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Back to Basics

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IDENTIFYING SHORING REQUIREMENTS TO MITIGATE CONFLICTS DURING CONCRETE REPAIRS

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2024
FALL CONVENTION

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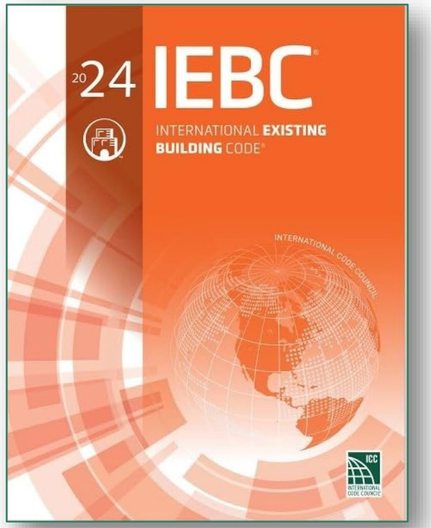
AGENDA

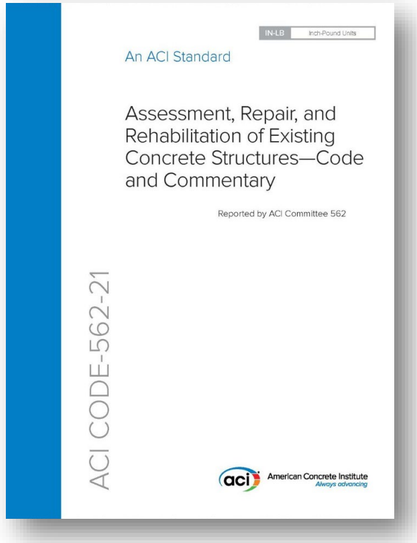
1. **Shoring Basics**
   a. Repair Process and Need for Shoring
   b. Code Requirements for Shoring
2. **Shoring Requirements**
   a. Requirements by Engineer
   b. Considerations for Contractor
   c. Benefits to Project
3. **Shoring Approaches**

SHORING BASICS

REPAIR PROCESS

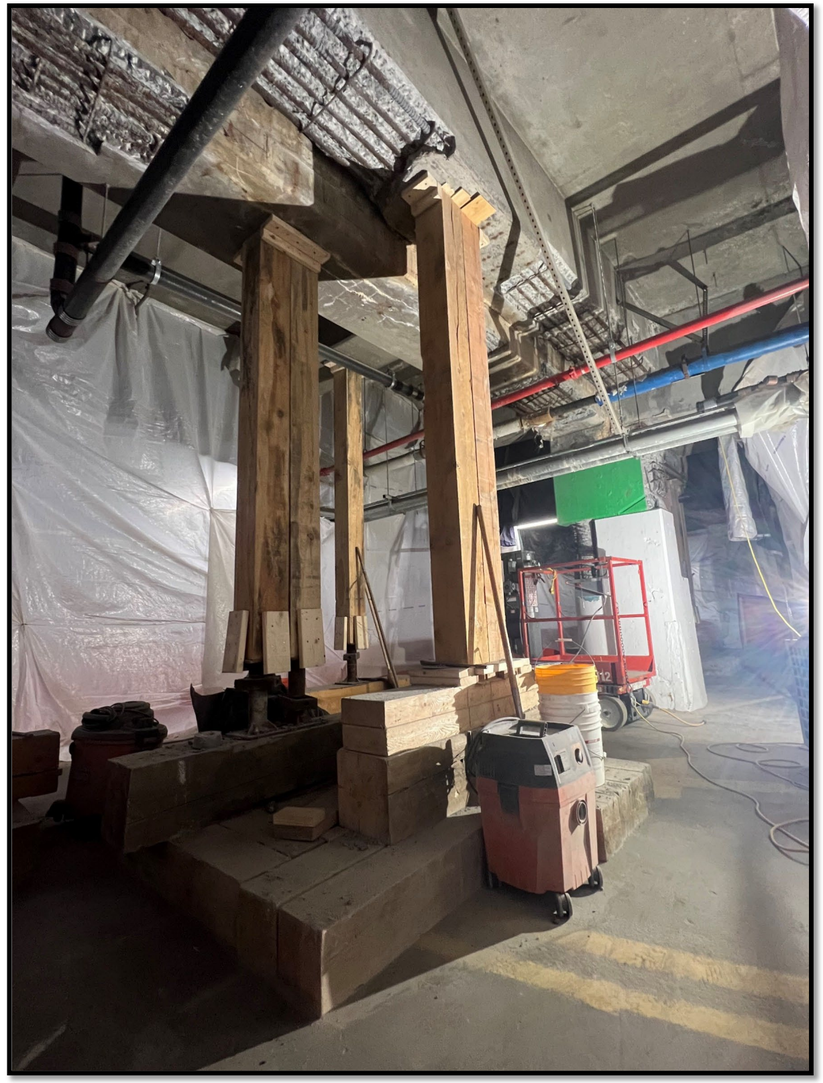
CODE REQUIREMENTS





REPAIR PROCESS

- Deteriorated concrete elements need to be further weakened to repair
  - Need to be temporarily shored prior to removal
- Shoring is utilized to maintain structural integrity
  - Can be used in many applications to support and brace
- The consideration and installation of shoring is crucial
  - Identified early in the design process
  - Implemented to begin the concrete repair process
- **But whose responsibility is it?**



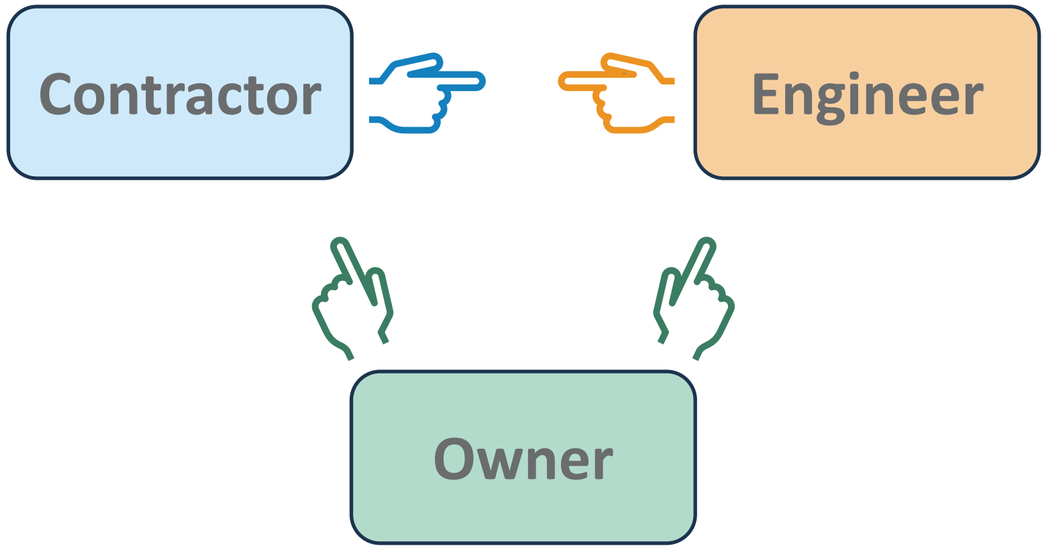
Live Content Slide

When playing as a slideshow, this slide will display live content

Poll: How often are shoring requirements provided on your projects?

REPAIR PROCESS

- **Is it Means and Methods?**
  - It is a gray area
  - Shoring many times falls under the catch-all language of the construction documents
    - "Shore as required"
  - By default, evaluating the need for **all** shoring can become the responsibility of the Contractor
  - Potential for conflict, additional costs, and schedule delays



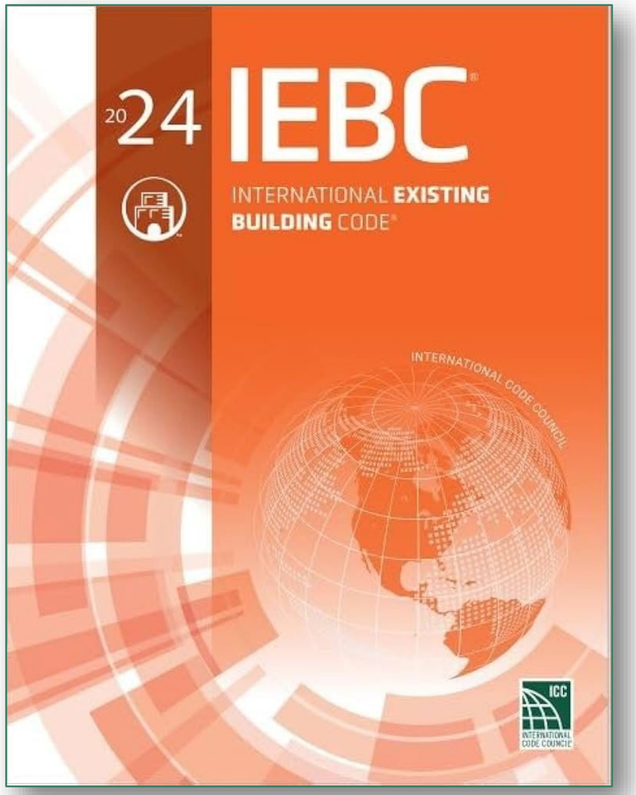
REPAIR PROCESS

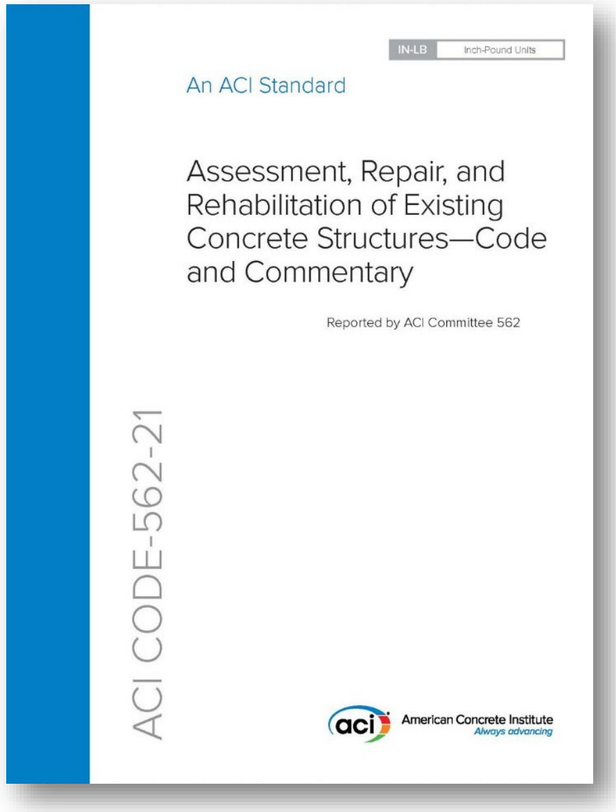
- Engineer has most of the information to identify the need for shoring at critical areas
  - Critical information can be lost if shoring requirements are not provided in the construction documents
- Absence of shoring requirements **can create unsafe conditions**
- Many of these pitfalls can be avoided by providing requirements in the construction documents and collaborating with the contractor during construction

CODE REQUIREMENTS

- Repairs of Existing Concrete Structures
  - Int. Existing Building Code (IEBC)
    - Specific shoring requirements not provided
  - ACI 562: Assessment, Repair, and Rehabilitation of Existing Concrete Structures
    - Adopted in FL, HI, NC, and OH

- Additional Guides for Shoring:
  - ACI 347.2: Guide for Shoring/Reshoring of Concrete Multistory Buildings (Primarily new concrete structures)





CODE REQUIREMENTS

- ACI 562-25 content follows repair process

CH 1—General Requirements
CH 2—Notation and Definitions
CH 3—Referenced Standards
CH 4—Criteria as a Stand-alone Code
CH 5—Loads, Factored Load Combinations, and Strength Reduction Factors
CH 6—Assessment, Evaluation, and Analysis
CH 7—Design of Structural Repairs
CH 8—Reinforcement Details and Condition
CH 9—Durability
CH 10—Fire-resistance, Assessment and Damage Repair
CH 11—Temporary Works
CH 12—Construction
CH 13—Quality Assurance

Shoring

Assessment

Design

Construction

CODE REQUIREMENTS

- ACI 562-25 Requirements
  - Deterioration due to corrosion or other mechanisms weakens the structure
    - Concrete removal to perform repairs will further weaken the structure
  - Concrete repair process requires implementation of shoring to support the existing structure
    - Need to maintain structural integrity
    - Support for structural elements varies
    - Consider condition of supporting elements
  - Recommends coordination between Engineer, Contractor, and shoring designer

12.3—Temporary shoring and bracing requirements

12.3.1 Construction documents shall specify (a) through (f) as applicable:

(a) Portions of the work that require temporary shoring and bracing during the period before rehabilitation work begins and during execution

(b) Design loads, locations, and necessary spacing limitations for the design of temporary shoring and bracing

(c) Pre-load of any shoring and bracing

(d) Limitations of vertical or lateral displacement of the shored or braced members

(e) Load transfer requirements or required sequences for installation to maintain structural stability

(f) Requirements for removal of temporary shoring and bracing

(g) Contractor's responsibilities to install, inspect, and maintain temporary shoring and bracing.

(h) Design requirements for shoring and bracing, if shoring design is delegated to the contractor

SHORING REQUIREMENTS

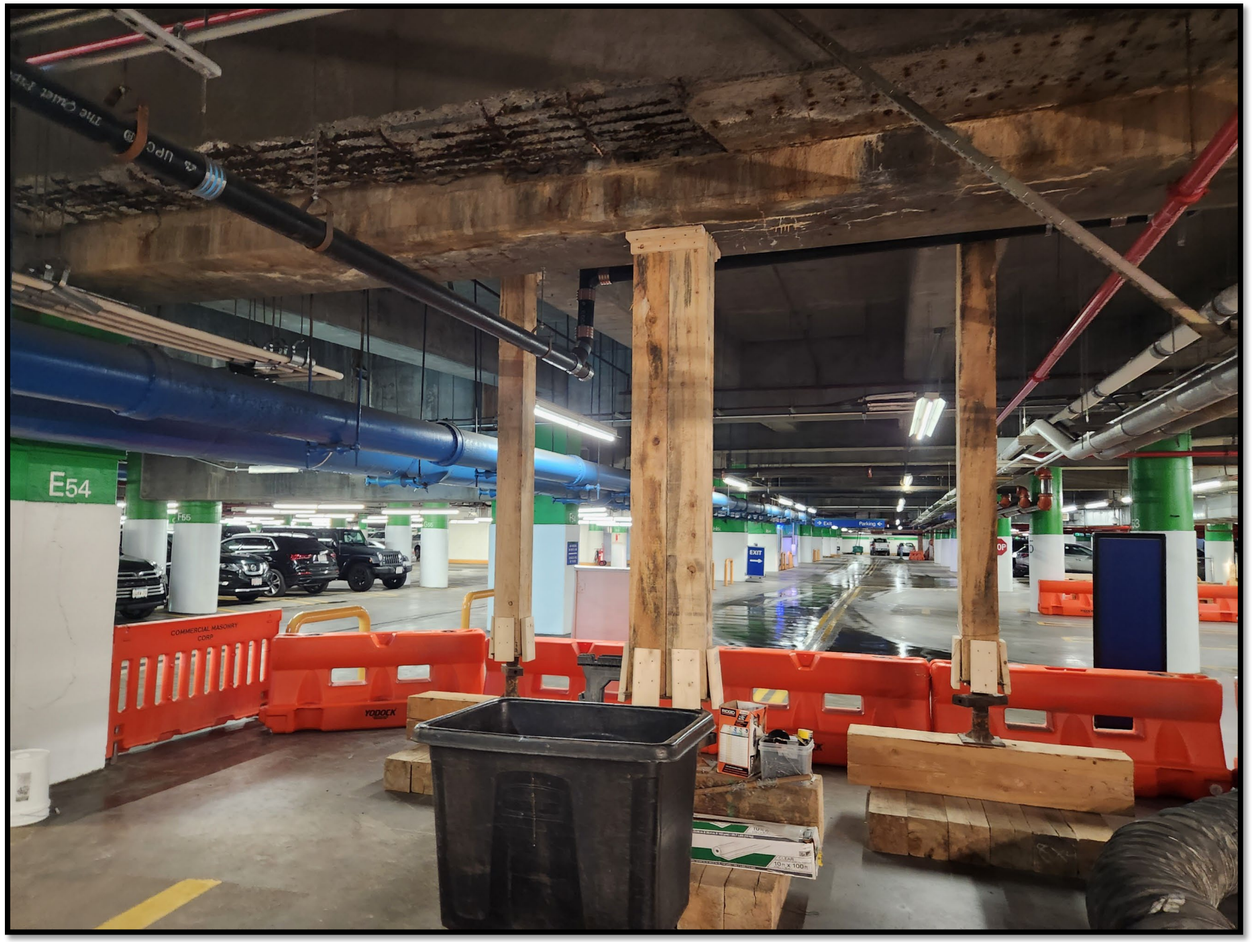
REQUIREMENTS BY ENGINEER

CONSIDERATIONS FOR CONTRACTOR

BENEFITS TO PROJECT

REQUIREMENTS BY ENGINEER

- The Engineer with their knowledge of the existing structure needs to provide requirements
  - The Contractor is not familiar with the existing structure to understand behavior and constraints
- The Engineer's construction documents need to **provide clear requirements** for the Contractor(s)
  - With suggested methods for final design by the Contractor's shoring engineer
    - Provides flexibility with products and installation procedures (means and methods)



