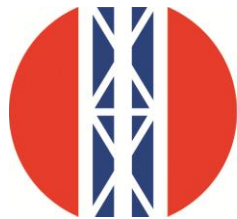


ACCELERATED ROADWAY CONSTRUCTION:

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

Presented by Aaron D. Goldberg, PE,

DOE



US WICK DRAIN

First Things First



Shutterstock

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:

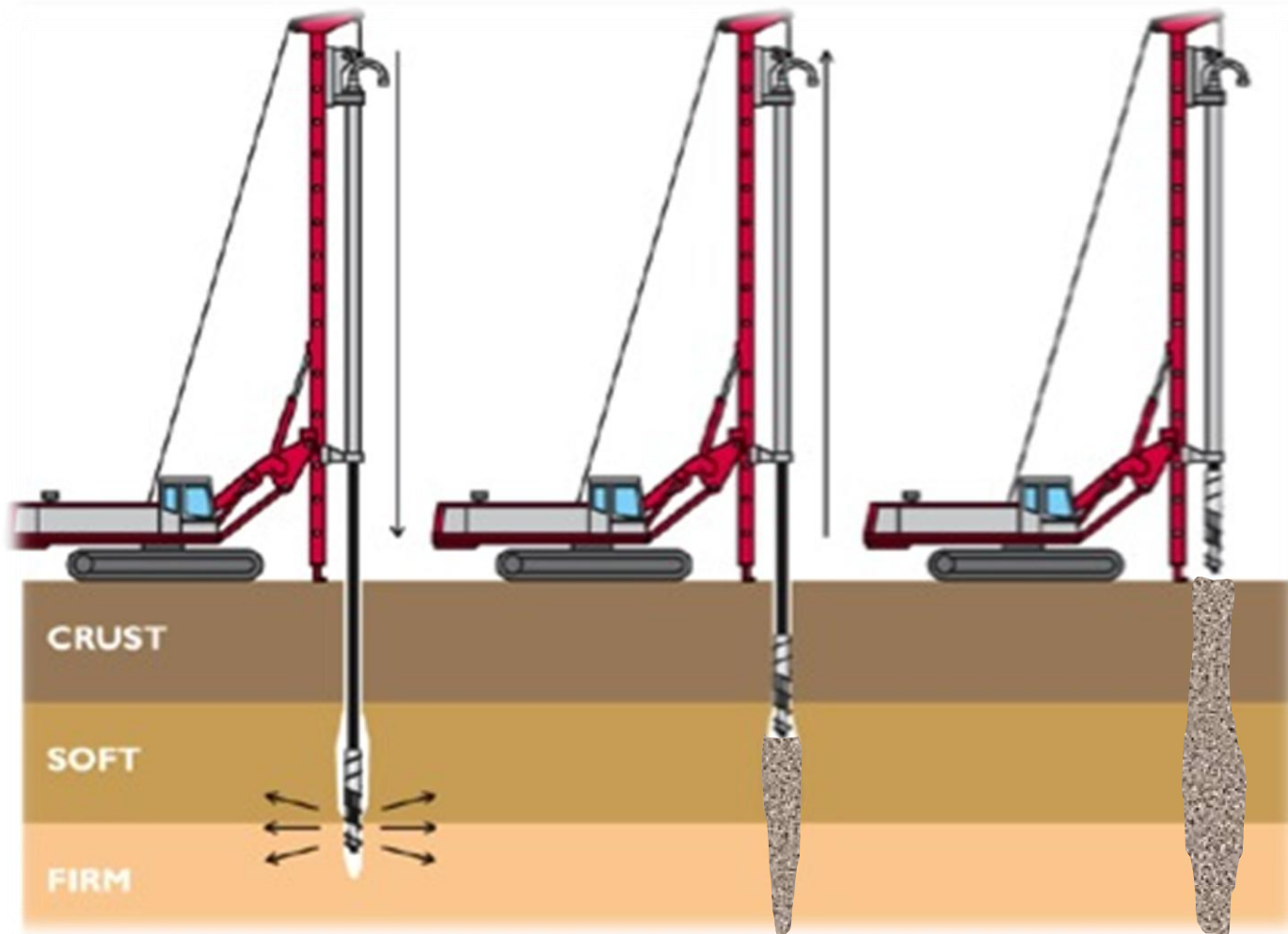
“A ground improvement solution comprised of grouted inclusions which act to reinforce a soil mass for the purpose of settlement control”

