Rigid Inclusions for Support of Embankments and MSE Walls in Soft Ground

Presented by Aaron D. Goldberg, PE, D.GE

US WICK DRAIN

First Things First

Presentation Outline

- **Introduction to Rigid Inclusions (Controlled Modulus Columns, CMC)**
- **Case History: I-29 and US 275 Interchange Project**
- **Case History: I-295 Direct Connect Project**
- **Case History: Ericson Avenue Project**

Controlled Modulus Columns (CMC)

Definition:

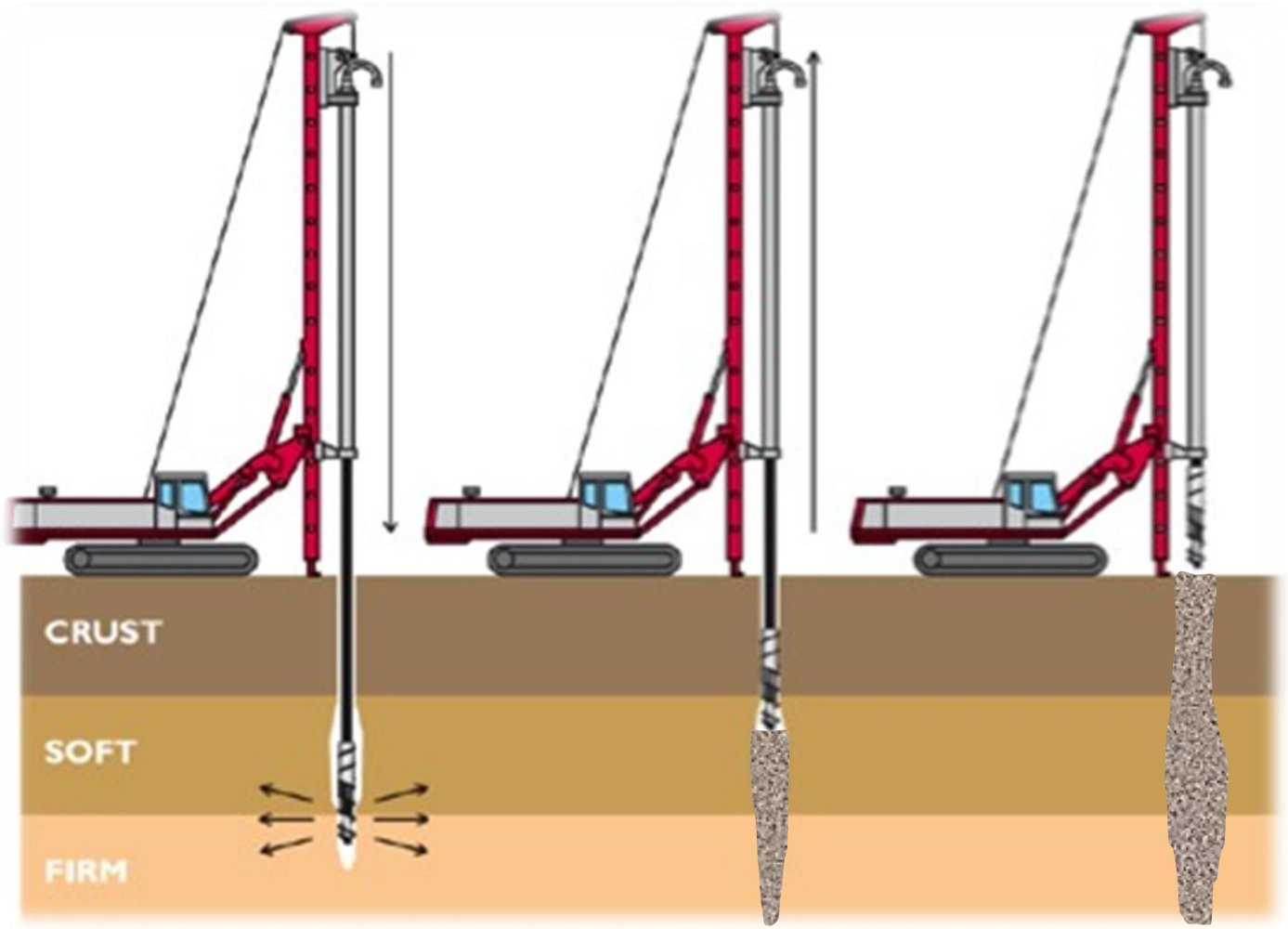
"A ground improvement solution comprised of grouted inclusions which act to reinforce a soil mass for the purpose of settlement control"

CMC is a technology using piling equipment to build solutions designed with a ground improvement approach and philosophy

CMCs are typically used as an alternate to:

- Driven piles
- ACIPs
- RAPs
- WDs+Surcharge
- PIFs
- Stone Columns
- Vibro-concrete cols.
- Overexcavation

TYPICAL INSTALLATION SEQUENCE



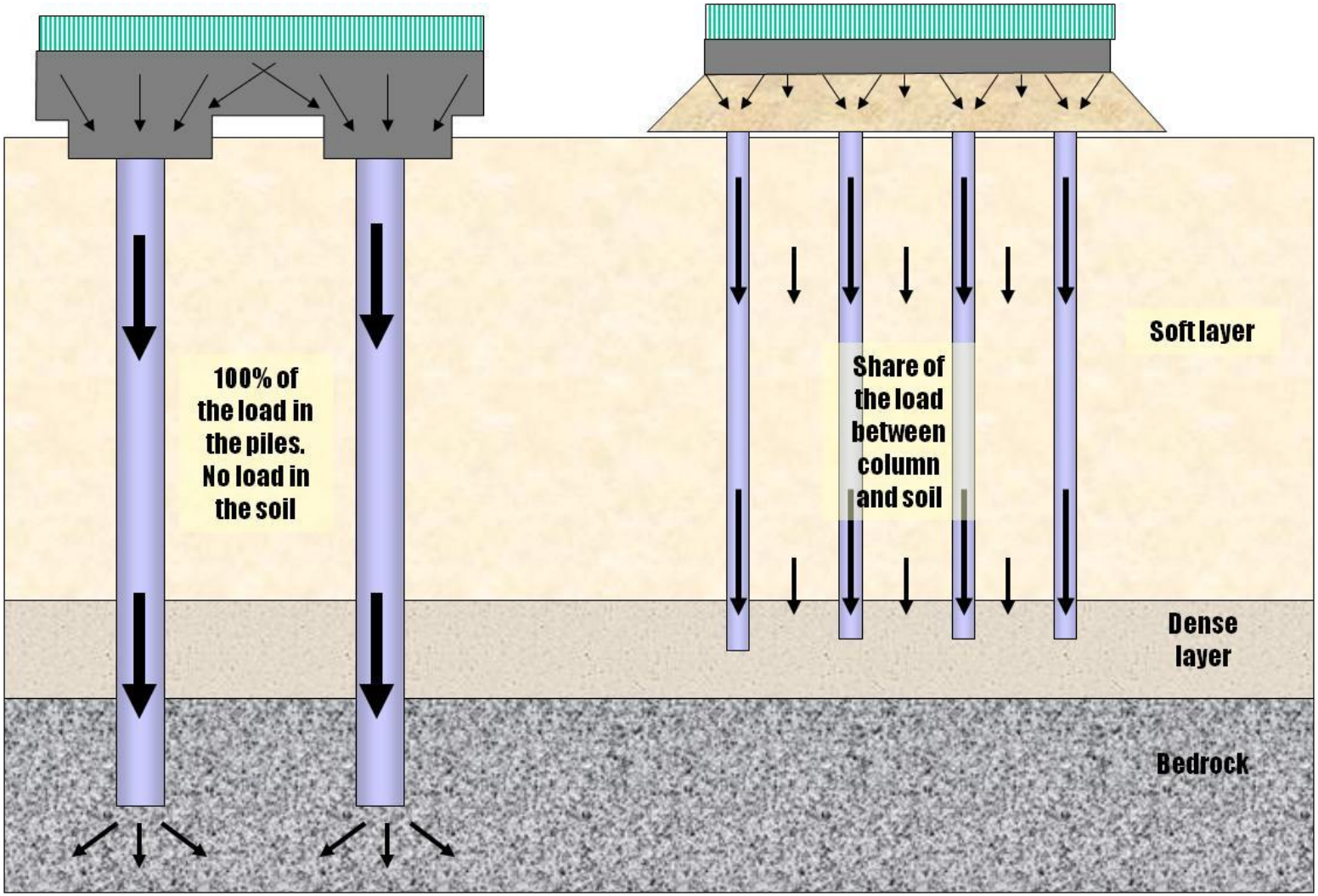

Backhoe or bobcat for cutoffs & platform maintenance
CMC Drill Rig
Ready mix truck
Concrete Pump

CONTROLLED MODULUS COLUMNS

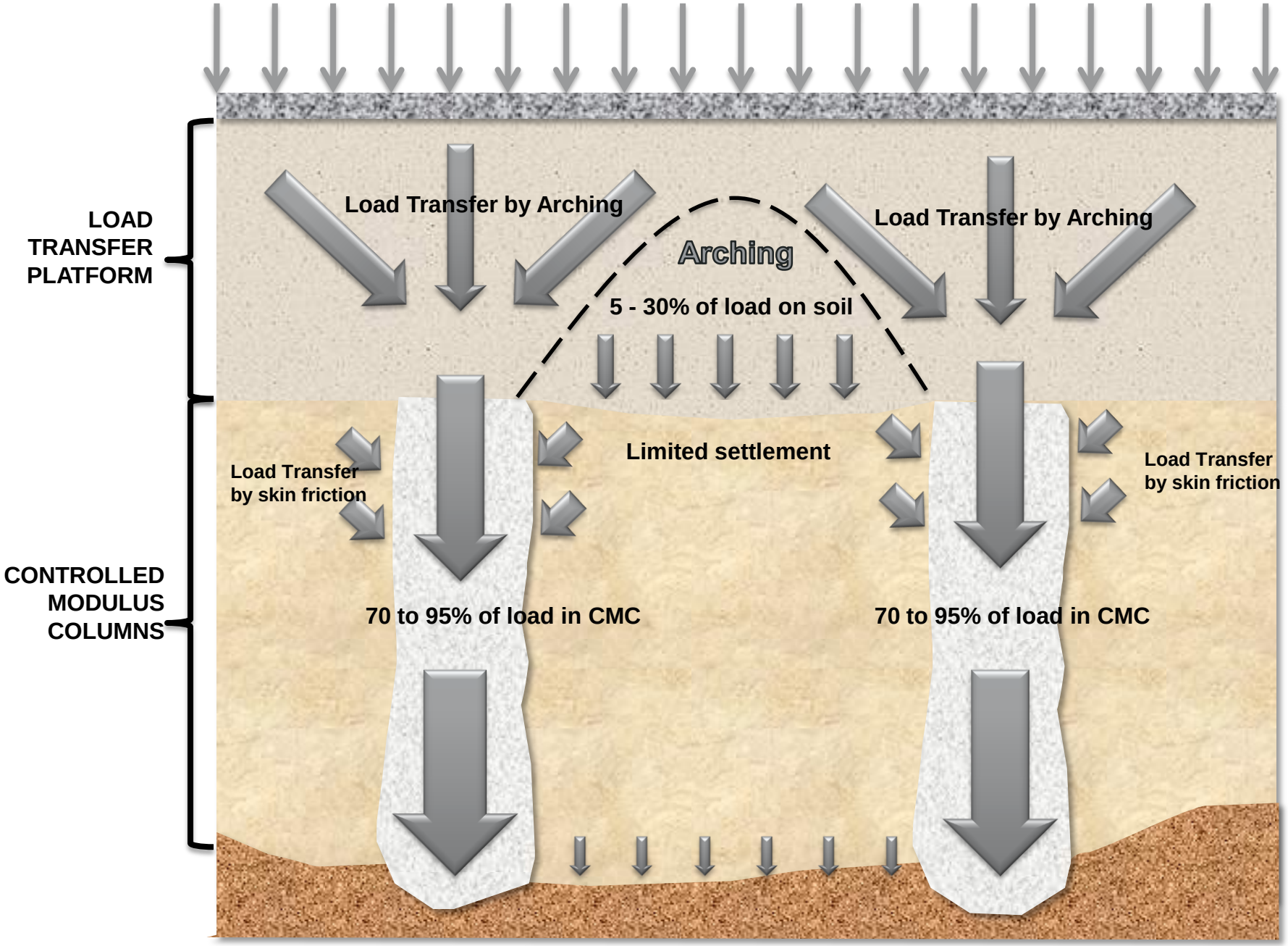
- Pile: An extension of the structure into the underlying ground for the purpose of transferring loads from the superstructure to deeper bearing strata.

