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2025 SPRING CONVENTION

AUSTIN, TEXAS • APRIL 13 – 16, 2025

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THE CASE OF THE SINKING COLUMN

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Restoration Engineer
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Live Content Slide

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

Poll: How familiar are you with micropile foundations and CFRP?

THE STRUCTURE

- 1-Supported Level, Cast-in-Place, Conventionally Reinforced Concrete Parking Structure
  - Original Construction – 1970
  - Plan Dimensions of approximately 165 feet by 160 feet
  - Supported Level is framed by a 2-way conventionally reinforced slab supported by cast-in-place drop panel columns
  - Provides parking for approximately 160 Vehicles

THE SITUATION

- New Building Owner noted significant deflection in slab.
- Two-Way slab w/ settlement at an isolated column.
- Previous repair drawings by others, 10 yrs prior, unknowingly noted ~3” settlement via slab elevation plans.
- Additional ~3” settlement observed beyond elevations noted in previous repair for ~6” total settlement.

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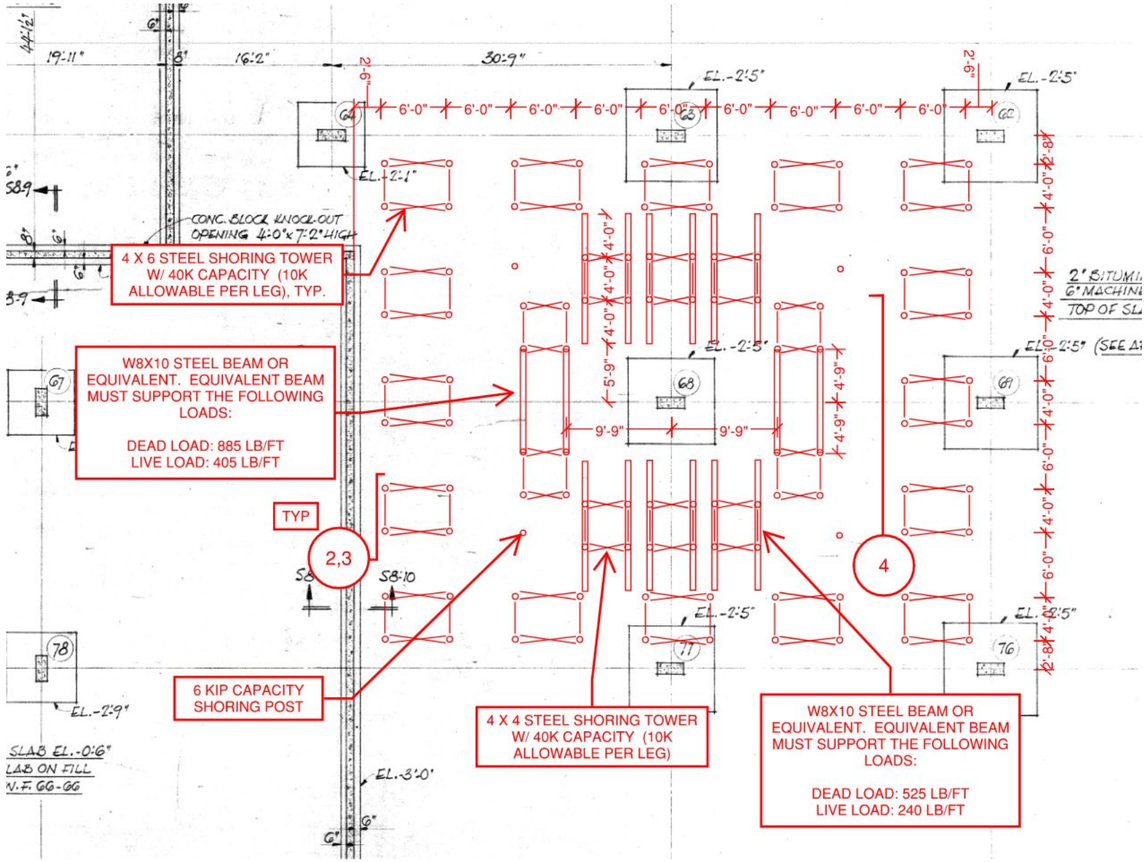
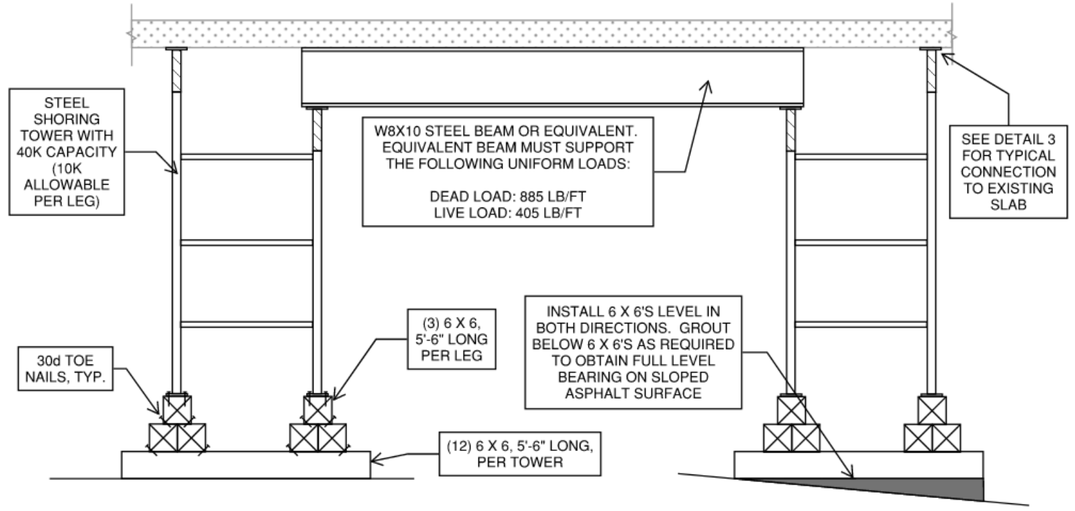
RECOMMENDED SHORING





NOTES:

1. ALL 6 X 6'S ARE SOUTHERN YELLOW PINE NO. 2 OR BETTER.
2. NAIL ALL TIMBERS TOGETHER TO PREVENT TIMBER FROM FALLING OR KICKING OUT.
3. SEE PLAN FOR SPACING AND LOCATION.