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

Ready mix truck

CMC Drill Rig

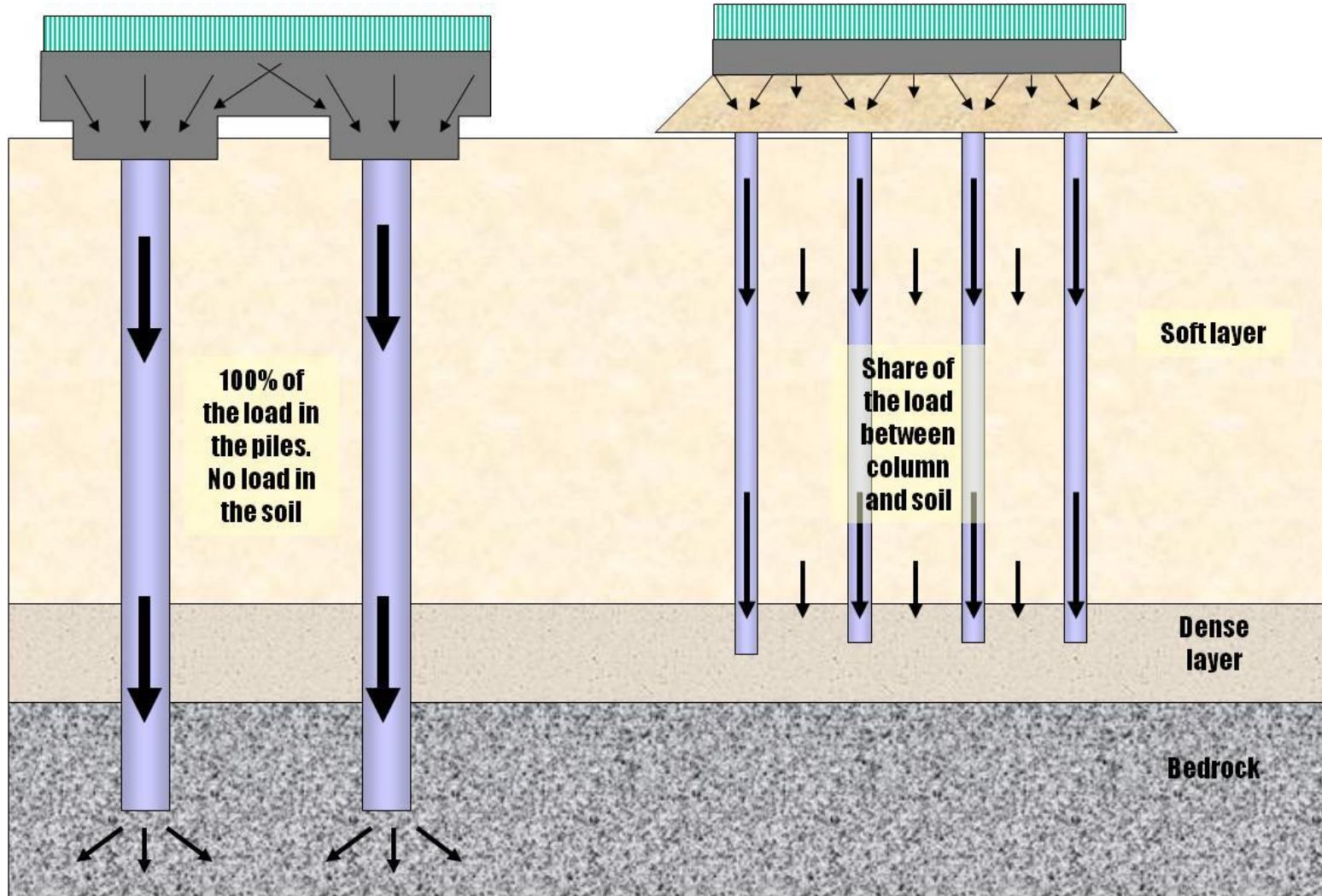
Concrete Pump



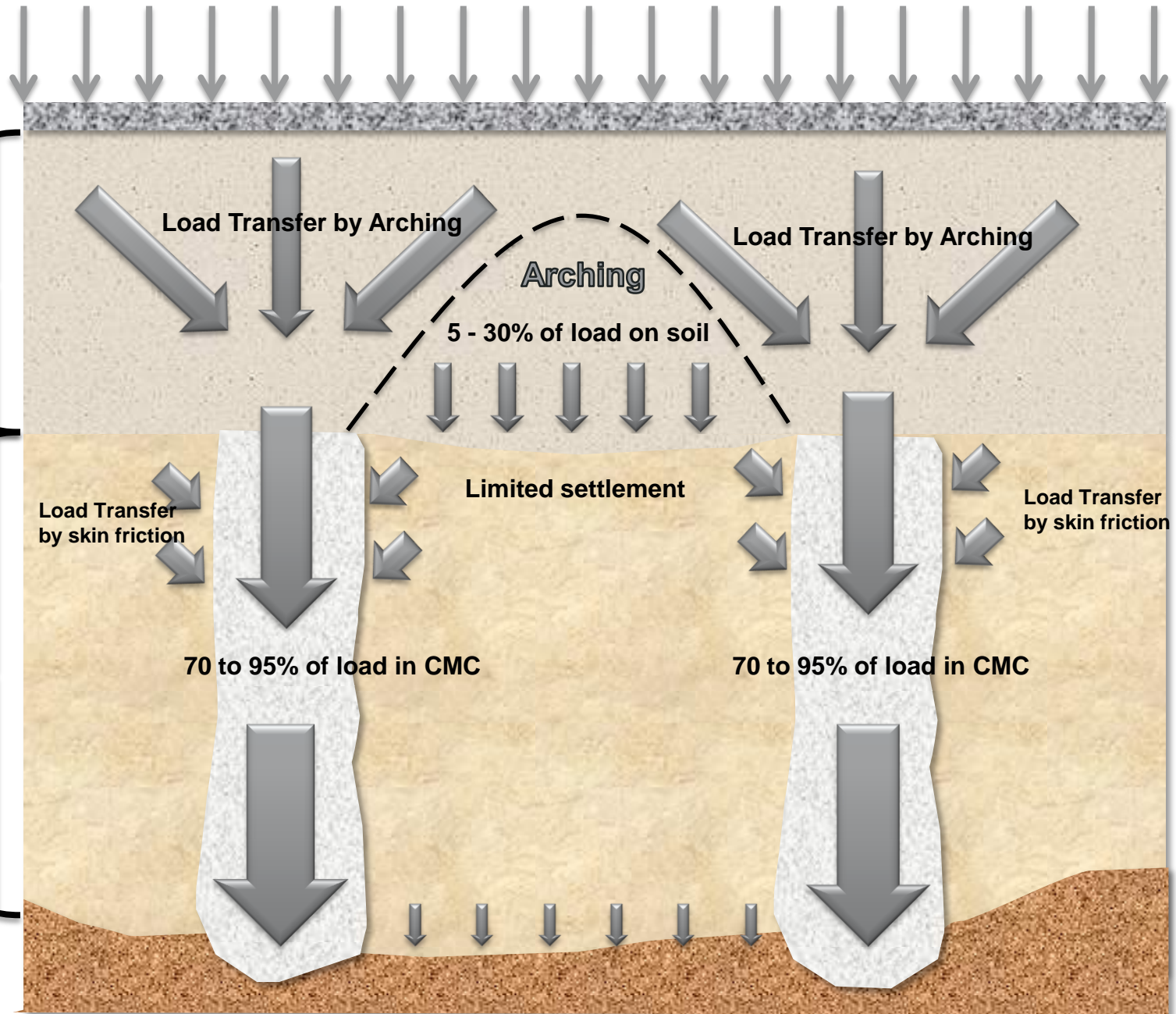
CONTROLLED MODULUS COLUMNS

- **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)