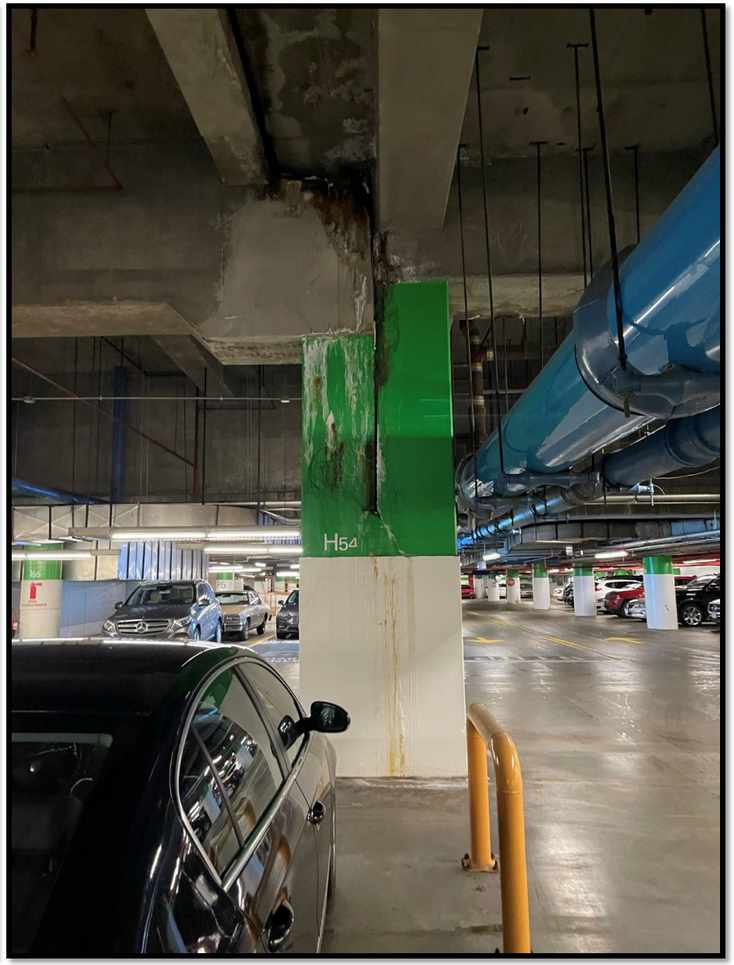
REQUIREMENTS BY ENGINEER

Considerations for Shoring Requirements for CDs

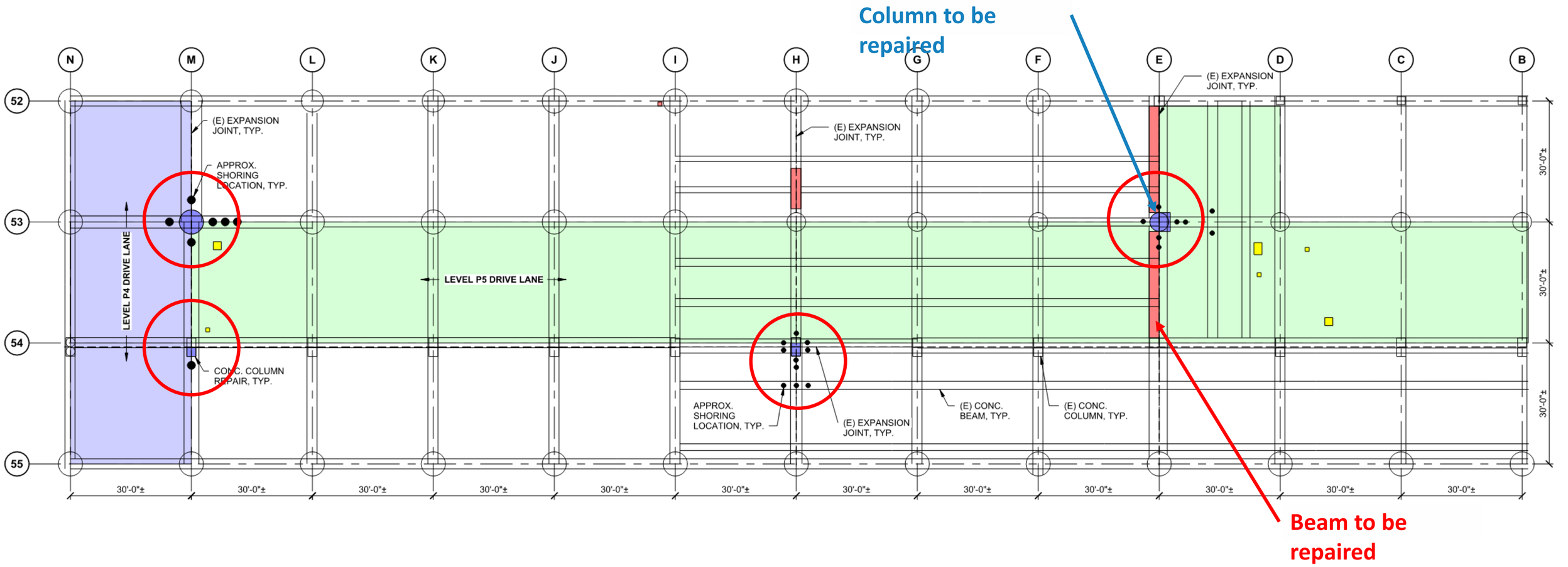
- ❑ Identify Locations and Elements Requiring Shoring
- ❑ Develop Shoring Loads
- ❑ Analyze Existing Structural Elements Supporting or Affected by the Shoring (As Required)
- ❑ Develop Shoring Plans and Elevations

REQUIREMENTS BY ENGINEER

- **Identify Locations and Elements Requiring Shoring**
  - During condition assessment and verified during design
    - Include cost for shoring locations in cost estimates and bid form
  - Drawings should show approximate extents of shoring at repair locations
    - Shown on repair plans or specific shoring drawings



REQUIREMENTS BY ENGINEER



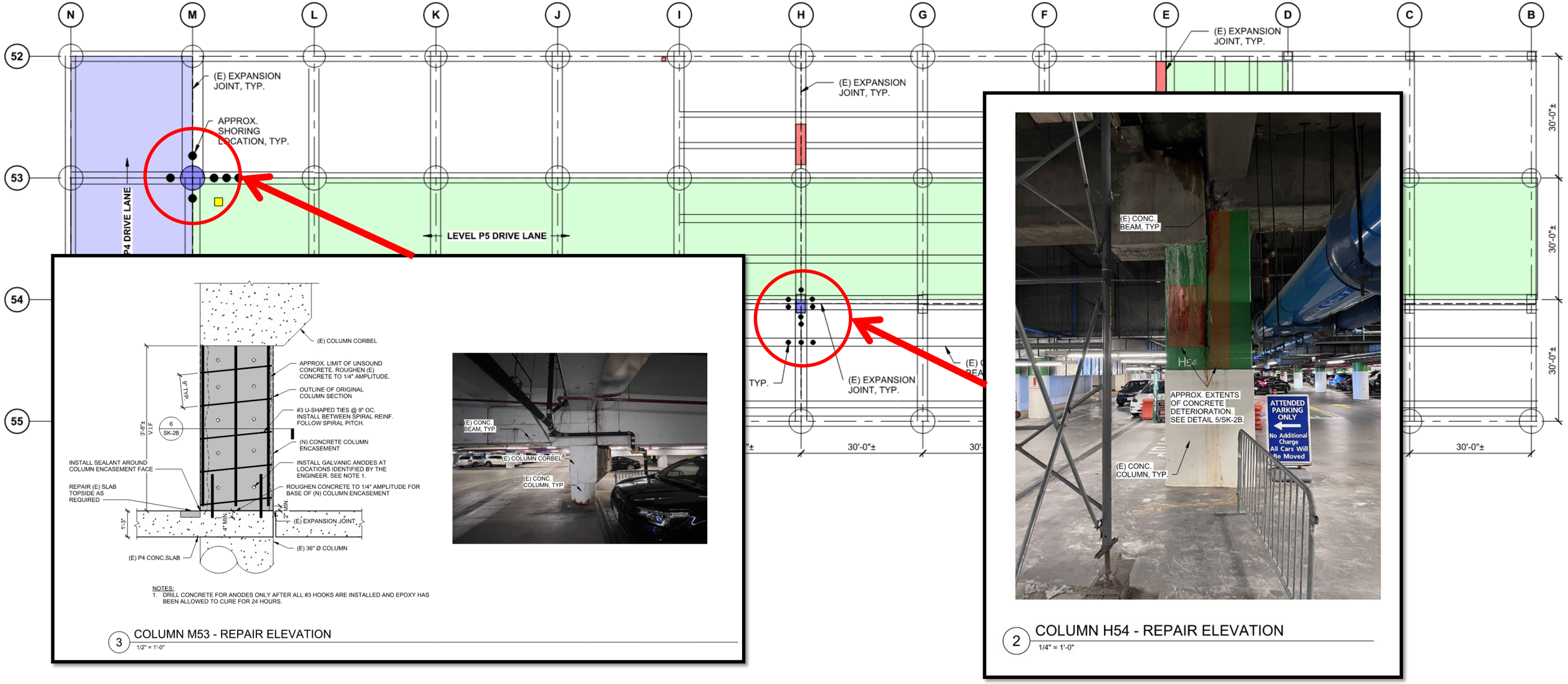
SHORING REQUIREMENTS:

1. THE CONTRACTOR AND THEIR ENGINEER ARE RESPONSIBLE FOR EVALUATING THE NEED FOR, DESIGNING, AND PROVIDING ADDITIONAL SHORING TO SAFELY SUPPORT THE EXISTING STRUCTURE DURING THE WORK.
2. THE CONTRACTOR SHALL SUBMIT SHOP DRAWINGS AND CALCULATIONS BEARING THE SEAL OF THE PROFESSIONAL STRUCTURAL ENGINEER LICENSED TO PRACTICE IN THE STATE OF MASSACHUSETTS WHO IS RESPONSIBLE FOR THE DESIGN OF THE SHORING SYSTEM.
3. FIELD-VERIFY ALL EXISTING CONDITIONS INCLUDING THE CONFIGURATION OF ALL THE STRUCTURAL, ARCHITECTURAL, AND MEP ELEMENTS AFFECTING THE WORK.
4. MAINTAIN EXISTING DRIVE LANES AS SHOWN TO ALLOW FOR GARAGE OPERATIONS. COORDINATE ANY PARTIAL CLOSURE WITH BOSTON PROPERTIES.

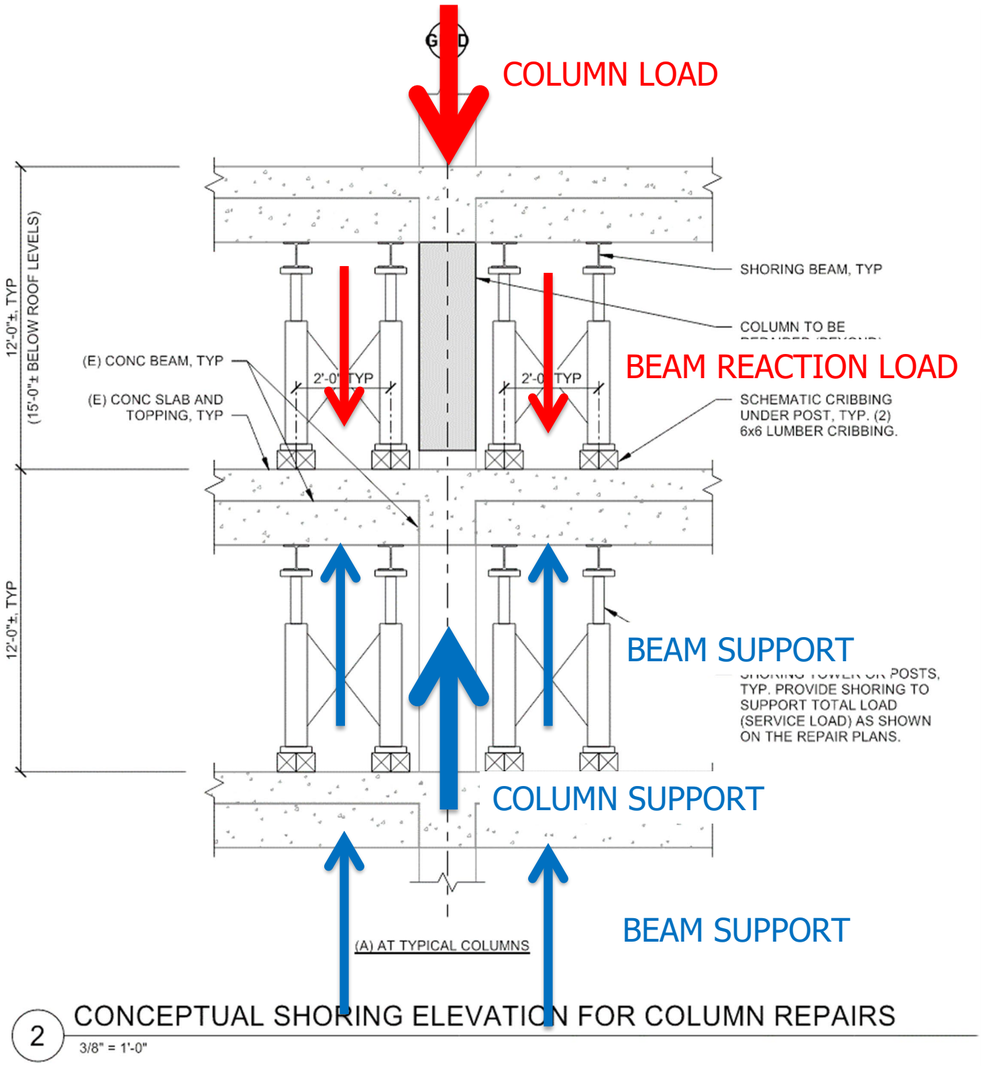
LEGEND:

- CONCRETE COLUMN REPAIR LOCATIONS
- APPROX. CONCRETE BEAM UNDERSIDE REPAIR LOCATIONS (SEE DETAIL 7/S1A)
- APPROX. CONCRETE SLAB UNDERSIDE REPAIR LOCATIONS (SEE DETAIL 8/S1A)
- APPROX. SHORING LOCATIONS

