

ACI Research in Progress Fall 2023

Behavior of Headed and Hooked Reinforcement Anchored in Beam-Column Knee Joints

Kinsey C. Skillen, Ph.D.





TxDOT Project 0-7155: Define/Refine Design Provisions for Headed and Hooked Reinforcement

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Assistant Professor of Civil Engineering

Texas A&M University

Research Questions

- Can joint strength and deformability be improved through the use of headed reinforcement? (Compared to existing detailing practice)
- Improve constructability?

Straddle Bents:



Straddle Bents:



Multi-pier Bent Caps:



Multi-pier Bent Caps:



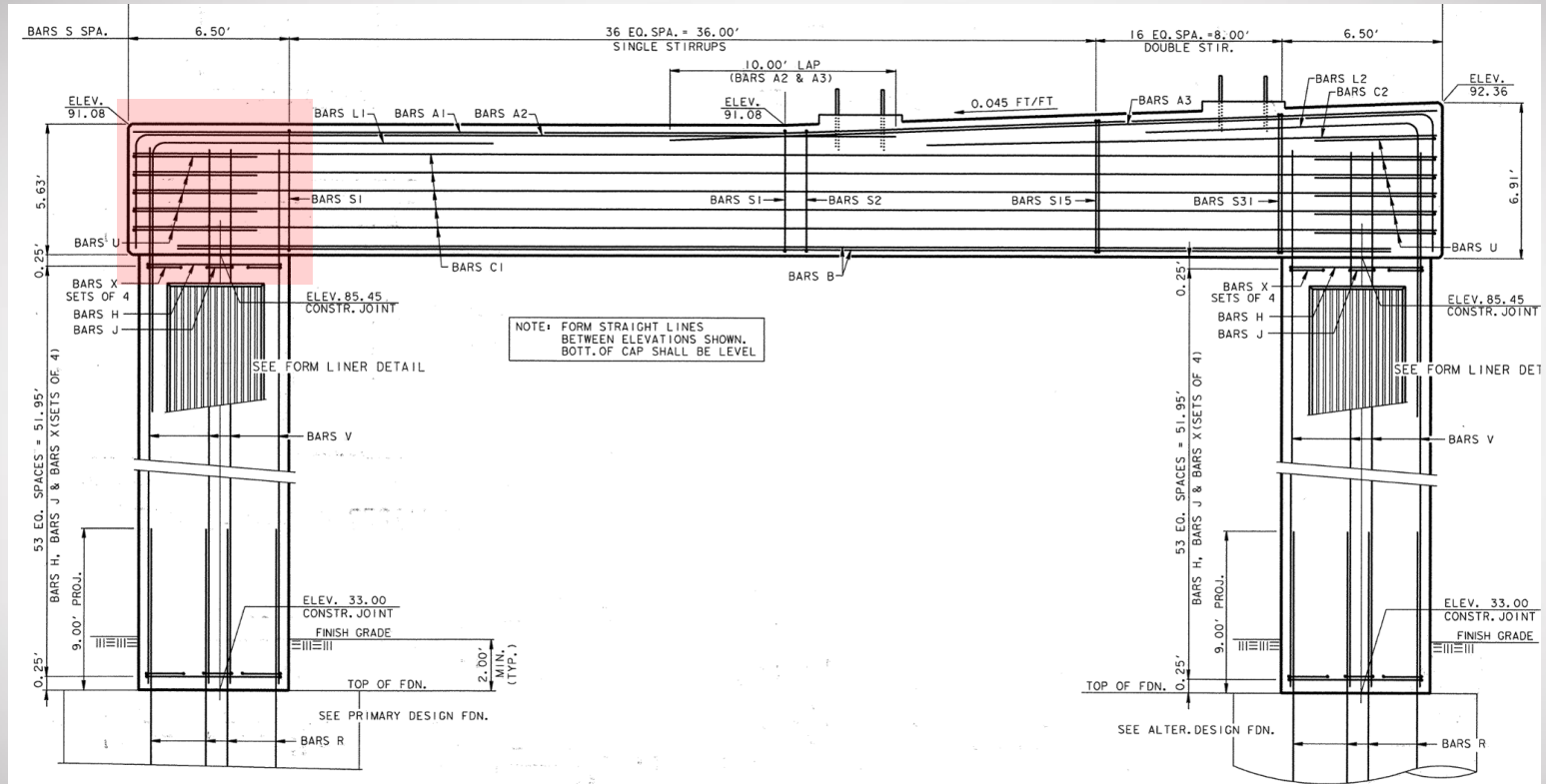
Cantilever Bents:



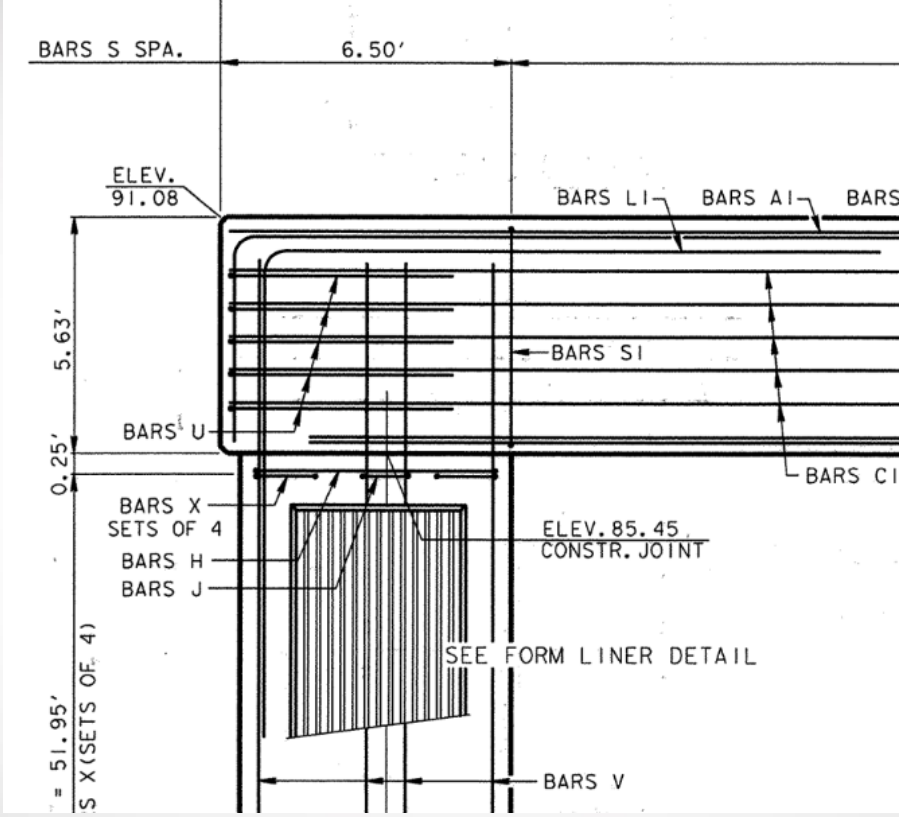
Existing details:



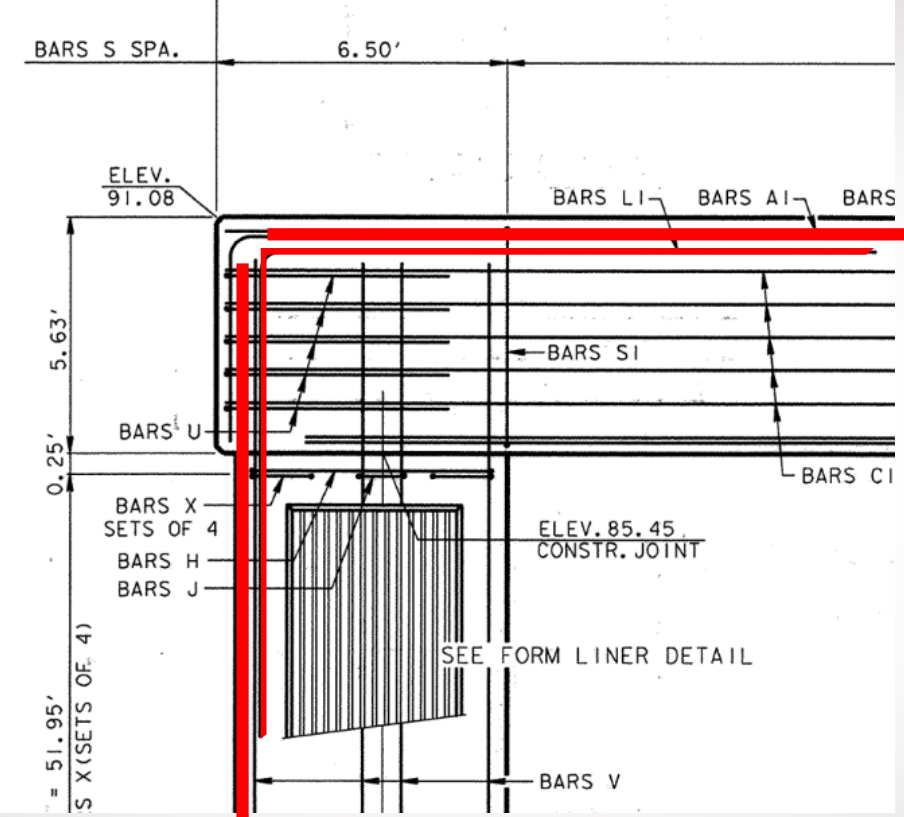
Splicing:



Splicing:



Splicing:



Coupling:

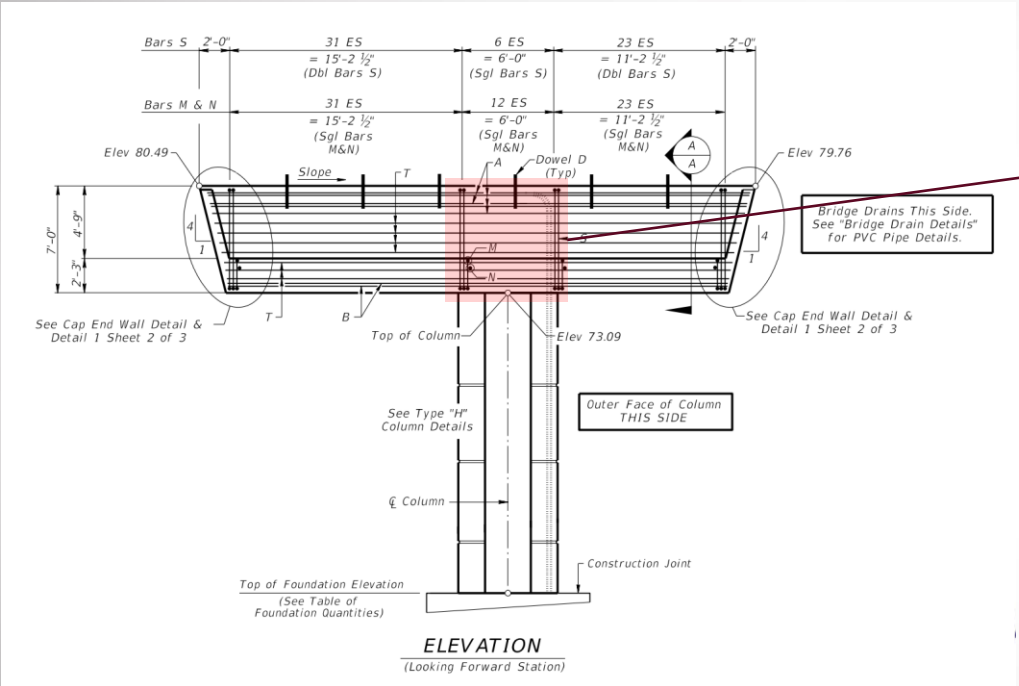


Fig. 11) IH69 NB to IH610 Bent 21

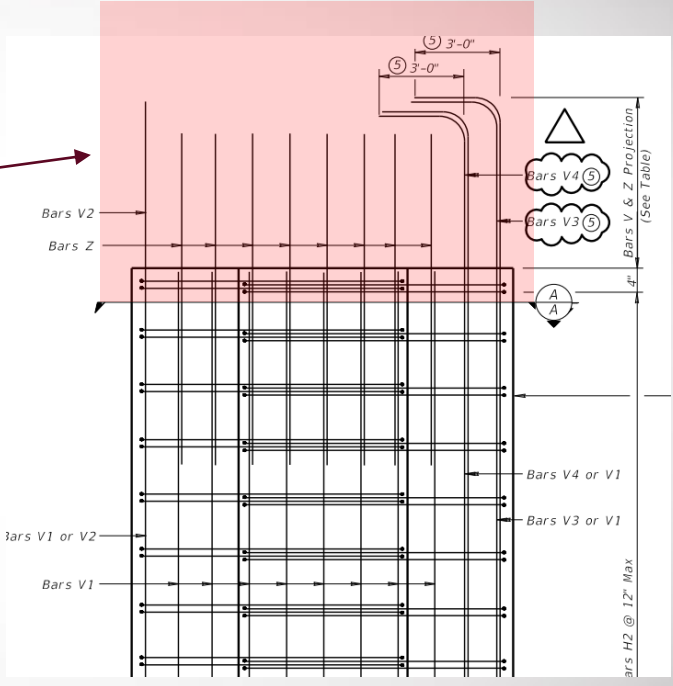
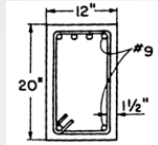
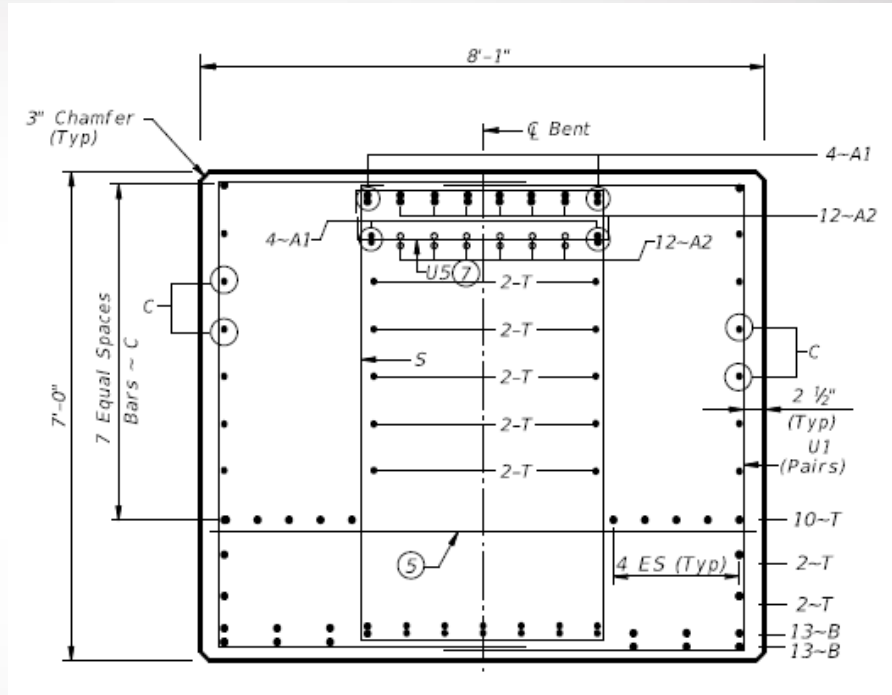


Fig. 12) Standard TxDOT Type H Column Details (TxDOT Standard Drawings)

Size & Group Effects:

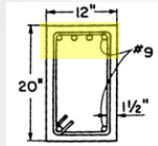


a)

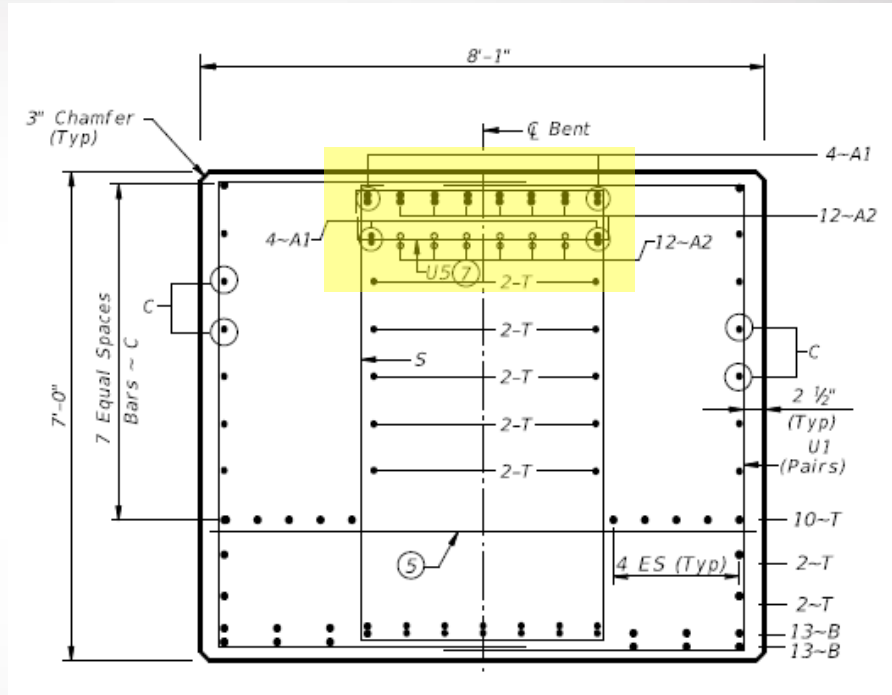


b)

Size & Group Effects:

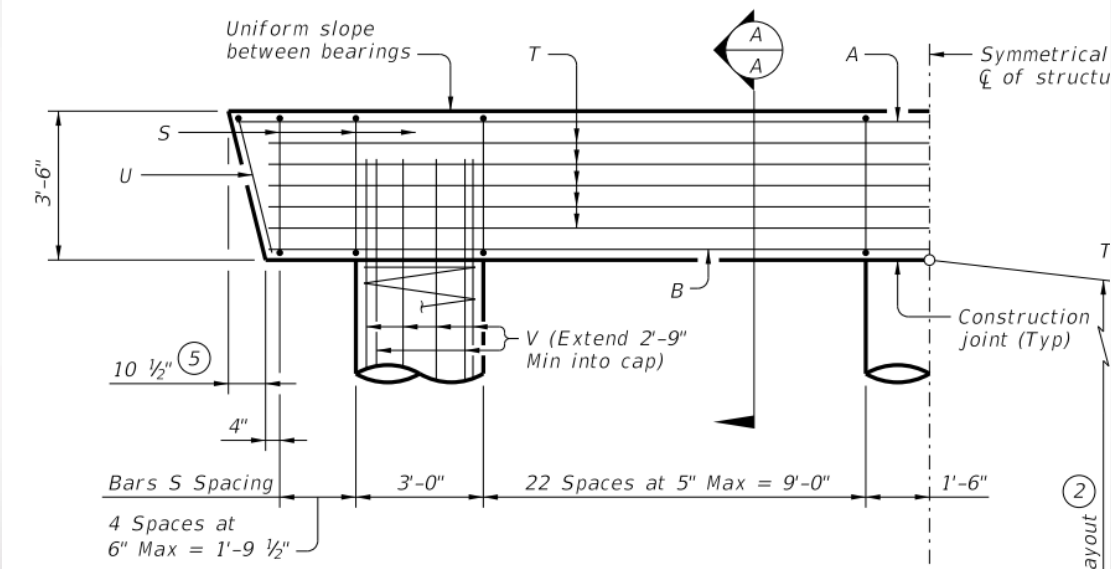


a)

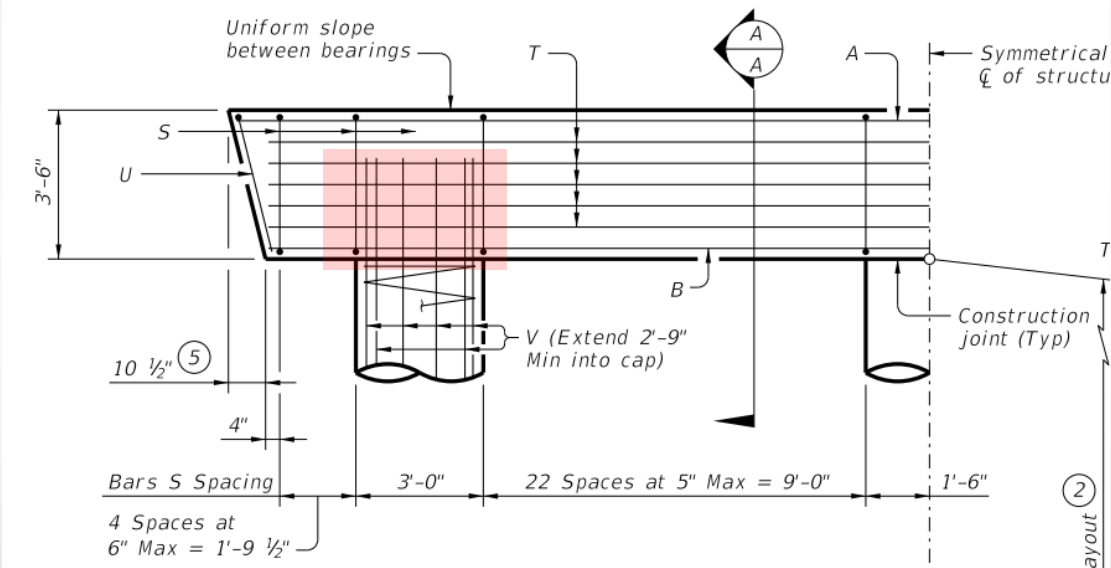


b)

Straight Extensions:



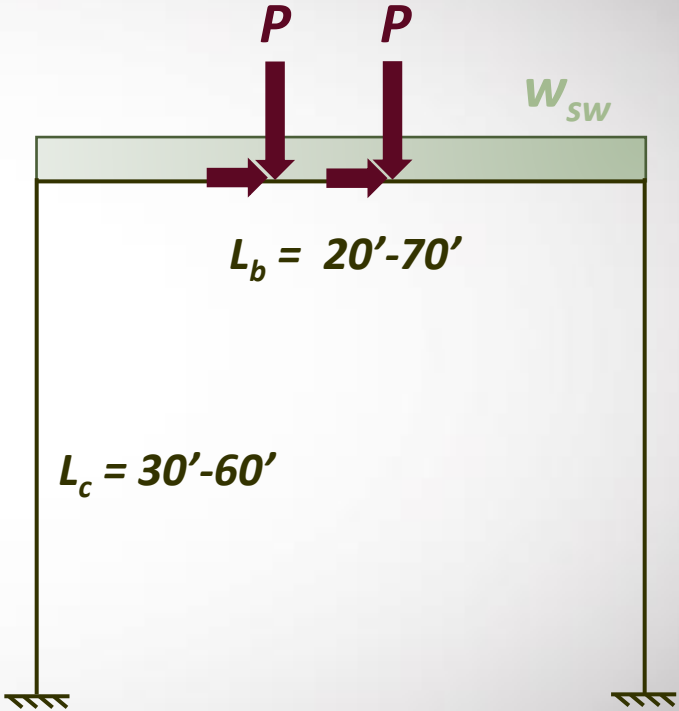
Straight Extensions:



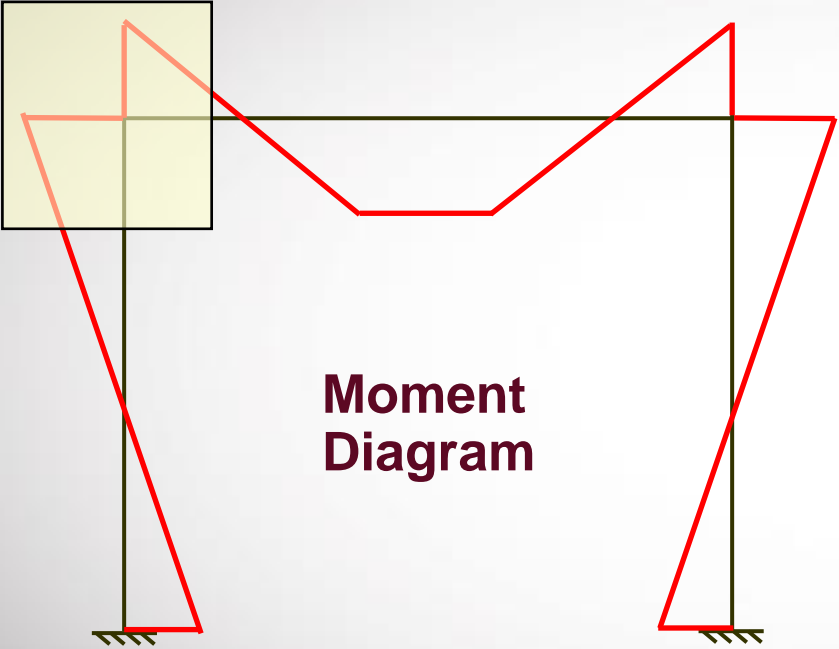
Recall:



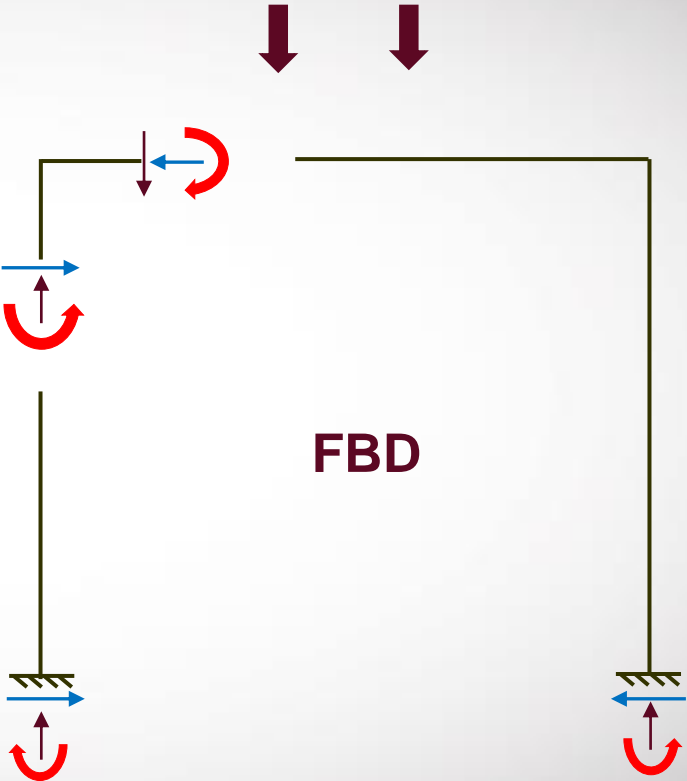
$L_b/L_c \sim 1-1.5$



Joint demands under gravity/vertical loading:

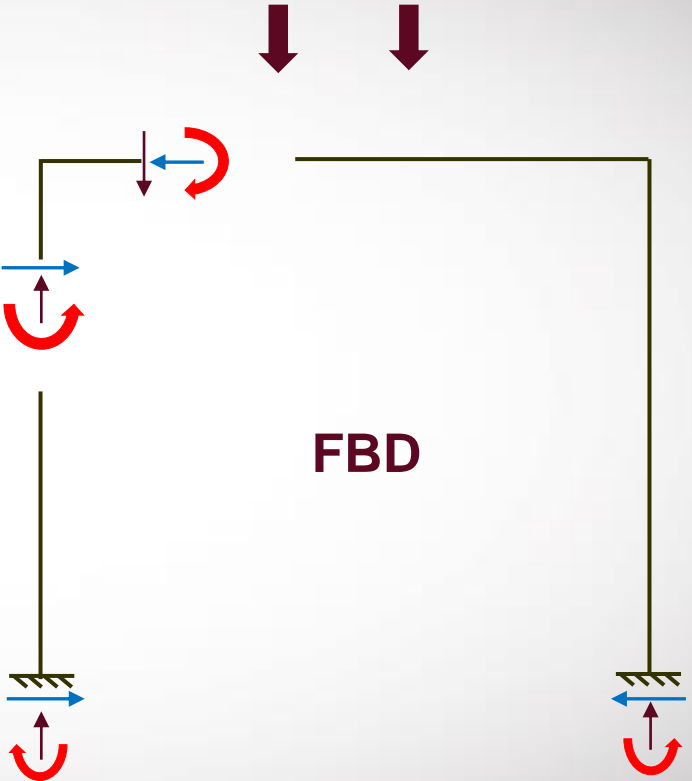
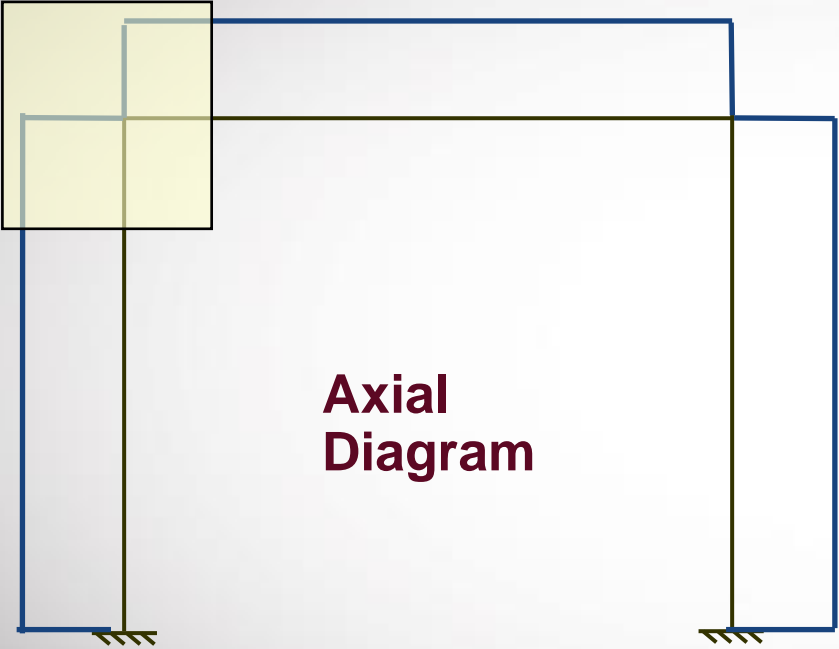


Moment Diagram

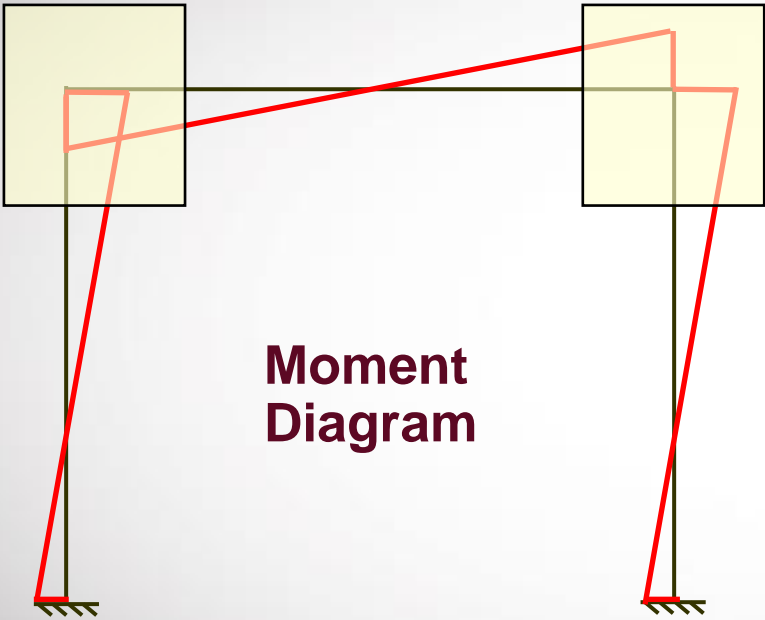


FBD

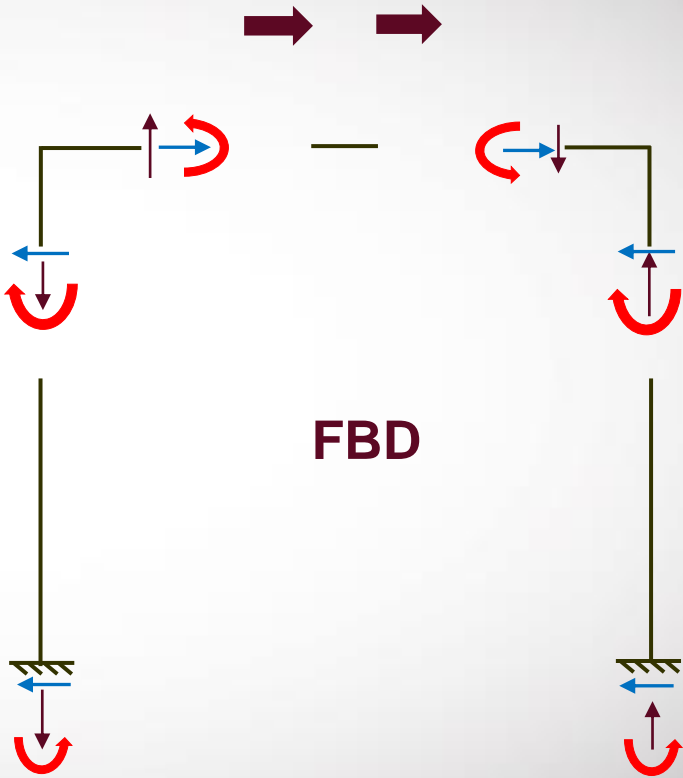
Joint demands under gravity/vertical loading:



Joint demands under lateral loading:

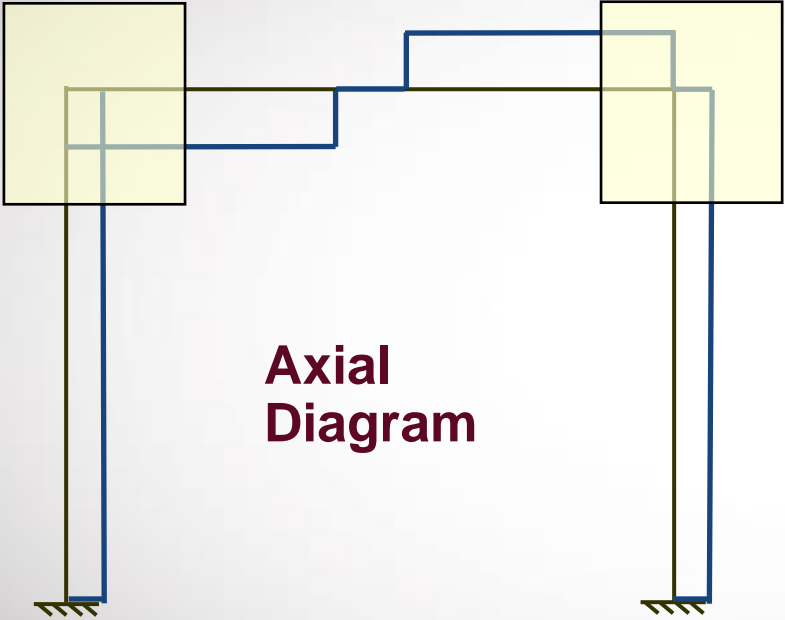


Moment Diagram

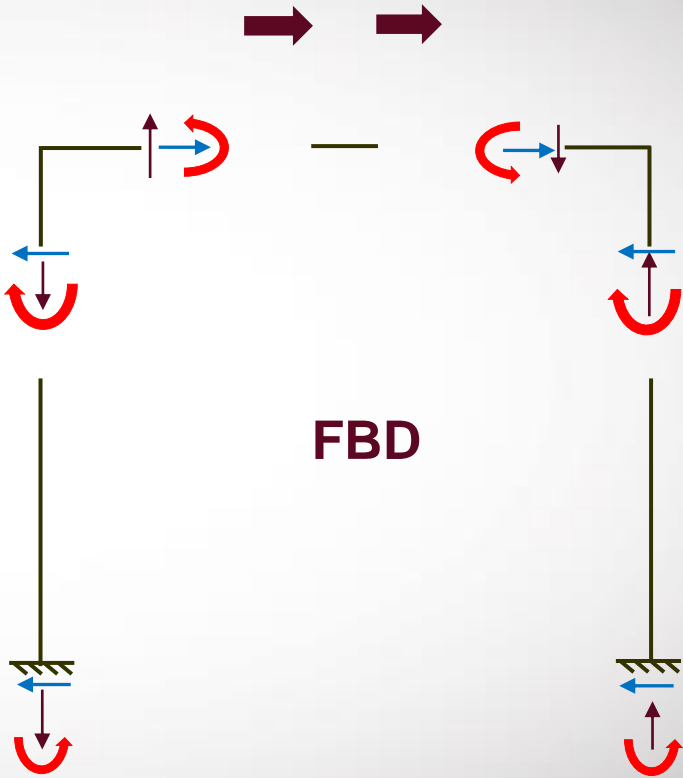


FBD

Joint demands under lateral loading:

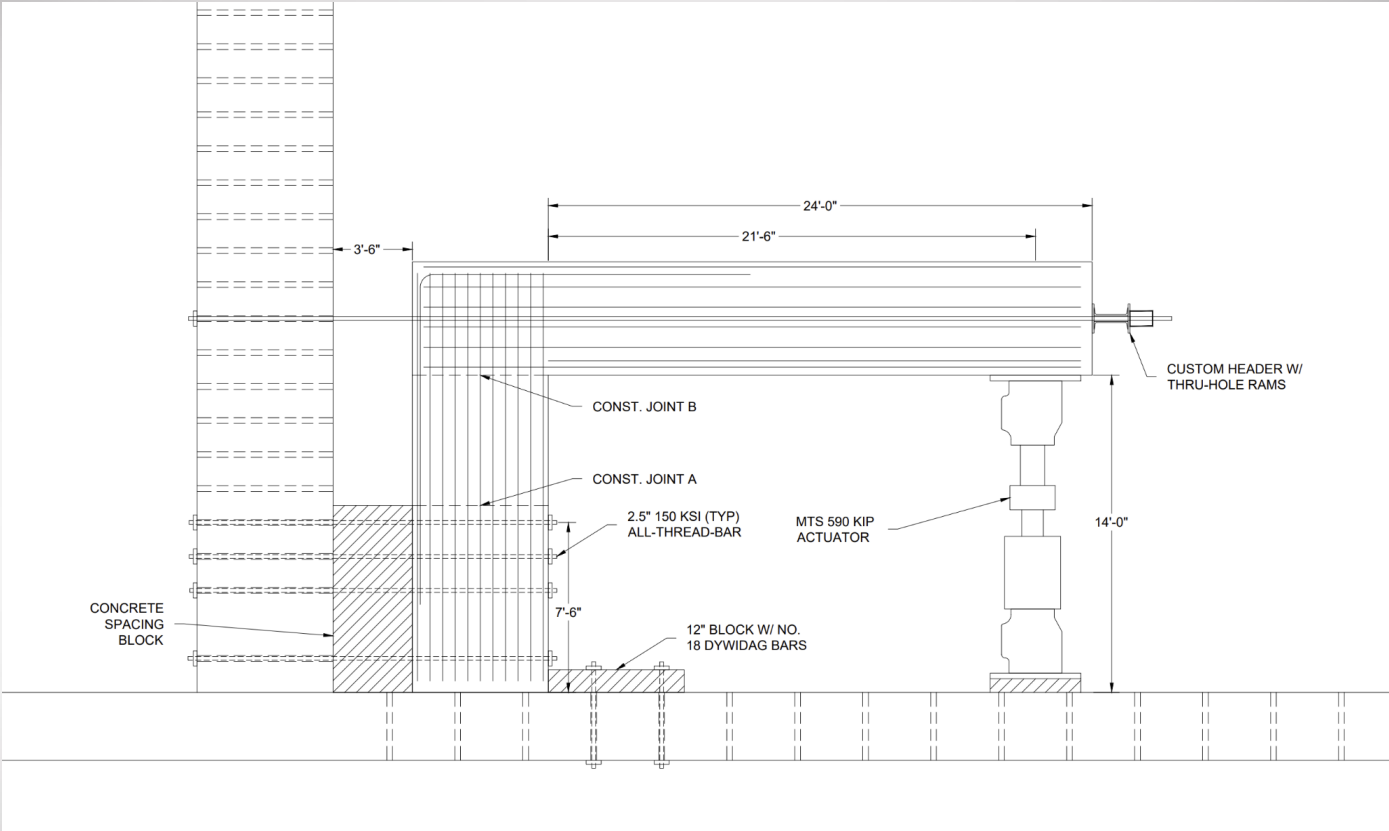


**Axial
Diagram**

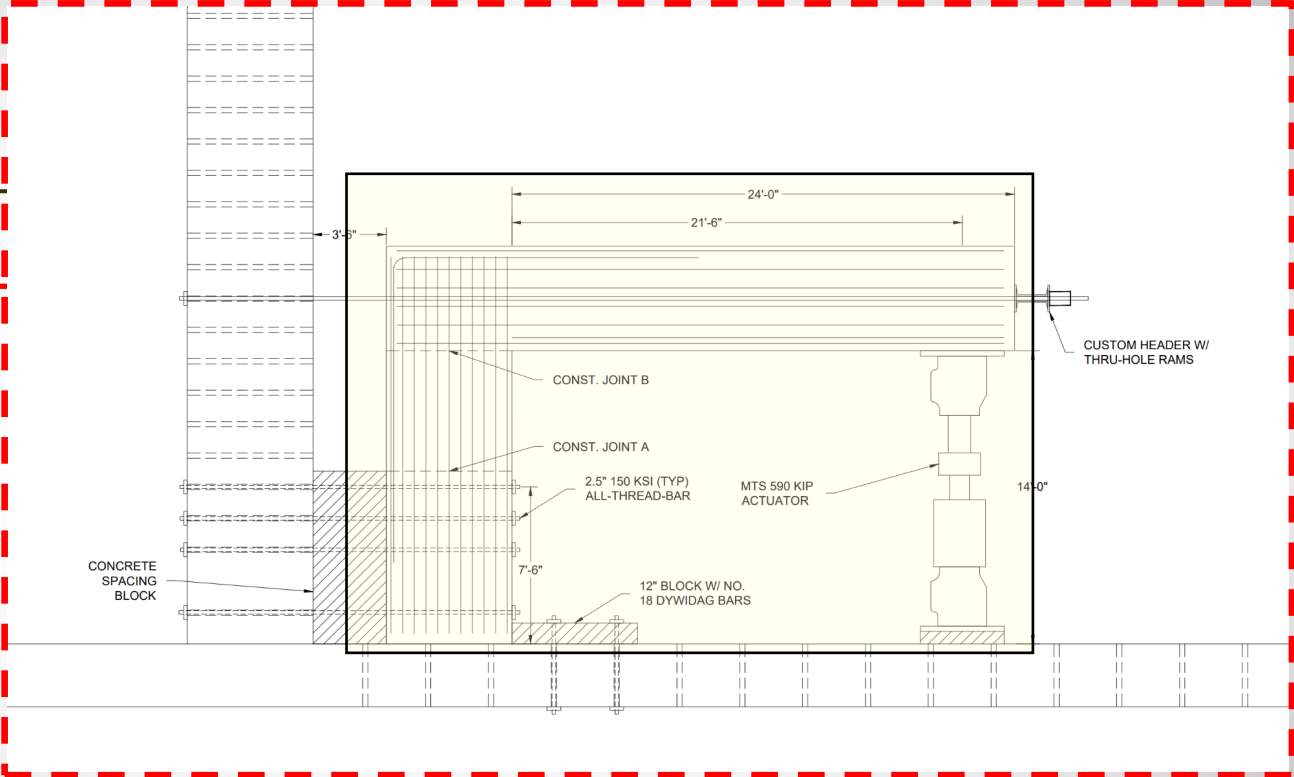
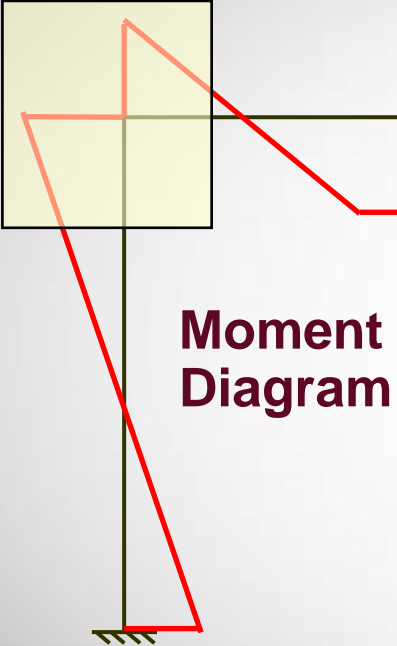


FBD

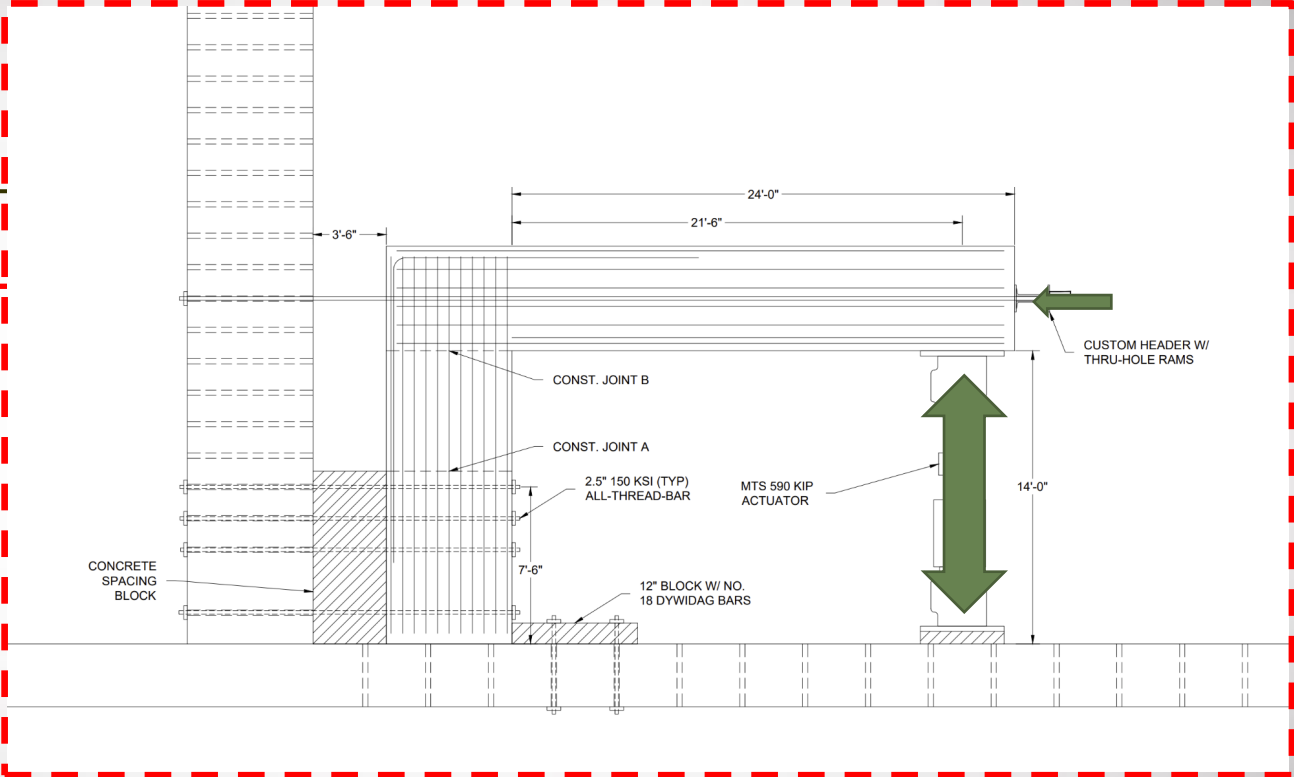
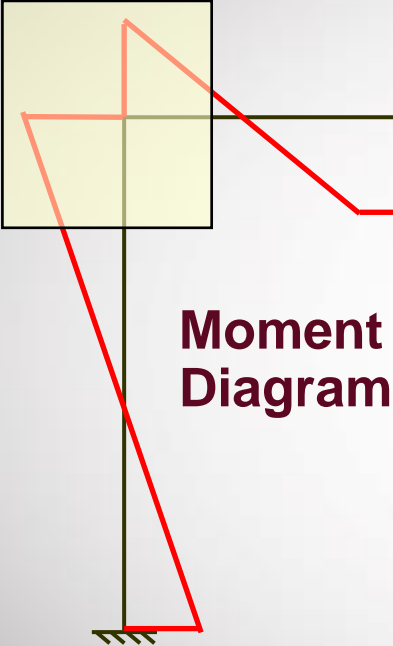
Test Setup:



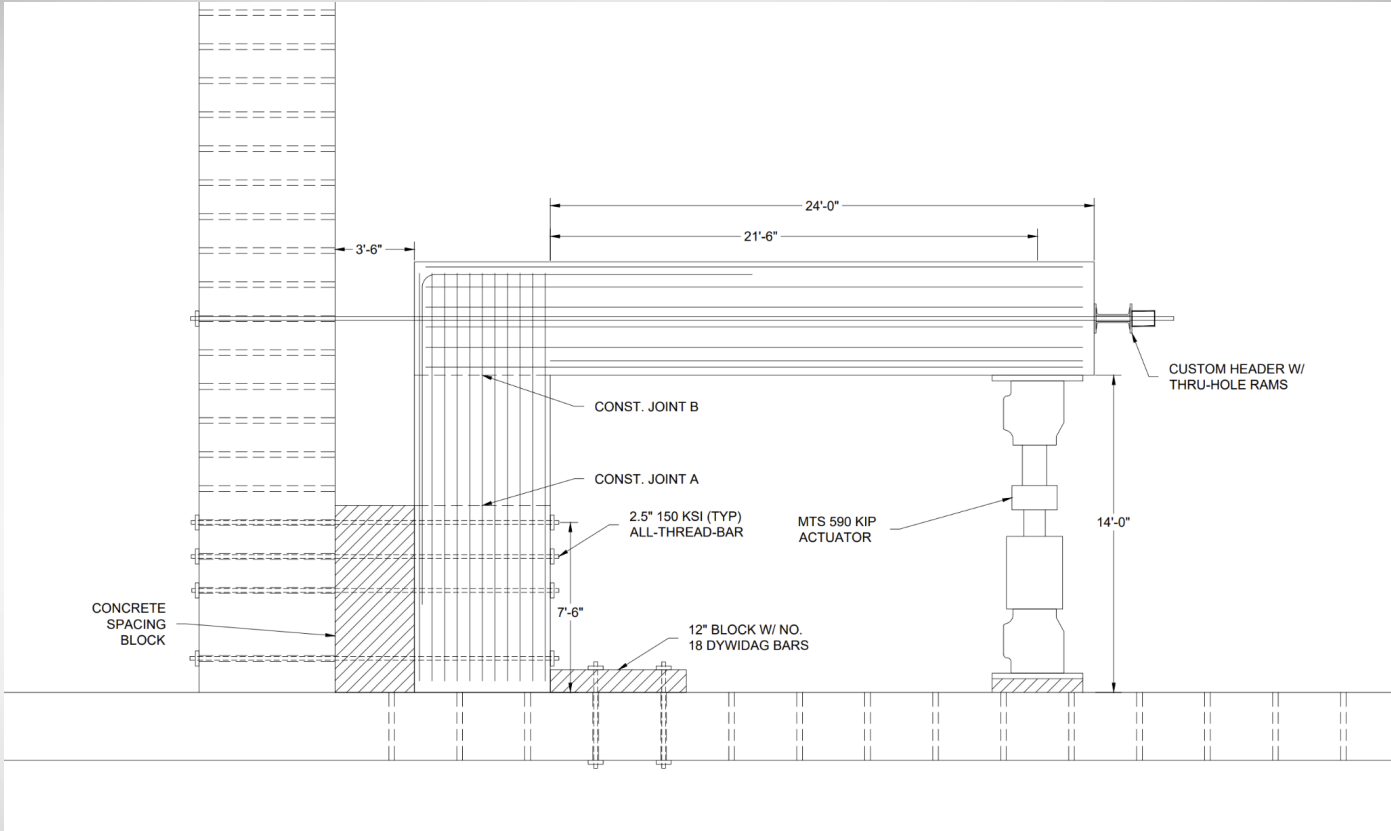
Joint demands under gravity/vertical loading:



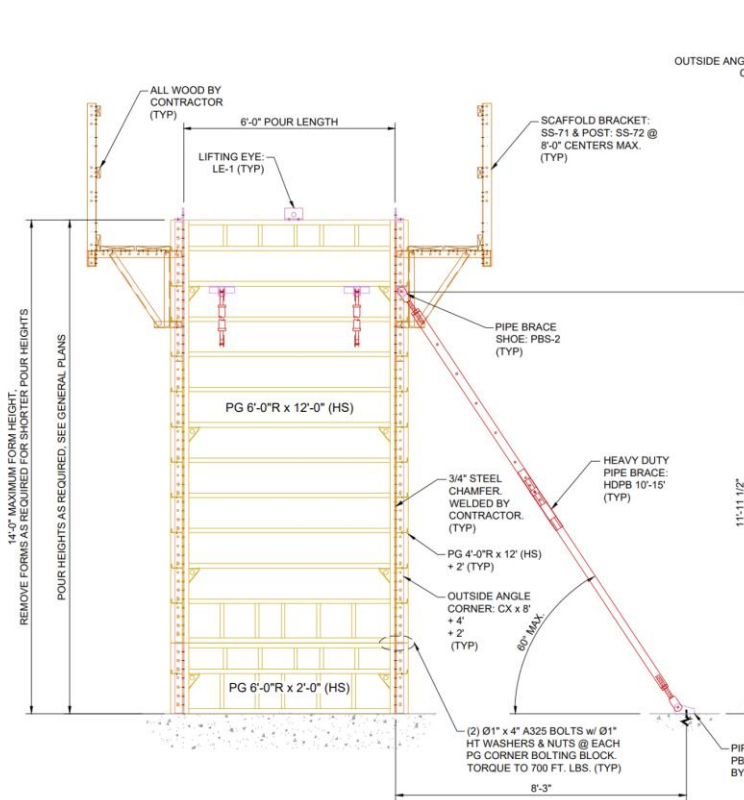
Joint demands under gravity/vertical loading:



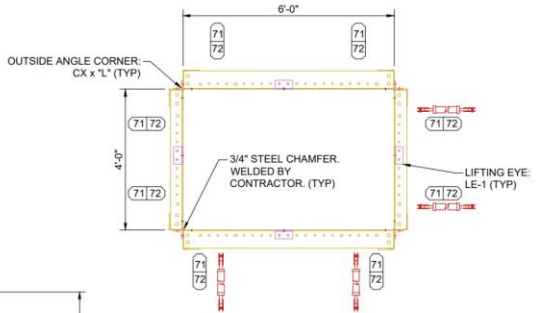
Test Setup:



Construction:



6' x 4' x 14'-0" COLUMN ELEVATION VIEW
(EFCO TO SUPPLY (1) SET OF FORMS AS SHOWN)



PLAN VIEW

- CONTRACTOR'S NOTES**
- SEE DRAWING #090 FOR BOLT THRU TUBE LOCATIONS.
 - PLASTIC PLUG ALL HOLES AS REQUIRED.
 - FIELD DRILL ALL HOLES AS REQUIRED.
 - LIFTING EYE LOCATIONS SHOWN ARE RECOMMENDED TO EVENLY DISTRIBUTE LIFTING EYE LOADS. LIFTING EYES SHOULD BE PLACED APPROXIMATELY EQUAL DISTANCE FROM ENDS OF PICK, RIGGING AND LIFTING BEAMS ARE REQUIRED TO ENSURE APPLIED LOADING DOES NOT EXCEED LIFTING EYE CAPACITIES. SEE SHEET #500 FOR CAPACITIES AND BOLTING DETAILS.

- DRAWING NOTES:**
- CONCRETE PRESSURE RATING OF FORMWORK, $C_{CP} = 1800$ PSF. REFER TO CONCRETE PRESSURE CHARTS ON DRAWING 002 TO DETERMINE ALLOWABLE PLACEMENT RATES RECOMMENDED BY ACI 347.
 - SEE DRAWING 001 FOR GENERAL NOTES AND DEFINITIONS.
 - SEE 400 SERIES DRAWINGS FOR ASSEMBLY PROCEDURES.
 - SEE 500 SERIES DRAWINGS FOR TYPICAL ASSEMBLY DETAILS.

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NO.	REVISION	DATE	BY

RELEASED FOR: **SEPTEMBER 11, 2023**
CONSTRUCTION

ENG. TITLE: **6' X 4' X 14' COLUMN ELEV & PLAN**
PROJECT: **BRIDGE CAP TESTING**

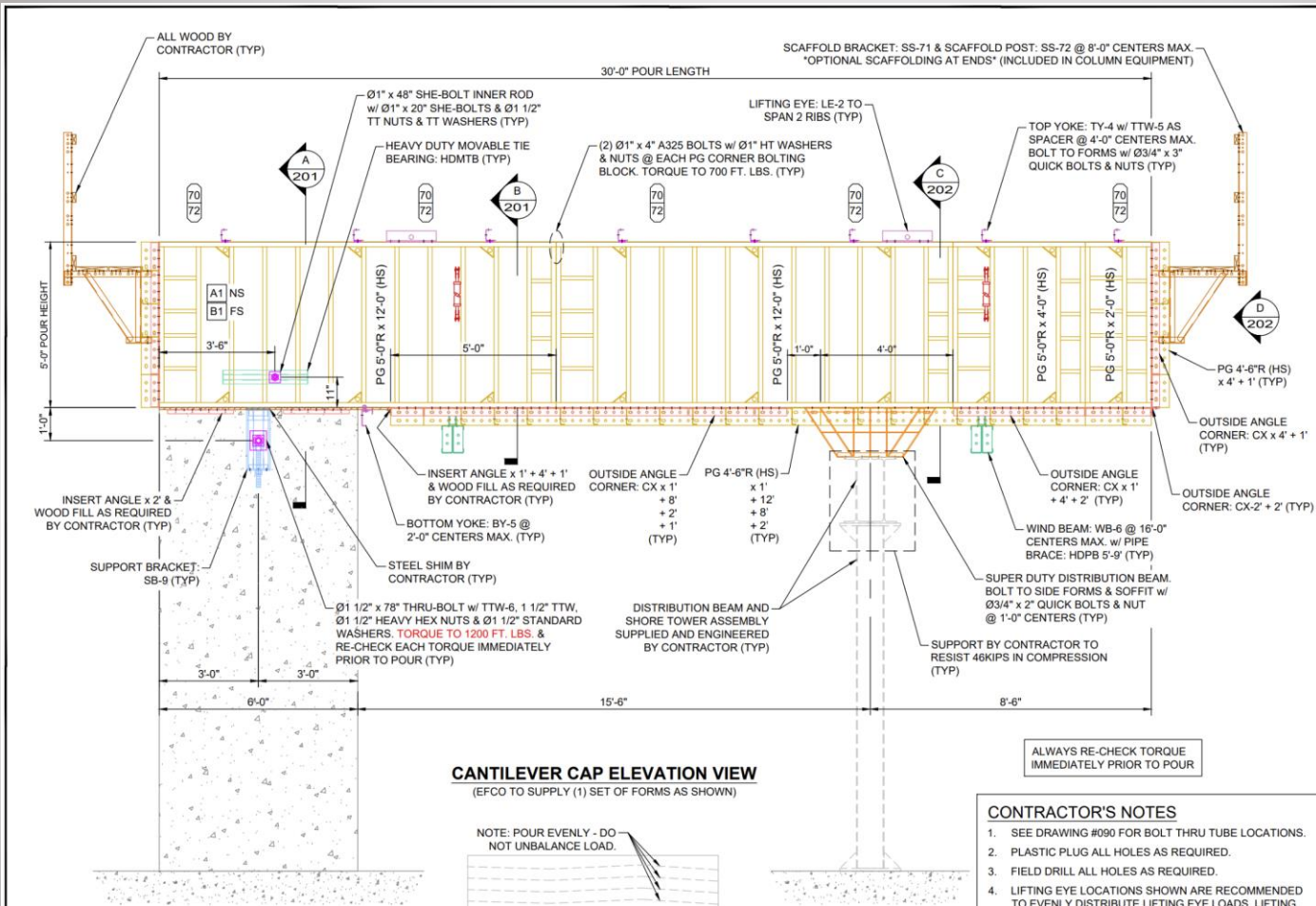
PROJECT: **TEXAS A&M UNIVERSITY - COLLEGE STATION, TEXAS**
LOCATION:

CONTRACTOR: **TEXAS A&M TRANSPORTATION INSTITUTE**
DETAILED BY: DATE DRAWN: ISSUED OFFICE:

TJF 7SEP23 **DALLAS**
CHECKED BY: DATE CHECKED: **REGISTERED OFFICE**
ALM 12SEP23 P343810

AGREEMENT NO. **101**

Construction:



CANTILEVER CAP ELEVATION VIEW
(EFCO TO SUPPLY (1) SET OF FORMS AS SHOWN)

- DRAWING NOTES:**
1. C_{CP} = FULL LIQUID HEAD FOR POUR $\leq 5'-0"$.
 2. SEE DRAWING 001 FOR GENERAL NOTES AND DEFINITIONS.
 3. SEE 400 SERIES DRAWINGS FOR ASSEMBLY PROCEDURES
 4. SEE 500 SERIES DRAWINGS FOR TYPICAL ASSEMBLY DETAILS.



FORMING AND SHORING EQUIPMENT FOR CONCRETE CONSTRUCTION
HOME OFFICE DES MOINES, IOWA, U.S.A.
DISTRICT OFFICES WORLDWIDE

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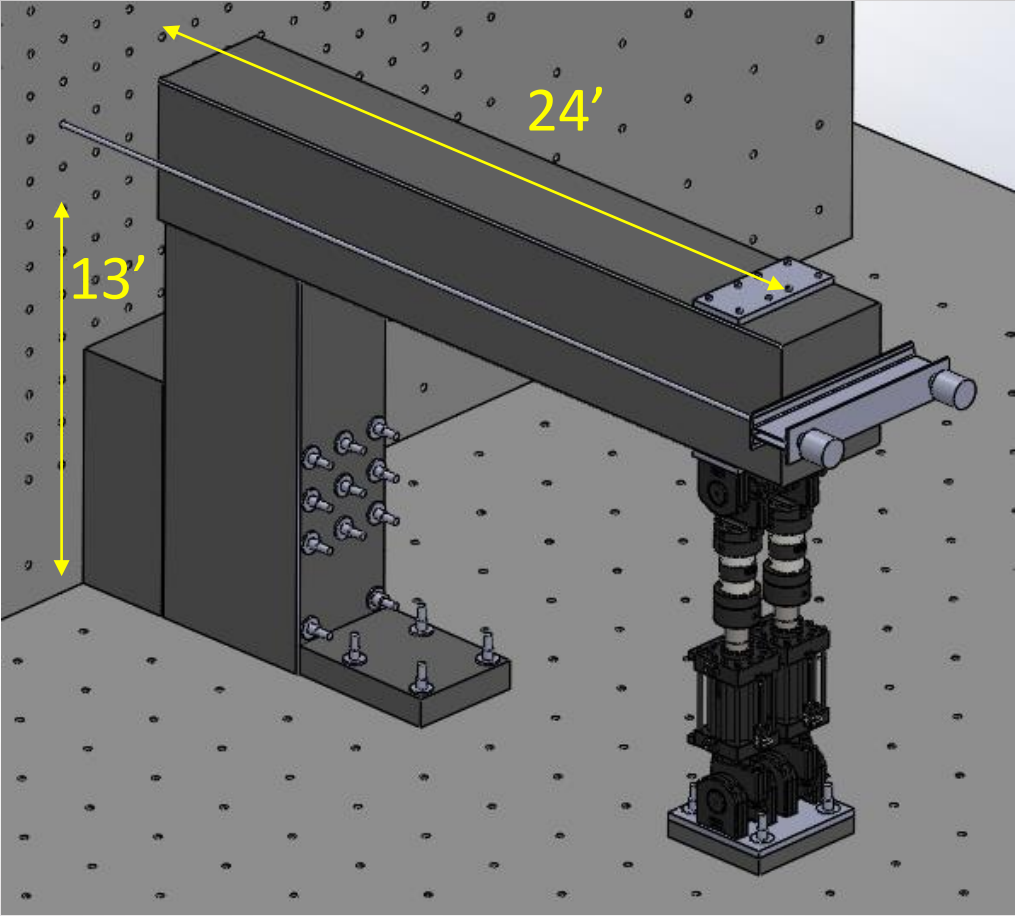
NO.	REVISION	DATE	BY