LOAD
TRANSFER
PLATFORM

Load Transfer by Arching

Arching

Load Transfer by Arching

5 - 30% of load on soil

Load Transfer
by skin friction

Limited settlement

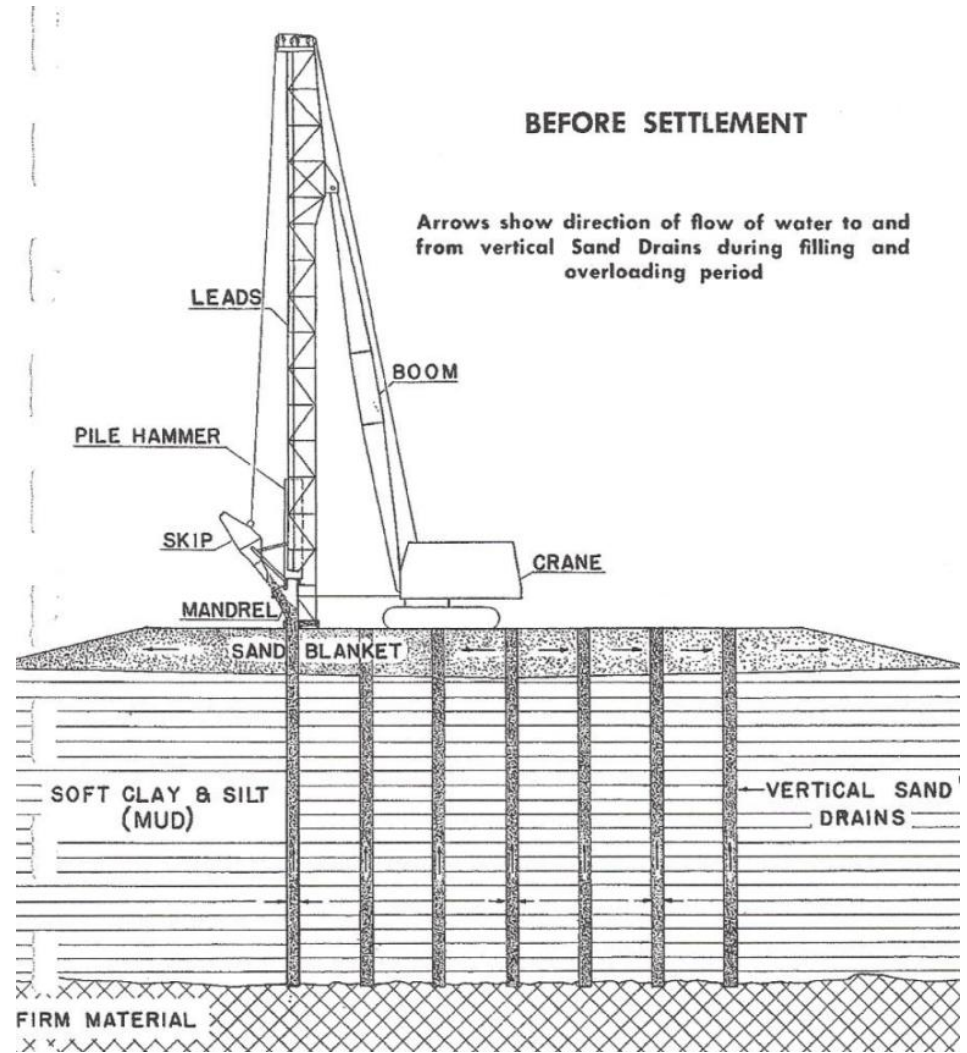
Load Transfer
by skin friction

