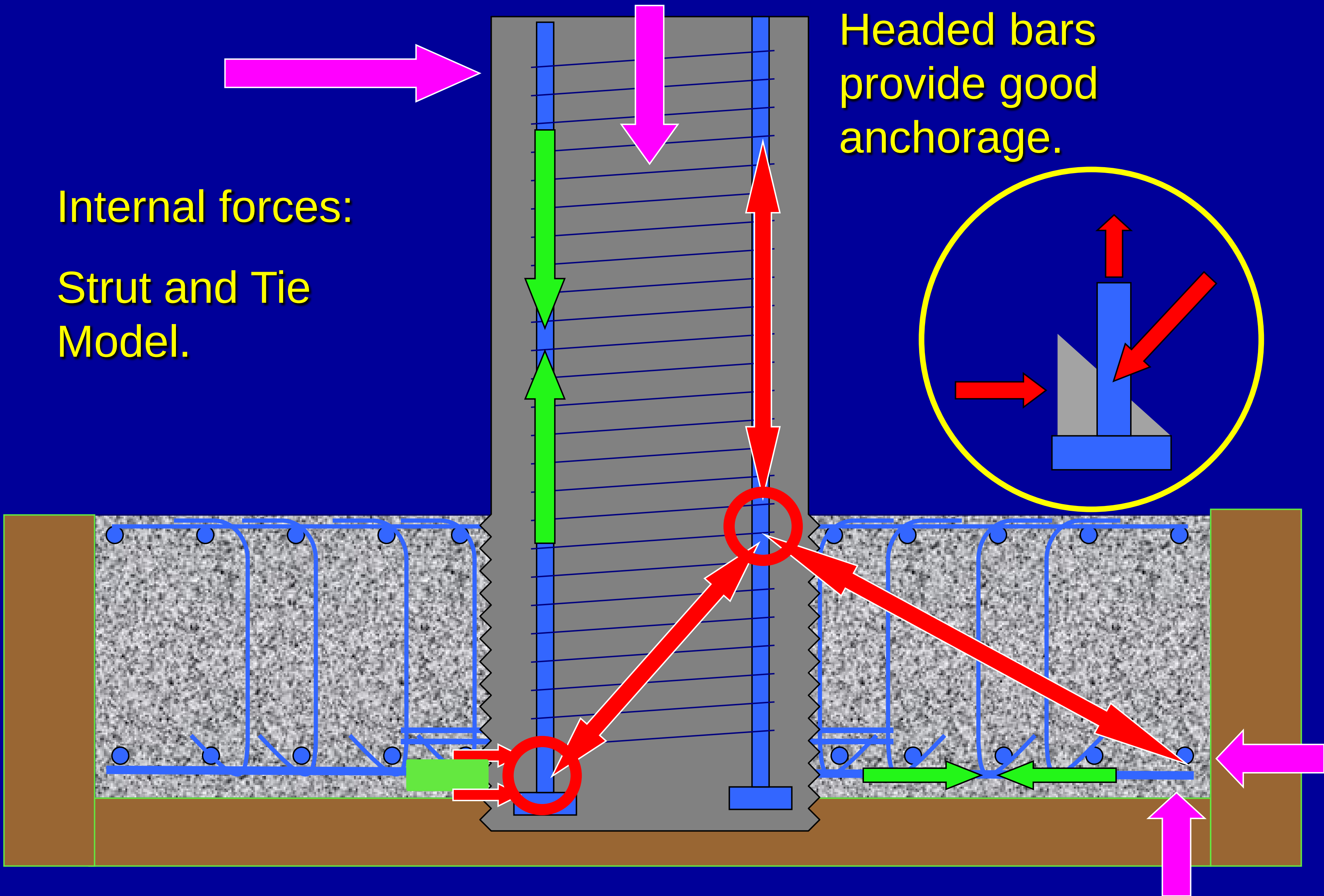


Footing Connection - Headed Bars

Internal forces:

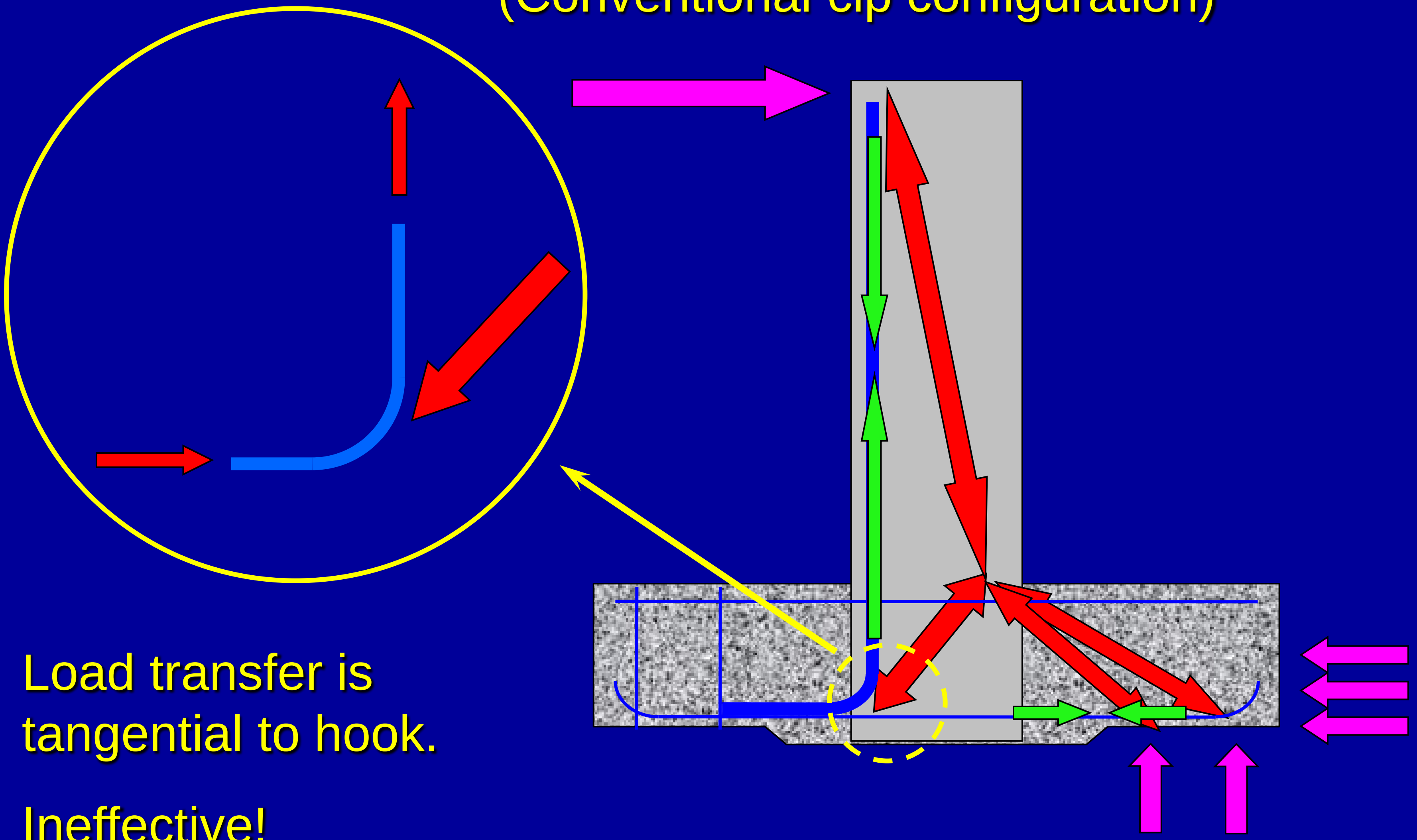
Strut and Tie Model.