REQUIREMENTS BY ENGINEER



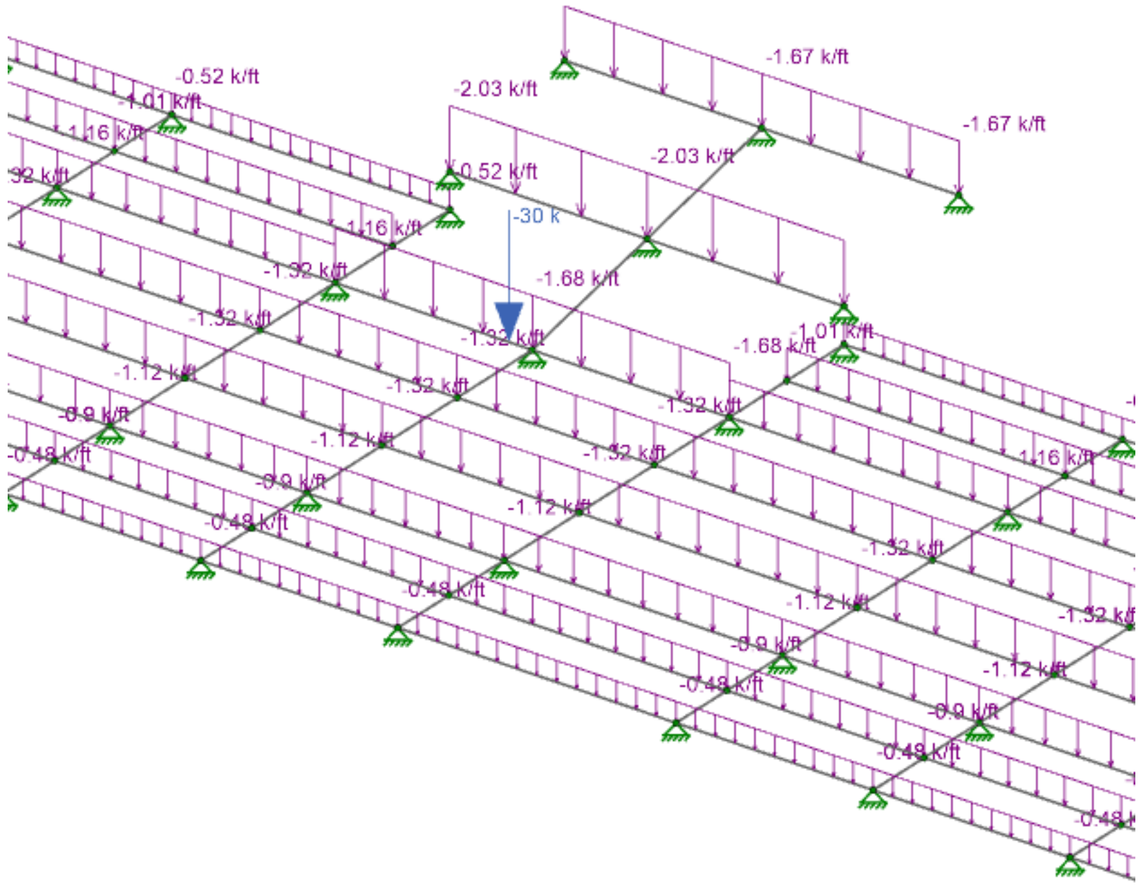
REQUIREMENTS BY ENGINEER



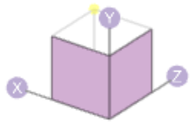
- **Develop Shoring Loads**
  - Review the load path and impact on existing structural elements
    - Loads may be redistributed due to repairs
    - Analyze existing structure as required
  - Calculate shoring loads (**service loads**)
    - Include all dead loads
    - Include live load if the structure remains operational (ASCE 7)
    - Include construction live load if occupied during construction (ASCE 37)
  - Provide loads to be resisted by shoring elements in CDs
    - Include requirements for cribbing based on grade conditions

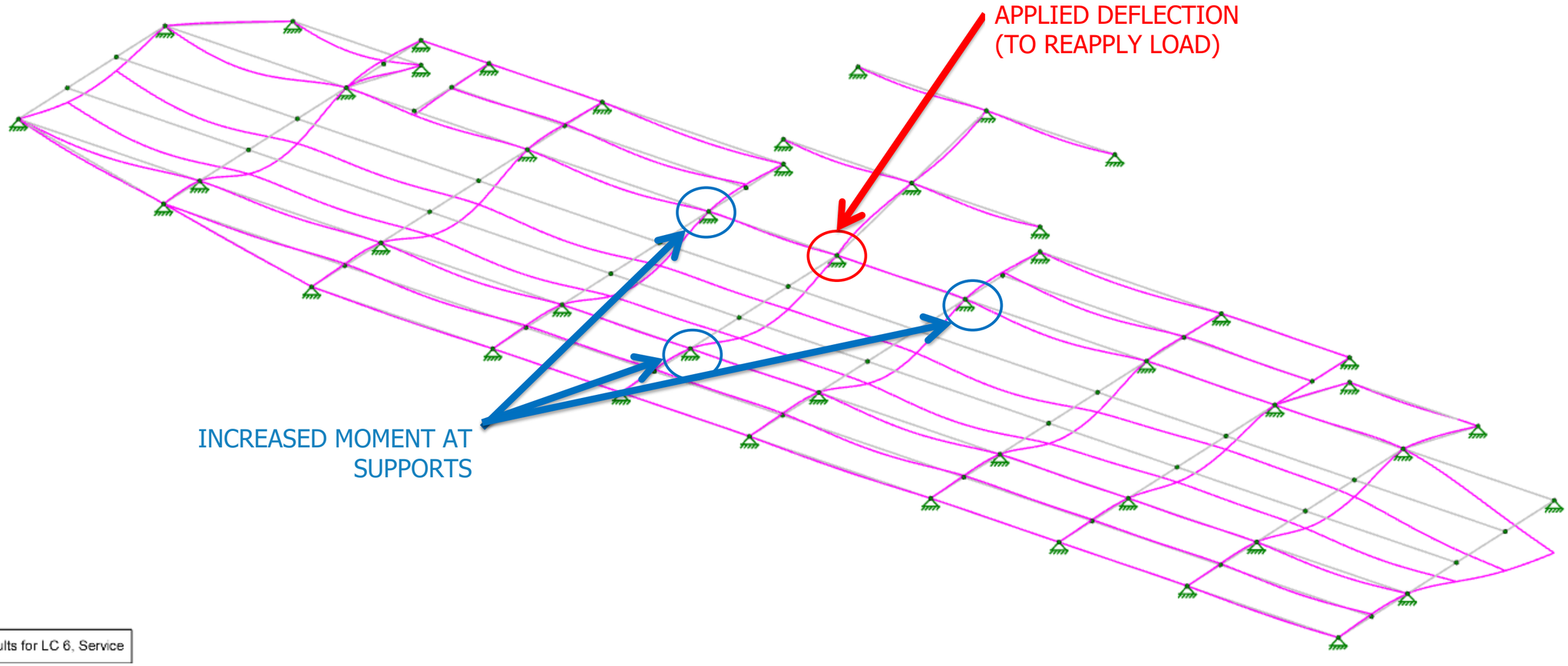
REQUIREMENTS BY ENGINEER

- **Analyze Existing Structure for Load Path**
  - Frequently cannot extend shoring to grade
    - Use the existing structure below for support
    - Minimize shoring costs by reducing the vertical extent of shoring
  - Analyze existing structural elements to support shoring loads
    - Existing structure becomes part of shoring system
    - Transfer loads around the weakened element
  - Review if load jacking is required

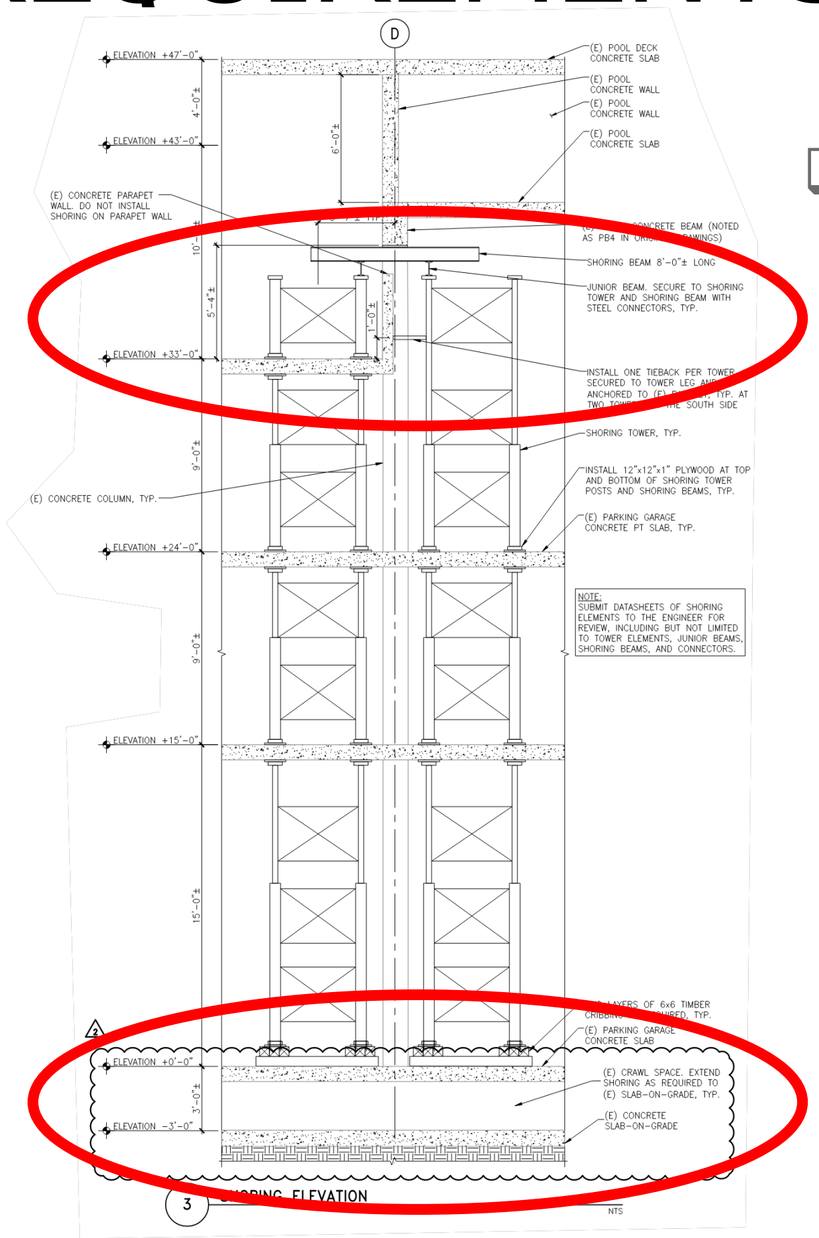


REQUIREMENTS BY ENGINEER



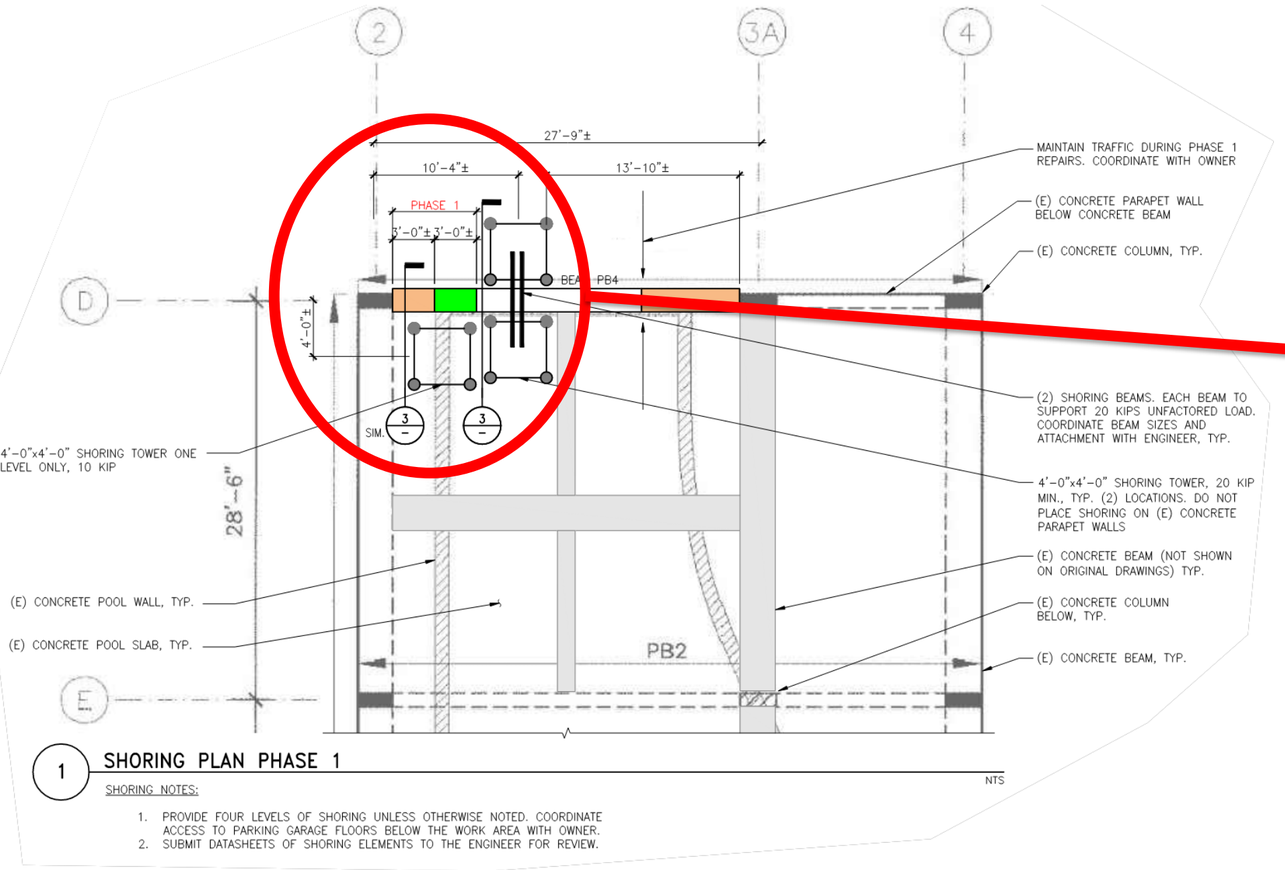


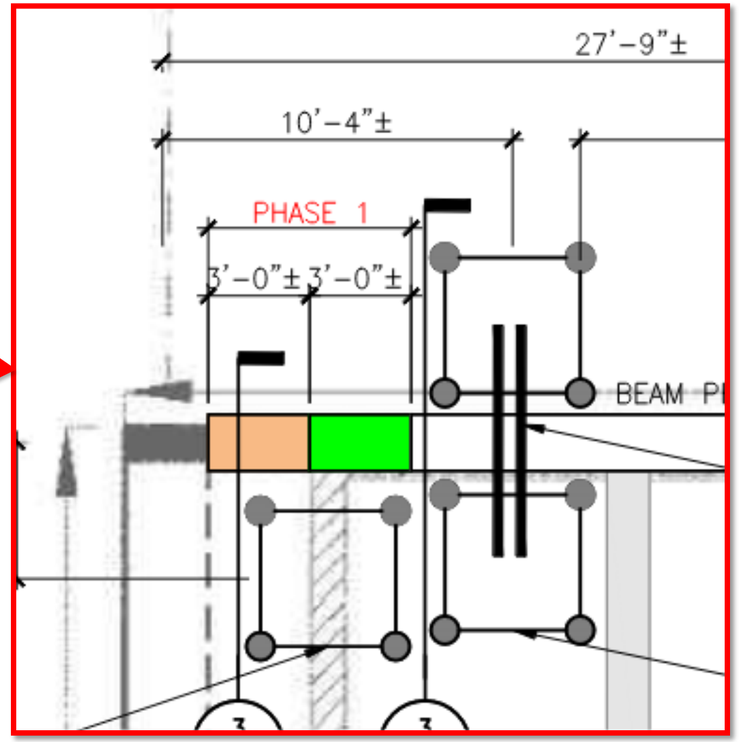
REQUIREMENTS BY ENGINEER



- **Develop Shoring Plans and Elevations**
  - Provide layouts for typical elements and specific locations with constraints requiring shoring
    - Provide requirements for cribbing
    - Add information to show constraints at locations, such as MEP-FP systems
    - Show active drive lanes, occupied areas, crawl spaces, mechanical rooms…
    - Show grade conditions for cribbing
  - Provide minimum shoring load requirements
  - Include phasing of repairs