70 to 95% of load in CMC

70 to 95% of load in CMC

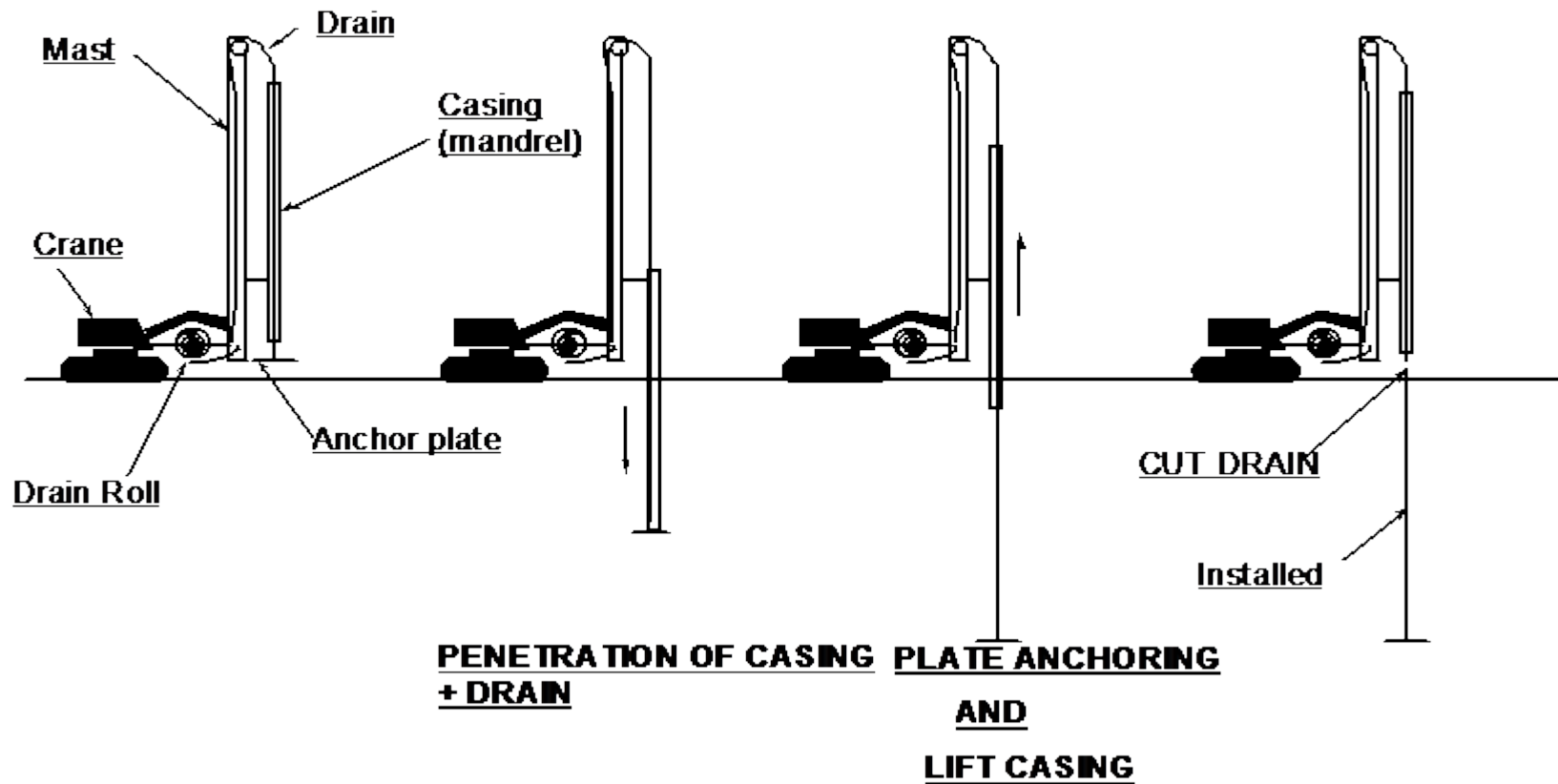
CONTROLLED
MODULUS
COLUMNS

REMINDER FROM THE PAST

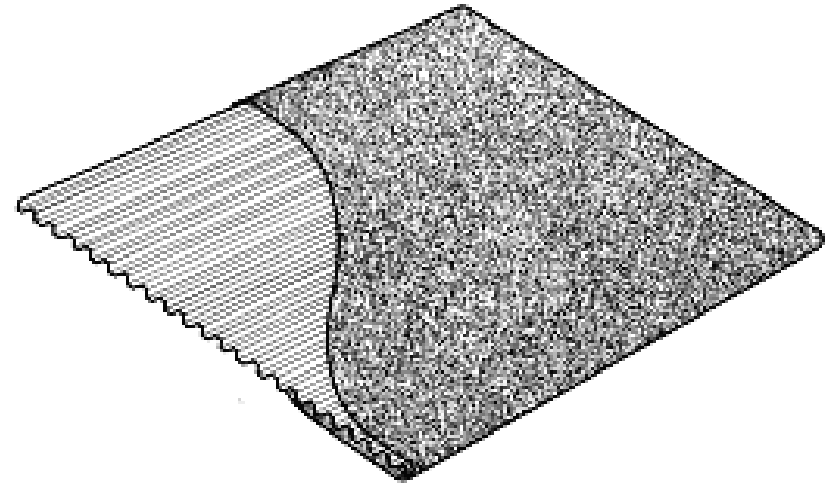
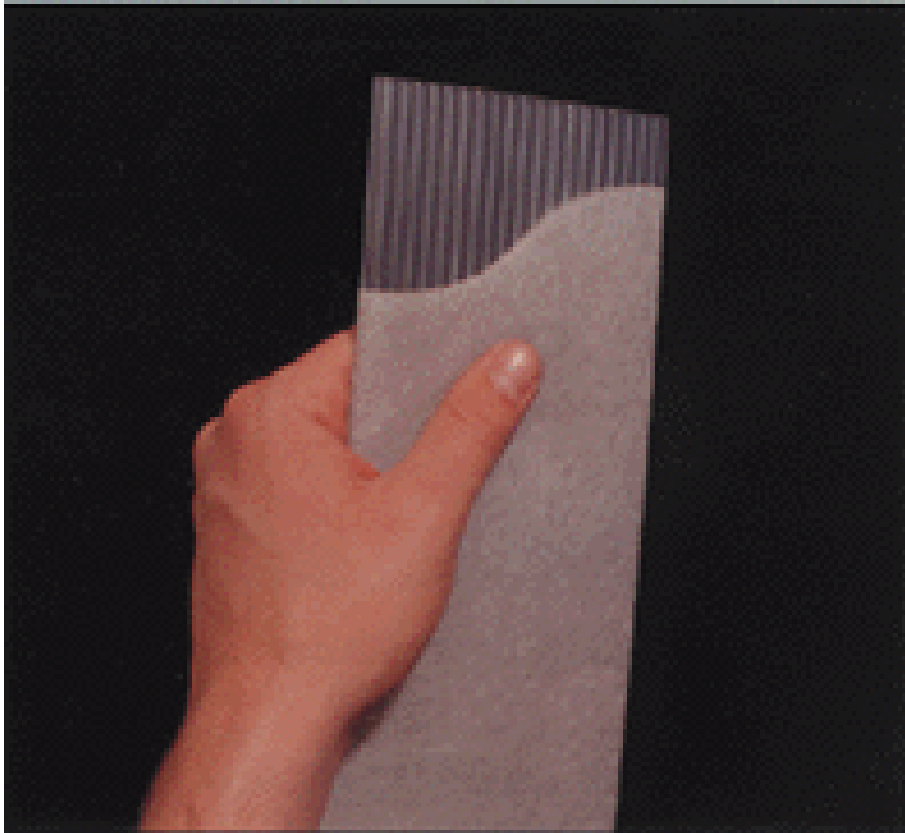