RELEASED FOR CONSTRUCTION
DATE: **SEPTEMBER 11, 2023**

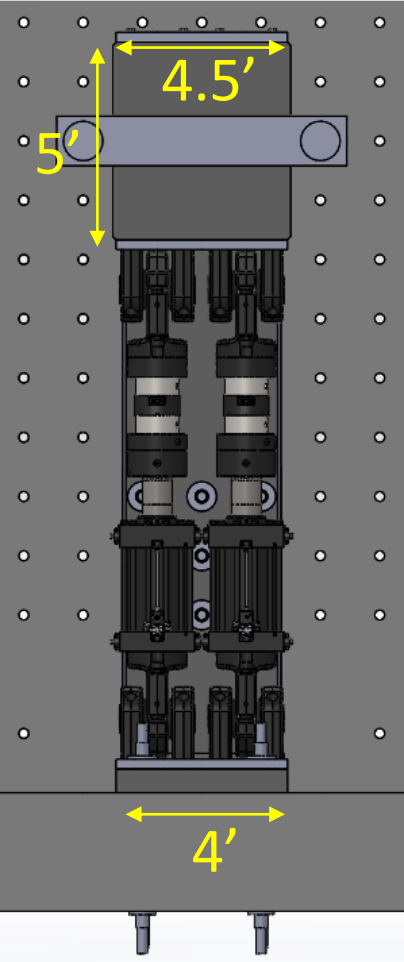
DWG TITLE: **CANTILEVER CAP ELEVATION**
PROJECT: **BRIDGE CAP TESTING**
PROJECT LOCATION: **TEXAS A&M UNIVERSITY - COLLEGE STATION, TEXAS**
CONTRACTOR: **TEXAS A&M TRANSPORTATION INSTITUTE**
DALLAS

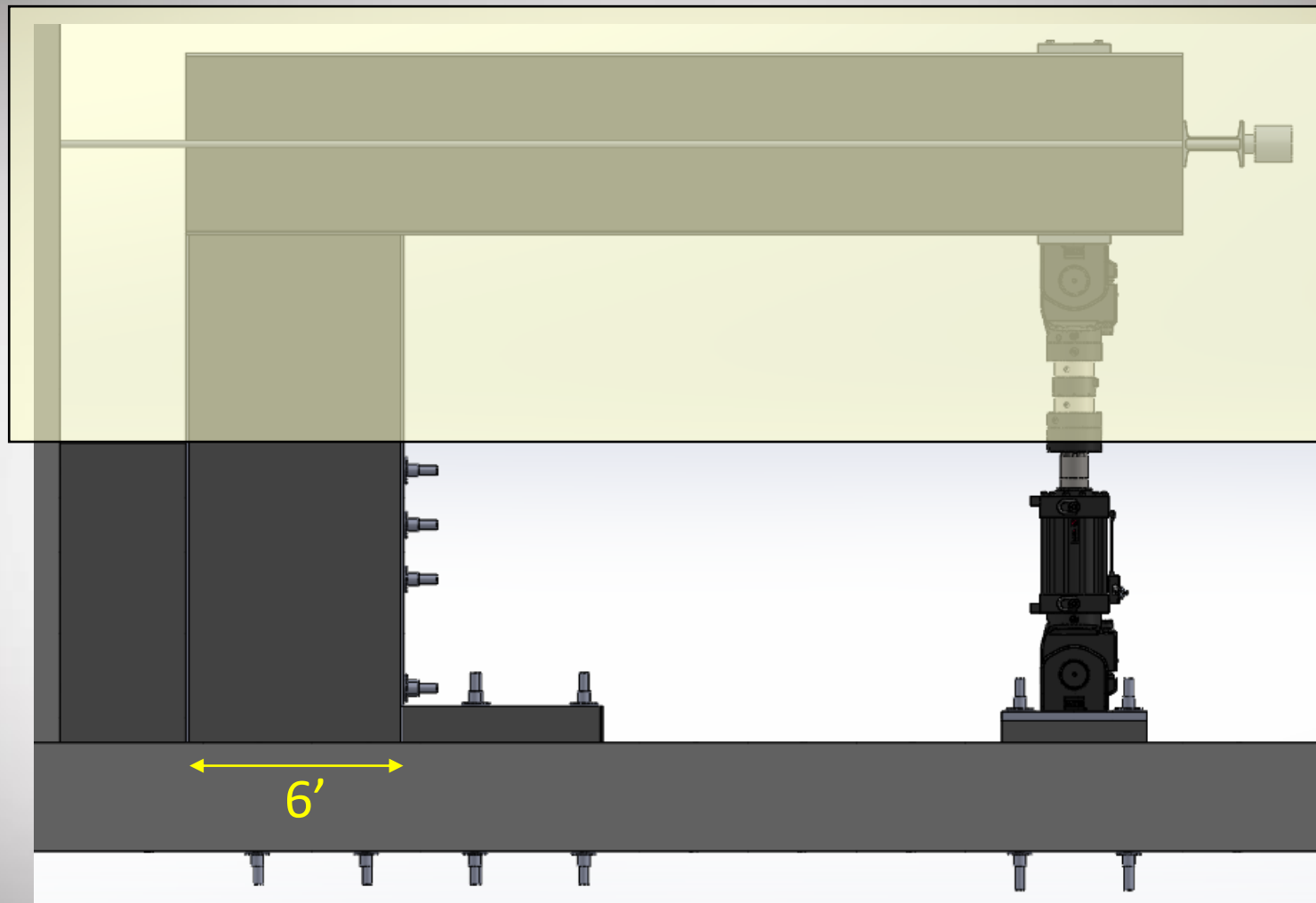
- CONTRACTOR'S NOTES**
1. SEE DRAWING #090 FOR BOLT THRU TUBE LOCATIONS.
 2. PLASTIC PLUG ALL HOLES AS REQUIRED.
 3. FIELD DRILL ALL HOLES AS REQUIRED.
 4. LIFTING EYE LOCATIONS SHOWN ARE RECOMMENDED TO EVENLY DISTRIBUTE LIFTING EYE LOADS. LIFTING

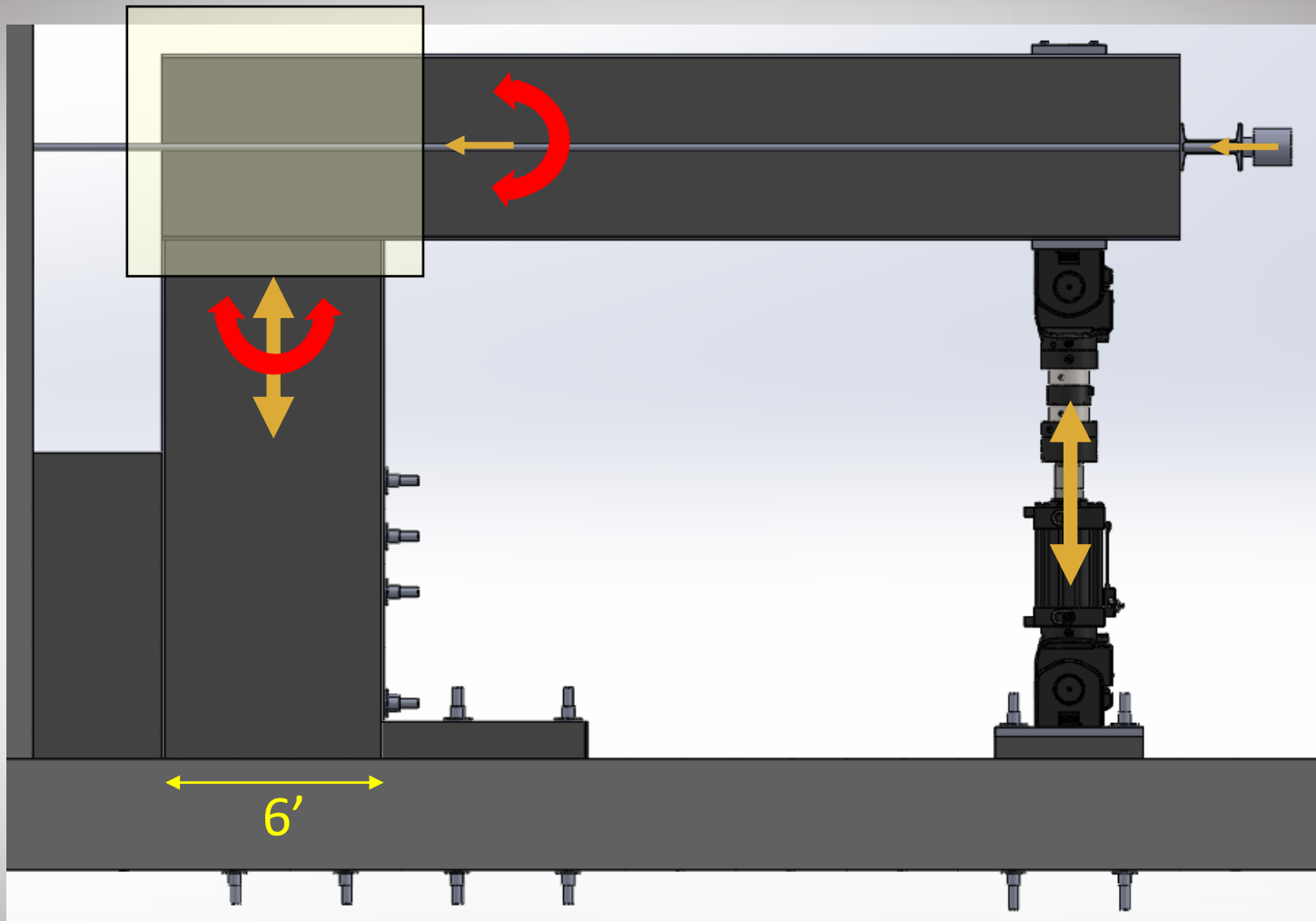
Prelim Setup:



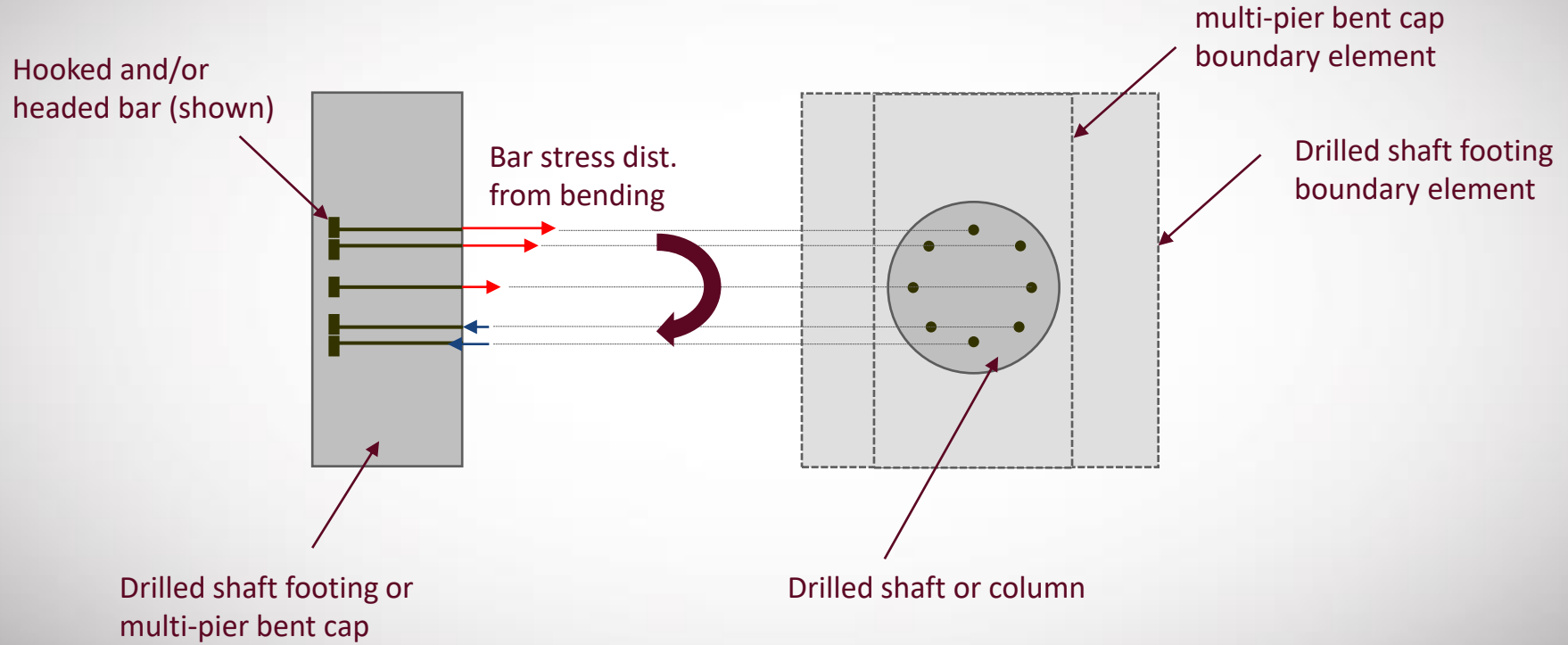
Prelim Setup



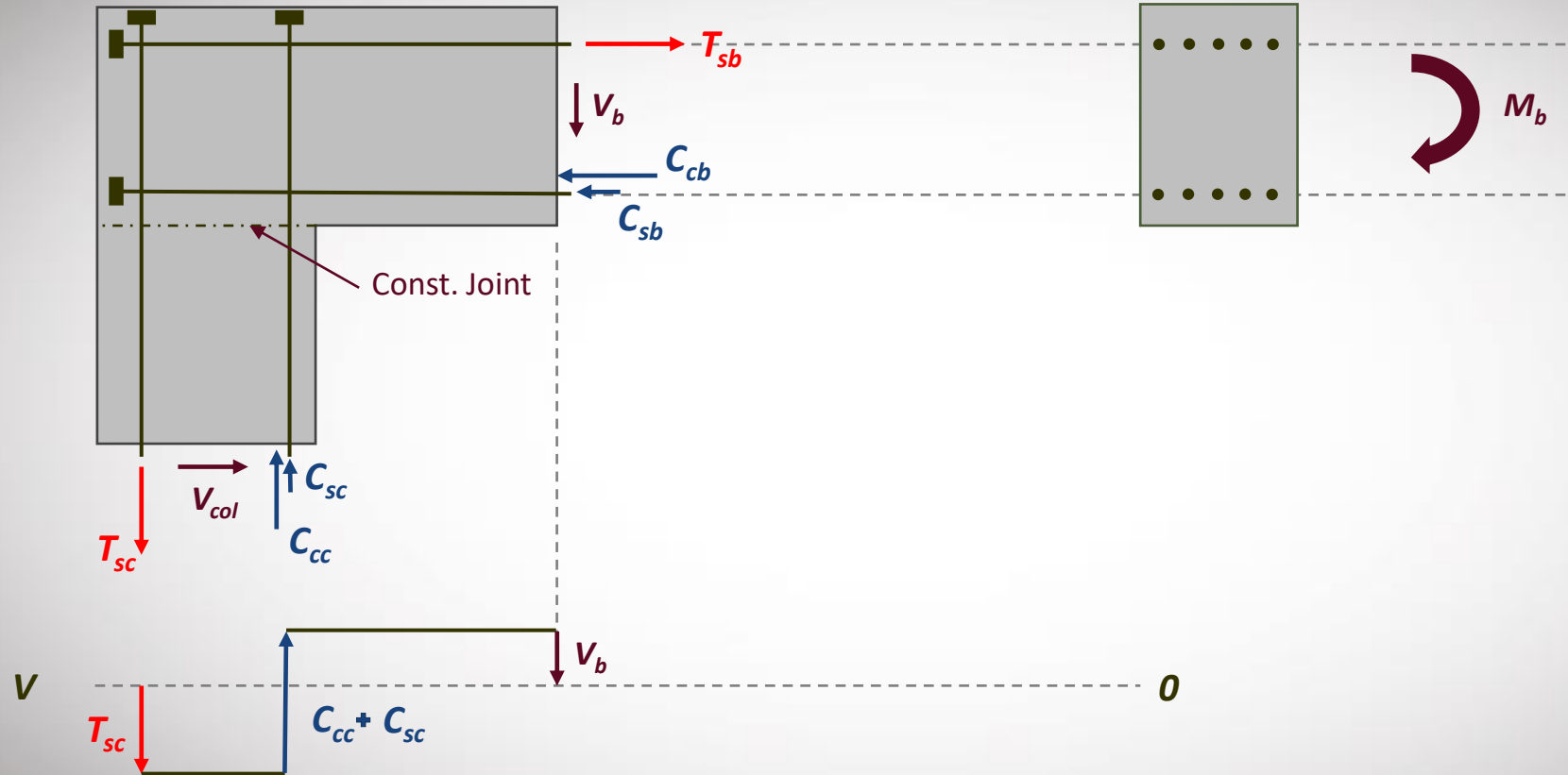




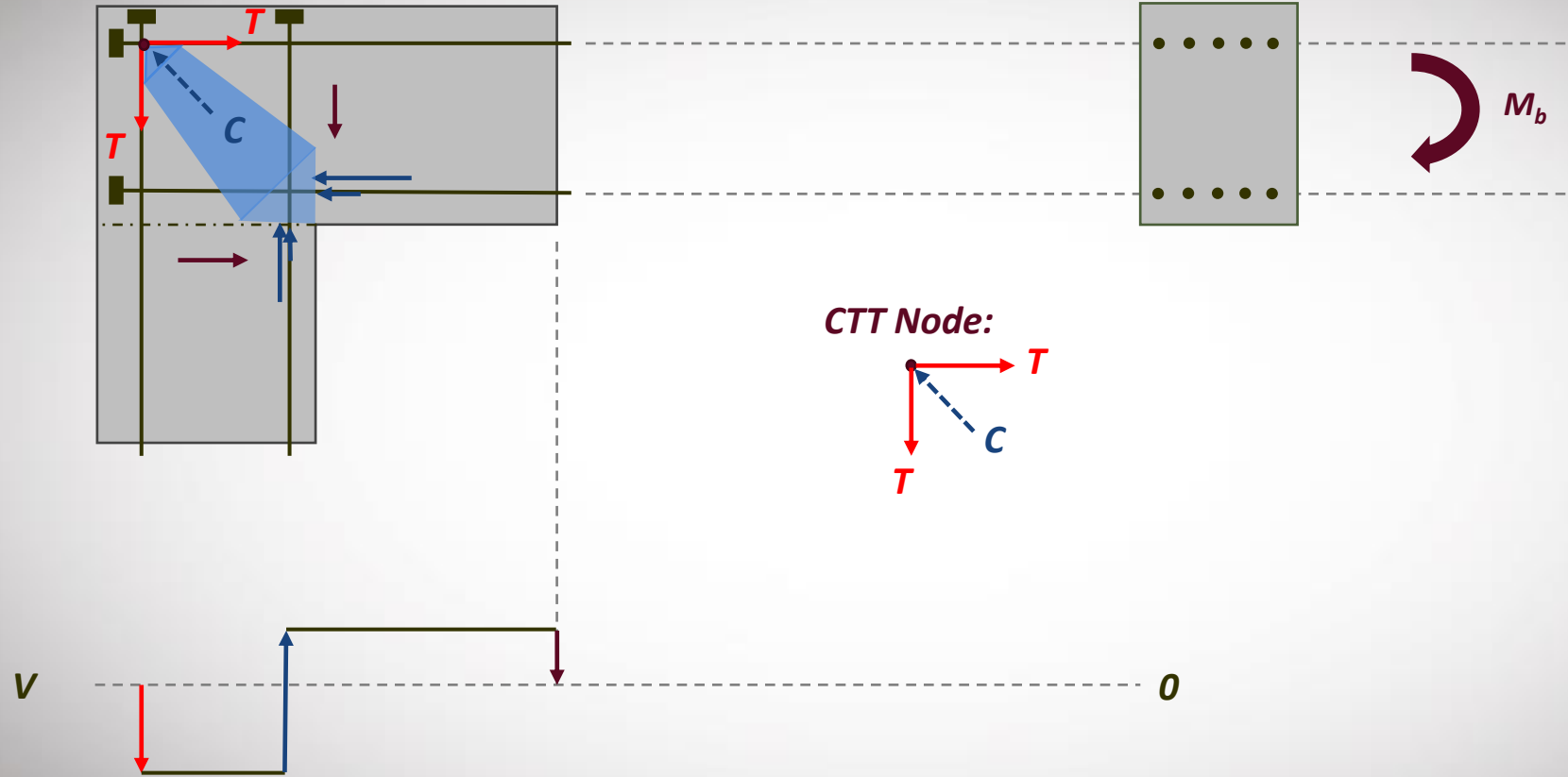
Research Needs: Effects of multiple reinforcing layers, bar stress gradient, geometry on strength and deformability of anchored heads or hooks:



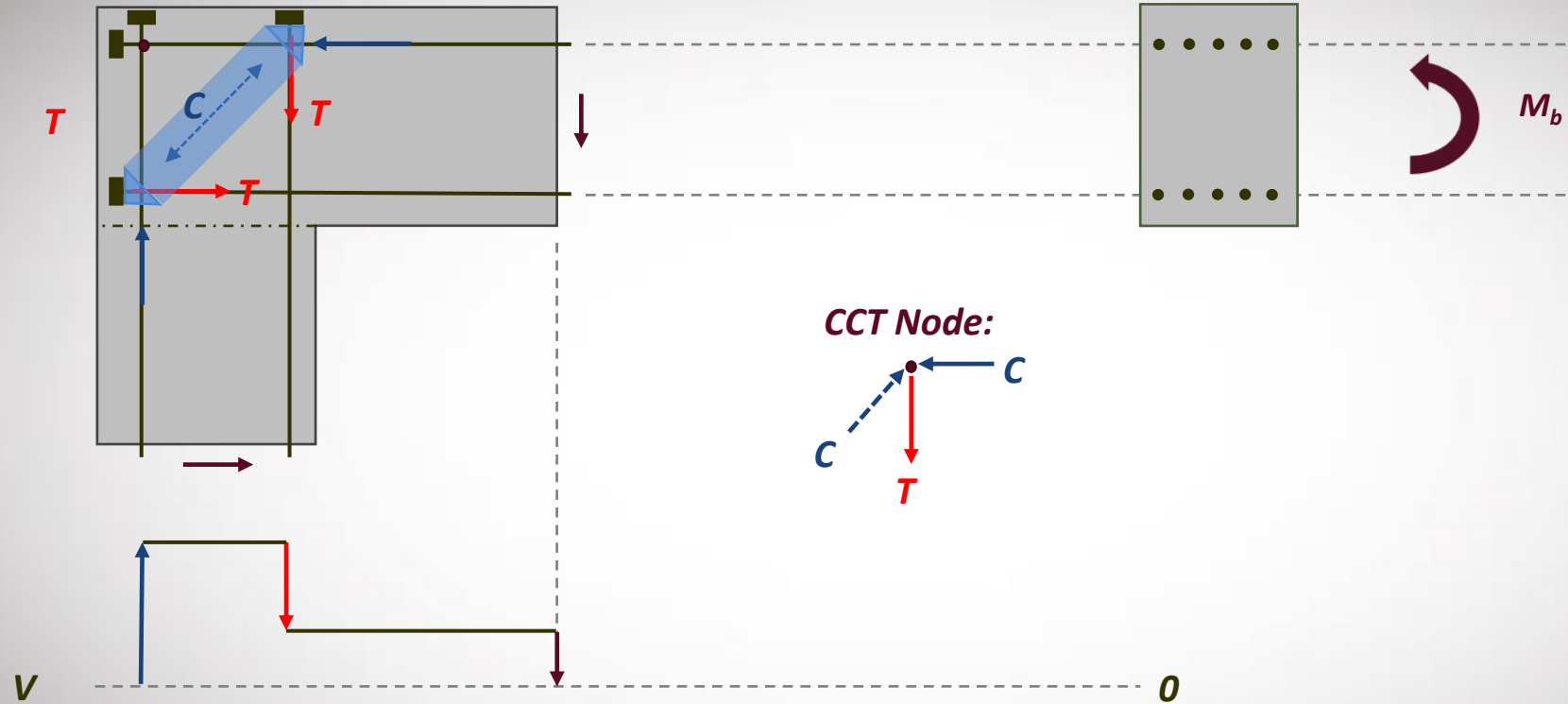
Research Needs: Knee joint behavior (Joint closing) w/ heads