- Ground Improvement: Installation of higher strength/stiffness inclusions in the ground to transform the physical behavior of the underlying soils from the behavior of the original soil to the composite behavior of the soil with the inclusions.

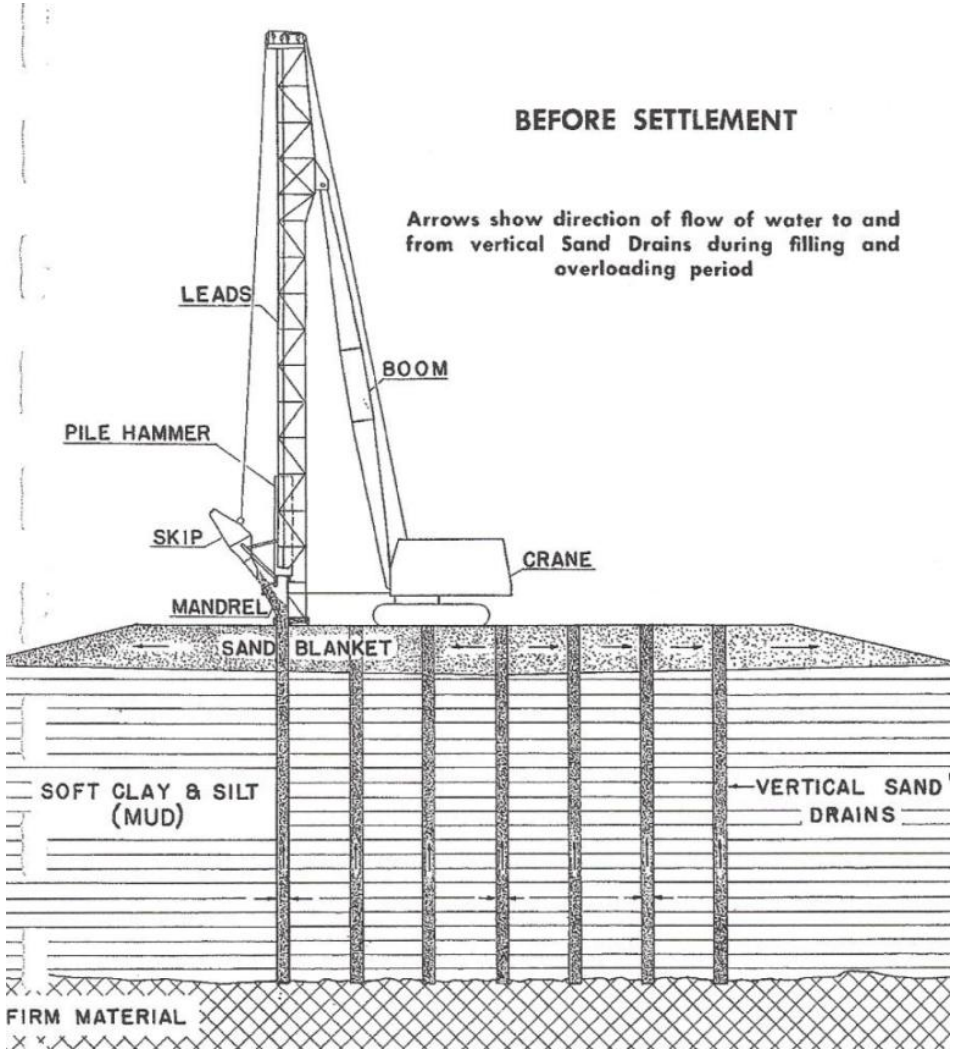
DEEP FOUNDATION SYSTEM vs. CMC SYSTEM



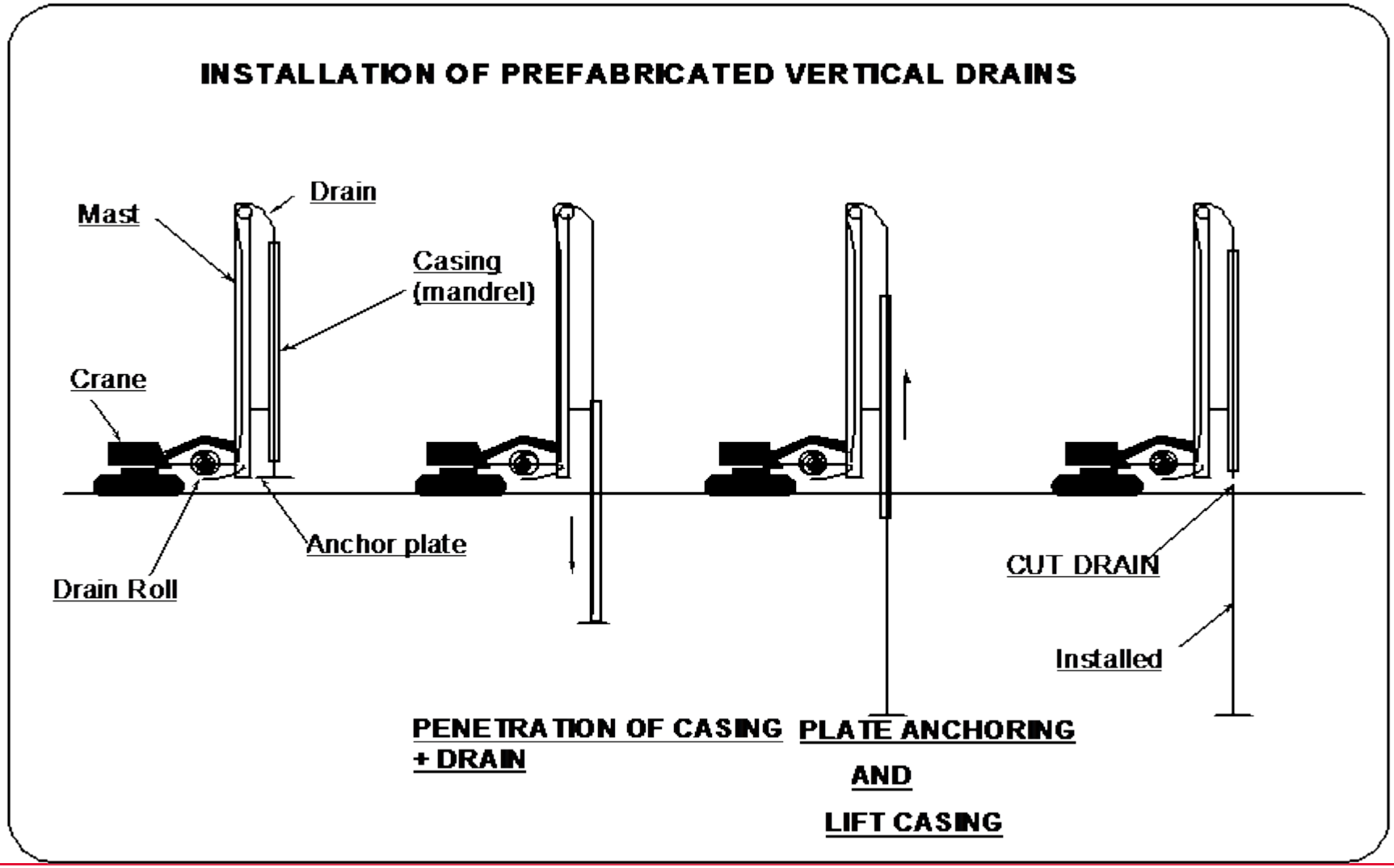
Uniform Load (building / embankment)



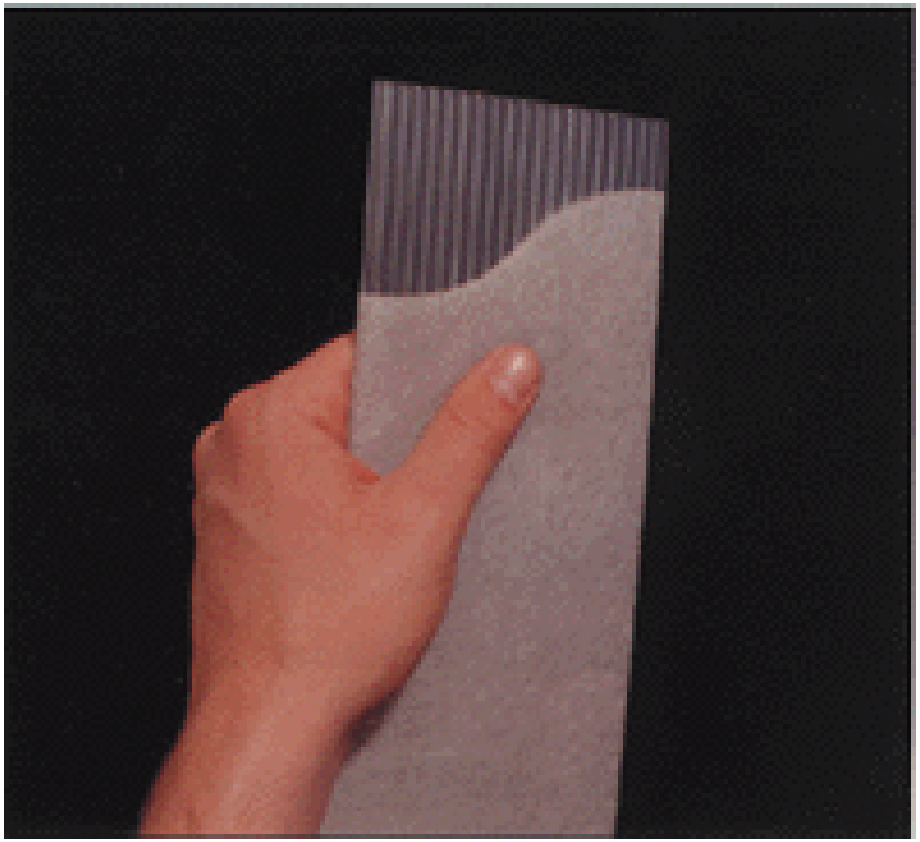
REMINDER FROM THE PAST

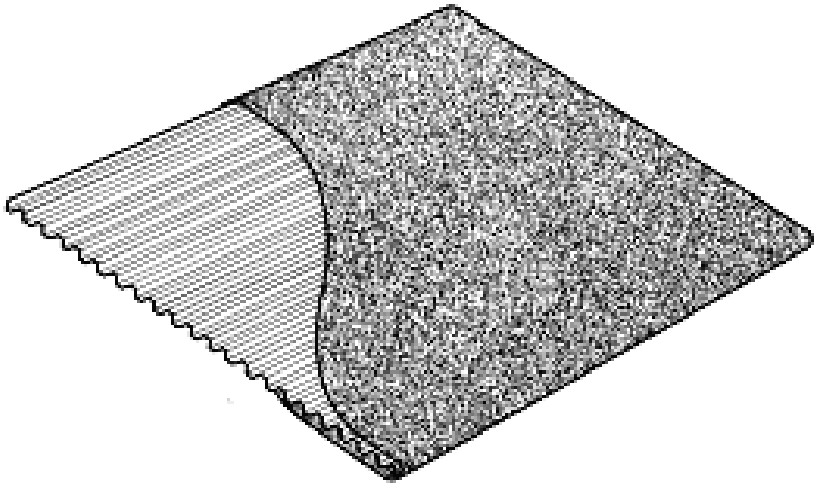


WICK DRAINS


INSTALLATION OF PREFABRICATED VERTICAL DRAINS
Mast
Drain
Casing
(mandrel)
Crane
Anchor plate
Drain Roll
CUT DRAIN
Installed
PENETRATION OF CASING
+ DRAIN
PLATE ANCHORING
AND
LIFT CASING