4 STEEL BEAM/SHORING TOWER ELEVATION

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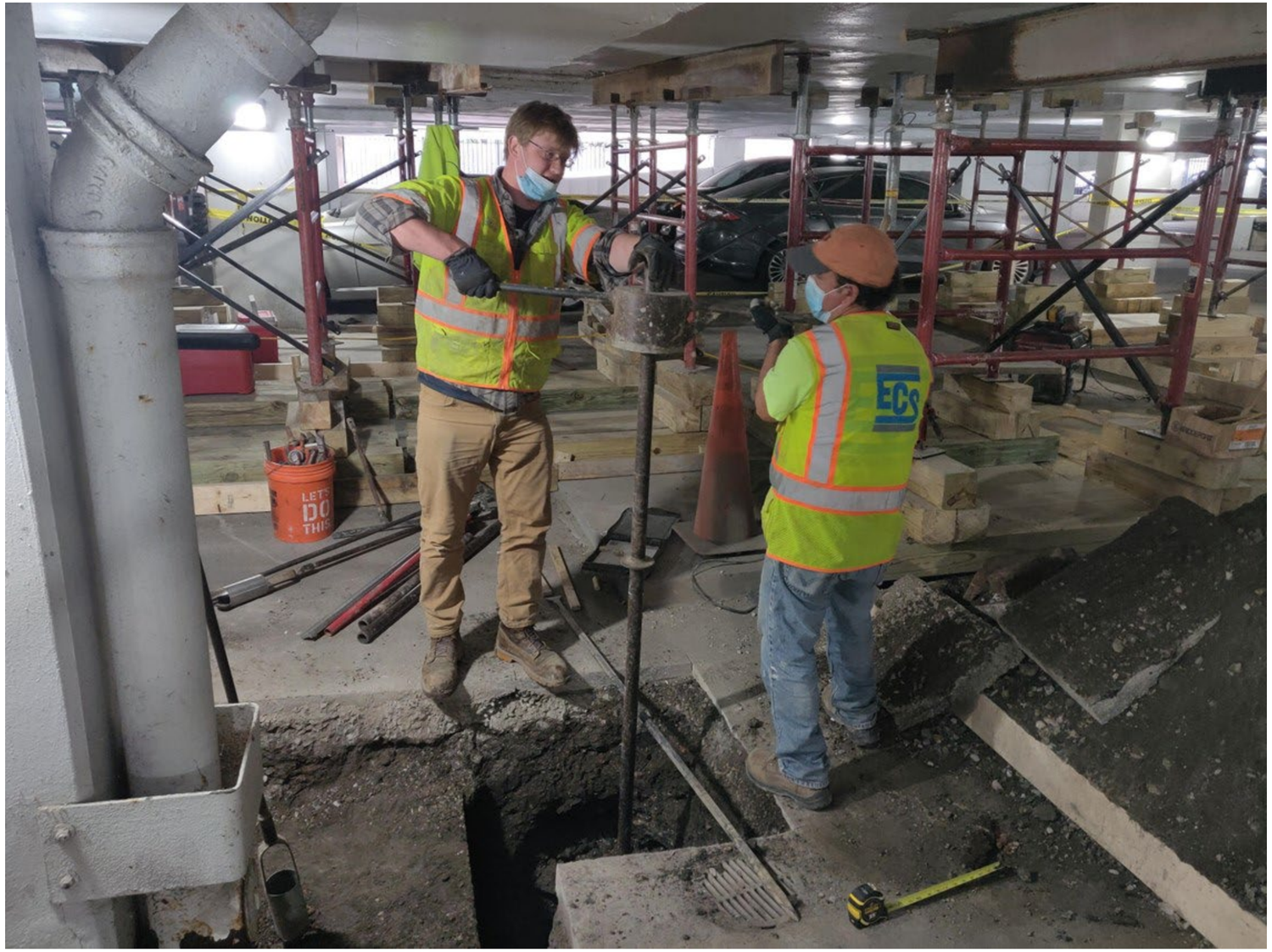

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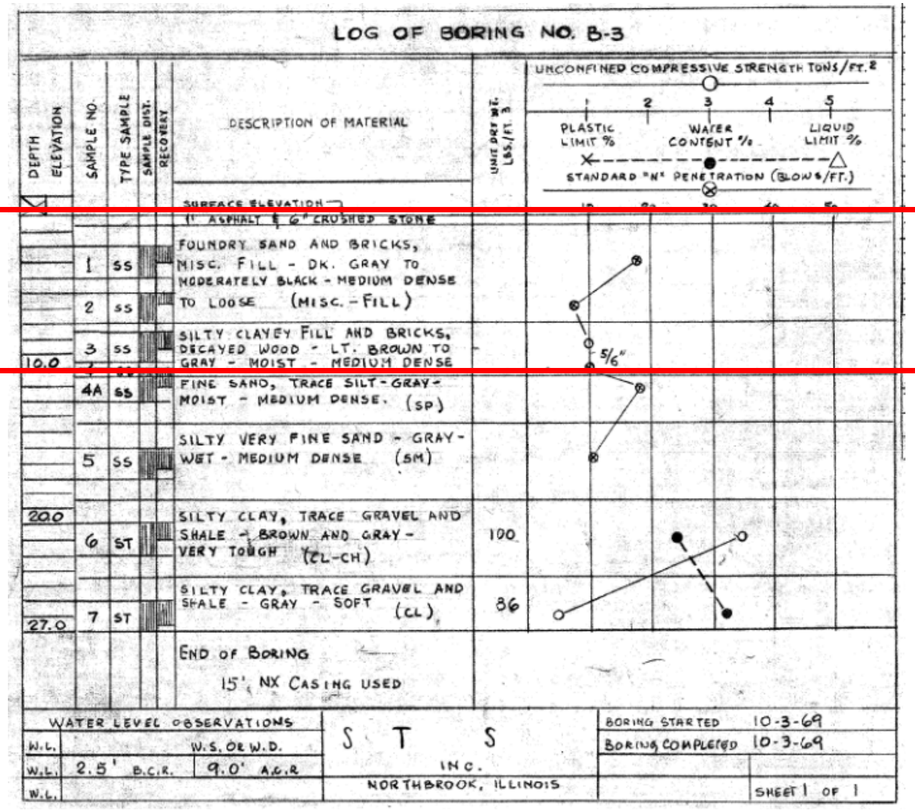
SOIL BORINGS

Original soil boring nearest to column



LOG OF BORING NO. B-3

DEPTH ELEVATION	SAMPLE NO.	TYPE SAMPLE	SAMPLE DIST.	RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.³
					SURFACE ELEVATION — 1" ASPHALT & 6" CRUSHED STONE	
	1	SS			FOUNDRY SAND AND BRICKS, MISC. FILL - DK. GRAY TO MODERATELY BLACK - MEDIUM DENSE	
	2	SS			TO LOOSE (MISC. - FILL)	
	3	SS			SILTY CLAYEY FILL AND BRICKS, DECAYED WOOD - LT. BROWN TO GRAY - MOIST - MEDIUM DENSE	
10.0						
	4A	SS			FINE SAND, TRACE SILT - GRAY - MOIST - MEDIUM DENSE. (SP)	
	5	SS			SILTY VERY FINE SAND - GRAY - WET - MEDIUM DENSE (SM)	
20.0						
	6	ST			SILTY CLAY, TRACE GRAVEL AND SHALE - BROWN AND GRAY - VERY TOUGH (CL-CH)	100
	7	ST			SILTY CLAY, TRACE GRAVEL AND SHALE - GRAY - SOFT (CL)	86
27.0						
					END OF BORING	
					15', NX CASING USED	

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.²

PLASTIC LIMIT % · WATER CONTENT % · LIQUID LIMIT %

STANDARD "N" PENETRATION (BLOWS/FT.)

5/6"

WATER LEVEL OBSERVATIONS

W.L. — W.S. OR W.D.

W.L. 2.5' B.C.R. — 9.0' A.C.R.

W.L.