REQUIREMENTS BY ENGINEER





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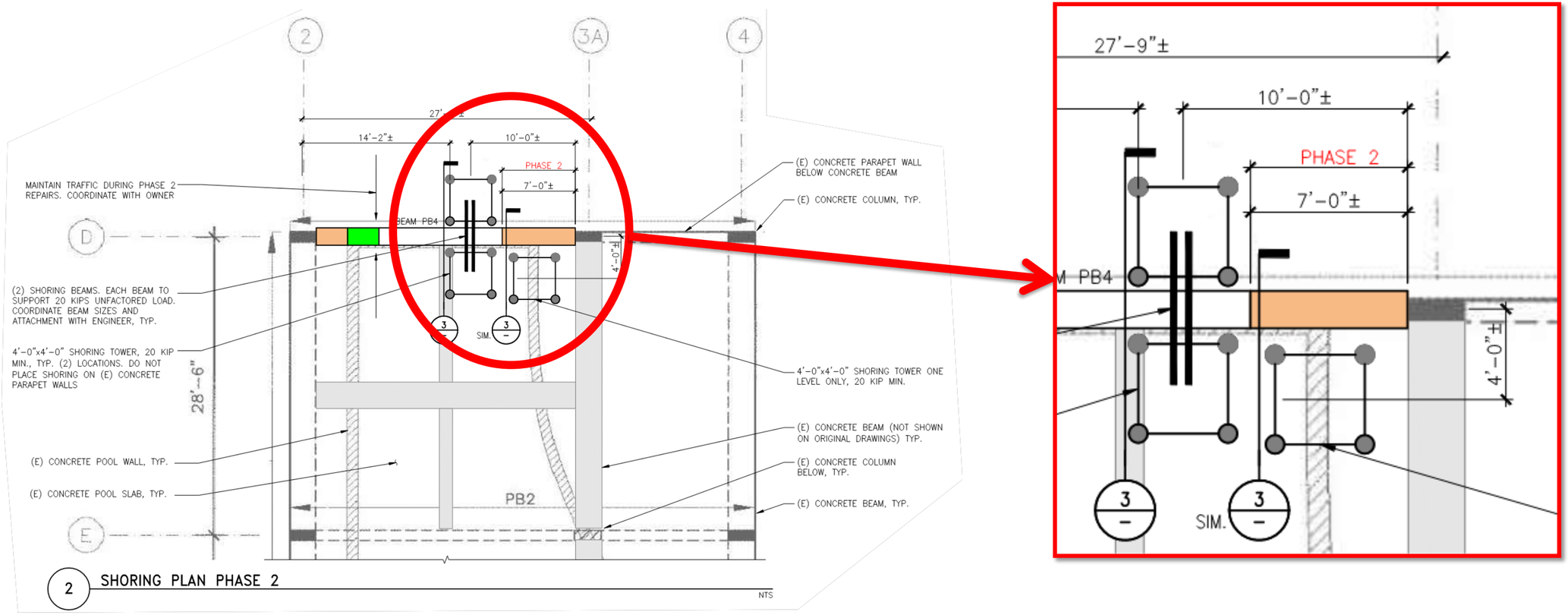
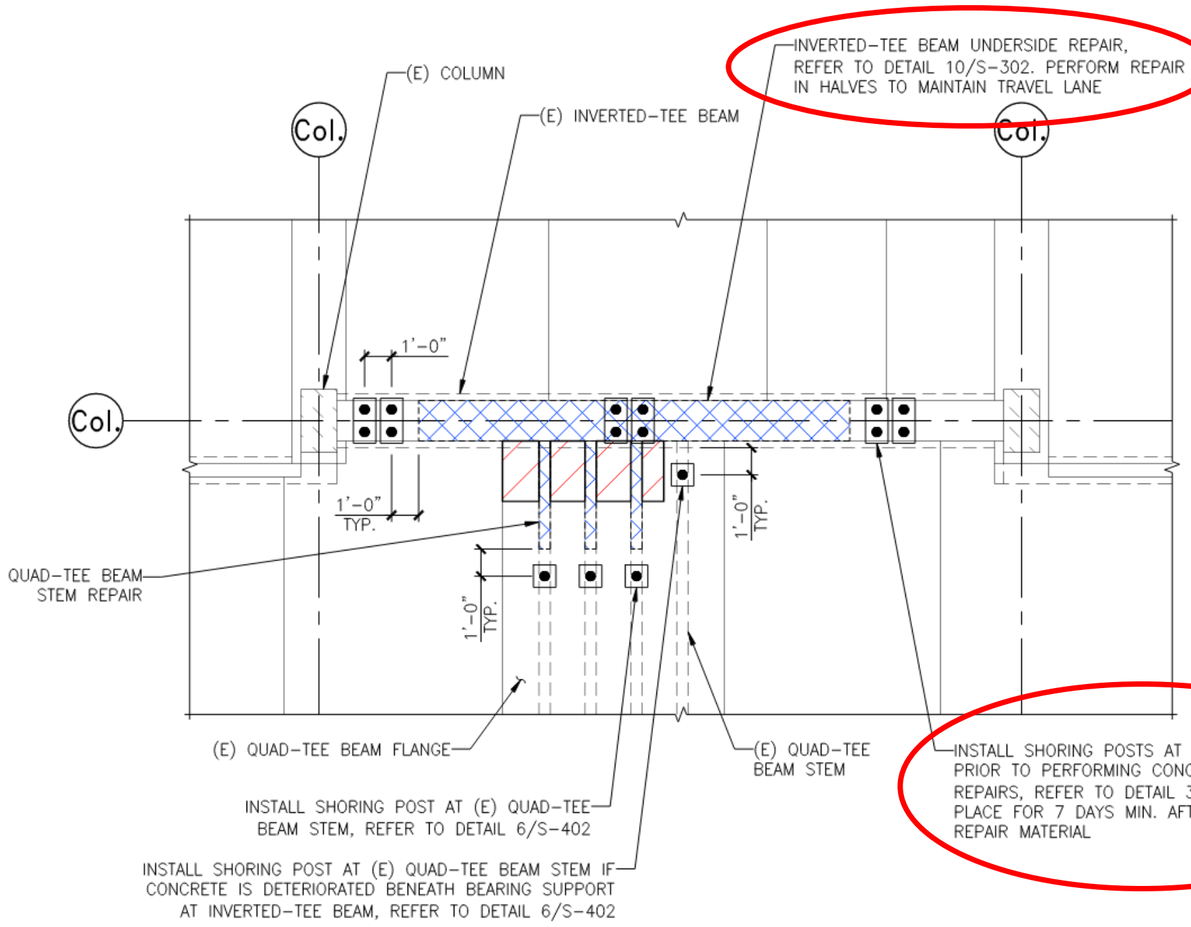


REQUIREMENTS BY ENGINEER



INVERTED-TEE BEAM UNDERSIDE REPAIR, REFER TO DETAIL 10/S-302. PERFORM REPAIR IN HALVES TO MAINTAIN TRAVEL LANE

NOTES:

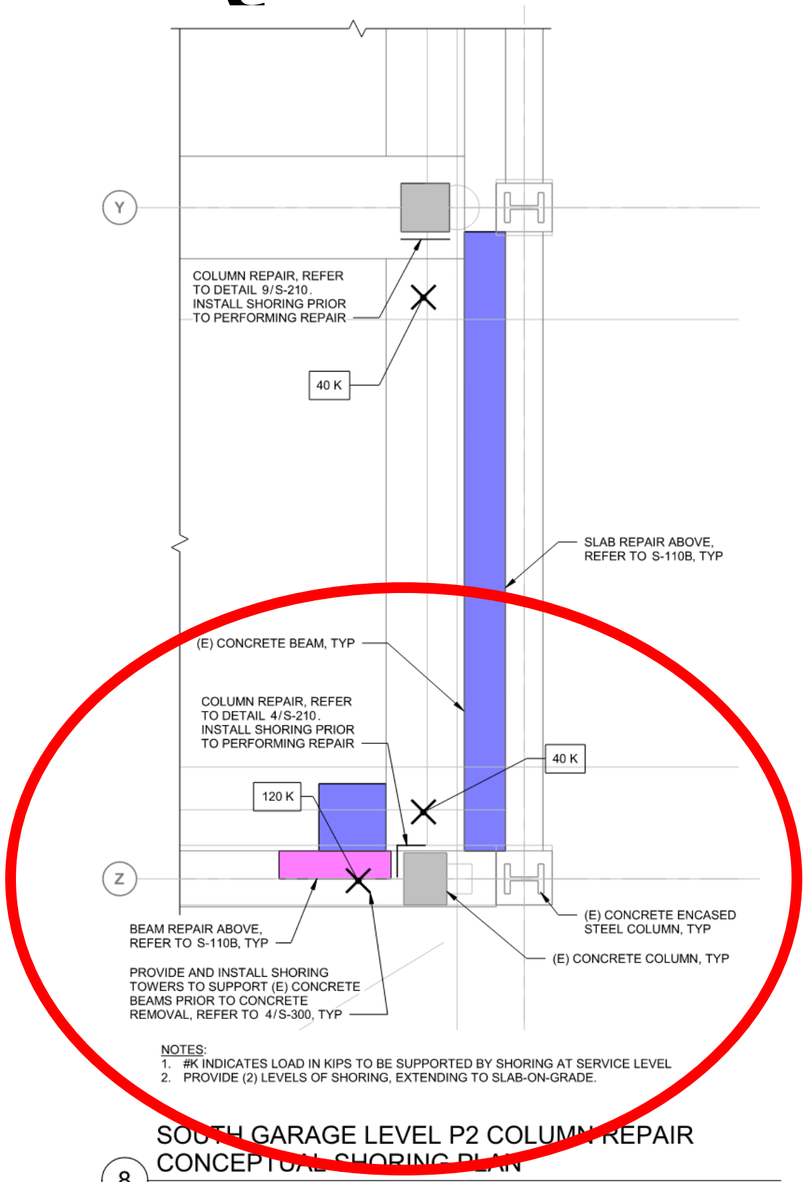
1. PROVIDE TWO LEVELS OF SHORING AT ELEVATED LEVELS.
2. SHORING SHOWN REPRESENTS THE MINIMUM REQUIREMENTS. THE CONTRACTOR IS RESPONSIBLE FOR EVALUATING THE NEED FOR DESIGNING, AND PROVIDING ADDITIONAL SHORING TO SUPPORT SAFELY THE EXISTING STRUCTURE AND FORMWORK DURING THE WORK.

INSTALL SHORING POSTS AT INVERTED-TEE BEAM PRIOR TO PERFORMING CONCRETE REMOVAL AND REPAIRS, REFER TO DETAIL 3/S-401. LEAVE IN PLACE FOR 7 DAYS MIN. AFTER PLACEMENT OF REPAIR MATERIAL

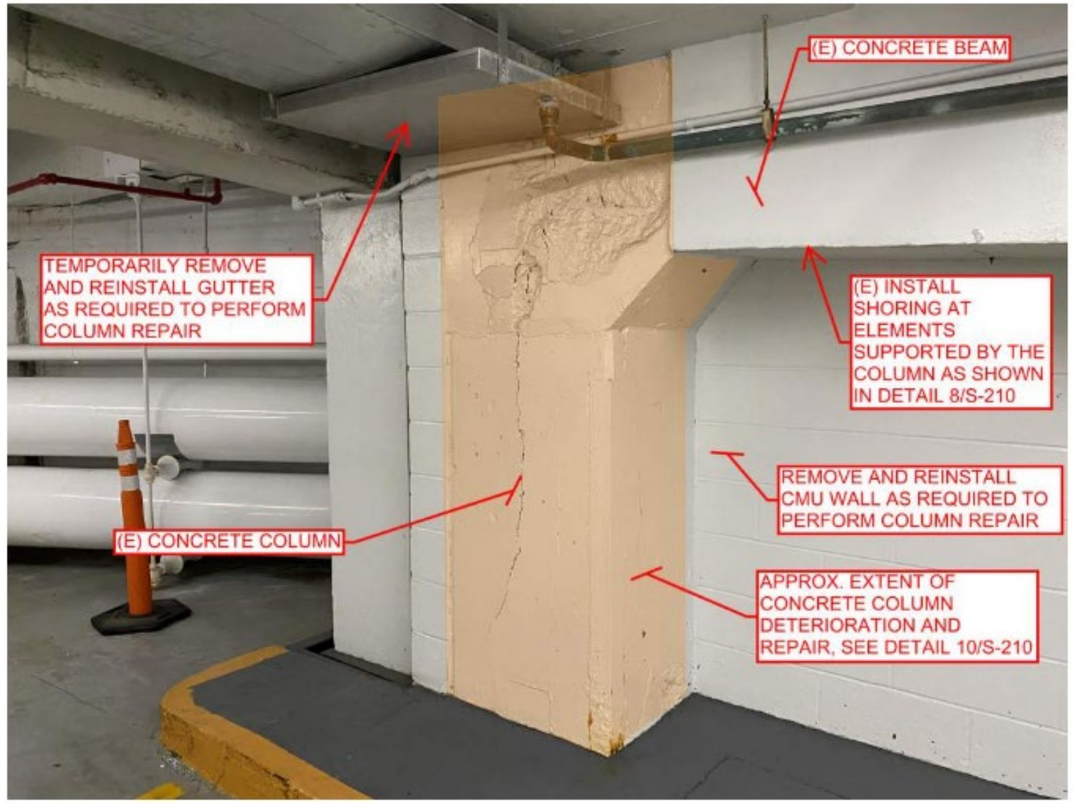
1 CONCEPT SHORING LAYOUT AT INVERTED-TEE AND QUAD-TEE BEAMS

NTS

REQUIREMENTS BY ENGINEER



8 SOUTH GARAGE LEVEL P2 COLUMN REPAIR CONCEPTUAL SHORING PLAN
1/4" = 1'-0"



4 SOUTH GARAGE LEVEL P2 COLUMN REPAIR DETAIL
NTS

CONSIDERATIONS FOR CONTRACTOR

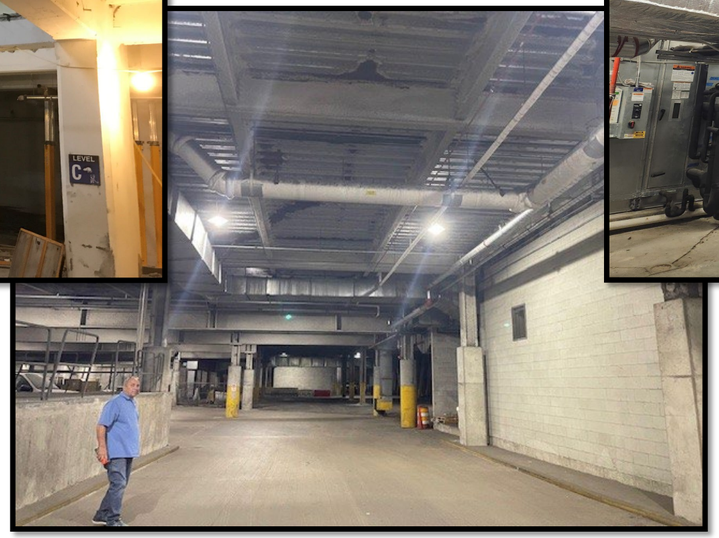
Important to consider constraints and types of shoring elements and techniques available for various applications

CONSIDERATIONS FOR CONTRACTOR

- The Contractor can leverage their extensive experience to identify potential issues regarding the constructability of the suggested shoring
  - Identifying issues early on during bidding or construction can mitigate change orders and delays later in the project
  - Proposing alternative shoring products or methods can reduce costs and schedule impact for installation