WICK DRAINS





I-29 and US 275 INTERCHANGE PROJECT

- **Project in Iowa, near Nebraska border**
- **Soils associated with Missouri River flood plain**
- **Over 14,000 CMC's installed**
- **18-inch diameter**
- **Design-Bid-Build traditional Project**
- **CMCs cut off for Load Transfer pad as well as utilities.**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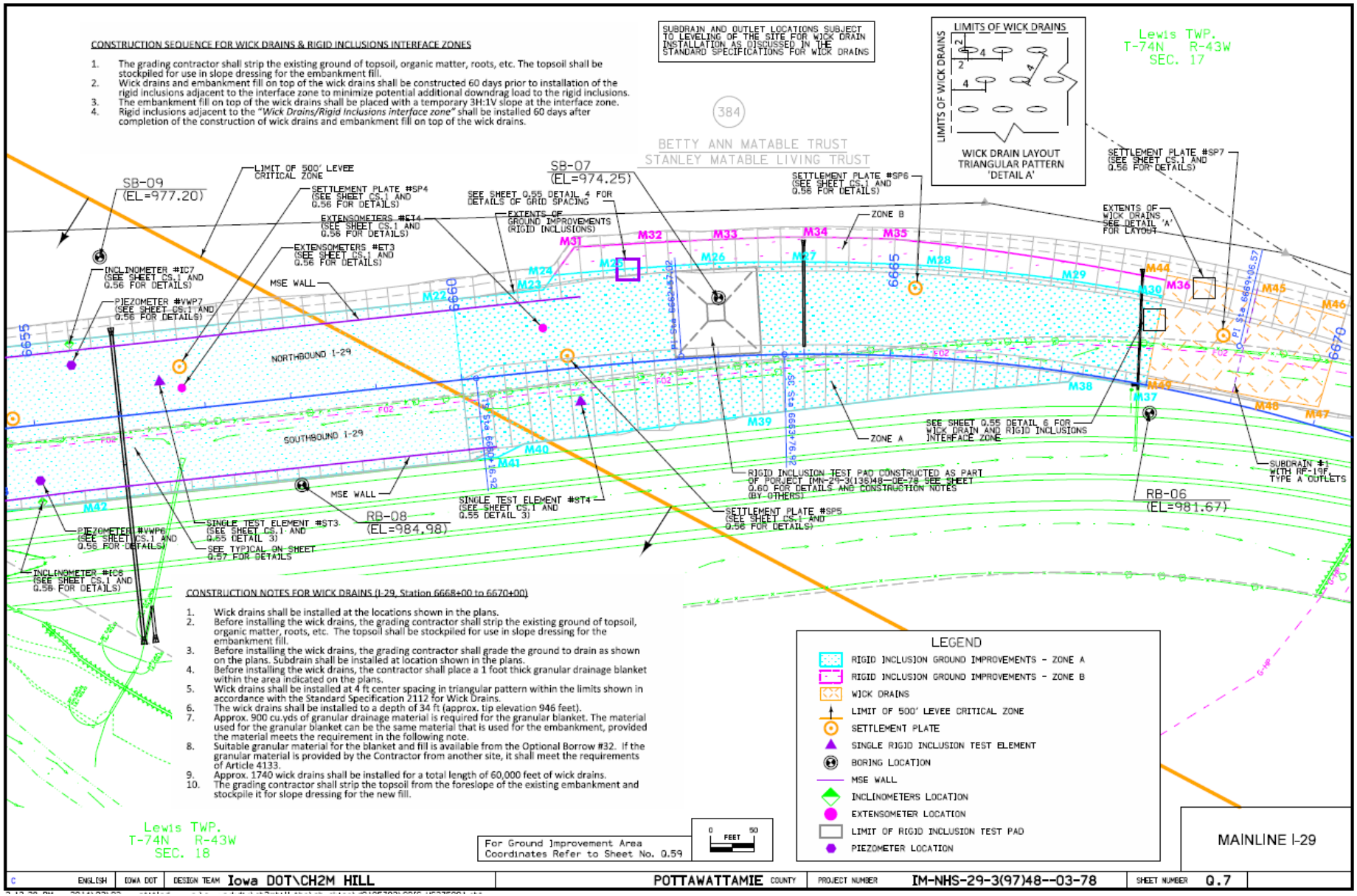
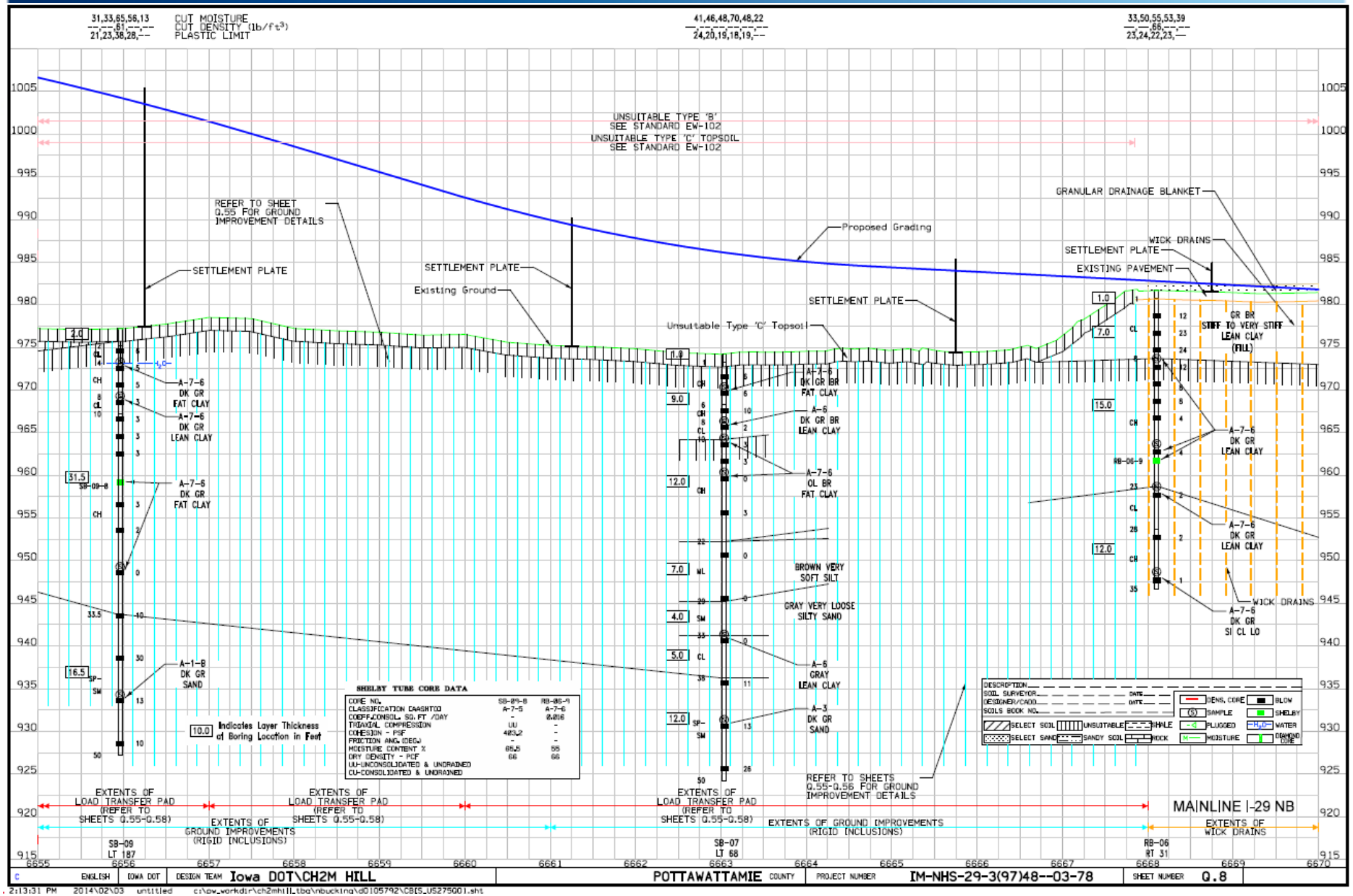
275
275
47
E Manawa Dr
Google





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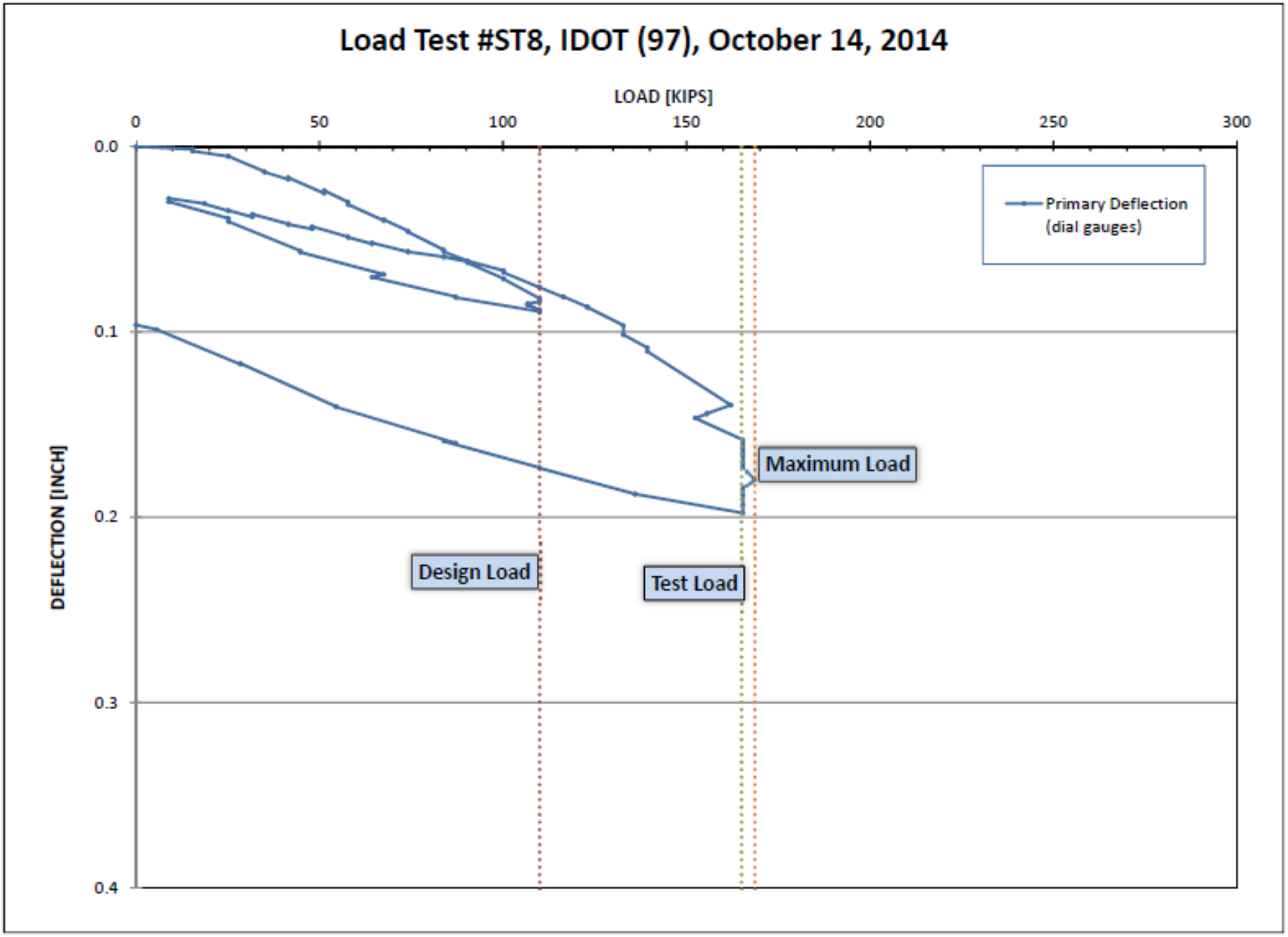
I-29 and US 275 INTERCHANG