Headed bars provide good anchorage.



Footing Connection

Hooked bars facing out
(Conventional cip configuration)



Load transfer is
tangential to hook.

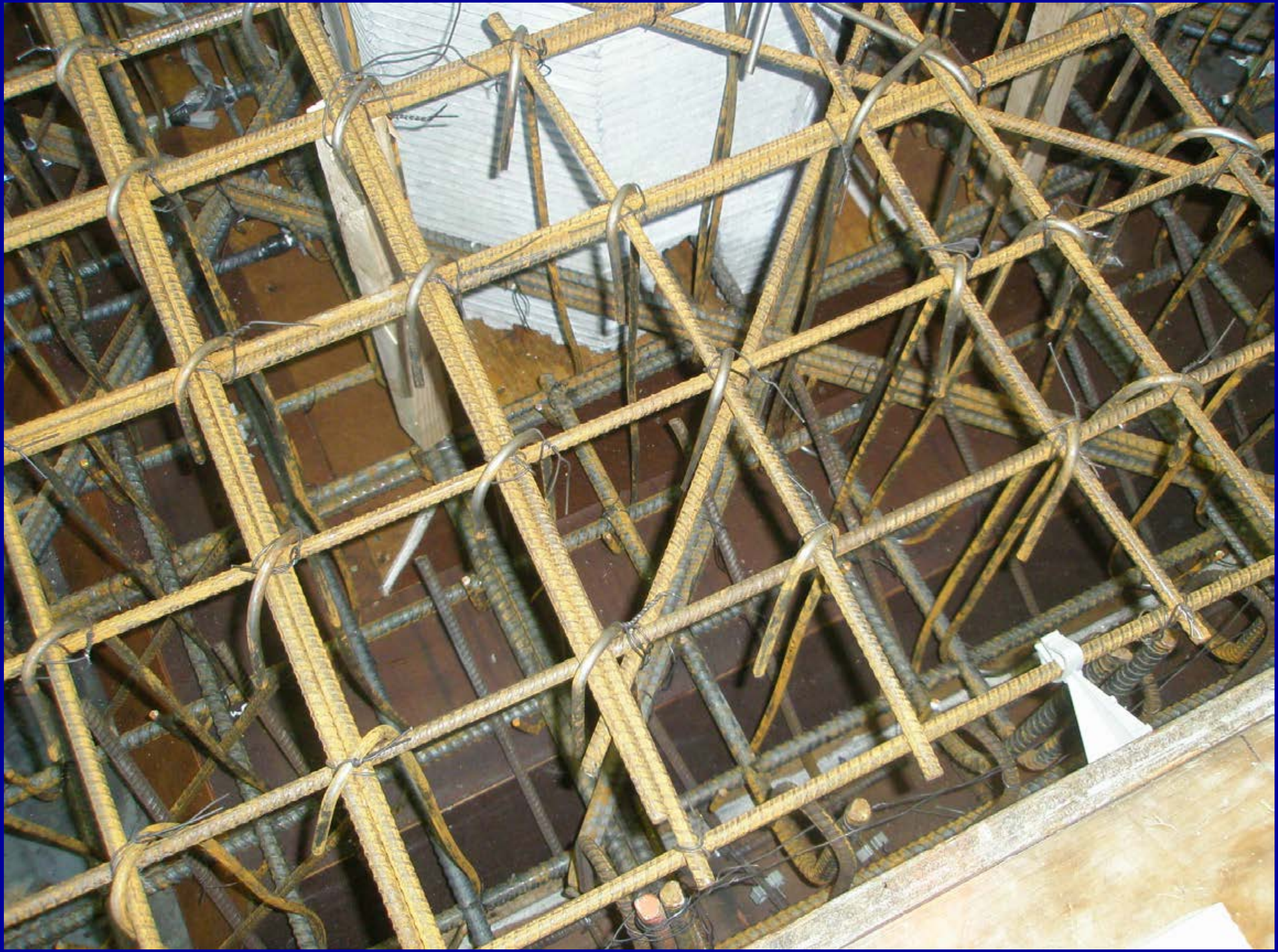
Ineffective!