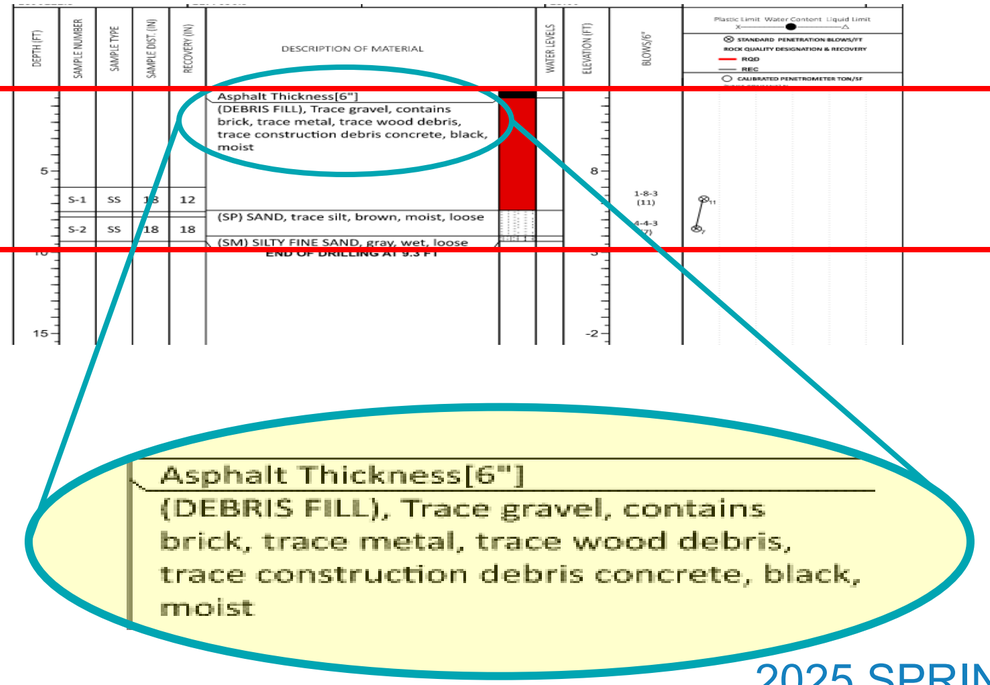
S T S INC. NORTHBROOK, ILLINOIS

BORING STARTED 10-3-69

BORING COMPLETED 10-3-69

SHEET 1 OF 1

New soil boring at column



DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
					Asphalt Thickness[6"] (DEBRIS FILL), Trace gravel, contains brick, trace metal, trace wood debris, trace construction debris concrete, black, moist			
5	S-1	SS	18	12			8	1-8-3 (11)
	S-2	SS	18	18	(SP) SAND, trace silt, brown, moist, loose			4-4-3 (7)
10					(SM) SILTY FINE SAND, gray, wet, loose		3	
					END OF DRILLING AT 9.5 FT			
15							-2	

Plastic Limit · Water Content · Liquid Limit

STANDARD PENETRATION BLOWS/FT

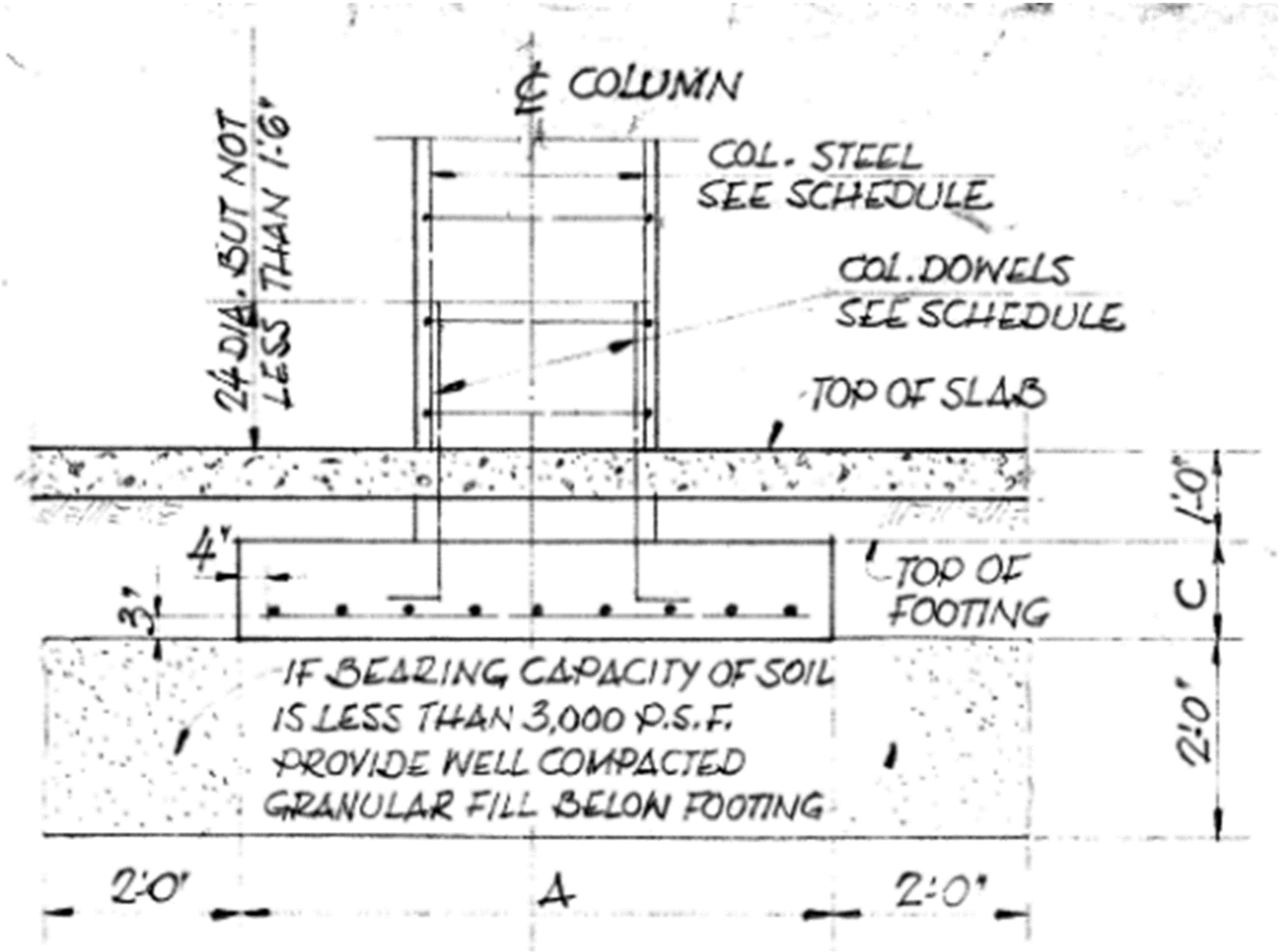
ROCK QUALITY DESIGNATION & RECOVERY

RQD

REC

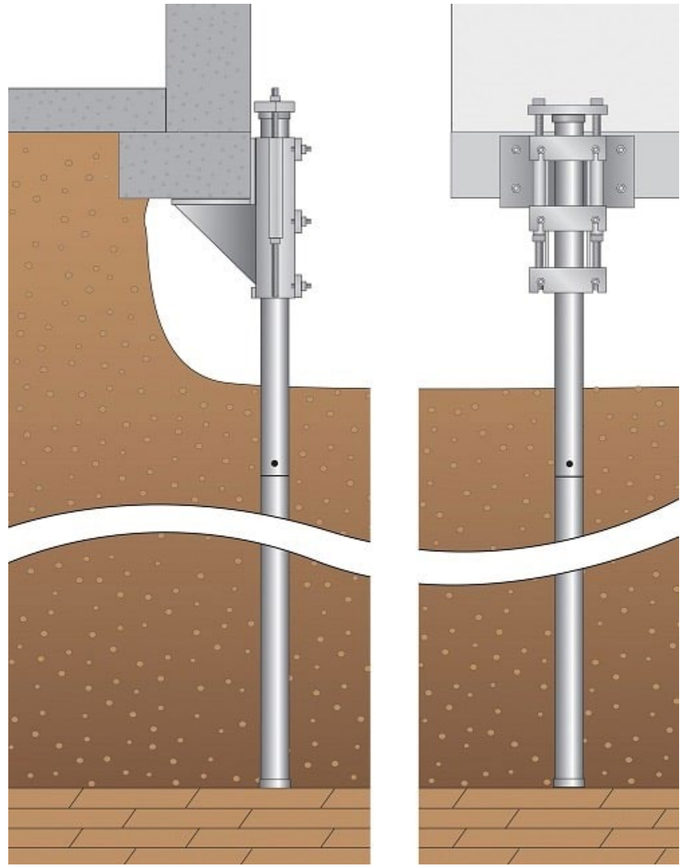
CALIBRATED PENETROMETER TON/SF

Asphalt Thickness[6"]
(DEBRIS FILL), Trace gravel, contains brick, trace metal, trace wood debris, trace construction debris concrete, black, moist