PETSMART
SCHWING

QUALITY CONTROL – COMPUTER MONITORING


Load Test #ST8, IDOT (97), October 14, 2014
LOAD [KIPS]
0
50
100
150
200
250
300
0.0
0.1
0.2
0.3
0.4
DEFLECTION [INCH]
Primary Deflection (dial gauges)
Maximum Load
Design Load
Test Load

I-29 and US 275 INTERCH

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CMC

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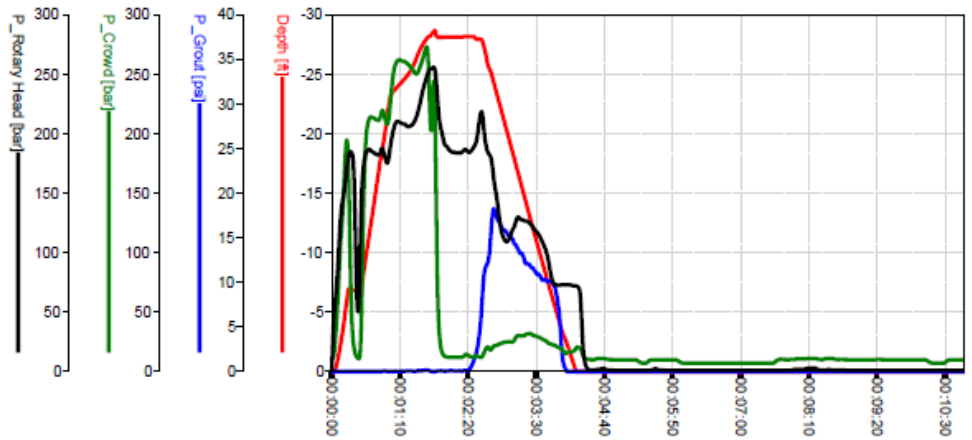
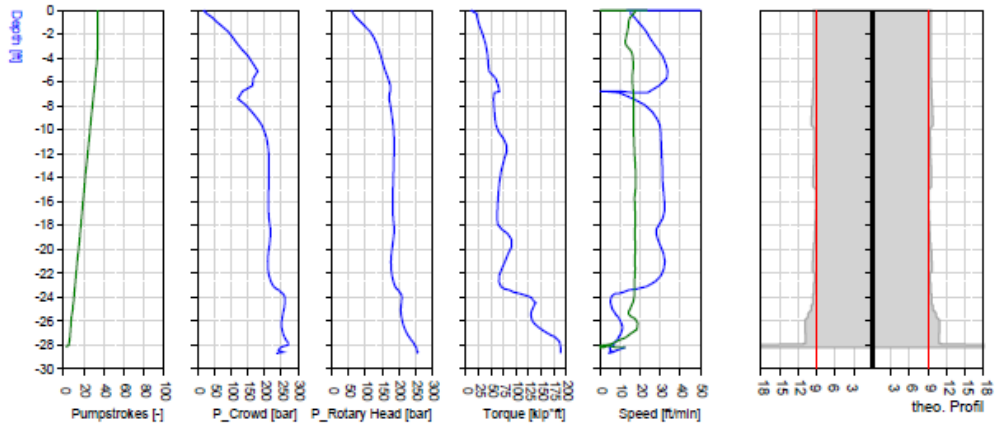
Job Site Data:		Data for CMC No:	ST8		
Project name:	IDOT (97)	Date:	10/7/2014	CMC length:	28.67 ft
Location:	Area 5	Starttime:	4:15:51 PM	CMC diameter:	18 inch
Client:	1115	Endtime:	4:26:40 PM	Theo. Volume:	50.7 ft³
Contract Number:	Hawkins Construction	Totaltime:	00:10:49	Act. Volume:	56.8 ft³
Drill Rig:	Enteco 6050 #3	Pausetime:	00:00:00	Overbreak:	12 %

Timediagram



Depthdiagram downwards upwards



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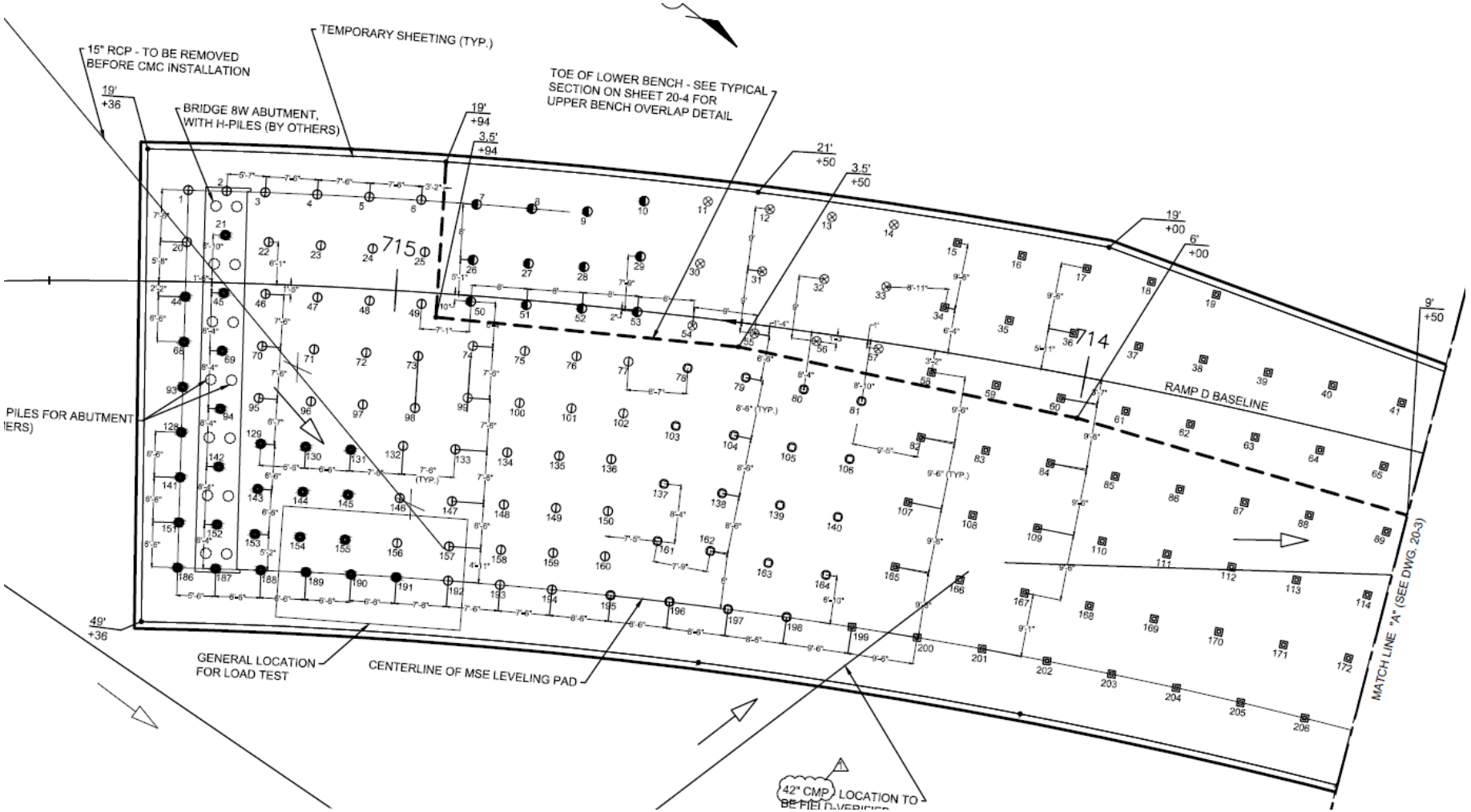
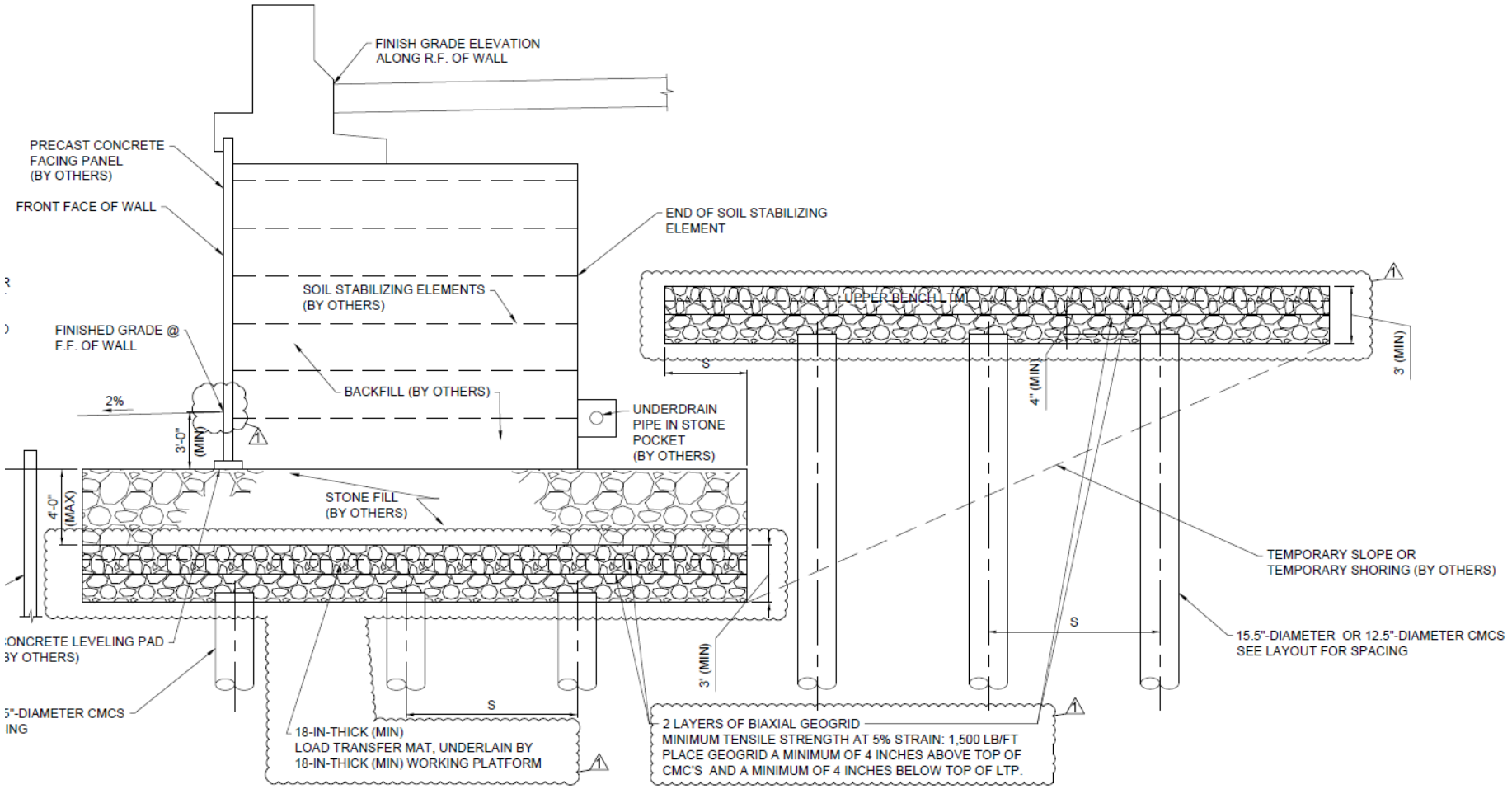
I-295 DIRECT CONNECT PROJECT