Socket Connection Test Program

Specimens – Test Matrix

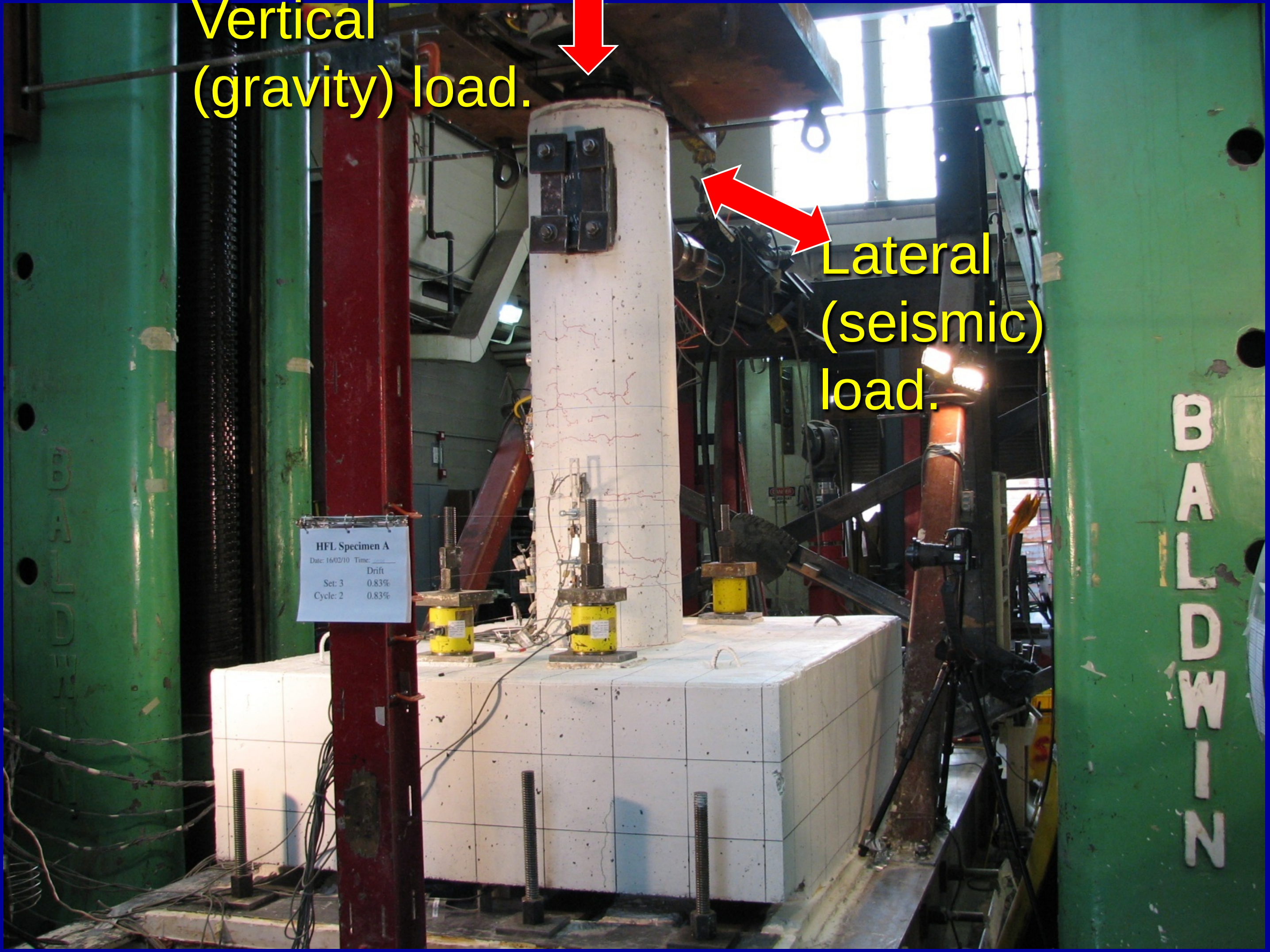
Specimen	h_f/D_c	Column slots	Diagonal bars	Stirrups
SF-1 (reference)	1.1	Yes	Full AASHTO shear friction	AASHTO prescriptive
SF-2	1.1	**No**	**1/3 AASHTO shear friction**	**1/2 AASHTO prescriptive**
SF-3	**0.5**	No	Full AASHTO shear friction	Strength