℄ COLUMN
COL. STEEL
SEE SCHEDULE
COL. DOWELS
SEE SCHEDULE
TOP OF SLAB
24 DIA. BUT NOT
LESS THAN 1'-6"
4"
3"
TOP OF
FOOTING
C
1'-0"
2'-0"
IF BEARING CAPACITY OF SOIL
IS LESS THAN 3,000 P.S.F.
PROVIDE WELL COMPACTED
GRANULAR FILL BELON FOOTING
2'-0"
A
2'-0"

THE RECOMMENDATION

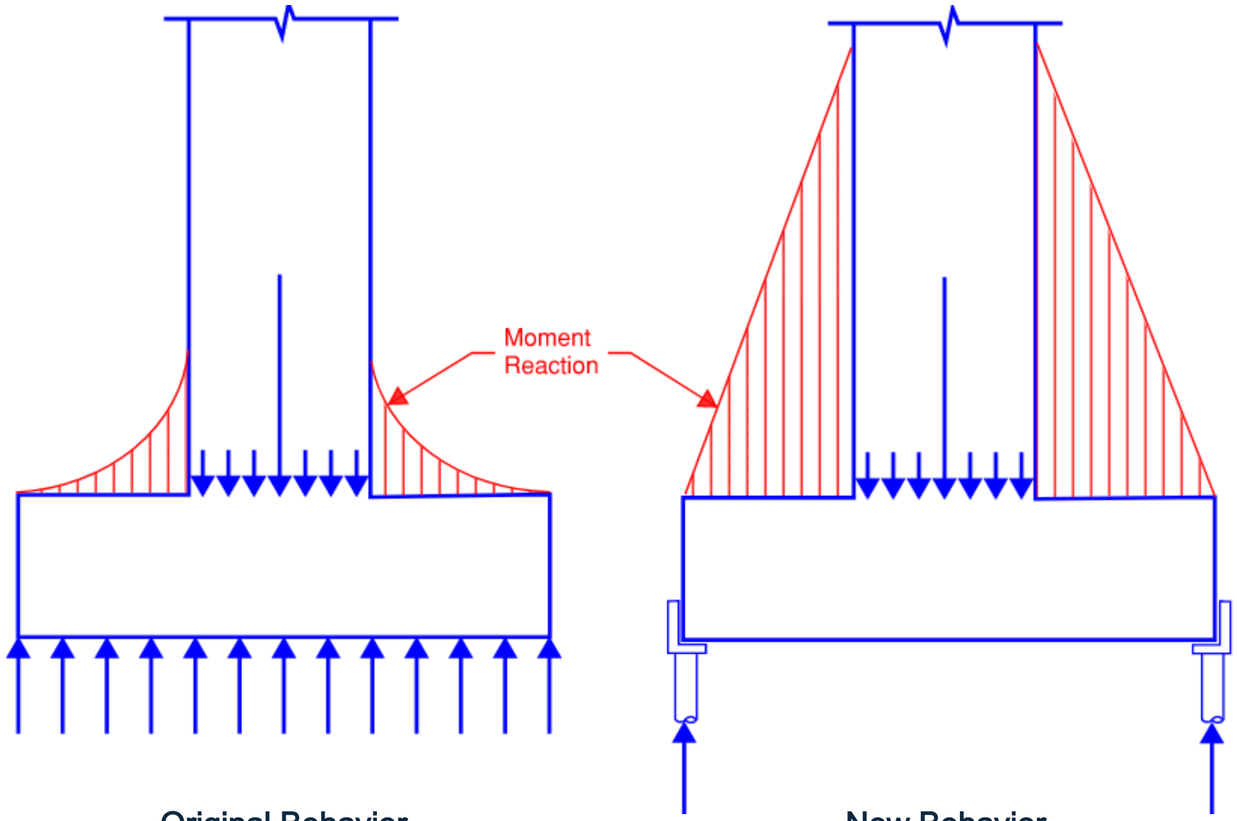
- Long term stabilization of footing using micropiles
  - Required additional soil boring outside the structure
- Strengthen negative moment region of slab for live loading
- Re-route drainage
- Protect repairs
- Opinion of Probable Cost $400k



Source: dailycivil.com

STRENGTHEN SPREAD FOOTING

- Changing the behavior of the spread footing
  - Thicken footing to add flexural and shear capacity
  - Provide shear friction dowels to transfer horizontal shear
- 37 kip reaction at support
- Weak soil region



Original Behavior

New Behavior

MICROPILE DESIGN

- First 7-6" of soil is debris fill, neglect and conservatively assume it is unsupported. Per CBC, add 5' for development of lateral force for next stratum of soil; therefore 12.5 feet of unsupported pile.
- CBC requires the pipe be designed to consider 1/16” section loss due to corrosion if not protected.

Overall Pier Strength Summary

	Uncorroded Pipe	Corroded Pipe	Design Force	OK?
Ungrouted Allowable Strength (Kips)	-	37.3	37	OK
Grouted Allowable Strength (Kips)	-	46.5	37	OK
Buckling Allowable Strength (Kips)	67.7	57.2	37	OK