- **Project in New Jersey, near Philadelphia**
- **Over 5,000 CMC's installed on Contract 1 and 5,500 coming up on Contract 2**
- **CMC support Design-Build within a traditional Design-Bid-Build Project**

I-295 DIRECT CONNECT PROJECT



I-295 DIRECT CONNECT PROJECT

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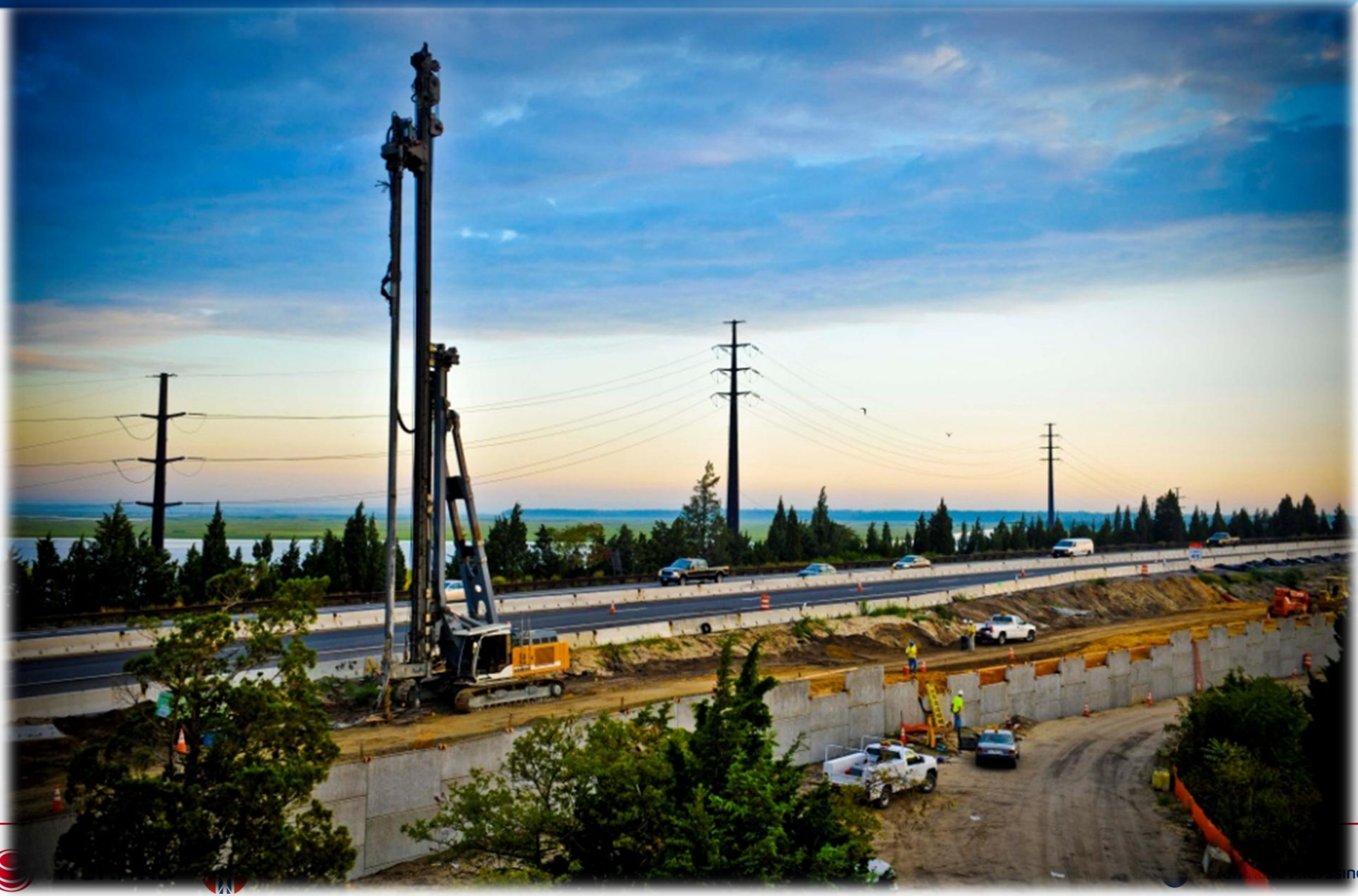
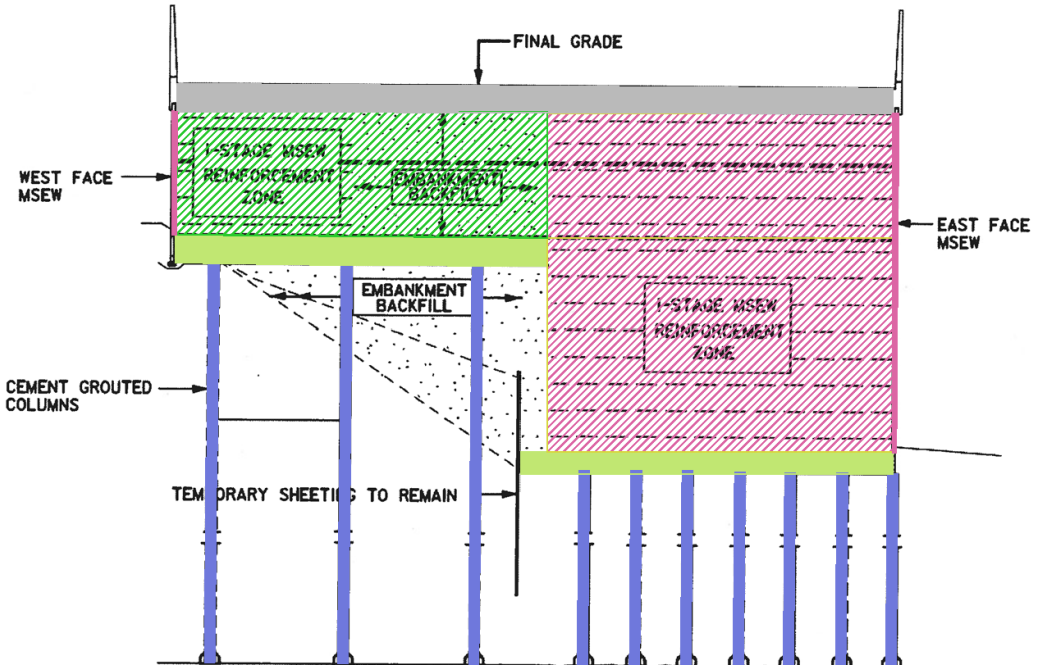
I-295 DIRECT CONNECT PROJECT