Socket Connection Reinforcement - SF-1

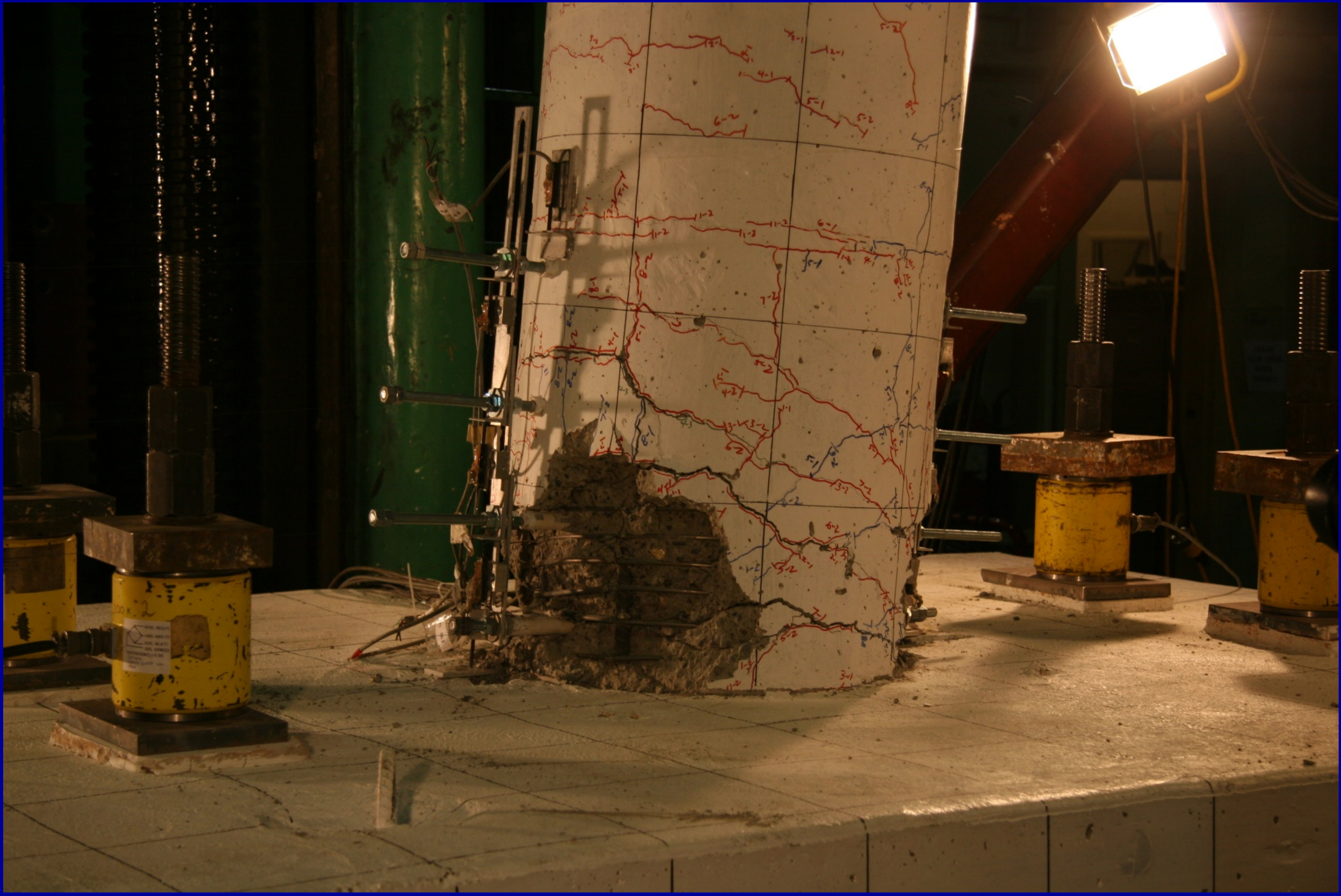


Diagonal “shear friction” steel. Vertical stirrups.

Test Setup

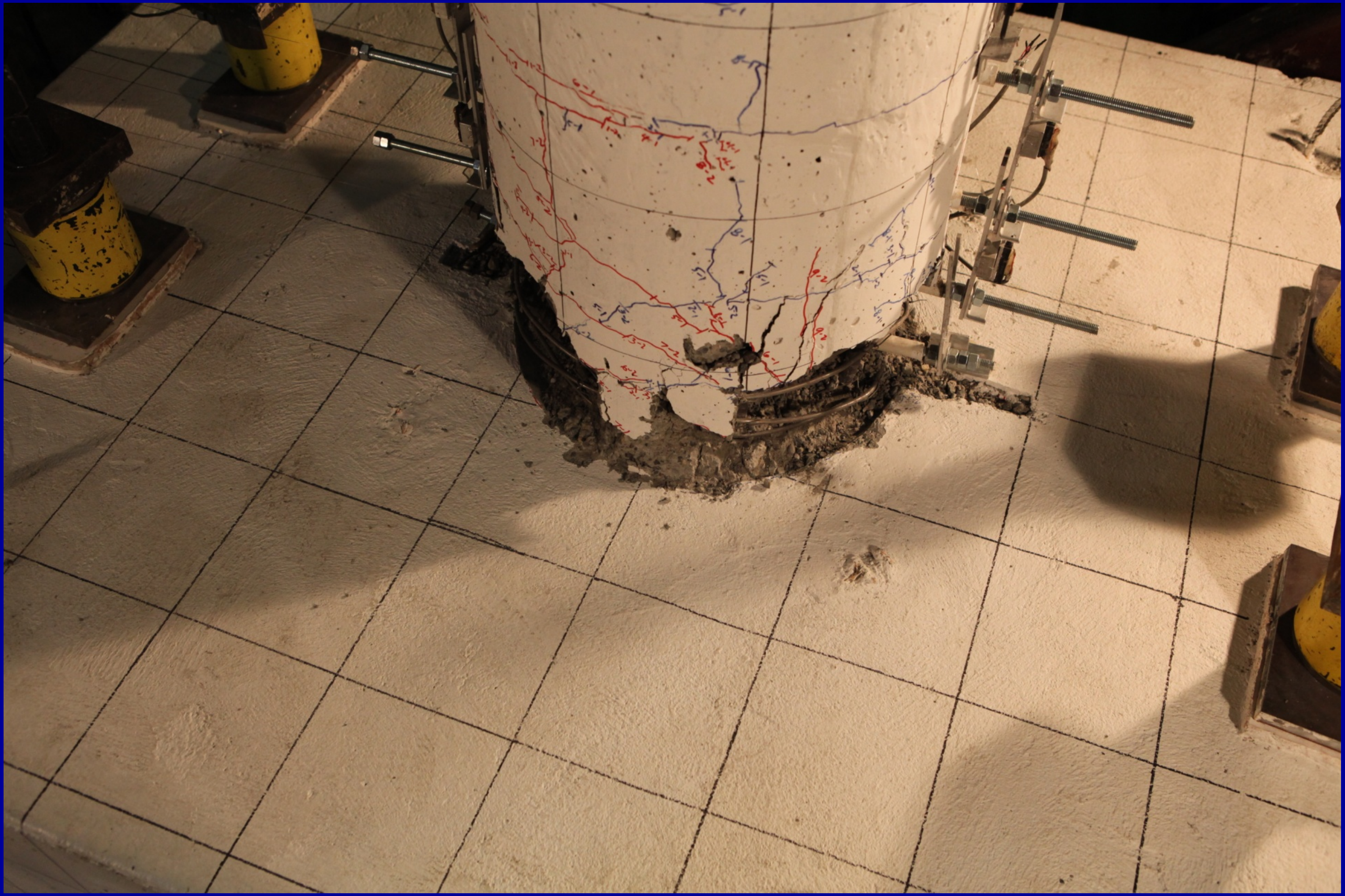

Vertical (gravity) load.
Lateral (seismic) load.
HFL Specimen A
Date: 16/02/10 Time:
Drift
Set: 3 0.83%
Cycle: 2 0.83%
BALDWIN