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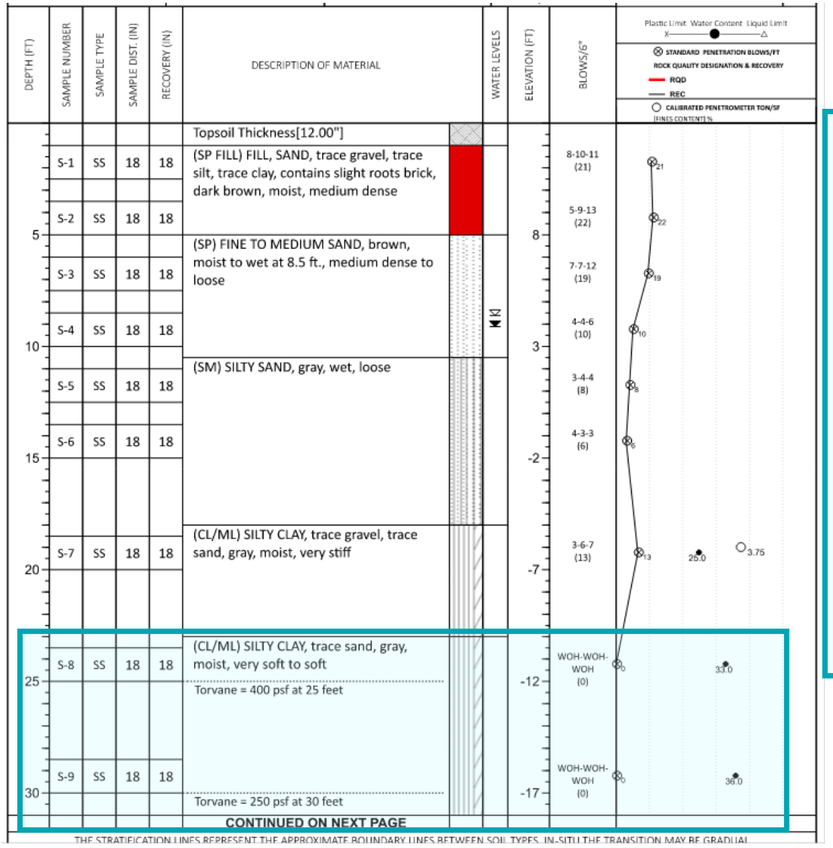
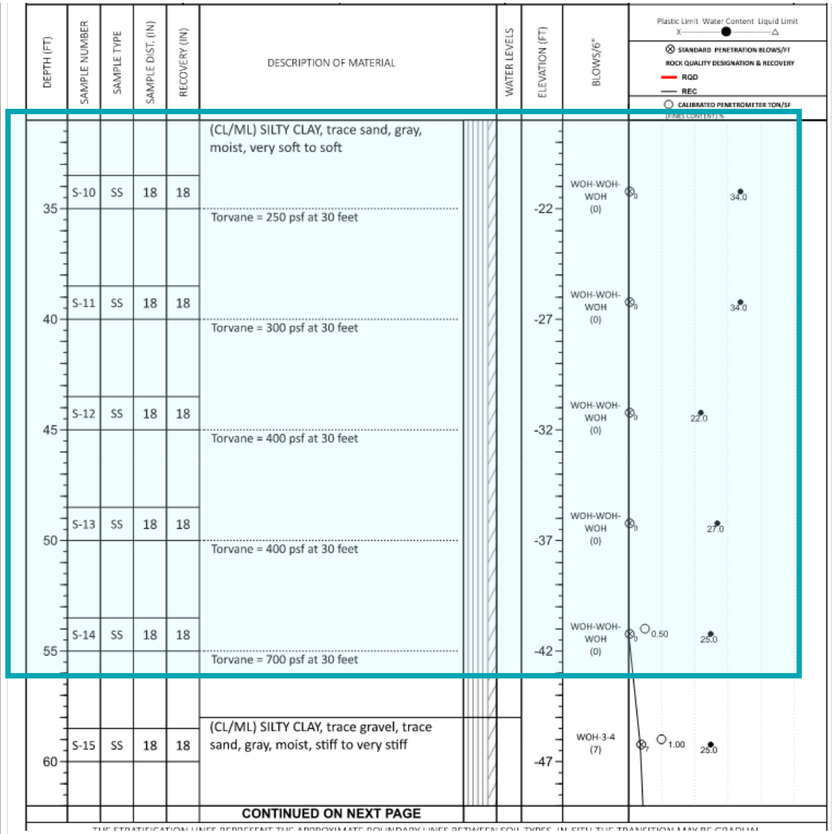


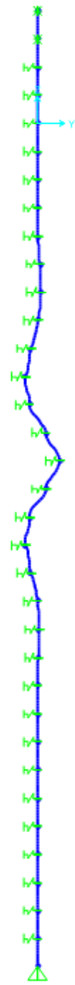


WHAT ABOUT THE SOFT SOIL REGION?

- Soft soil region at depth 25 ft to 55 ft
- FHWA Micropile Design and Construction Publication
  - If Soil Modulus Limit is less than measured Soil Elastic Modulus, then buckling does not need to be considered.
  - Confirmed that elastic modulus was greater than modulus limit

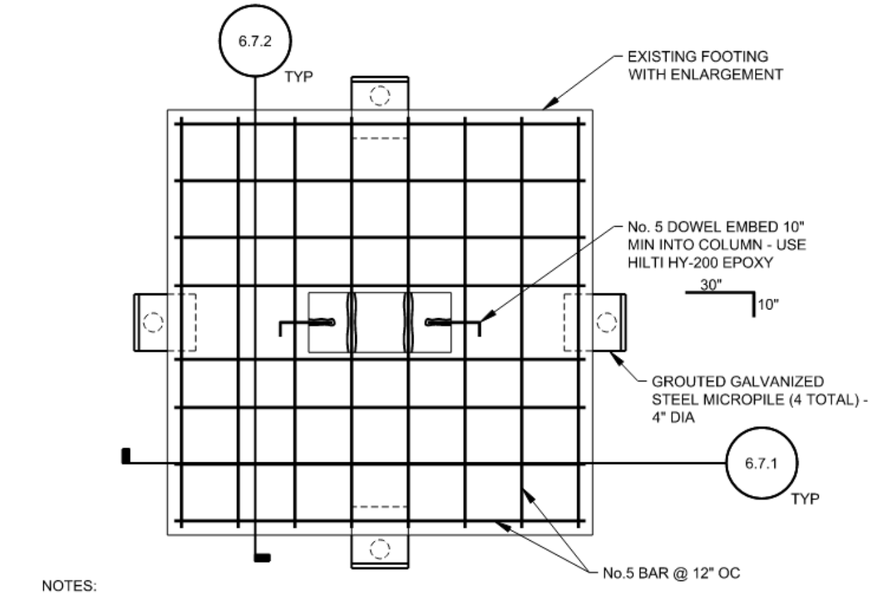
$$E_s^{LIMIT} = \frac{1}{\left[\left(\frac{4I}{A^2}\right)\left(\frac{E}{F_y^2}\right)\right]}$$

Depth	Elastic Modulus (ksf)
20 feet to 25 feet	1500
25 feet to 30 feet	750
30 feet to 40 feet	500
40 feet to 50 feet	750
50 feet to 68 feet	1000