CONSIDERATIONS FOR CONTRACTOR

Evaluation for Additional Shoring



Parking and Lane Closures

Access and Constraints

Sequencing of Repairs

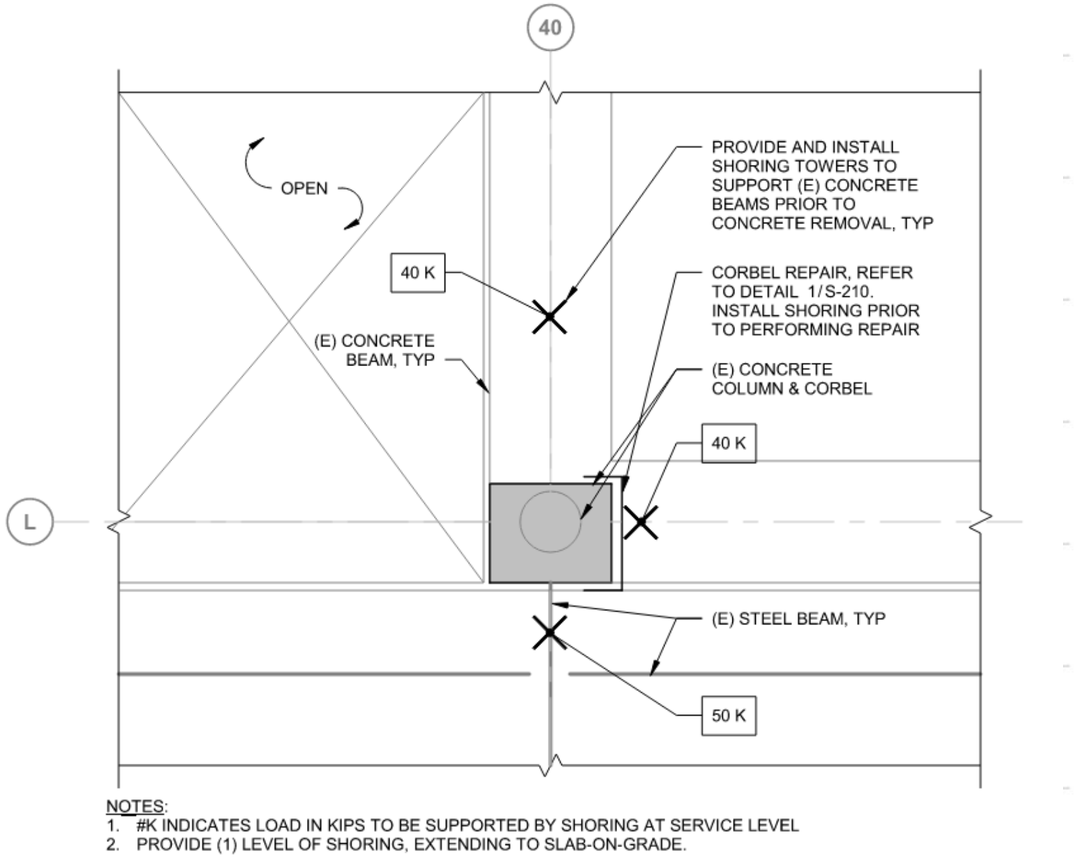
CONSIDERATIONS FOR CONTRACTOR

SELECTION OF SHORING ELEMENTS

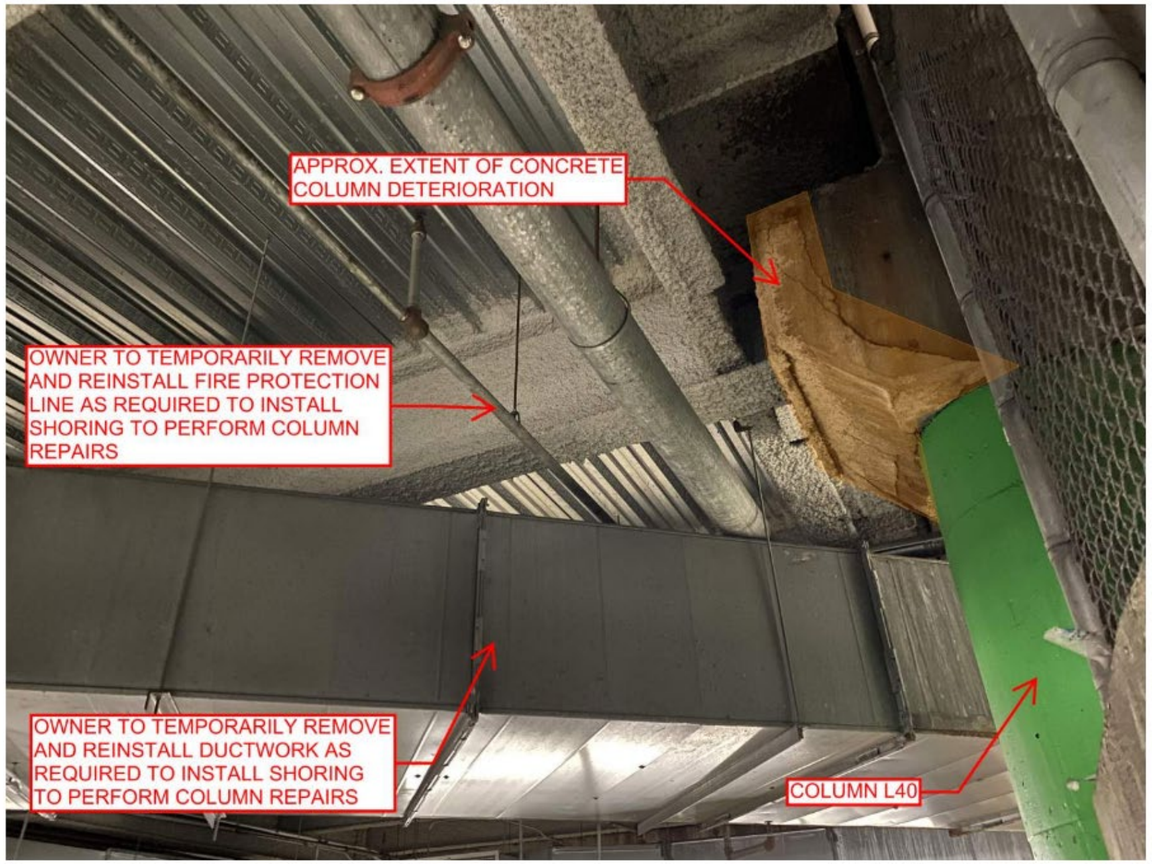
- **Location, location, location**
  - Shoring approaches and elements are typically dictated by accessibility and constraints to repair location
  - These constraints are not always shown on the construction documents
- Types and sequencing of repairs
- Availability of shoring materials and systems

CONSIDERATIONS FOR CONTRACTOR

SELECTION OF SHORING ELEMENTS



5 NORTH GARAGE LEVEL P4 COLUMN REPAIR CONCEPTUAL SHORING PLAN
1/4" = 1'-0"



1 EXISTING CONDITIONS AND UTILITIES AT LOCATION 3
NTS

CONSIDERATIONS FOR CONTRACTOR

SELECTION OF SHORING ELEMENTS

Shoring Posts (Small…)

Shoring Posts (and Big!)

CONSIDERATIONS FOR CONTRACTOR

SELECTION OF SHORING ELEMENTS

Shoring Towers

Shoring Towers/Frames

CONSIDERATIONS FOR CONTRACTOR

SELECTION OF SHORING ELEMENTS

Cribbing

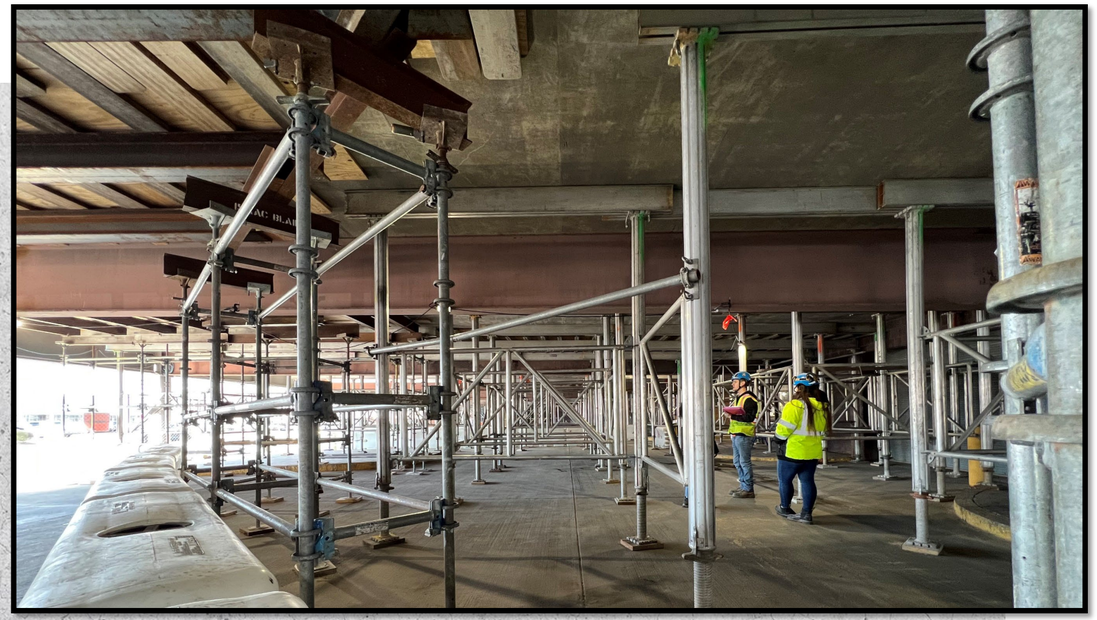
Load Jacking

CONSIDERATIONS FOR CONTRACTOR

SELECTION OF SHORING ELEMENTS

Preloading of Elements

Lateral Bracing



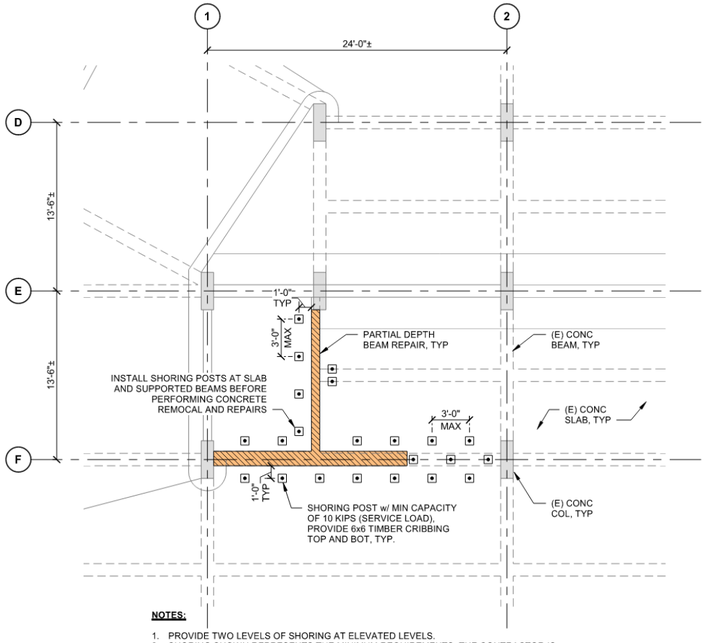
BENEFITS TO PROJECT

A cooperative attitude between the Engineer and Contractor is advantageous to the success of a project and can minimize costs for all parties

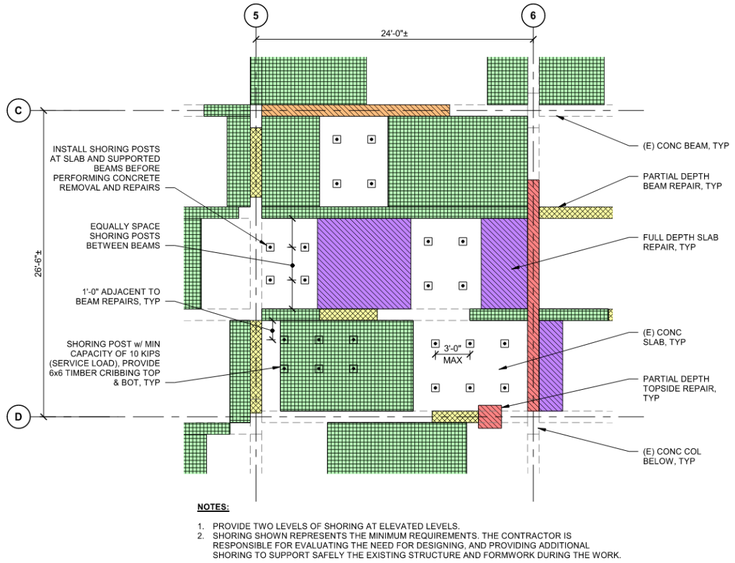
BENEFITS TO PROJECT

Division 02

5. Shoring – Levels C and 1 Repairs	021000 Details 3-4/S-300	1 ls	–	$_____
6. Shoring – Levels 8M and 9 Repairs	021000 Details 3-4/S-300	1 ls	–	$_____
7. Shoring – Column Repairs	021000 Details 1-2/S-300	1 ls	–	$_____



3 CONCEPTUAL SHORING LAYOUT FOR BEAM REPAIRS
3/16" = 1'-0"



4 CONCEPTUAL SHORING LAYOUT FOR SLAB REPAIRS
3/16" = 1'-0"

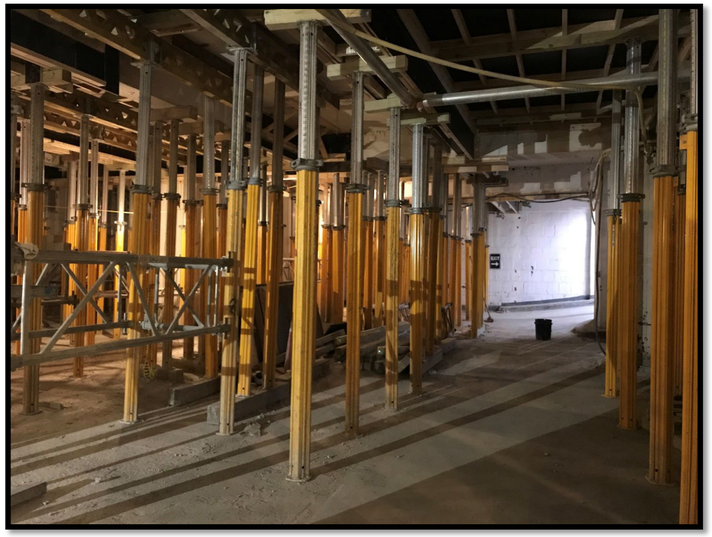
- Providing requirements upfront within the construction documents **levels the playing field for bidders**
  - Allows opportunity for Contractors to ask questions upfront
  - Mitigates future RFIs
  - Minimizes variability in costs
- Depending on the project, the EOR may act as the shoring designer as well

BENEFITS TO PROJECT

- Collaboration between the Engineer and the Contractor(s), even during the bidding phase, can **mitigate discrepancies and constructability issues** early on in the project
  - Reduces schedule impacts and costs
  - Team effort to address shoring modifications and RFIs and develop solutions