Lateral load Test



After testing to 10% drift

Footing undamaged – SF-2

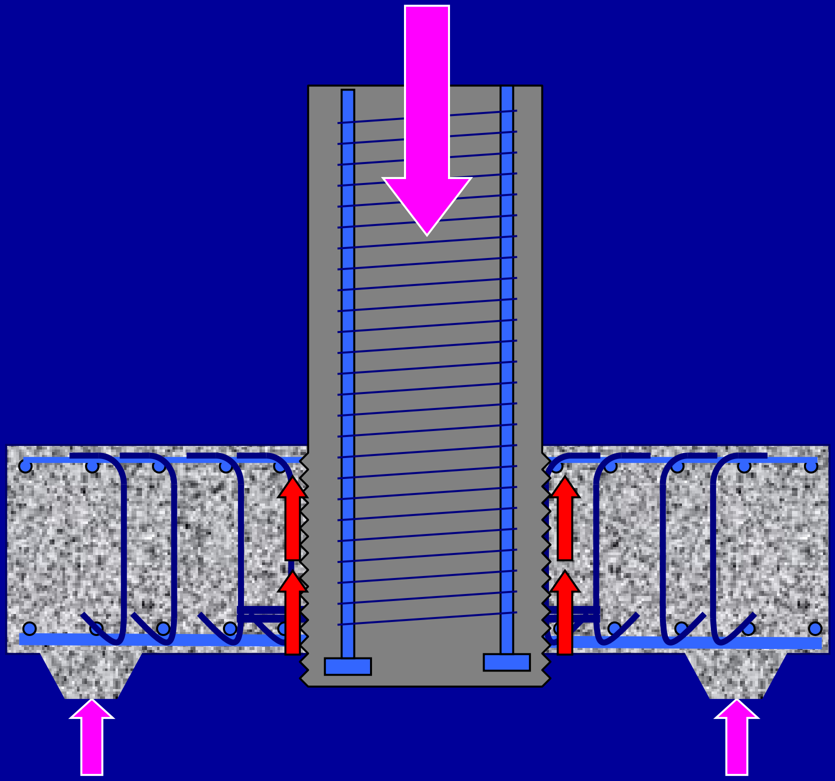


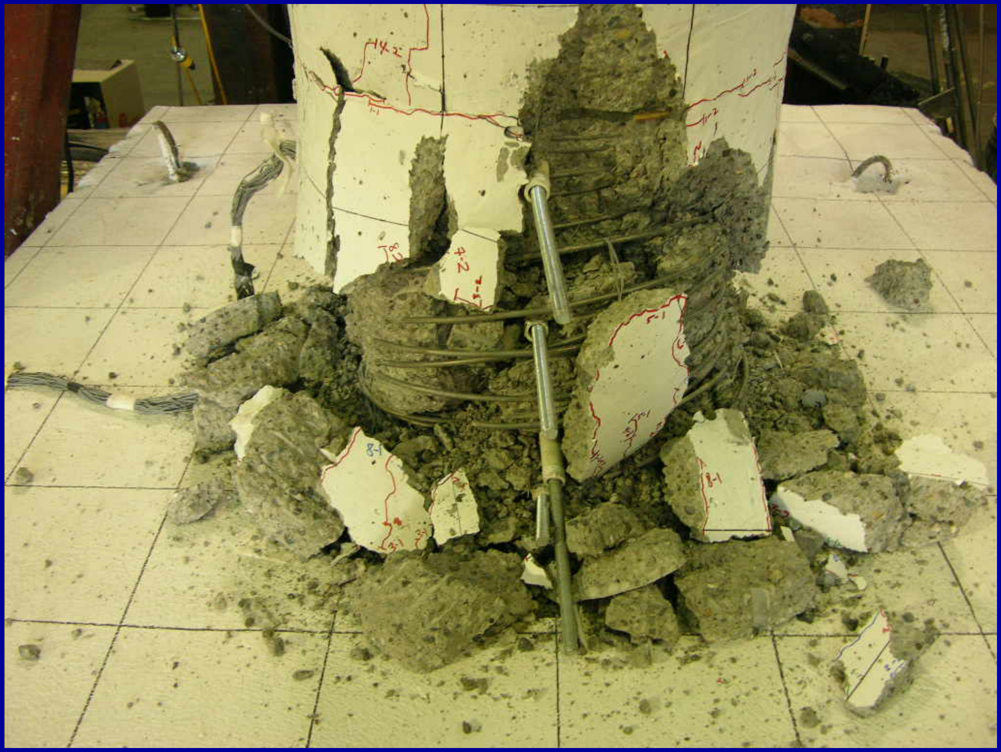
SF-1/SF-2 Seismic Test

- Failure in column.
- Footing undamaged.
- Behavior identical to conventional c.i.p. system.

- Seismic performance exactly as wanted.