WICK DRAINS

INSTALLATION OF PREFABRICATED VERTICAL DRAINS



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.**

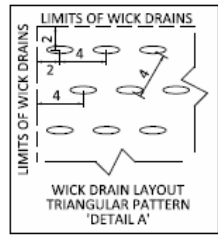


Lewis TWP.
T-74N R-43W
SEC. 17

CONSTRUCTION SEQUENCE FOR WICK DRAINS & RIGID INCLUSIONS INTERFACE ZONES

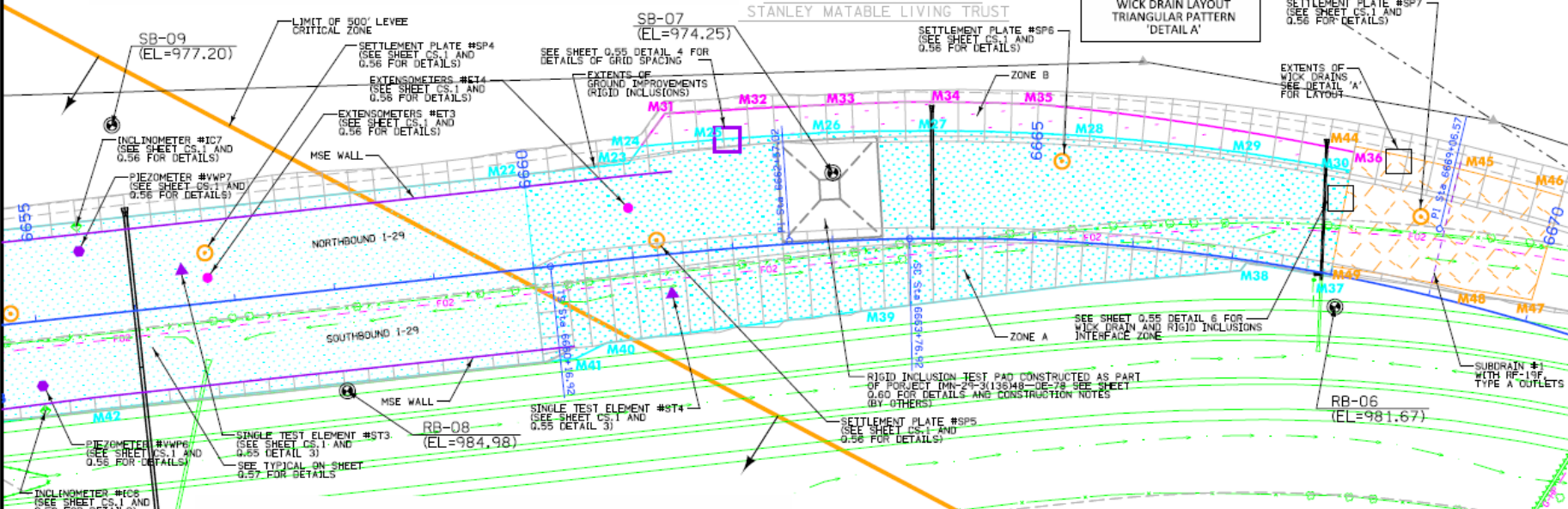
1. The grading contractor shall strip the existing ground of topsoil, organic matter, roots, etc. The topsoil shall be stockpiled for use in slope dressing for the embankment fill.
2. Wick drains and embankment fill on top of the wick drains shall be constructed 60 days prior to installation of the rigid inclusions adjacent to the interface zone to minimize potential additional downward load to the rigid inclusions.
3. The embankment fill on top of the wick drains shall be placed with a temporary 3H:1V slope at the interface zone.
4. Rigid inclusions adjacent to the "Wick Drains/Rigid Inclusions Interface zone" shall be installed 60 days after completion of the construction of wick drains and embankment fill on top of the wick drains.

SUBDRAIN AND OUTLET LOCATIONS SUBJECT TO LEVELING OF THE SITE FOR WICK DRAIN INSTALLATION AS DISCUSSED IN THE STANDARD SPECIFICATIONS FOR WICK DRAINS



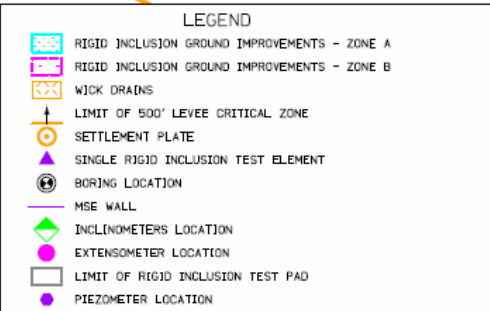
384

BETTY ANN MATABLE TRUST
STANLEY MATABLE LIVING TRUST



CONSTRUCTION NOTES FOR WICK DRAINS (I-29, Station 6668+00 to 6670+00)

1. Wick drains shall be installed at the locations shown in the plans.
2. Before installing the wick drains, the grading contractor shall strip the existing ground of topsoil, organic matter, roots, etc. The topsoil shall be stockpiled for use in slope dressing for the embankment fill.
3. Before installing the wick drains, the grading contractor shall grade the ground to drain as shown on the plans. Subdrain shall be installed at location shown in the plans.
4. Before installing the wick drains, the contractor shall place a 1 foot thick granular drainage blanket within the area indicated on the plans.
5. Wick drains shall be installed at 4 ft center spacing in triangular pattern within the limits shown in accordance with the Standard Specification 2112 for Wick Drains.
6. The wick drains shall be installed to a depth of 34 ft (approx. tip elevation 946 feet).
7. Approx. 900 cu. yds of granular drainage material is required for the granular blanket. The material used for the granular blanket can be the same material that is used for the embankment, provided the material meets the requirement in the following note.
8. Suitable granular material for the blanket and fill is available from the Optional Borrow #32. If the granular material is provided by the Contractor from another site, it shall meet the requirements of Article 4133.
9. Approx. 1740 wick drains shall be installed for a total length of 60,000 feet of wick drains.
10. The grading contractor shall strip the topsoil from the foreslope of the existing embankment and stockpile it for slope dressing for the new fill.