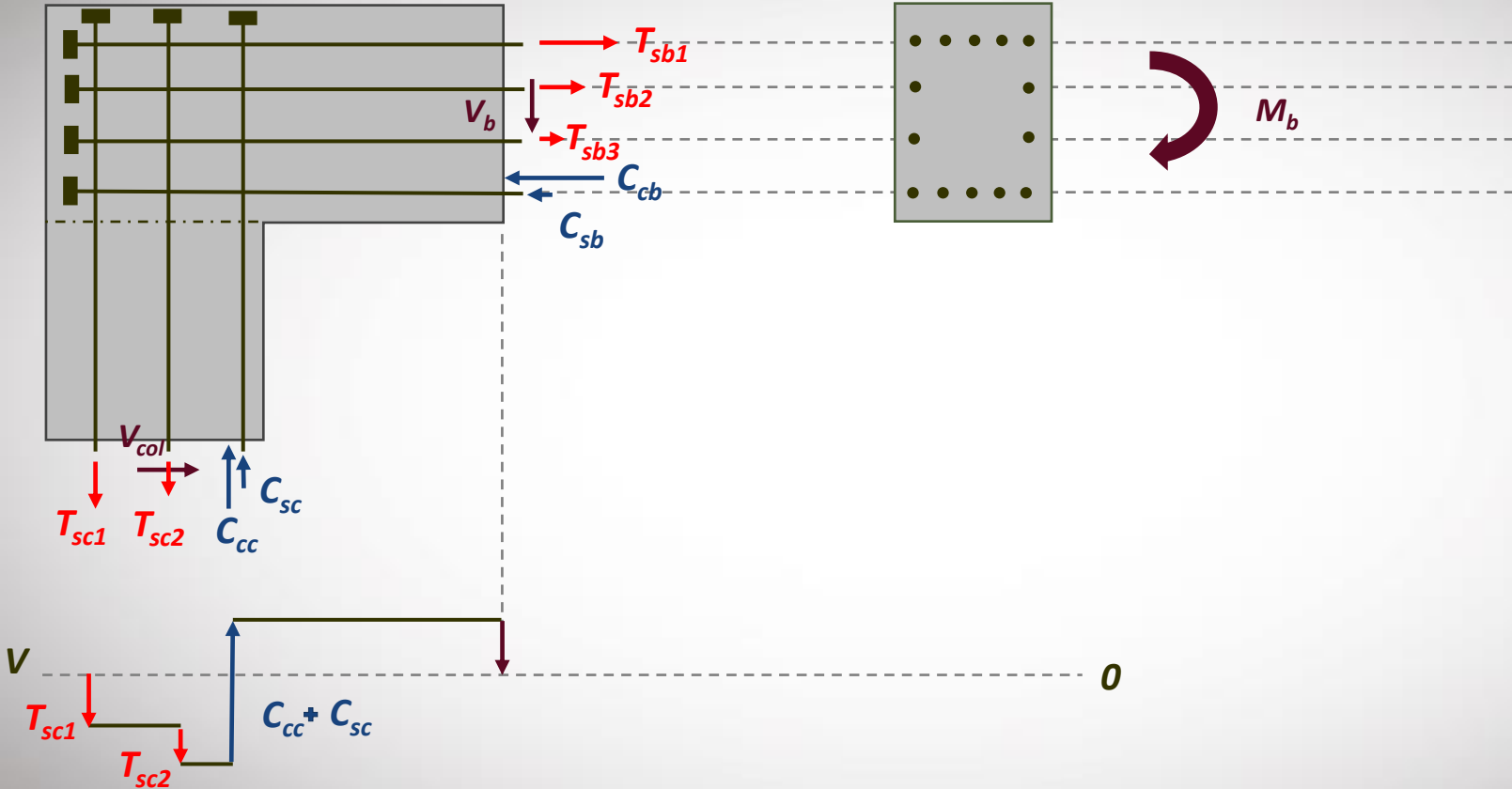
Research Needs: S&T relationships (Joint Closing) CTT Node



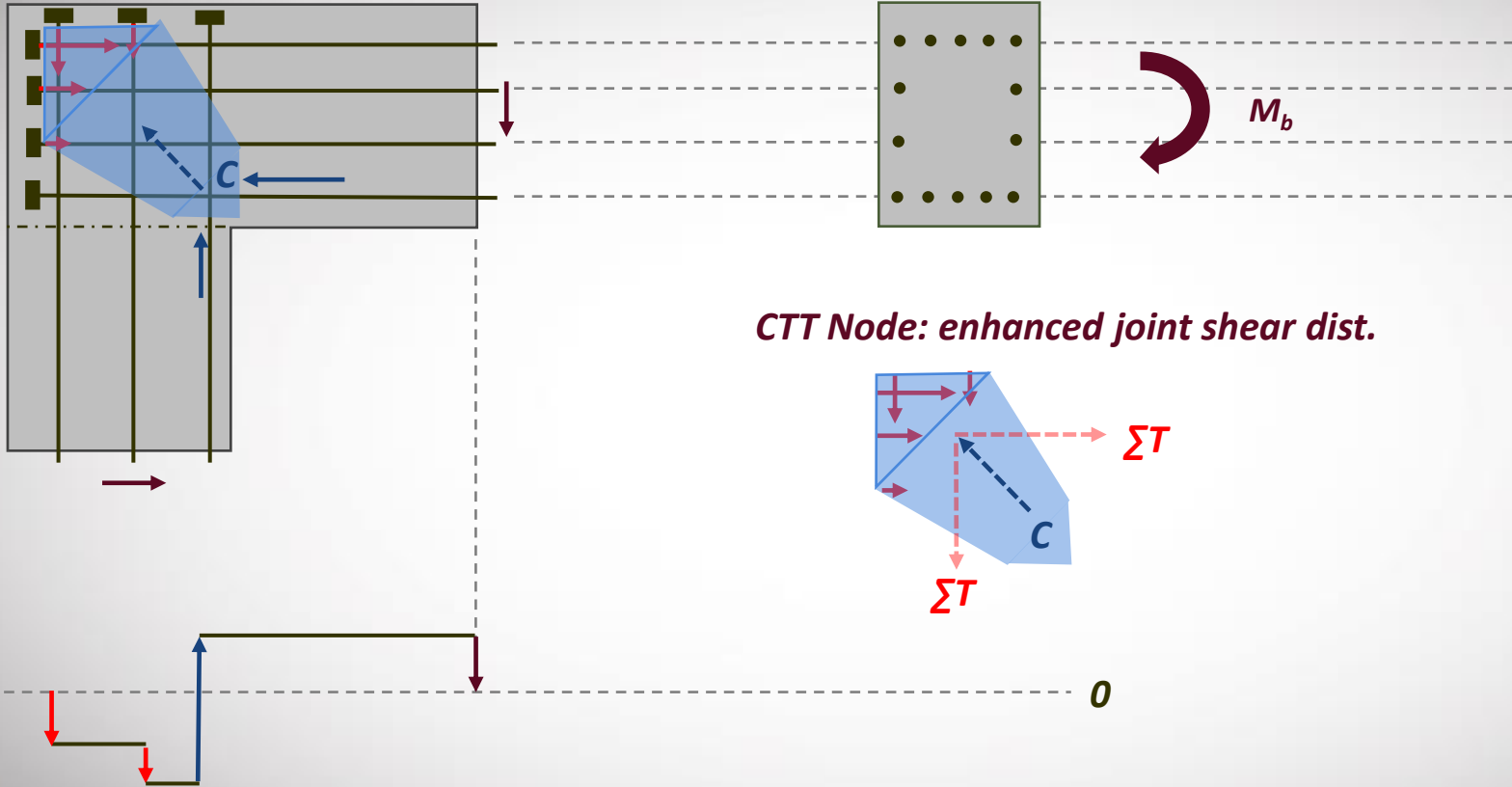
Research Needs 2b: S&T relationships (Joint Opening) CCT Node w/ heads



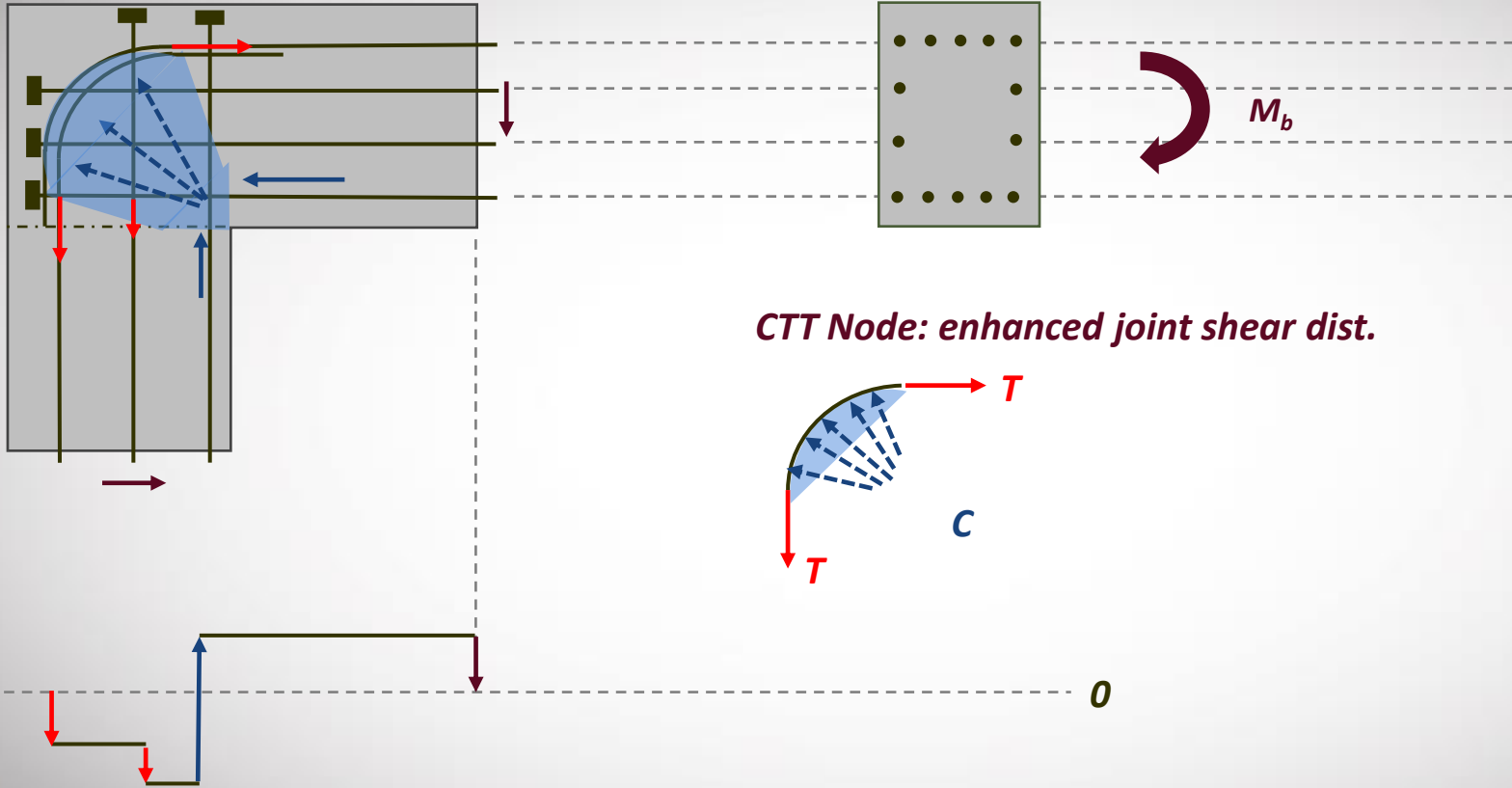
Research Needs: Knee joint behavior (joint closing) w/ heads

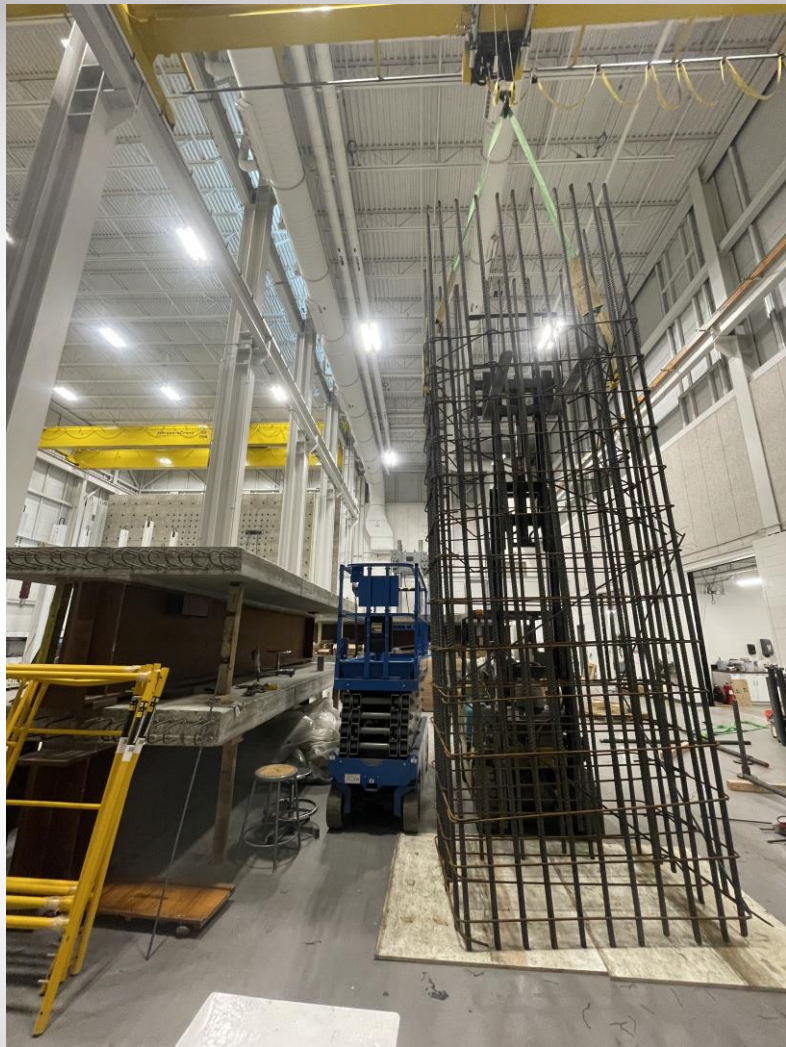


Research Needs: Knee joint behavior (joint closing) w/ heads



Research Needs: Knee joint behavior (joint closing) w/ heads + hooks





Questions?