SF-1/SF-2 Gravity Load Test

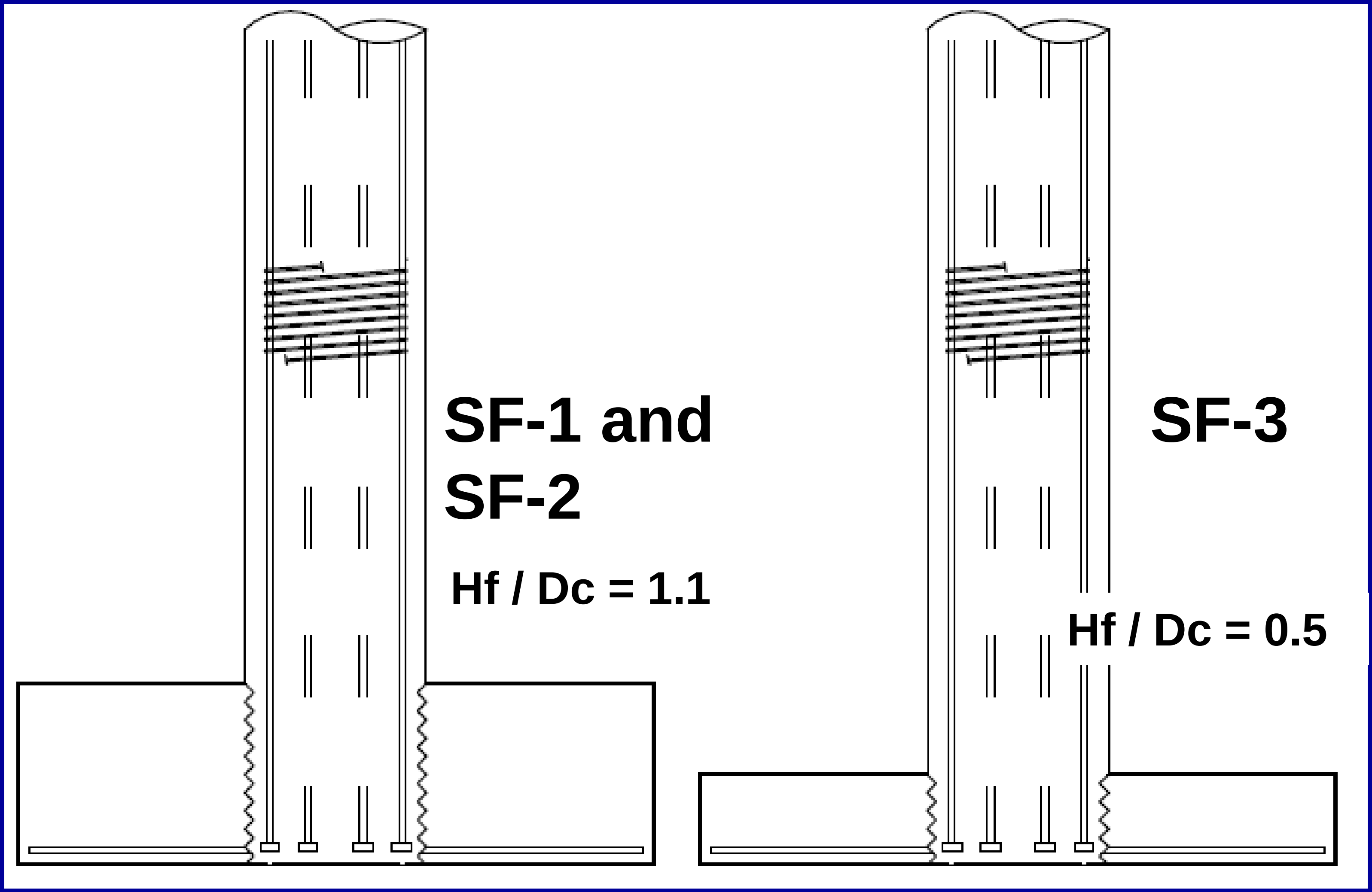




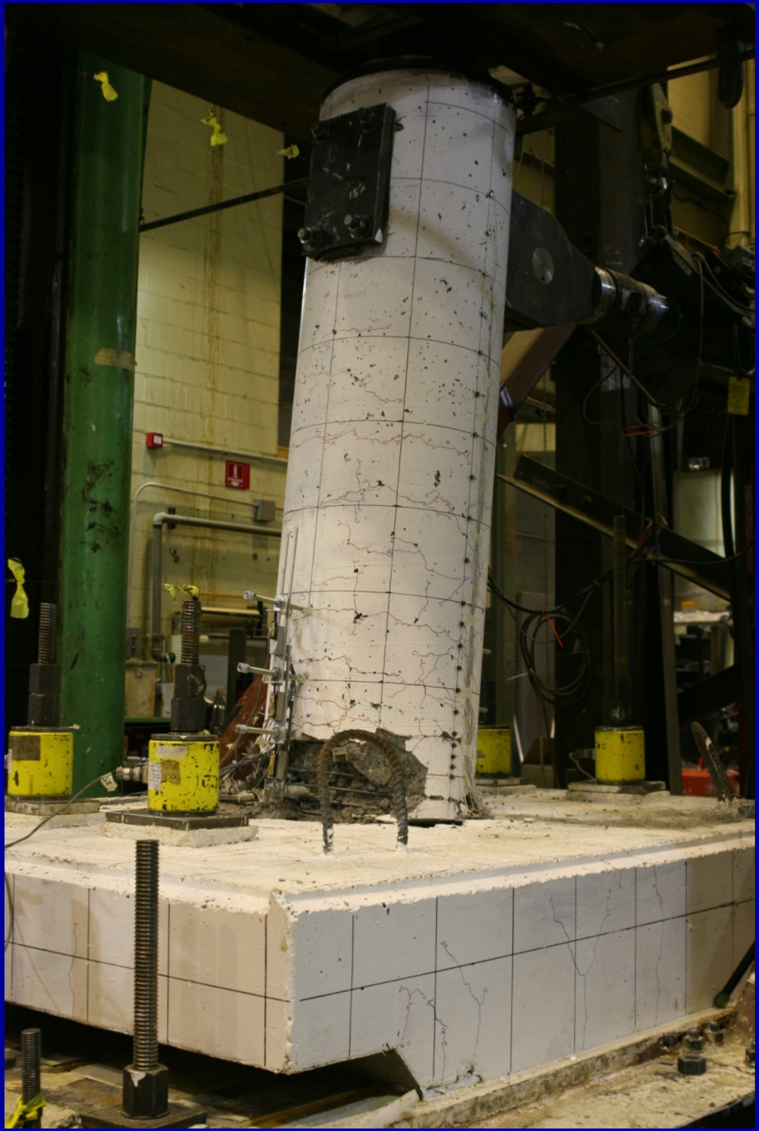
Column crushed at: 850 kips = 3.5 * (1.25DL + 1.75LL).