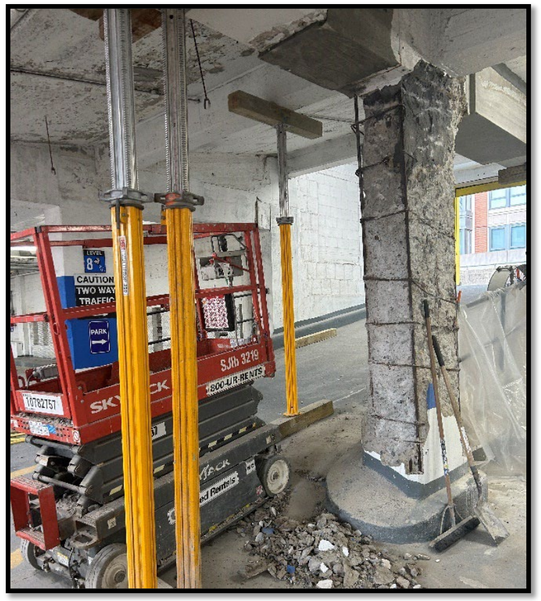
SHORING APPROACHES

SLABS



BEAMS

COLUMNS



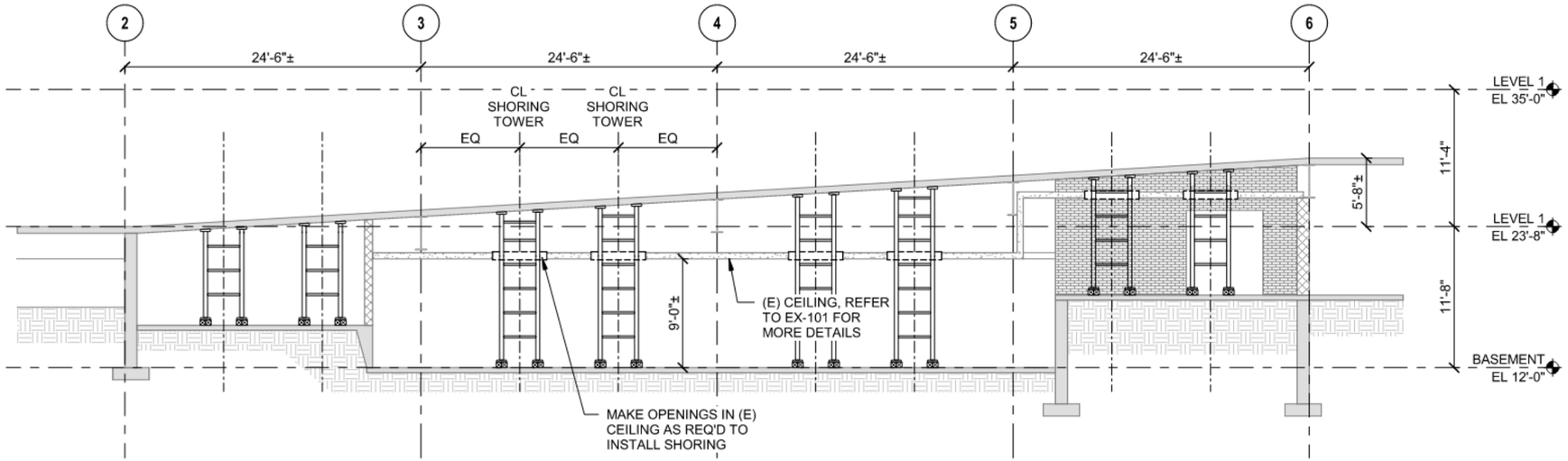
» SHORING APPROACHES

SHORING FOR SLAB REPAIRS

- Consider the following:
  - Type of structural slab system and behavior
  - Impact due to loss of continuity
  - Spacing of shoring elements
  - Condition of supporting elements below

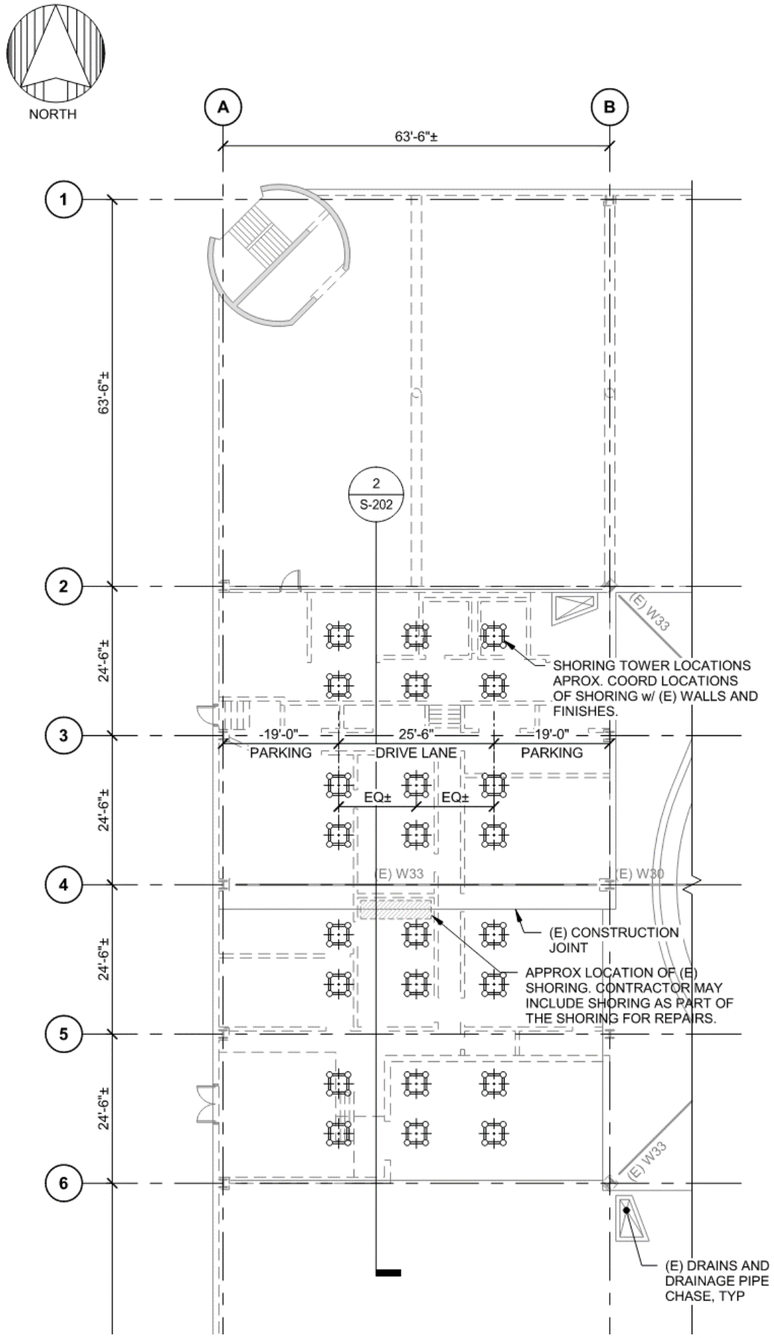
- Example: Shoring at Post-Tensioned Reinforced Concrete Slab

SHORING APPROACHES

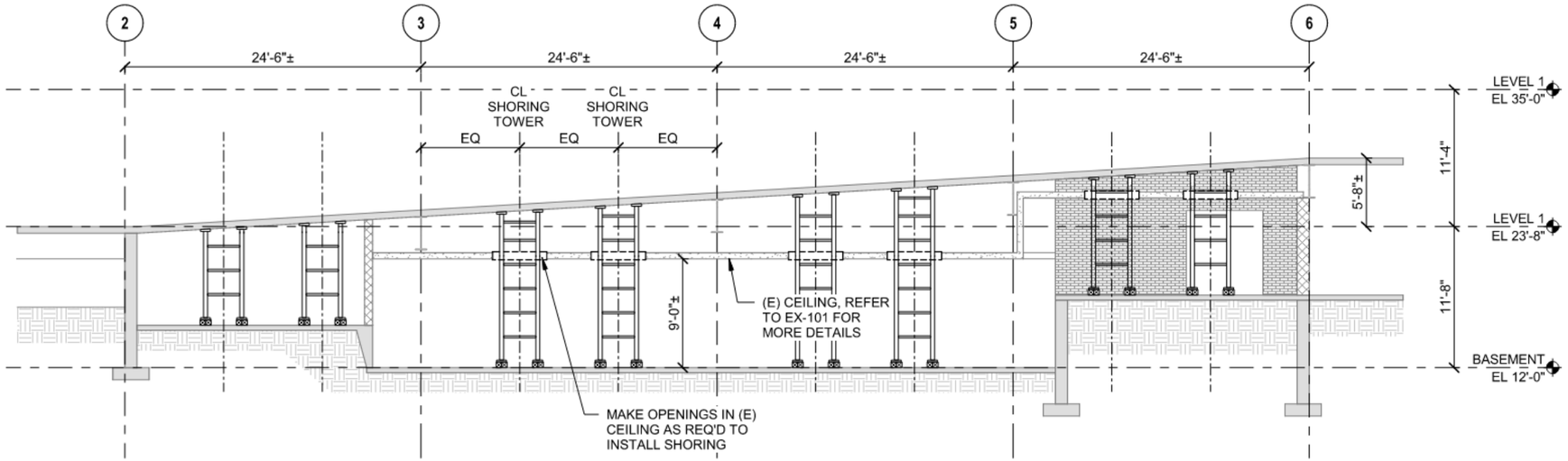


2 SUGGESTED SHORING ELEVATION AT RAMP FROM LEVELS 1 TO 2

1/8" = 1'-0"



SHORING APPROACHES



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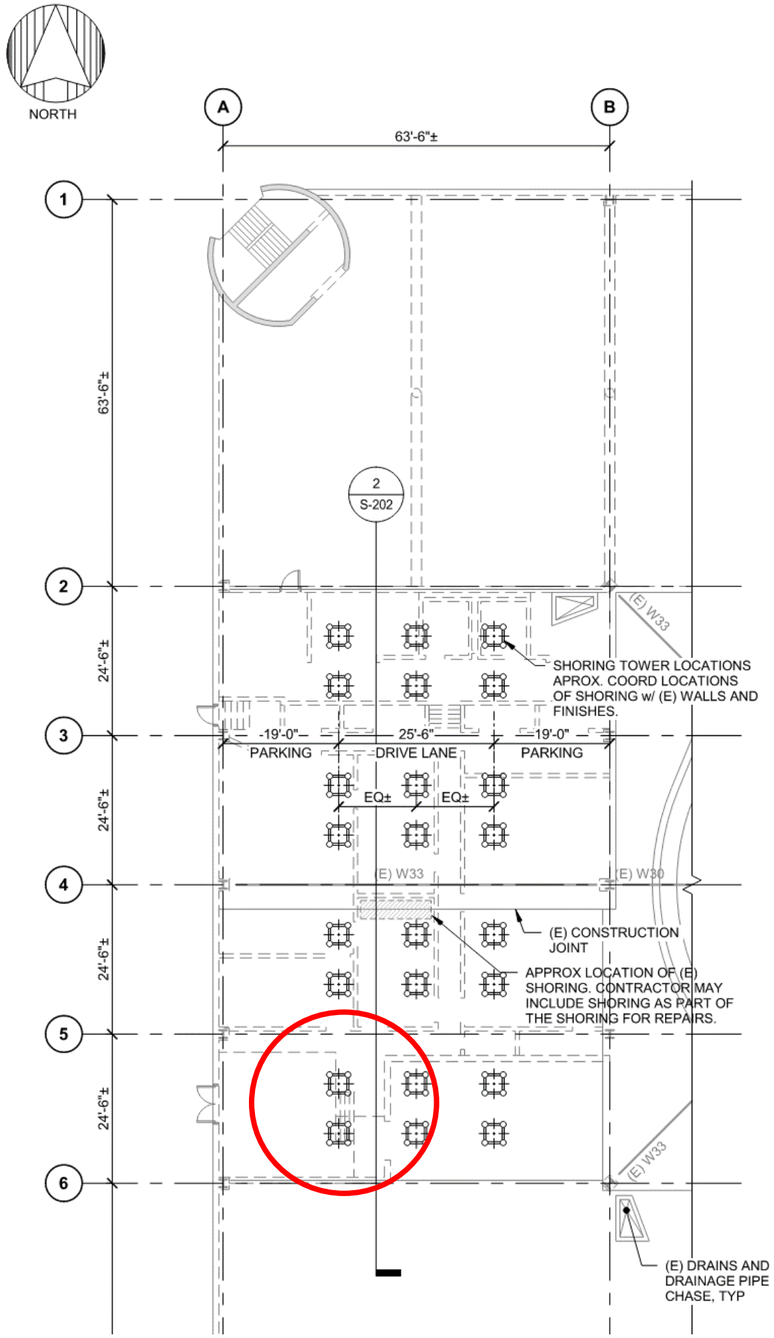


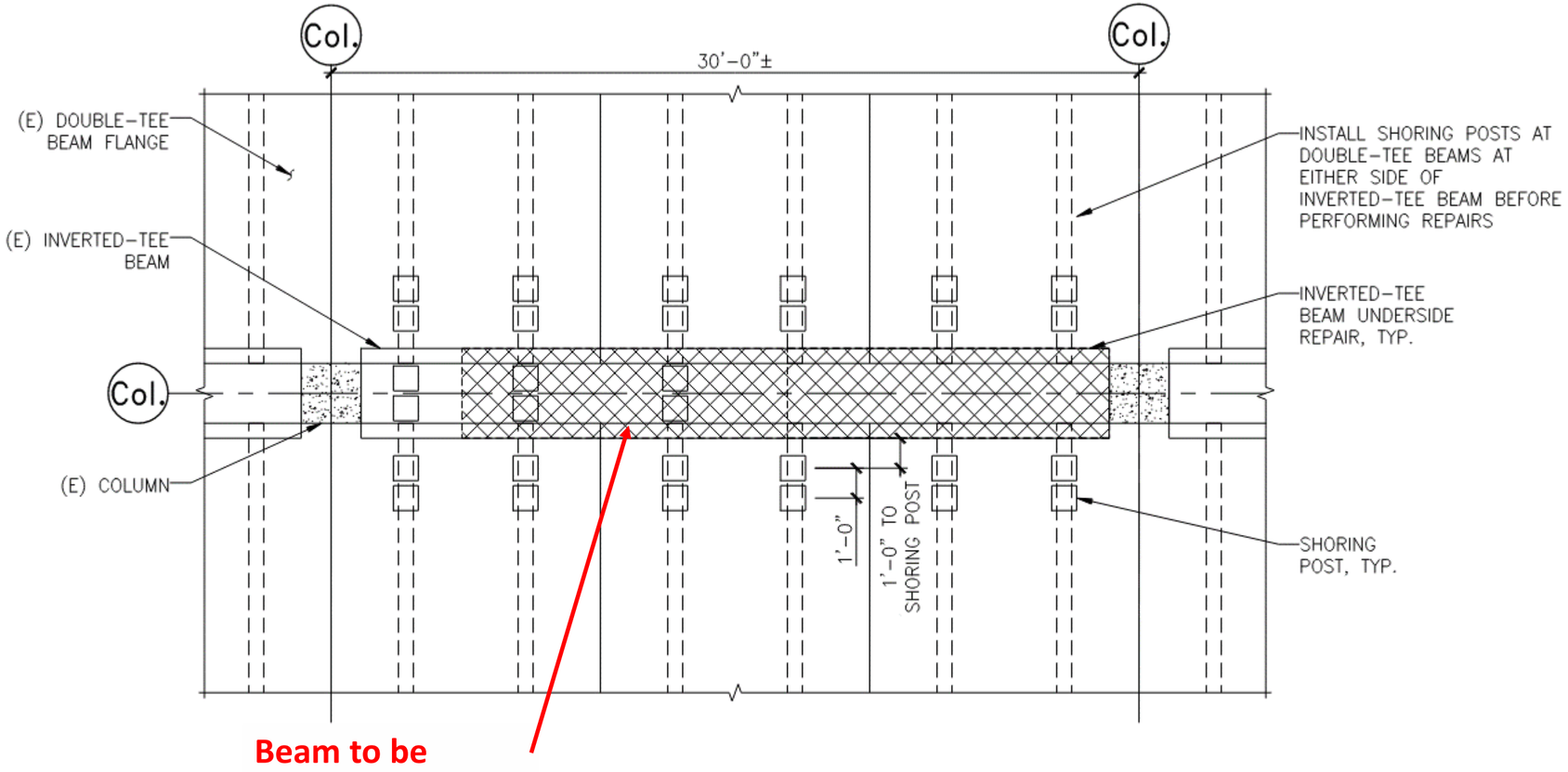
» SHORING APPROACHES

SHORING FOR BEAM REPAIRS

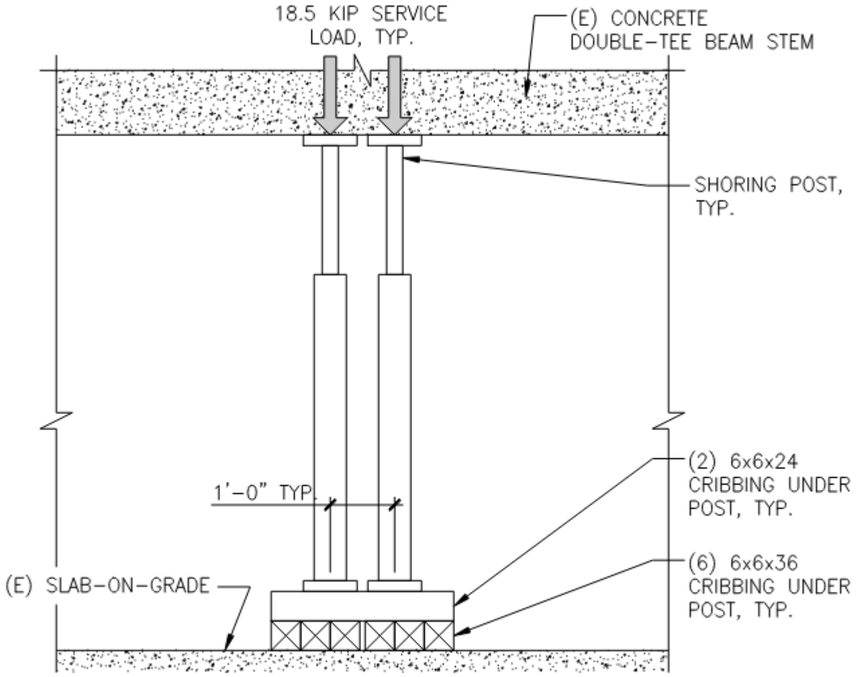
- Consider the following:
  - Similar considerations to slab repairs
  - Continuity of beam elements
  - Shoring members framing into element (slab, tributary beams, etc.) and existing load path
  - Phasing the repairs and sequencing the shoring to minimize shoring required
  - Load jacking may be required