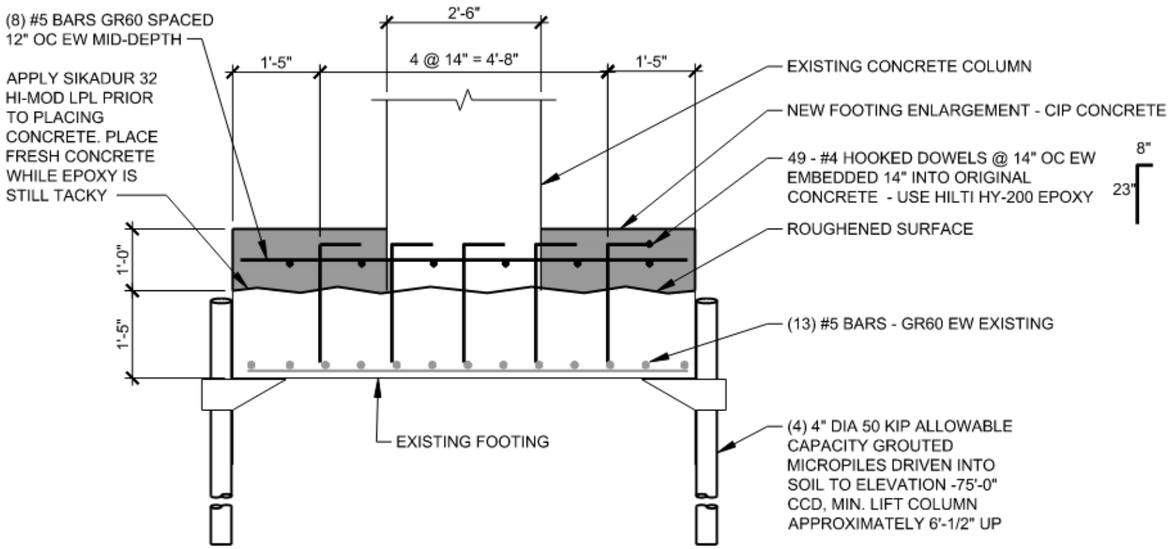
Buckling at ~80kip >> 37kip design

THE DETAILS



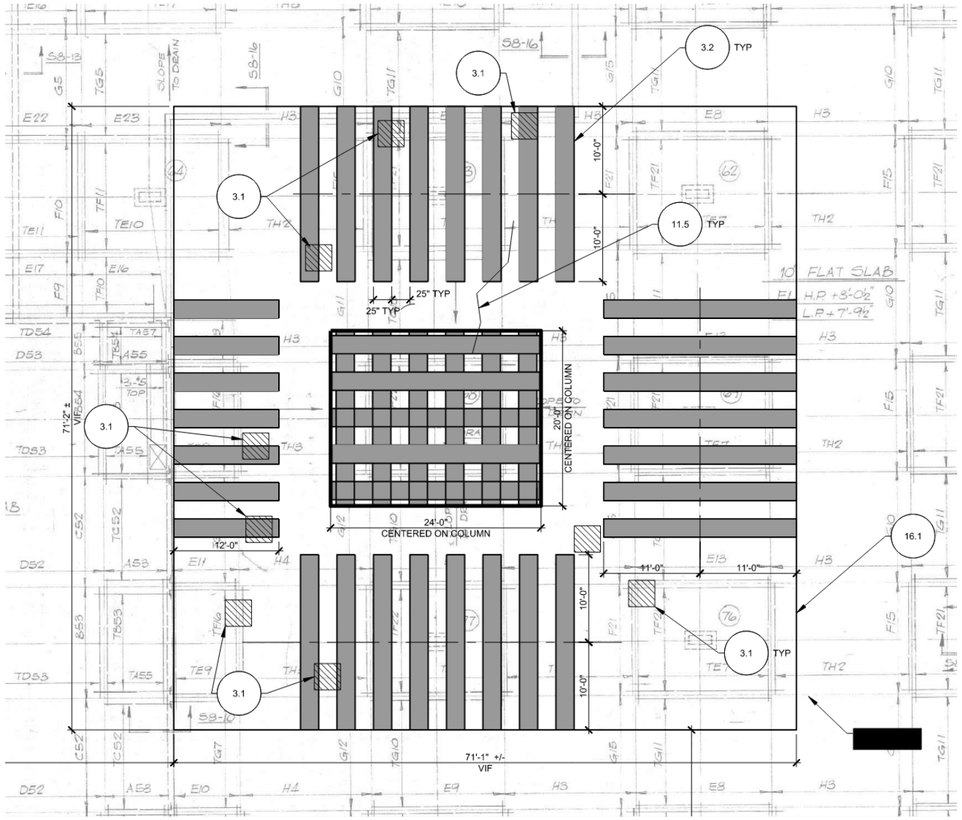
NOTES:
1. "L" DOWELS TO TIE NEW CONCRETE TO EXISTING FOOTING - NOT SHOWN FOR CLARITY.
2. MIRCOPILE CAPACITY = 50 KIP ALLOWABLE (MIN). 4 TOTAL, GROUTED AND DRIVEN INTO SOIL TO ELEVATION -75'-0" CCD, MIN. LIFT COLUMN APPROXIMATELY 6-1/2" UP.
3. BACKFILL UNDERSIDE OF FOOTING AFTER LIFTING W/ CLSM (FLOWABLE FILL) WITH 1200 PSI COMPRESSIVE STRENGTH.
4. STEEL MICROPILES AND ASSEMBLY TO BE HOT DIPPED GALVANIZED.

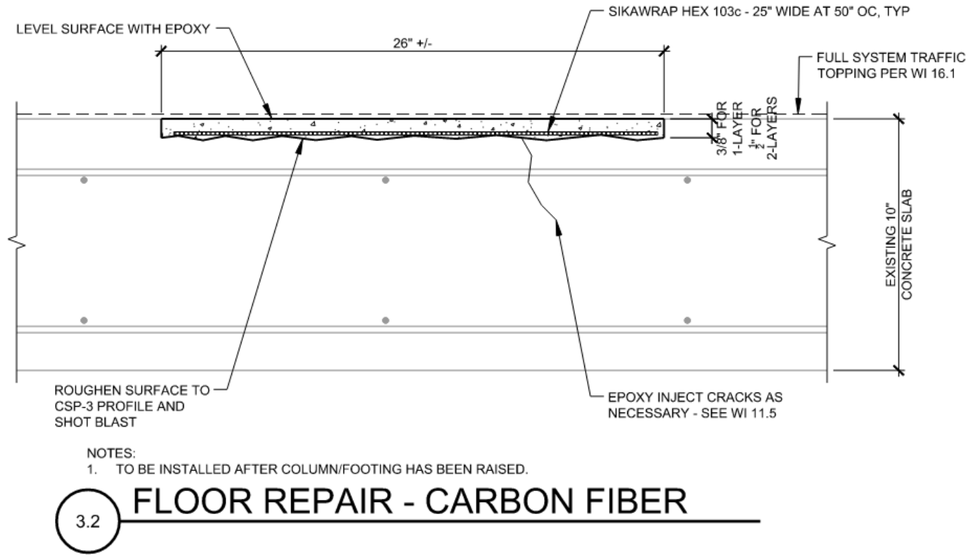
6.7 COLUMN AND FOOTING REPAIR



6.7.1 COLUMN AND FOOTING REPAIR

STRENGTHEN SLAB NEGATIVE MOMENT REINFORCEMENT





NOTES:
1. TO BE INSTALLED AFTER COLUMN/FOOTING HAS BEEN RAISED.

3.2 FLOOR REPAIR - CARBON FIBER

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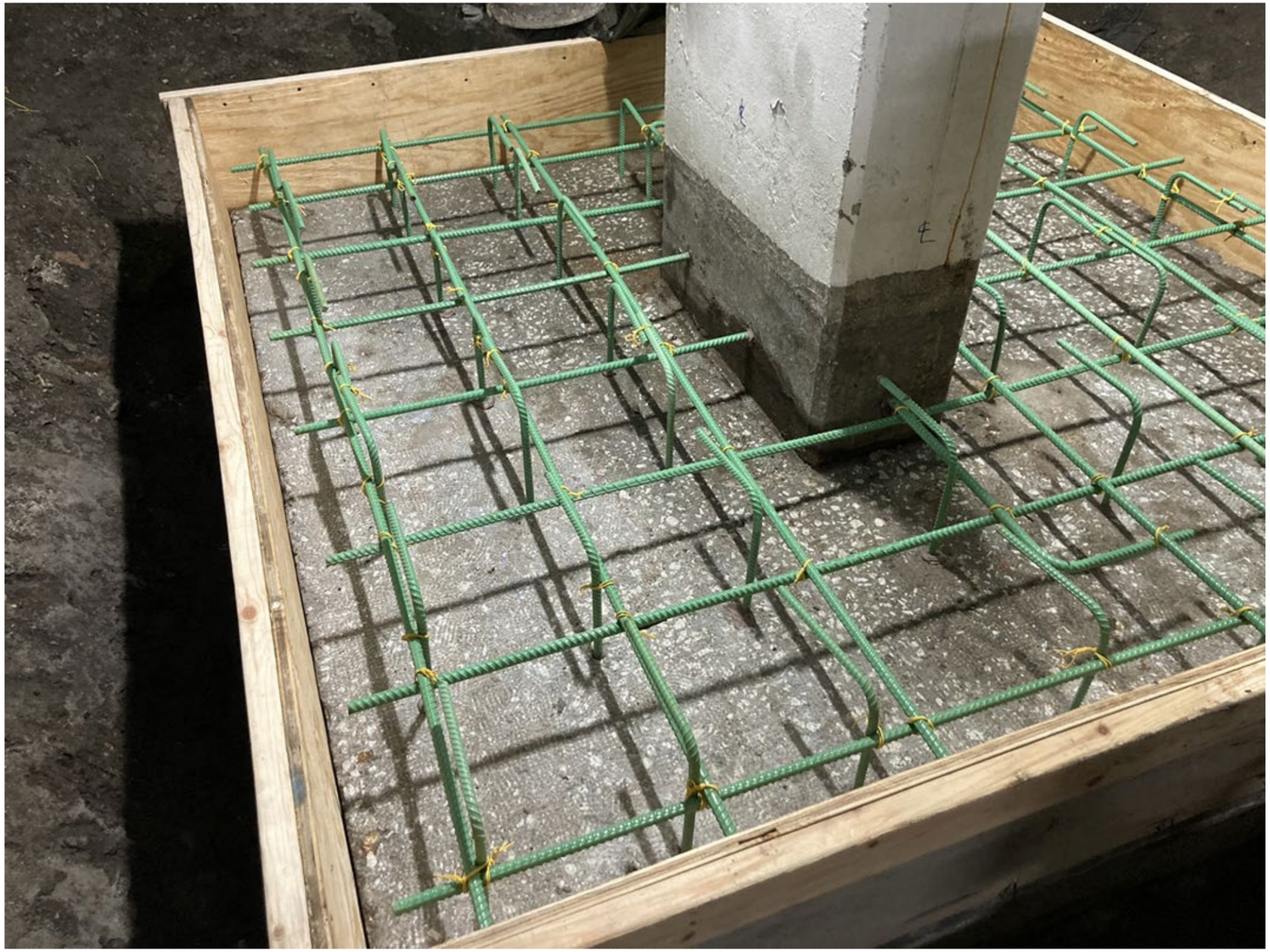