No damage to footing. No sign of punch-through failure

SF-3 Geometry

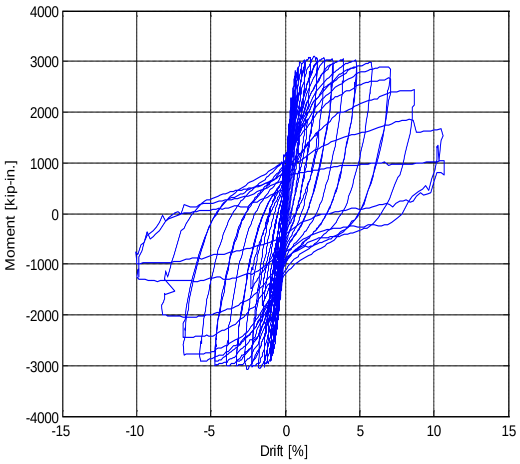


SF-3 during its last cycle (10% drift)

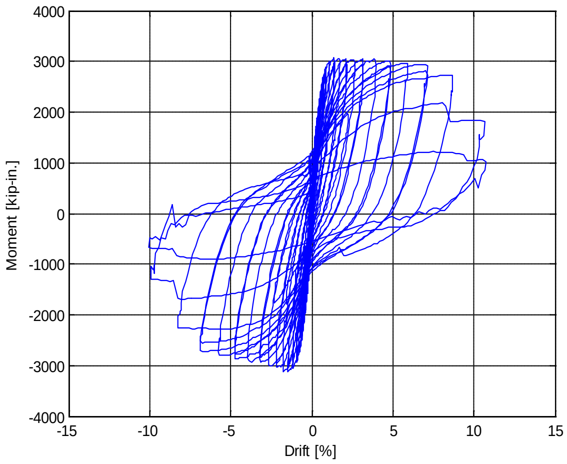


SF-3's Punching Shear and Moment Transfer Failure

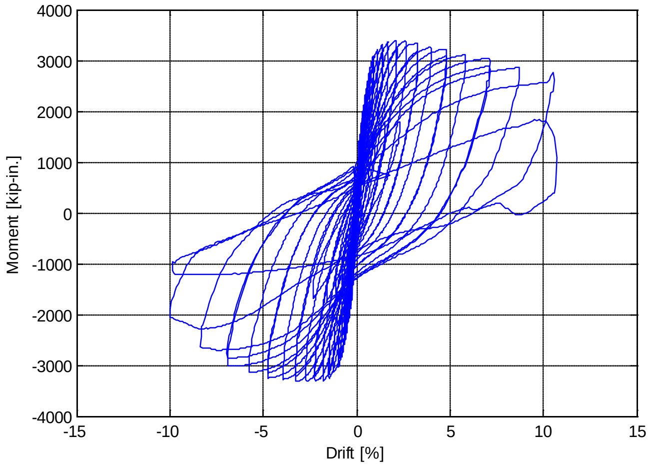
Quasi-static Test Results



SF-1



SF-2



SF-3

Combined punching shear and moment transfer in the last cycle

Field Deployment

Socket Connection

Large-bar, Large-duct Connection

Final Product

Conclusions

- Accelerated Construction:
  - Shorter construction time, especially if used together with large-bar, large-duct connection.
  - Simple to fabricate, transport and erect on site.
- Seismic Performance:
  - Terminators provide better anchorage than hooked bars facing outwards.
  - Footing undamaged in lateral load and vertical load tests.
  - Connection works as well as, or better than, conventional cast-in-place construction.

Thank You

References:

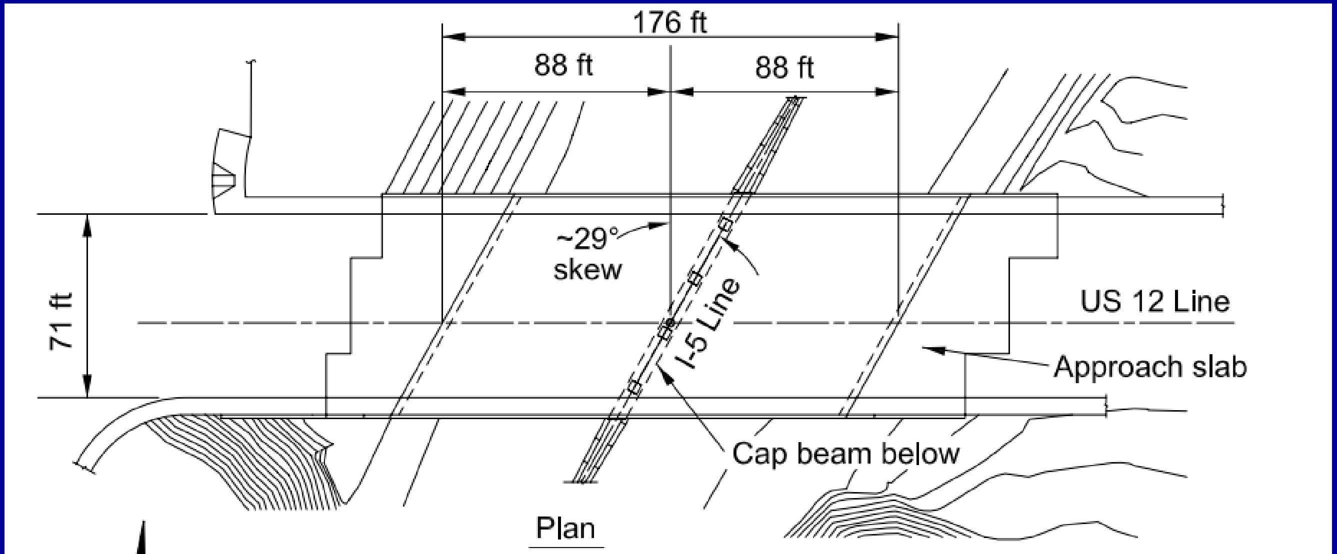
1. Pang, J.B.K., Eberhard, M.O., and Stanton, J.F. (2010). “Large-bar Connection for Precast Bridge Bents in Seismic Regions," *Journal of Bridge Engineering, ASCE,* pp. 231-239