- Example: Shoring at Prestressed Reinforced Concrete Beam

SHORING APPROACHES



SHORING LAYOUT (INVERTED-TEE BEAM REPAIRS)



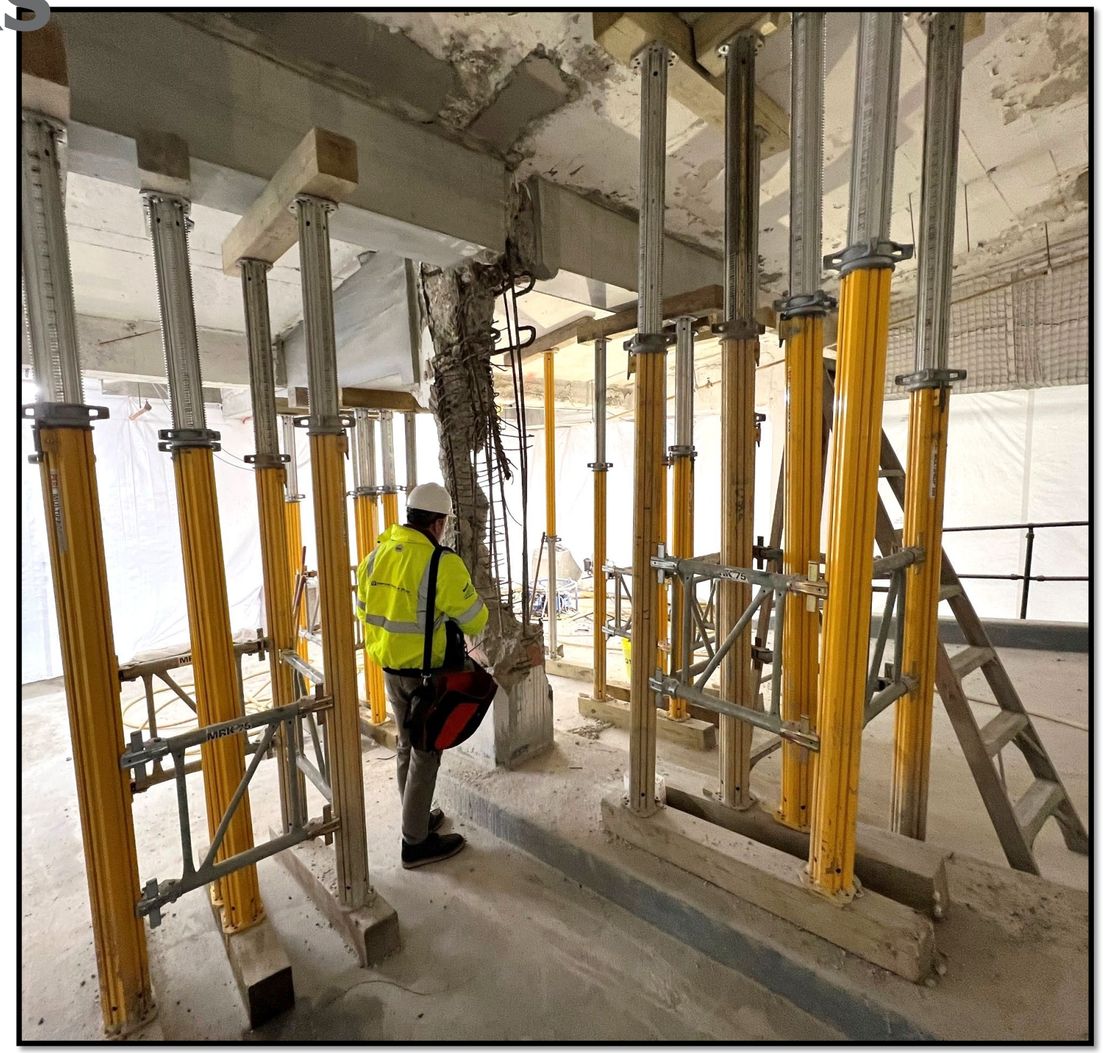
ELEVATION VIEW

» SHORING APPROACHES

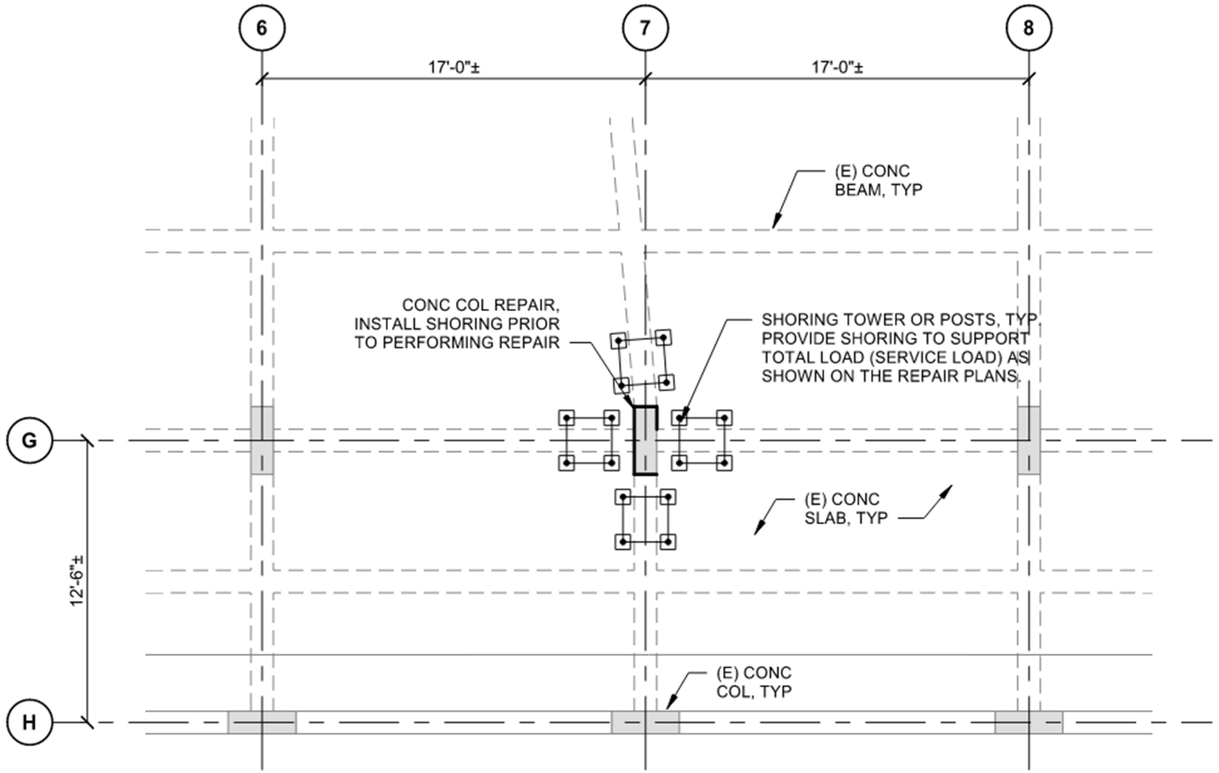
SHORING FOR COLUMN REPAIRS

- Consider the following:
  - Phasing the repairs and sequencing the shoring to minimize shoring required
  - Plain concrete section (the confined section) to resist the column load during repairs
  - Analyzing the existing structure to support and redirect the column load path
    - Avoid shoring to grade if possible
  - Load jacking or analyzing the existing structure to develop additional loads due to added deflection

- Example: Shoring at Steel Reinforced Concrete Column



SHORING APPROACHES

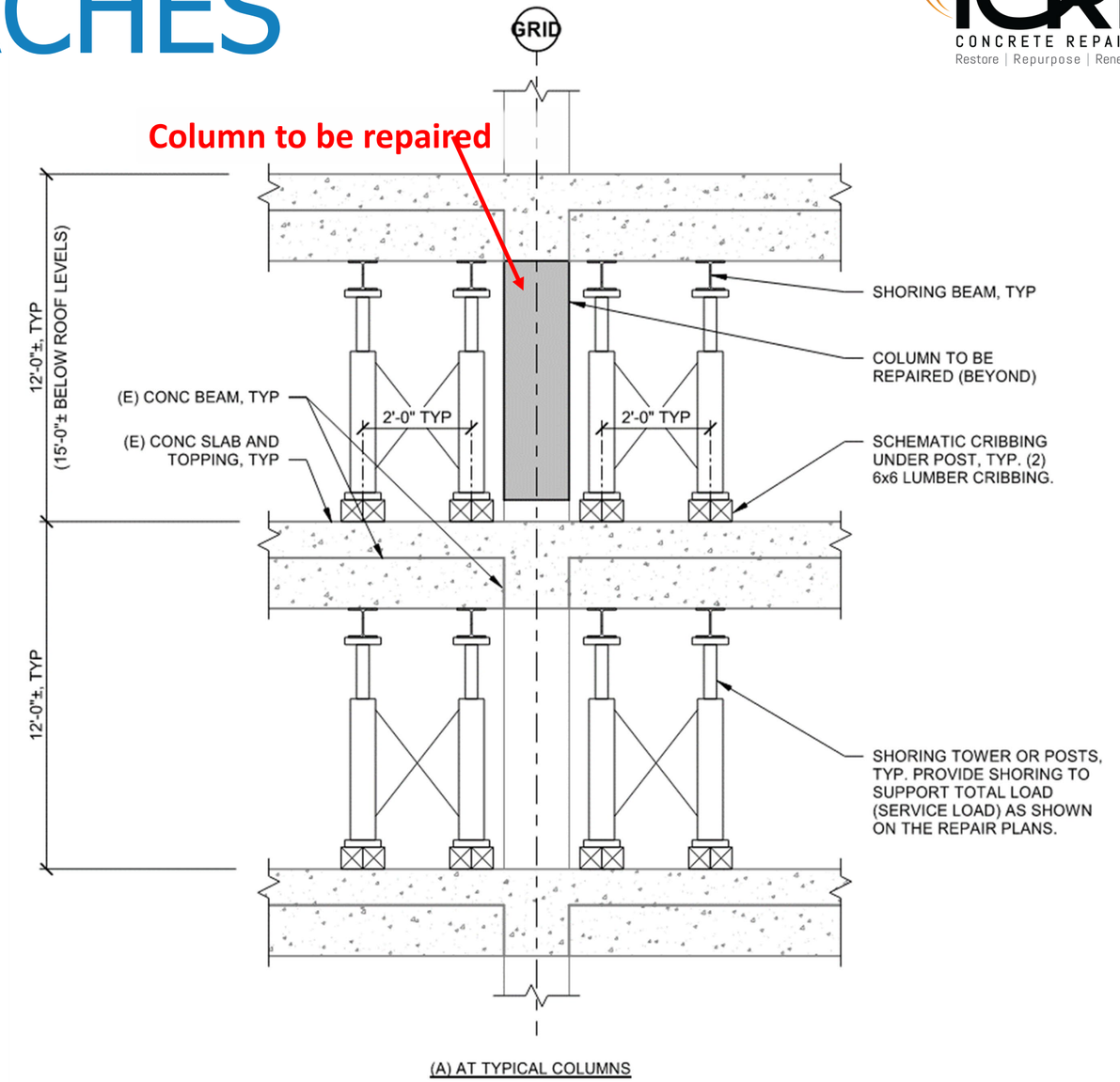


NOTES:

1. CONCEPTUAL SHORING LAYOUT IS SIMILAR FOR ALL COLUMN REPAIRS. REFER TO REPAIR PLANS FOR SPECIFIC SHORING LOADS AT EACH REPAIR LOCATION.
2. PROVIDE TWO LEVELS OF SHORING AT ELEVATED LEVELS, UON. TWO LOCATIONS REQUIRE ADDITIONAL SHORING, REFER TO REPAIR PLANS AT LEVELS 5 AND 8.
3. SHORING SHOWN REPRESENTS THE MINIMUM REQUIREMENTS. THE CONTRACTOR IS RESPONSIBLE FOR EVALUATING THE NEED FOR DESIGNING, AND PROVIDING ADDITIONAL SHORING TO SUPPORT SAFELY THE EXISTING STRUCTURE AND FORMWORK DURING THE WORK.

1 CONCEPTUAL SHORING LAYOUT FOR COLUMN REPAIRS

3/16" = 1'-0"

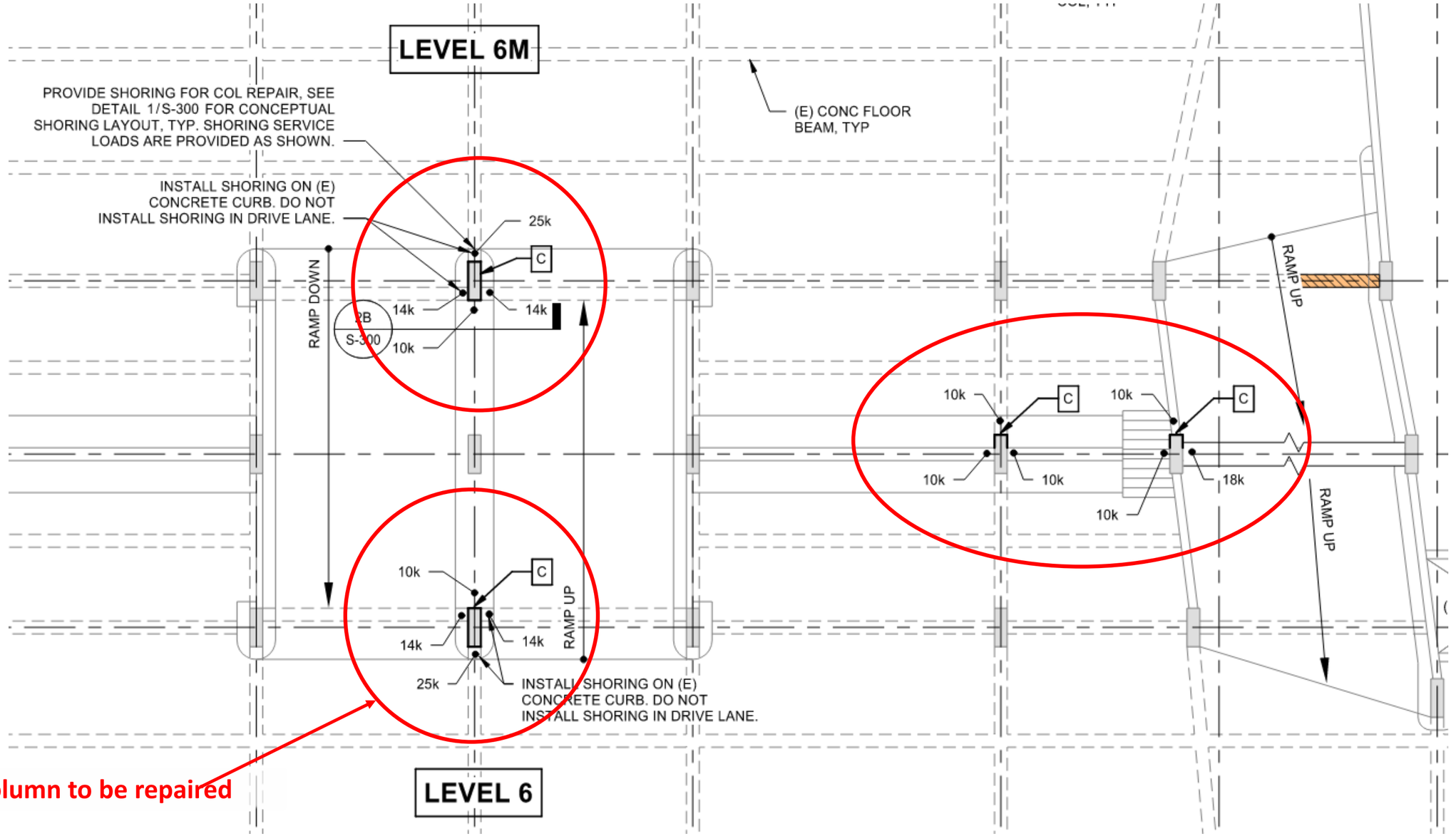


(A) AT TYPICAL COLUMNS

2 CONCEPTUAL SHORING ELEVATION FOR COLUMN REPAIRS

3/8" = 1'-0"