Lewis TWP.
T-74N R-43W
SEC. 18

For Ground Improvement Area
Coordinates Refer to Sheet No. 0.59



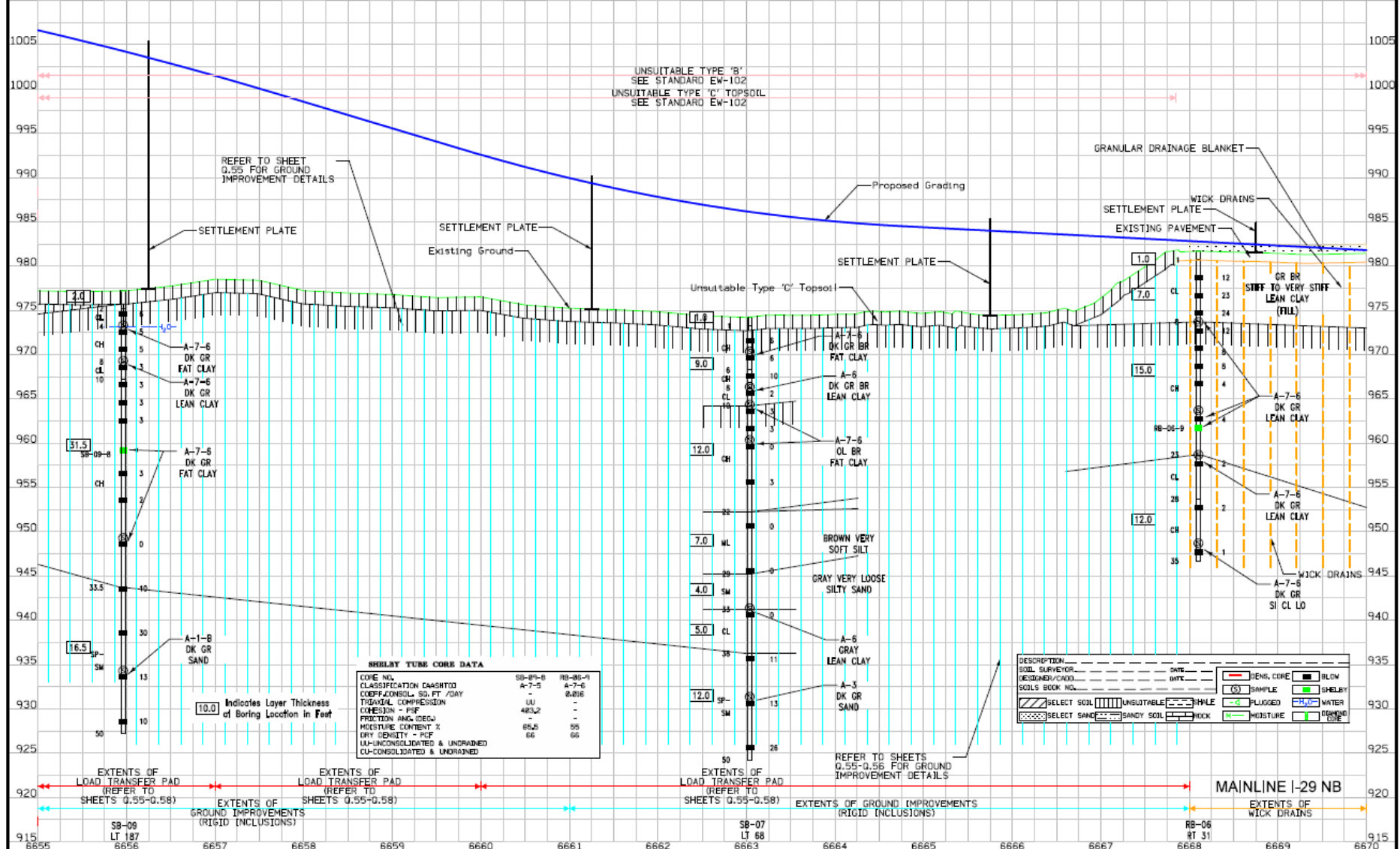
MAINLINE I-29

31,33,55,56,13
21,23,35,28,---

CUT MOISTURE
CUT DENSITY (lb/ft³)
PLASTIC LIMIT

41,46,48,70,48,22
24,20,19,18,19,---

33,50,55,53,39
65,---
23,24,22,23,---



SHELBY TUBE CORE DATA

CORE NO.	CLASSIFICATION	SH-09-8	SH-07-8	RB-06-9
A-7-5	A-7-6	-	-	0.018
COEFF. CONSOL. SO. FT. / DAY	UU	-	-	-
TRIAxIAL COMPRESSION	483.2	-	-	-
PROXION ANG. (DEG)	65.5	55	66	66
MICROTURE CONTENT %	66	66	66	66
DRY DENSITY - PCF	-	-	-	-
UN-CONSOLIDATED & UNDRAINED	-	-	-	-
CU-CONSOLIDATED & UNDRAINED	-	-	-	-

DESCRIPTION

SOIL SURVEYOR	DATE	DRWG. NO.	DATE
DESIGNER/CADD			
SOILS BOOK NO.			