2. Khaleghi, B., Schultz, E., Seguirant, S., Marsh, L., Haraldsson, O., Eberhard, M. and Stanton, J. (2012). “Accelerated Bridge Construction in Washington State -- From Research to Practice,” *PCI Journal*, Autumn, pp. 34-49

3. Haraldsson, O.S., Janes, T.M., Eberhard, M.O. and Stanton, J.F. (2013). "Seismic Resistance of Socket Connection between Footing and Precast Column," *Journal of Bridge Engineering, ASCE,* Autumn, pp. 910-919

US 12 Grand Mound over I-5

- Two spans, tall abutments at ends, and a four column bent at center.
- Socket connection used with large-bar-large-duct column-to-beam connection



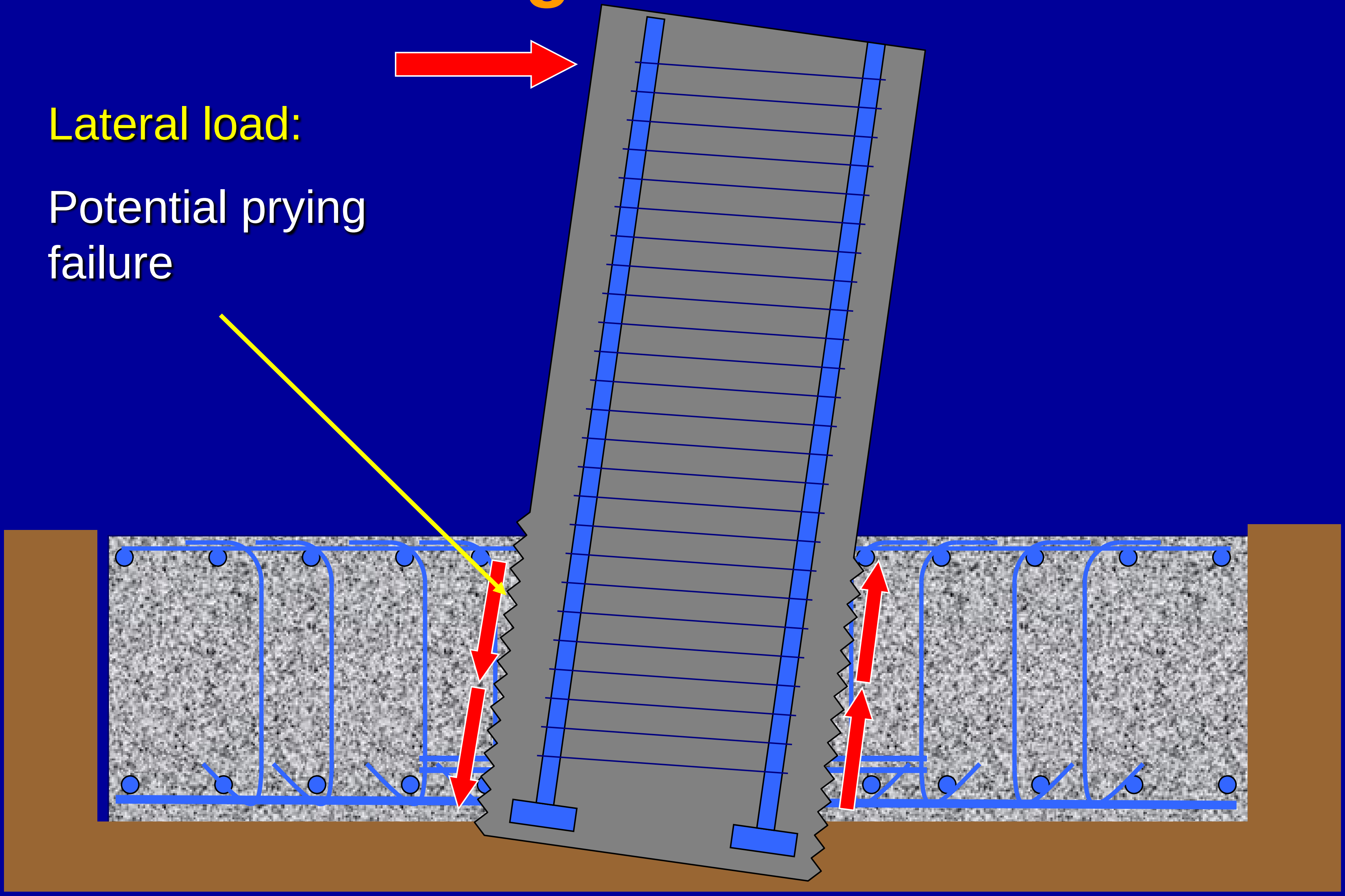
New Footing Connection - Test

Spread Footing Cast - SF-1

Footing Connection

Lateral load:

Potential prying failure



Spread Footing Connection

Constructability

- Column has no projecting bars.
- No “form-savers”.
- Easy to fabricate and transport.