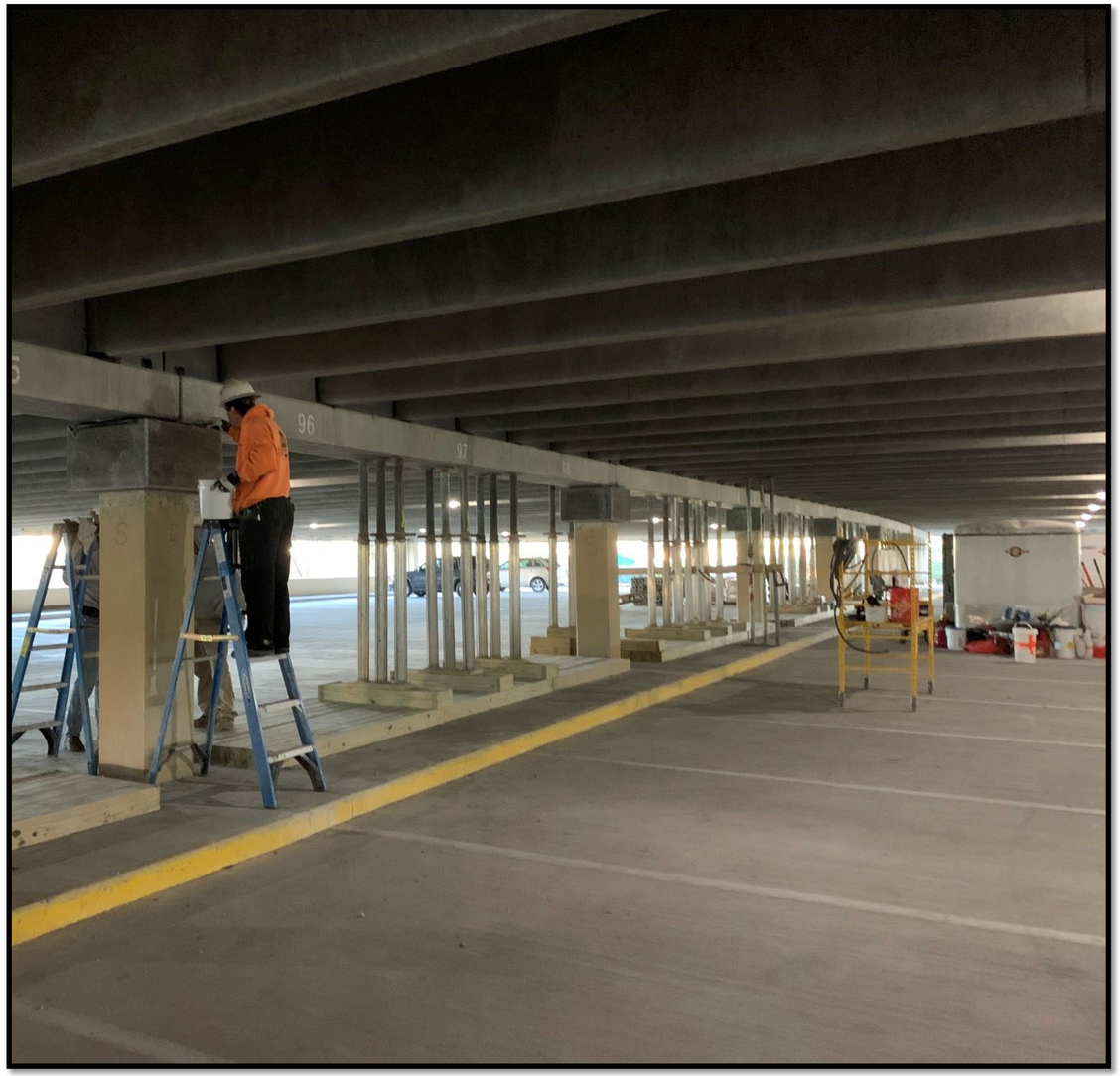
SHORING APPROACHES



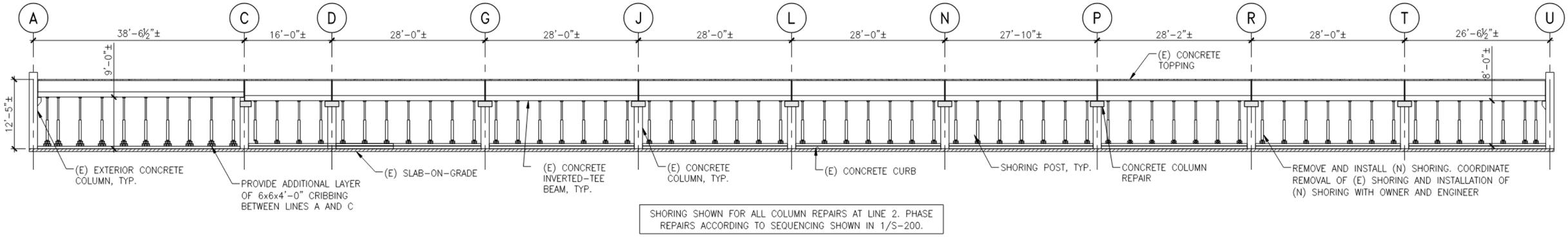
SHORING APPROACHES

CRIBBING FOR REPAIRS

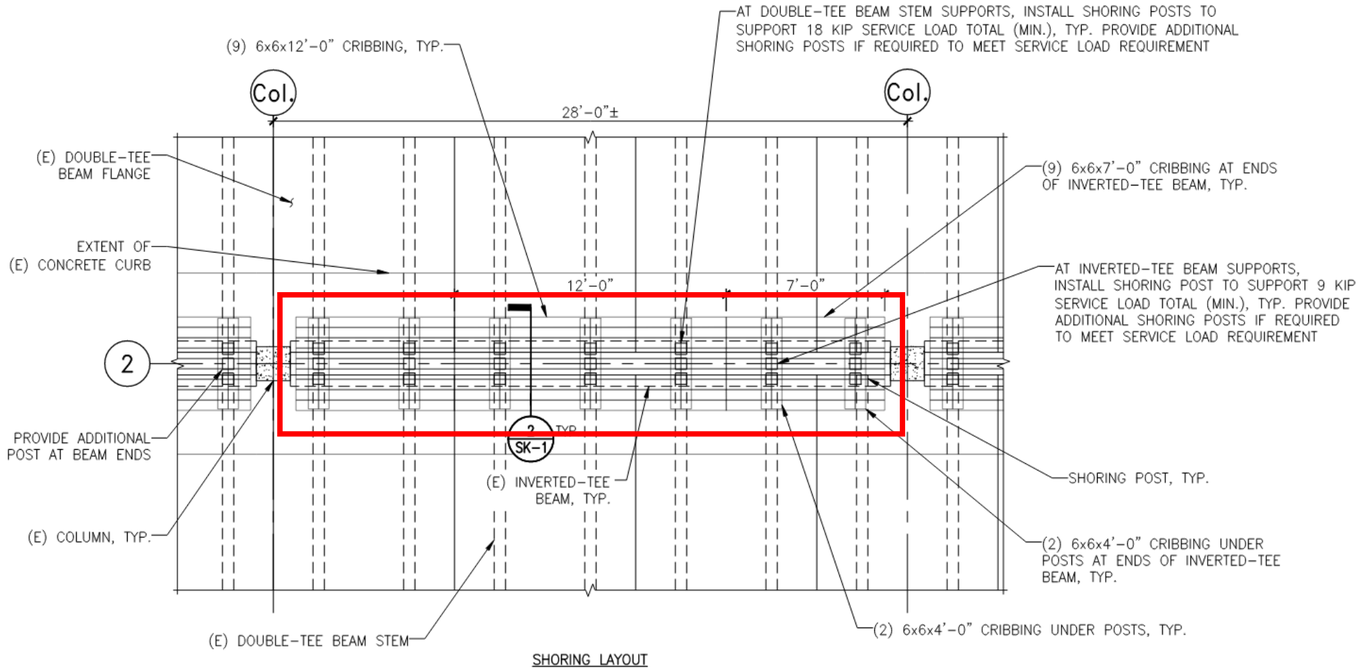
- Consider the following:
  - Condition of the supporting material and the allowable bearing pressure it can sustain
  - Extent of bearing required and the grouping of adjacent shoring bearing locations



SHORING APPROACHES



SHORING SHOWN FOR ALL COLUMN REPAIRS AT LINE 2. PHASE REPAIRS ACCORDING TO SEQUENCING SHOWN IN 1/S-200.

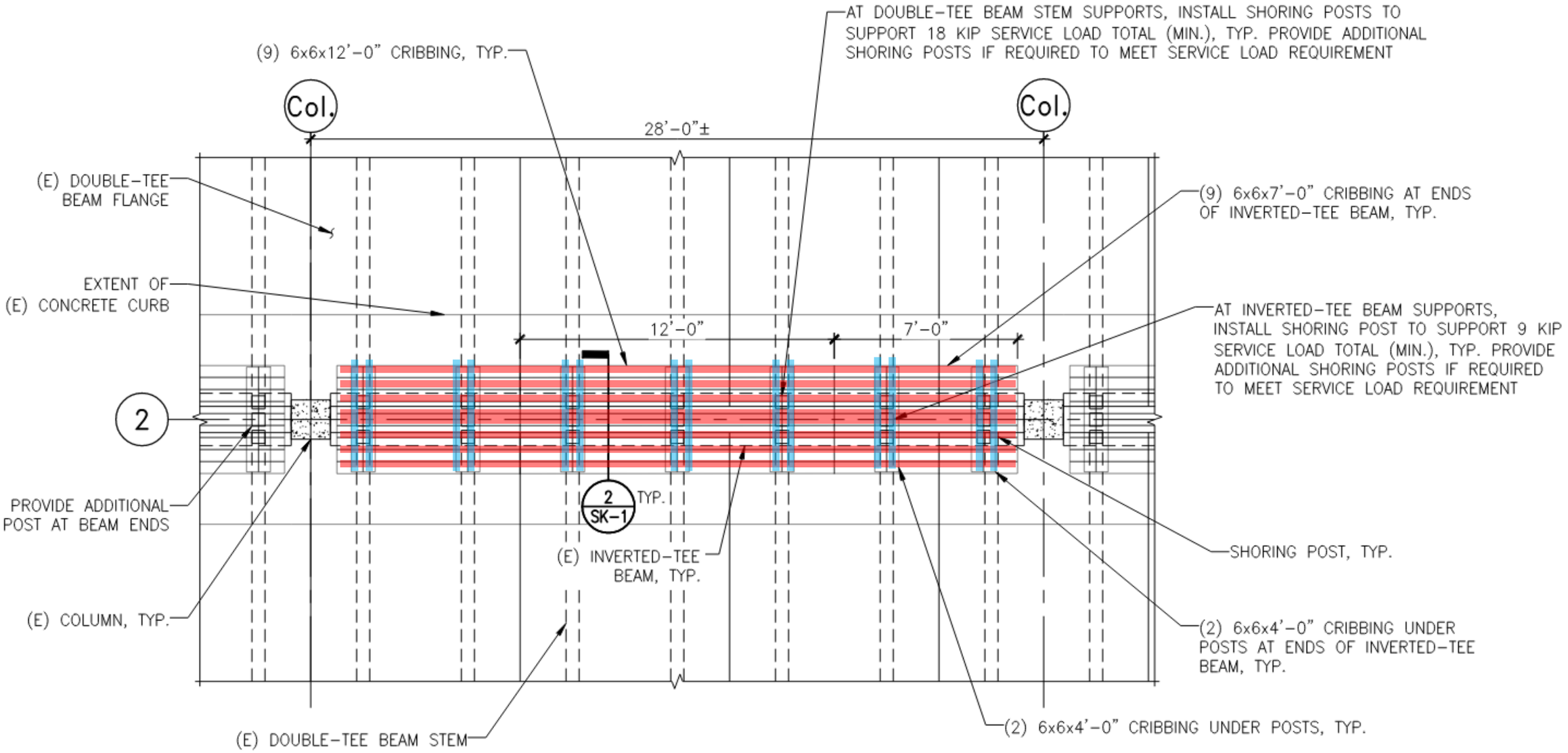


SHORING LAYOUT

1 SHORING LAYOUTS FOR LINE 2 COLUMN REPAIRS

NTS

SHORING APPROACHES

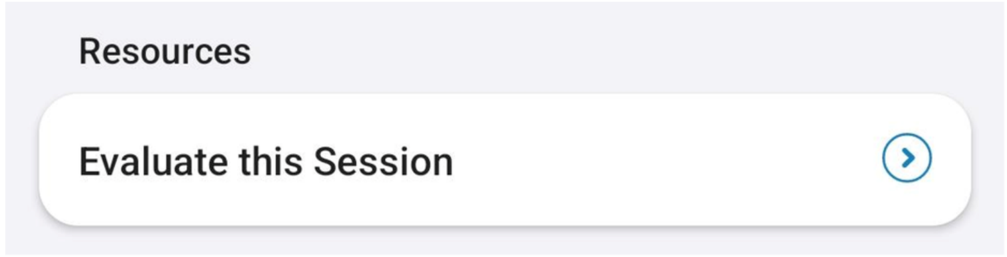


SHORING LAYOUT

KEY TAKEAWAY

Developing and providing shoring requirements can significantly benefit a project by maintaining structural integrity, reducing construction costs, lead times, and schedule delays, and mitigating risks and conflicts during construction.

SESSION EVALUATION



To complete the session evaluation, open the ICRI Convention App.

Under **Plan Your Event,** select Schedule, and then the Technical Session you are attending. Select the sub-session you are attending, scroll down to Resources, and select Evaluate this Session.

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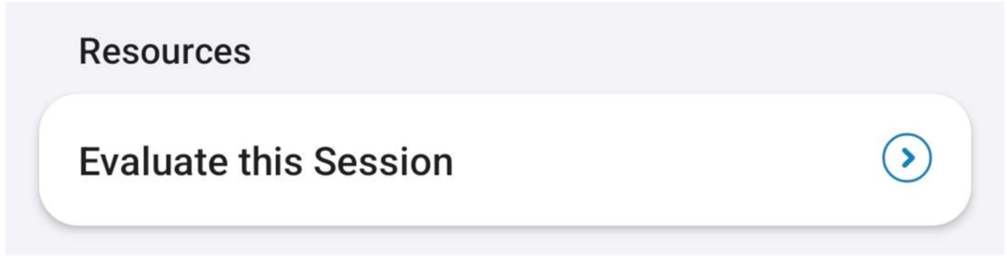
SESSION EVALUATION



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THANK YOU
FOR YOUR ATTENTION

Benjamin Rybaltowski, P.E.

Senior Consulting Engineer

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