I-295 DIRECT CONNECT PROJECT

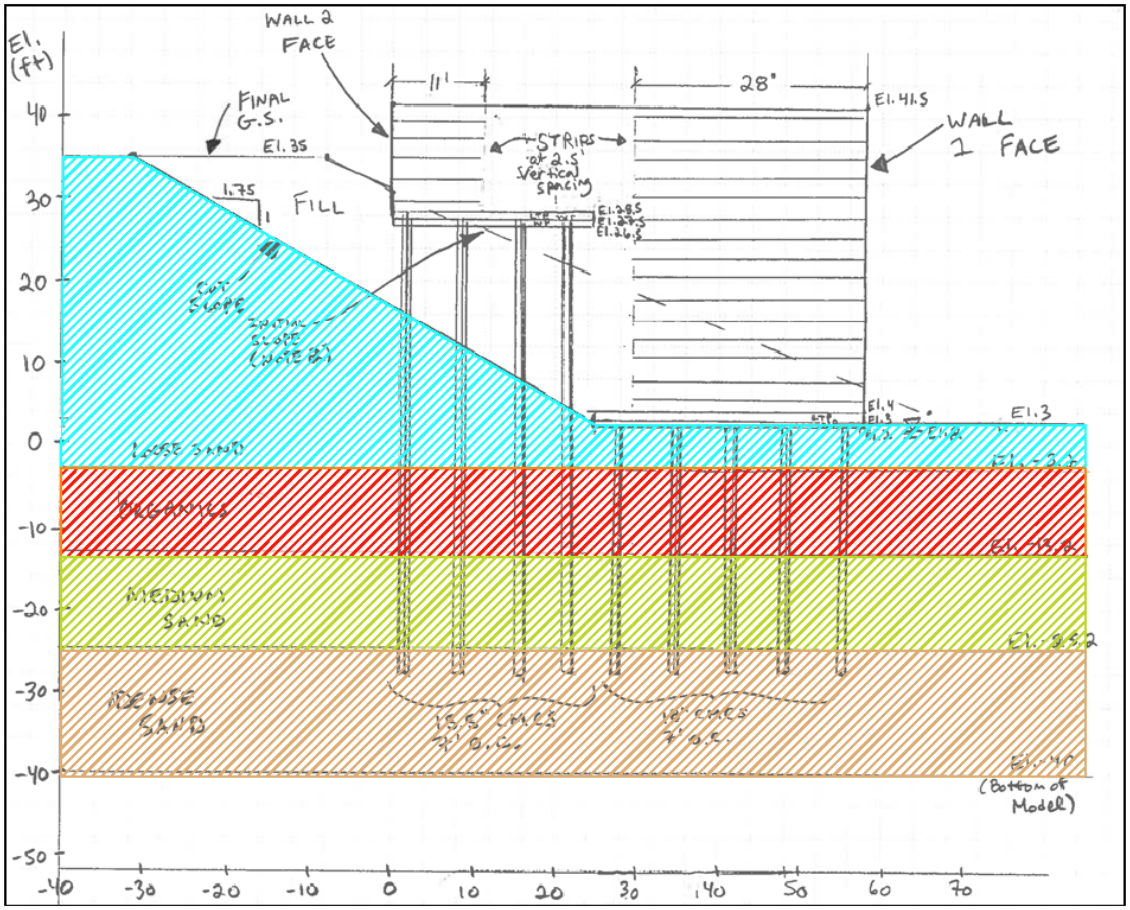
Construction Staging

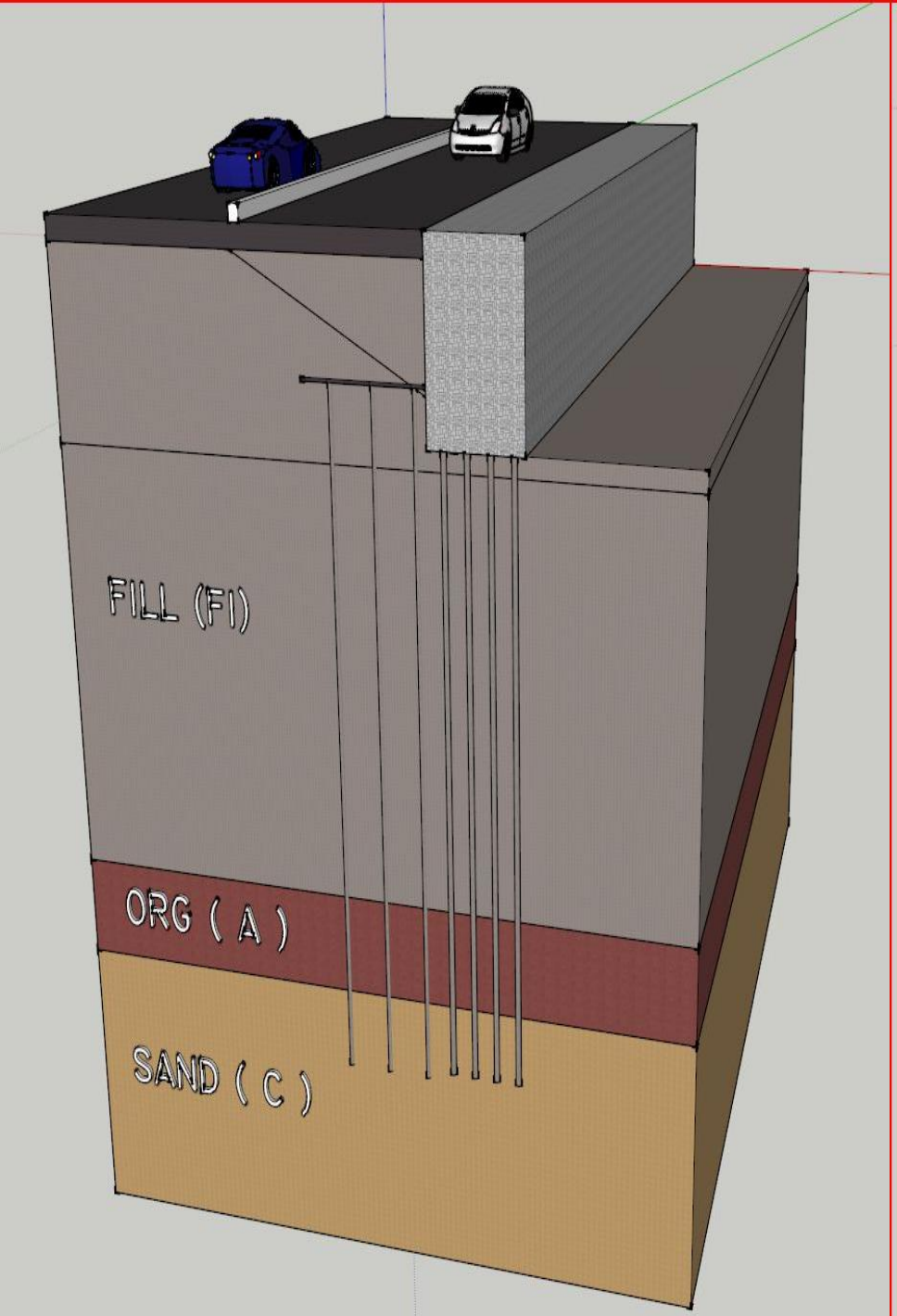
- Cut slope to lower working pad
- Install temporary sheeting, lower working pad
- Install CMCs for lower wall
- Backfill lower wall to upper bench elevation
- Install CMCs for upper wall
- Backfill upper wall to roadway elevation
- Finish grade, place pavement

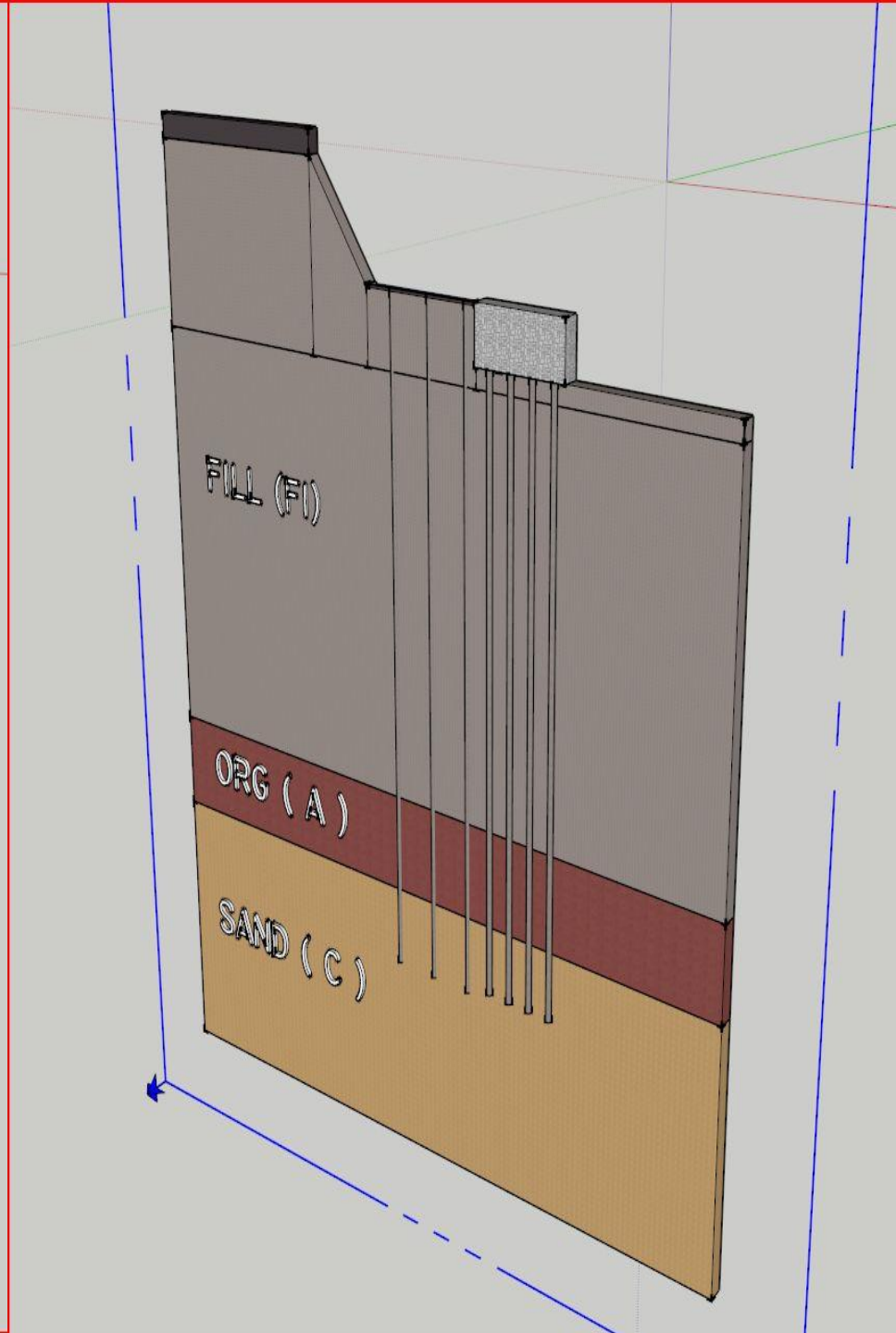


I-295 DIRECT CONNECT PROJECT

Modeled Soil Profile

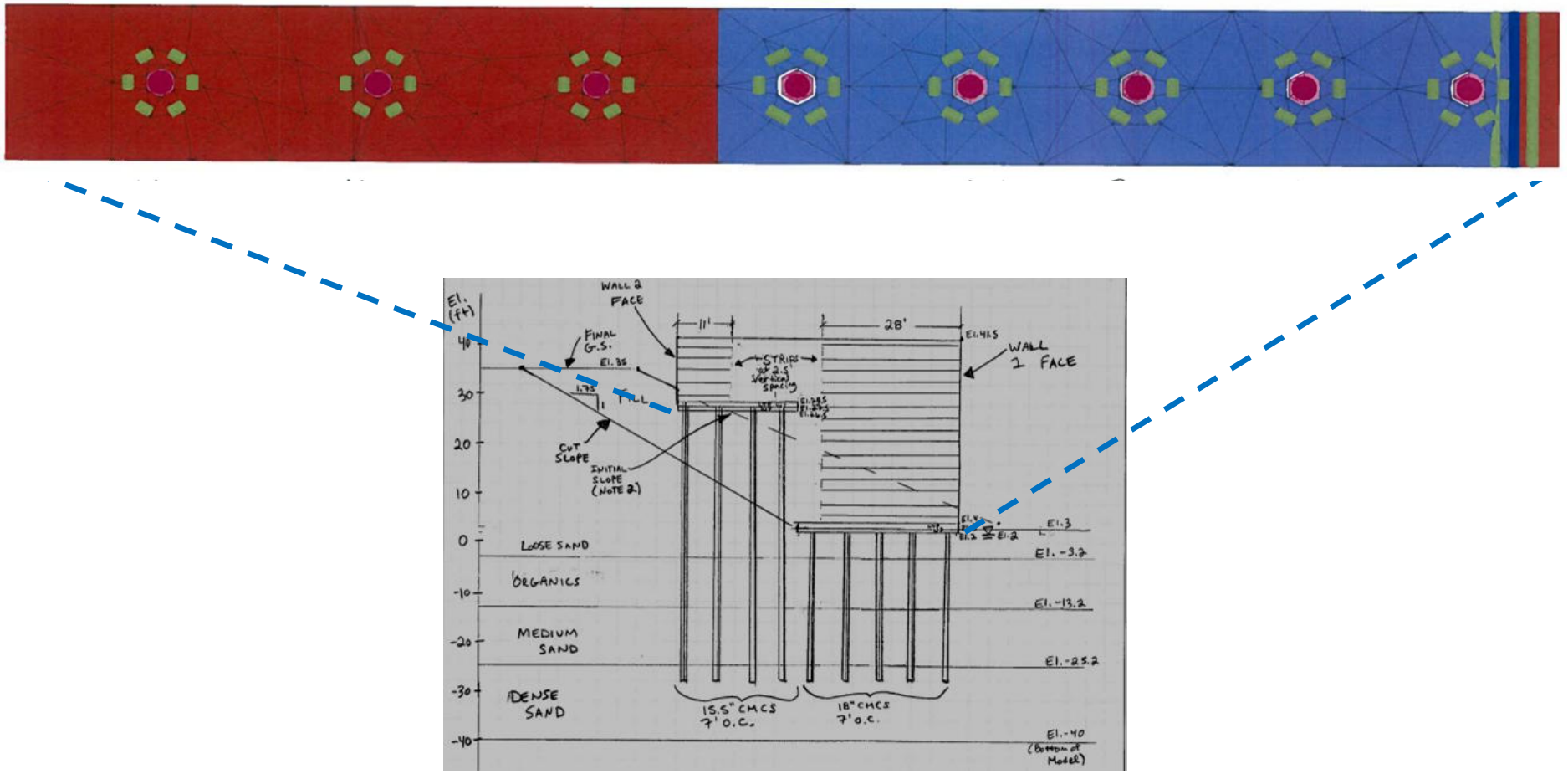



FILL (FI)
ORG (A)
SAND (C)


FILL (FI)
ORG (A)
SAND (C)