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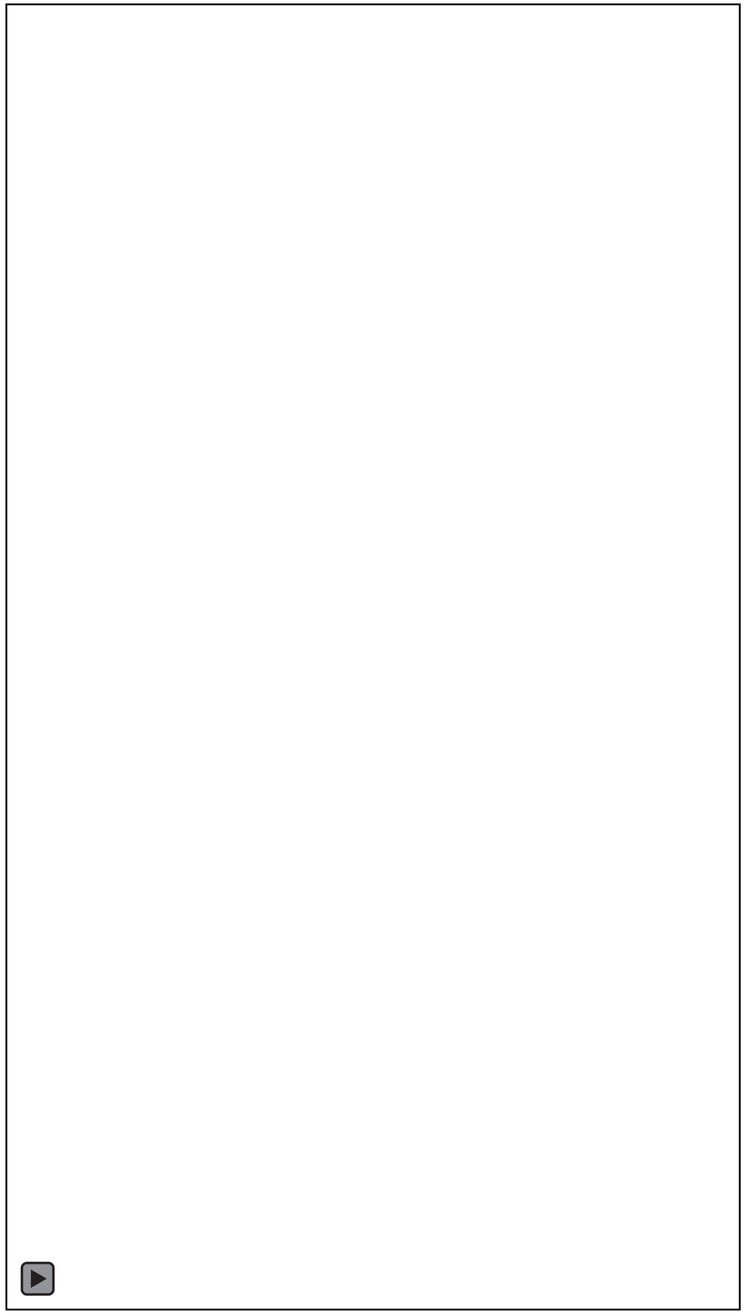