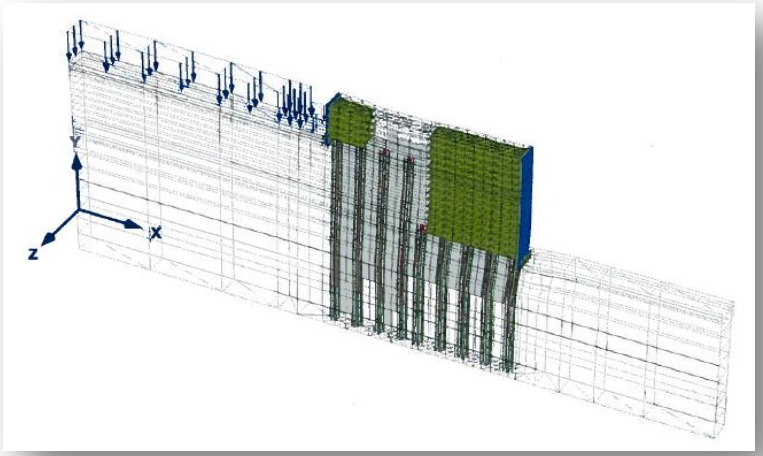
I-295 DIRECT CONNECT PROJECT

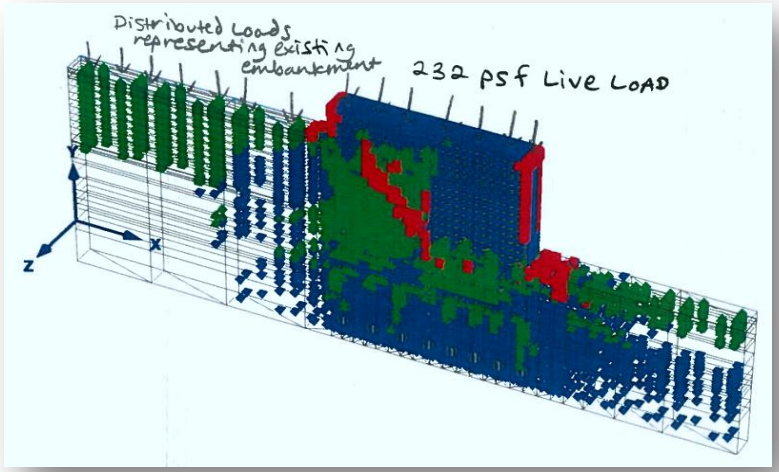
3D Model Plan View – Slice Through Entire Embankment

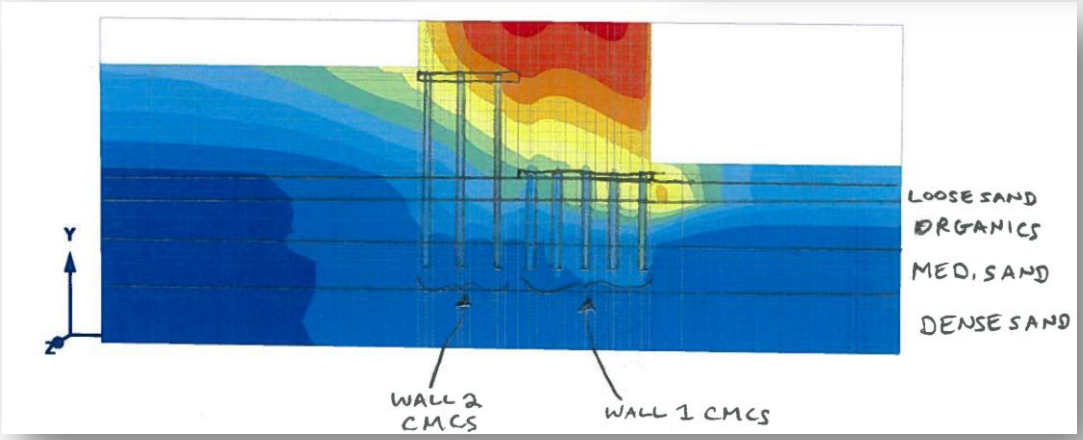


I-295 DIRECT CONNECT PROJECT

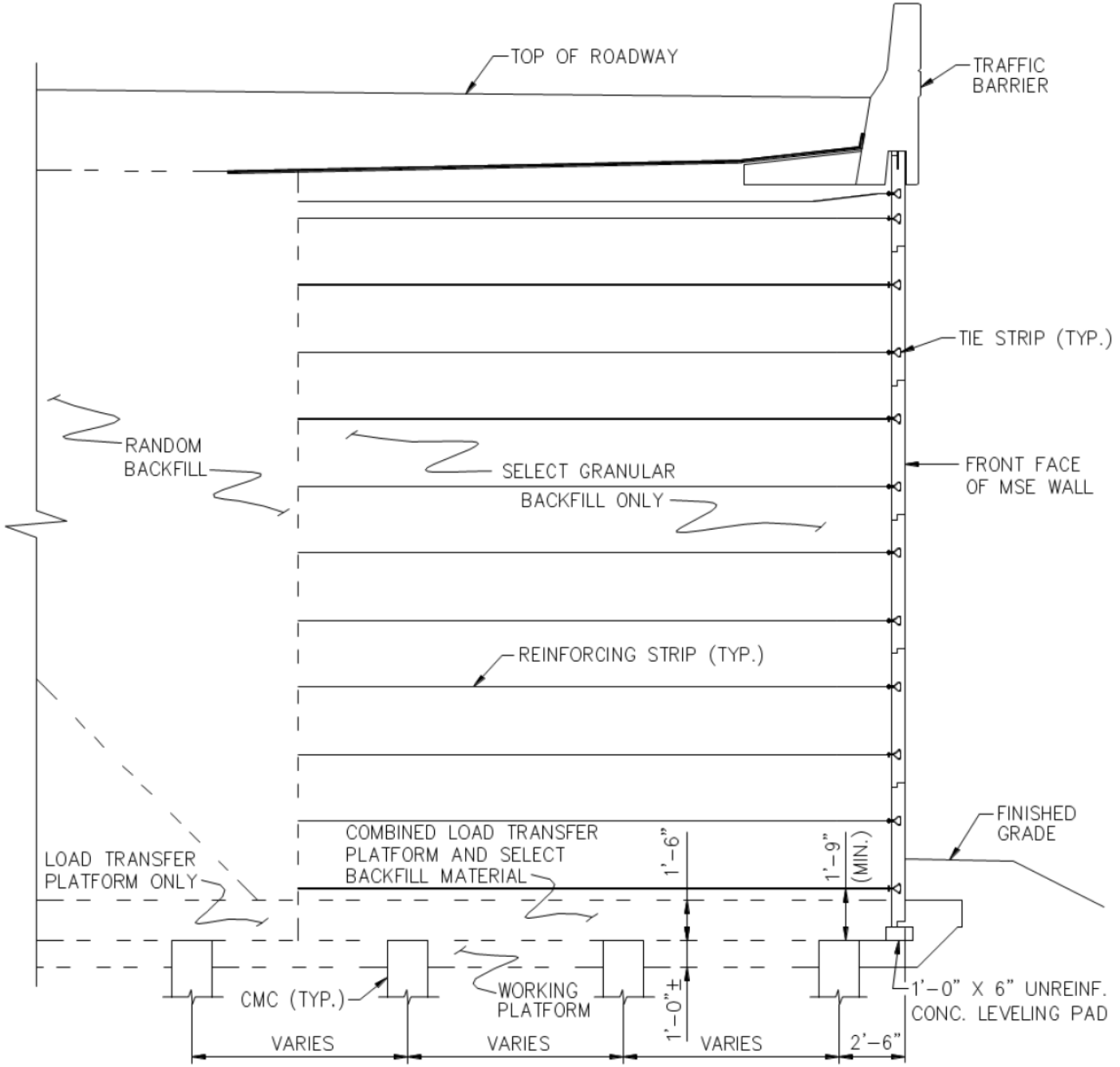
Plaxis Results







I-295 DIRECT



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I-29 and US 275

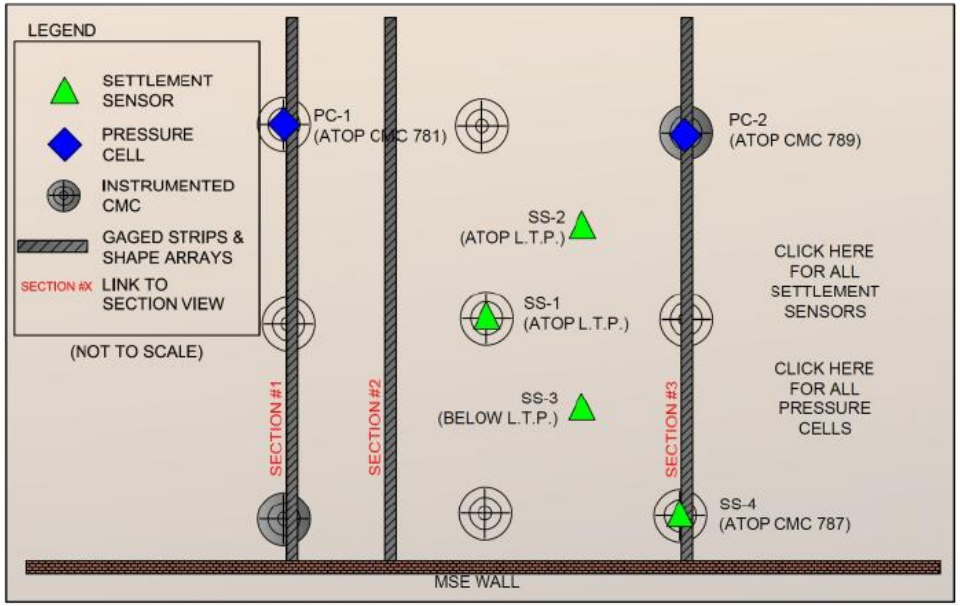


Figure 4. Plan view of the instrumentation

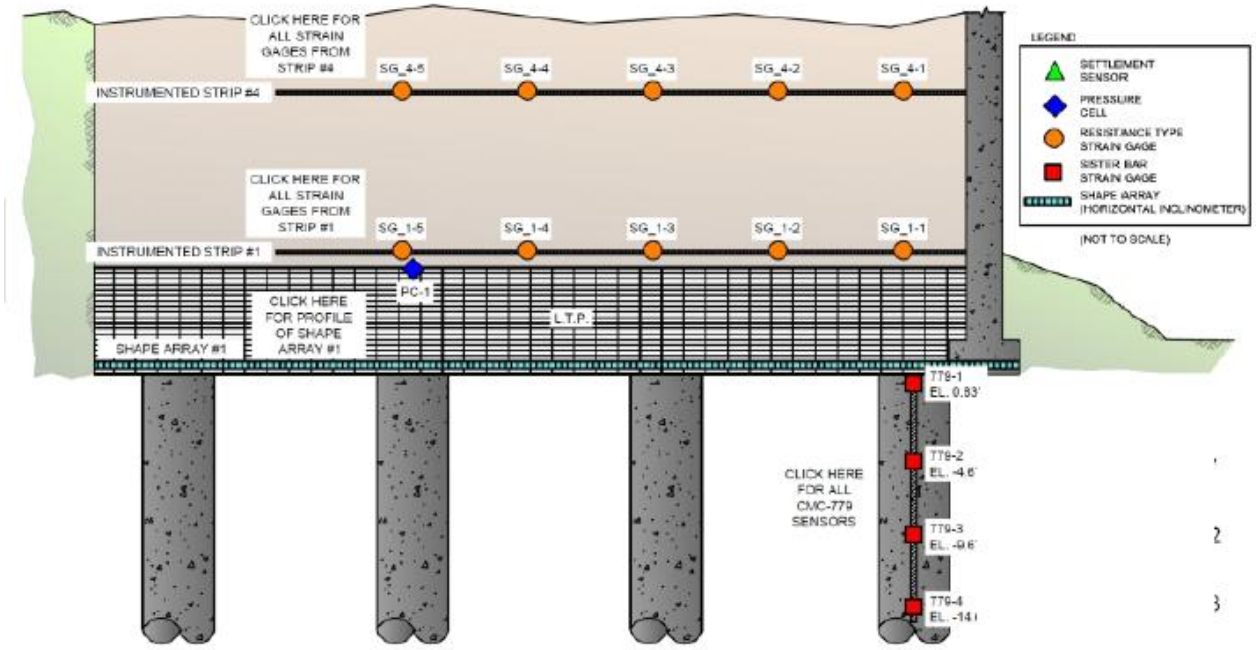
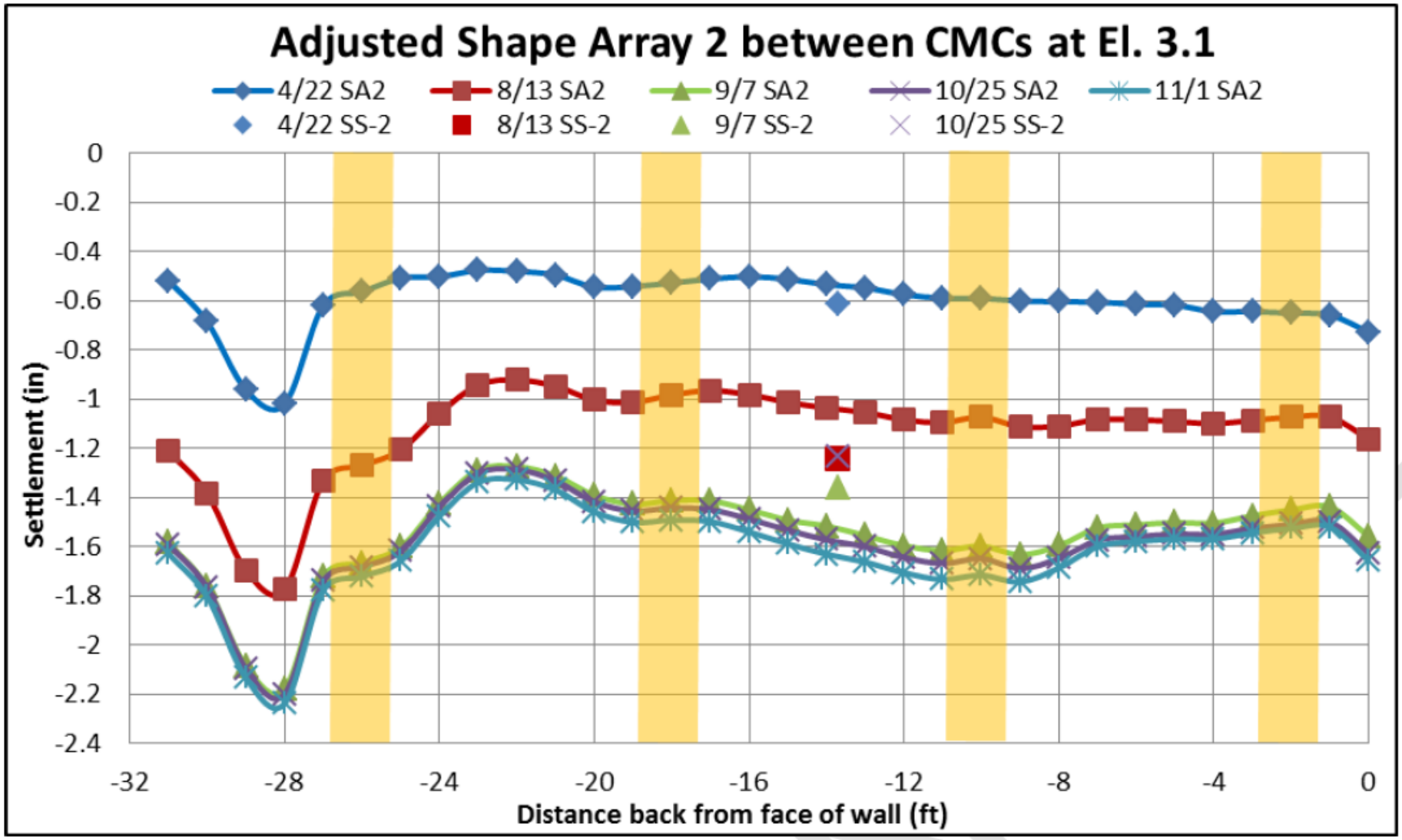


Figure 5. Section #1 of the instrumentation.

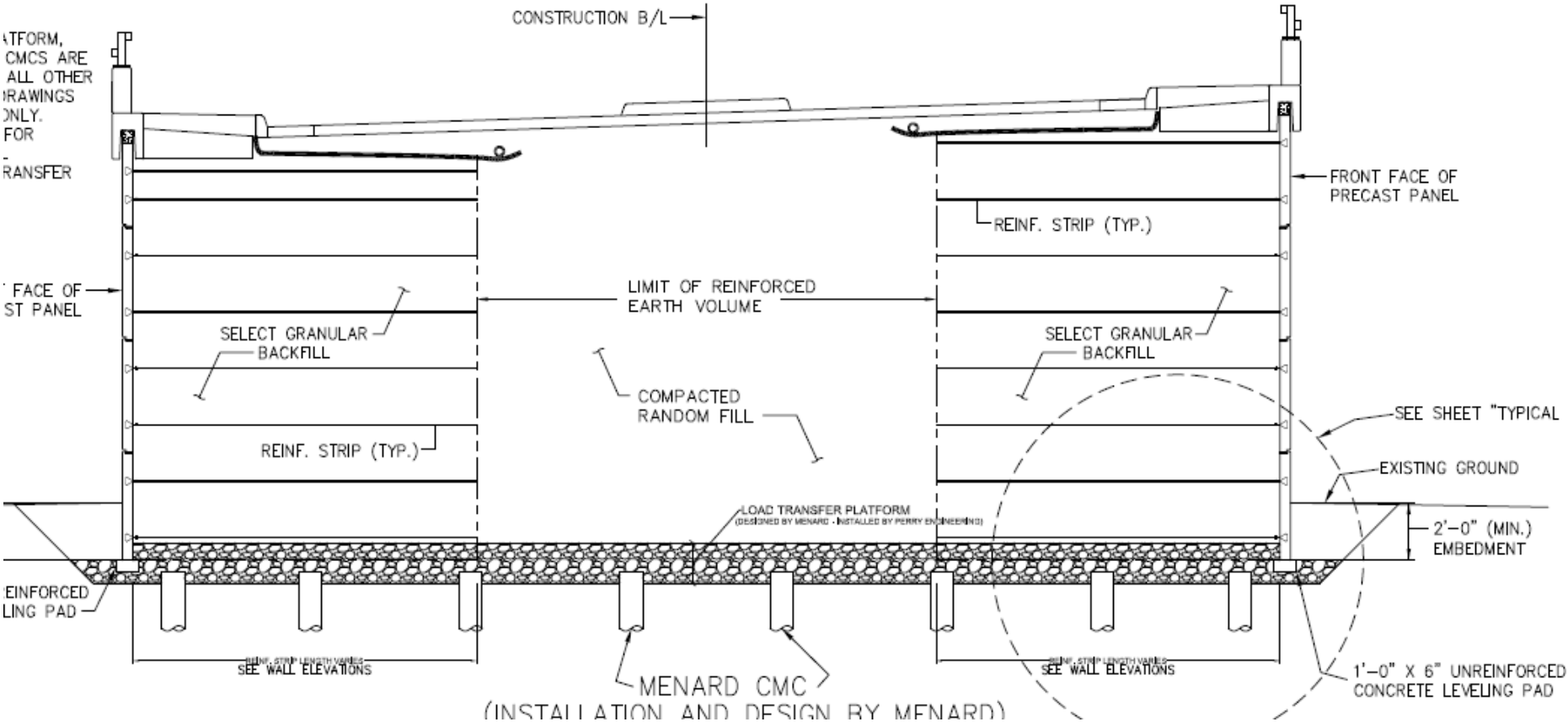
I-29 and US 275 INTERCHANGE PROJECT



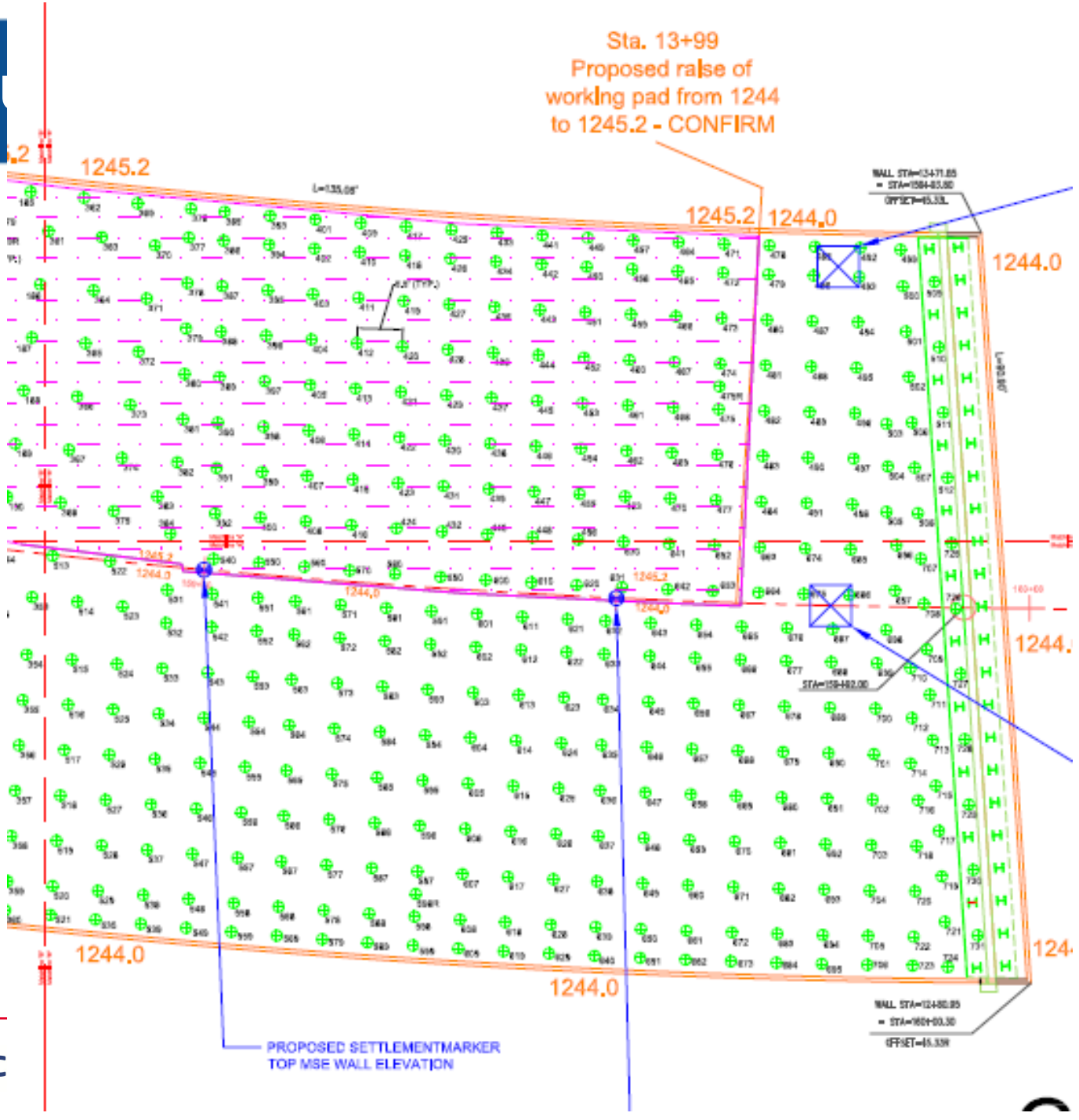
ERICSON AVENUE PROJECT

- **Project in Virginia, near James Madison University**
- **Value-Engineering Proposal Project**
- **Replaced lightweight fill (geofoam) with ground improvement and traditional MSE all construction.**

ERICSON AVENUE PROJECT



ERICSON AVENU



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CONCLUSIONS

- **Accelerated construction by supporting embankments and MSE walls is possible by means of CMC rigid inclusions**
- **Multiple geometries for new construction and widening can be accommodated**

END

- **Thanks to STGEC and ALDOT!**