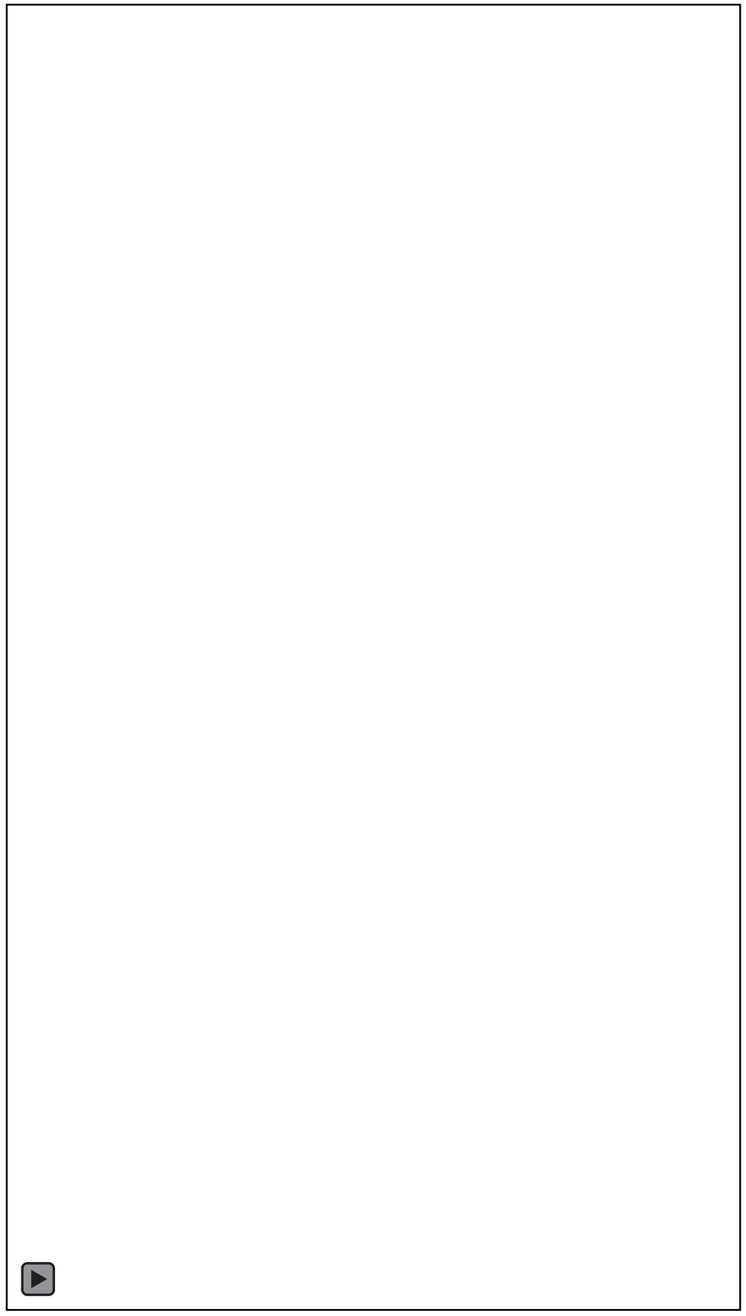

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1-inch

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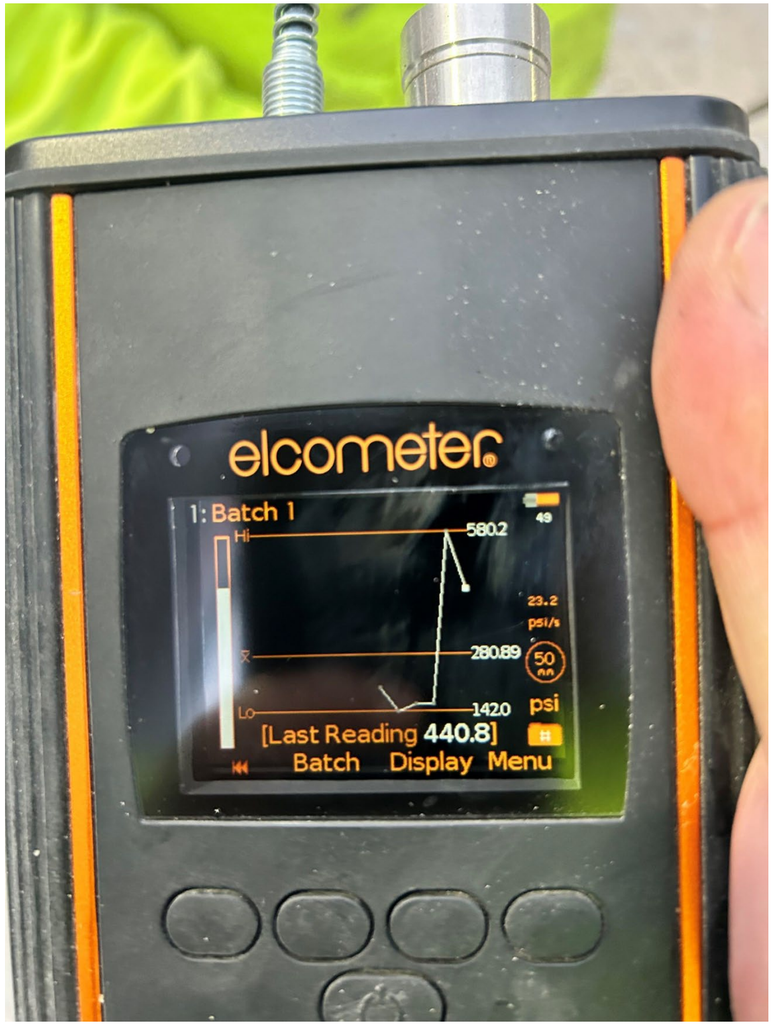
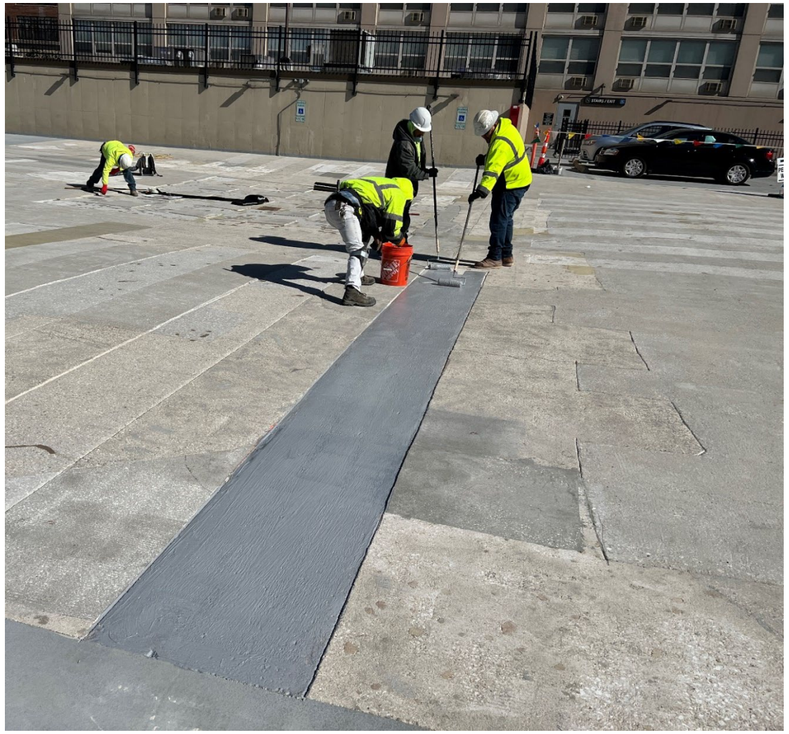


FRP STRIP INSTALLATION



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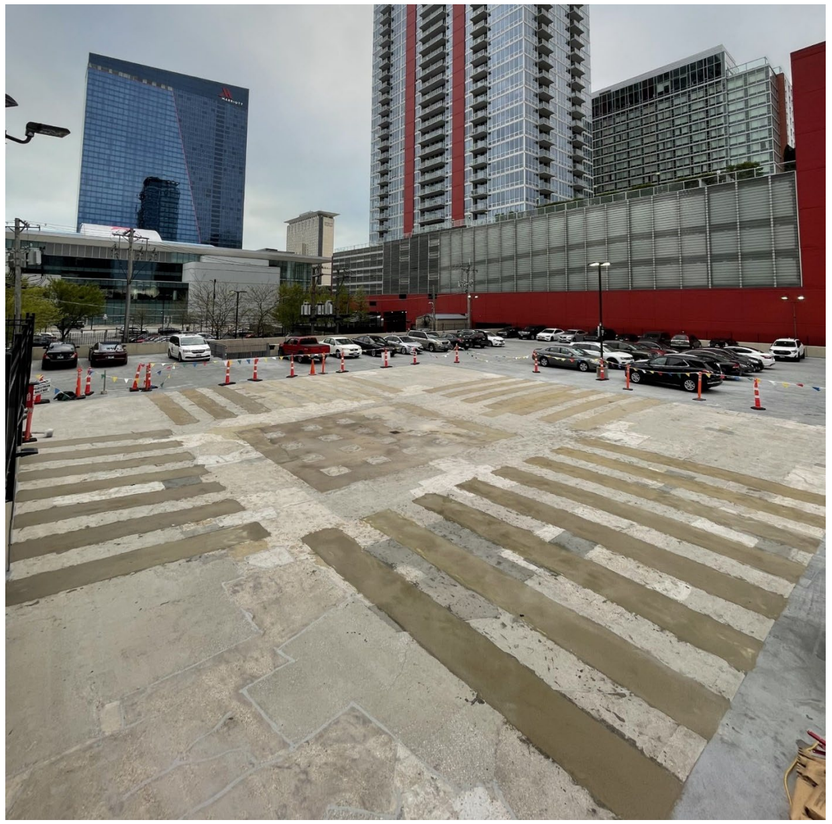

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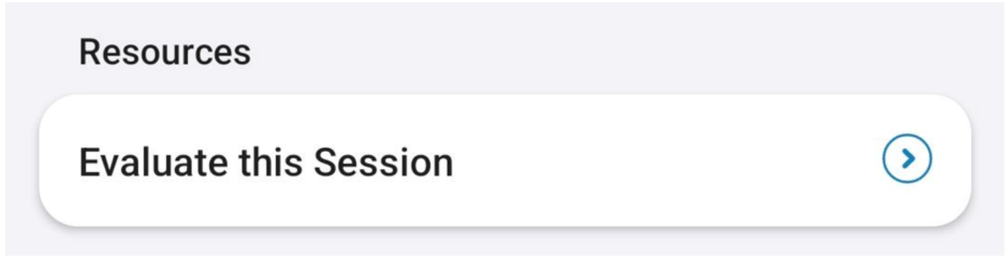
SESSIONEVALUATION



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ANY QUESTIONS?

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CONSULTANTS