(S) SAMPLE (M) BLOW
 (C) SELECT SOIL UNSUITABLE (H) HOLE
 (D) SELECT SAND SANDY SOIL (W) WICK
 (M) MOISTURE (D) DEMO CORE



I-29 and US 275 INTERCHANG





QUALITY CONTROL – COMPUTER MONITORING

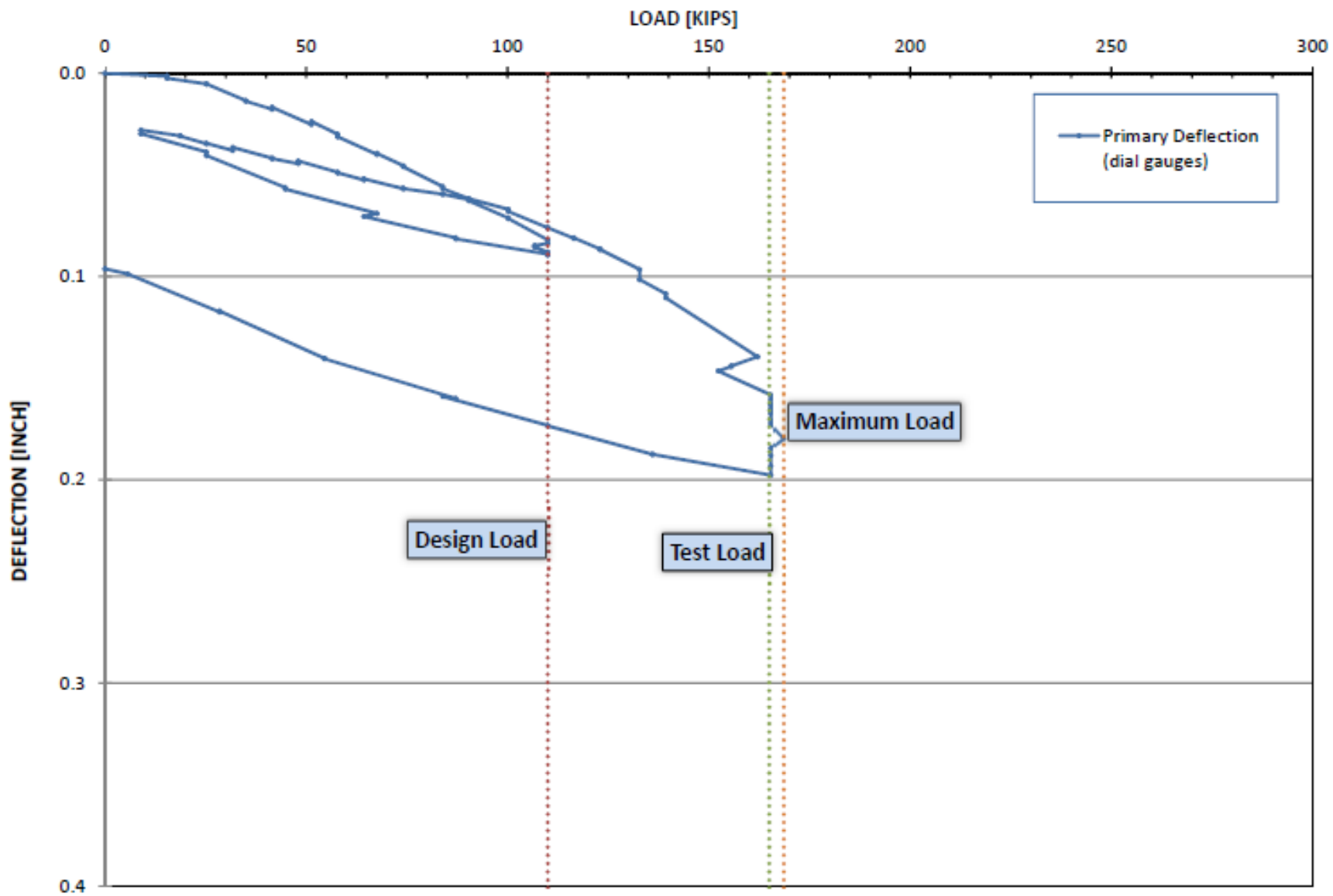


Control panel with multiple buttons and a joystick.

Function	Function	Function	Function
Start	Stop	Emergency Stop	Reset
... (many more buttons)



Load Test #ST8, IDOT (97), October 14, 2014



I-29 and US 275 INTERCH

DGI-Menard
CMC



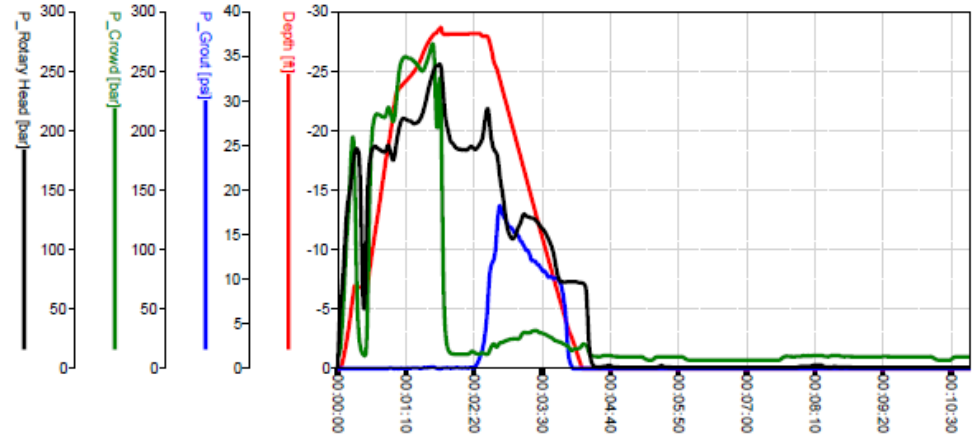
Job Site Data:

Project name: IDOT (97)
 Location: Area 5
 Client: 1115
 Contract Number: Hawkins Construction
 Drill Rig: Enteco 6050 #3

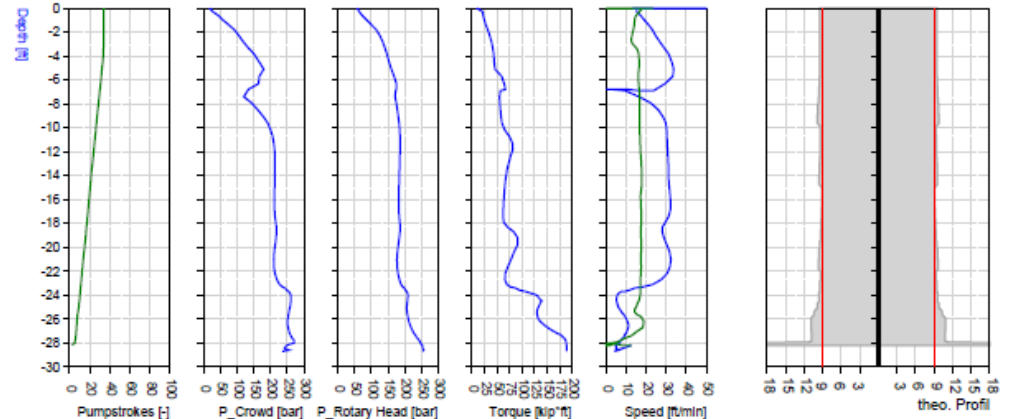
Data for CMC No: ST8

Date: 10/7/2014
 Starttime: 4:15:51 PM
 Endtime: 4:26:40 PM
 Totaltime: 00:10:49
 Pausetime: 00:00:00
 CMC length: 28.67 ft
 CMC diameter: 18 inch
 Theo. Volume: 50.7 ft³
 Act. Volume: 58.8 ft³
 Overbreak: 12 %

Timediagram



Depthdiagram downwards upwards

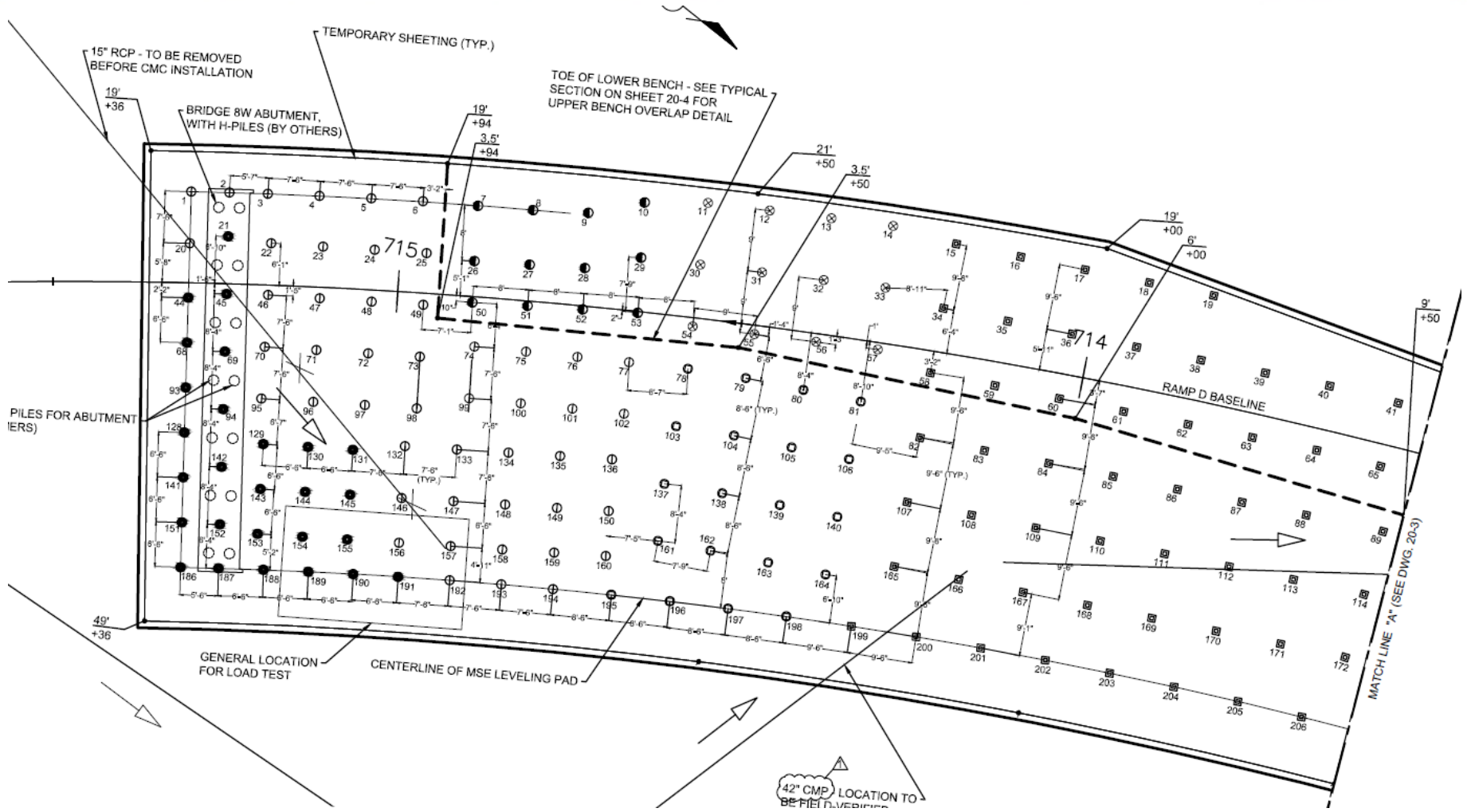


US WICK DRAIN

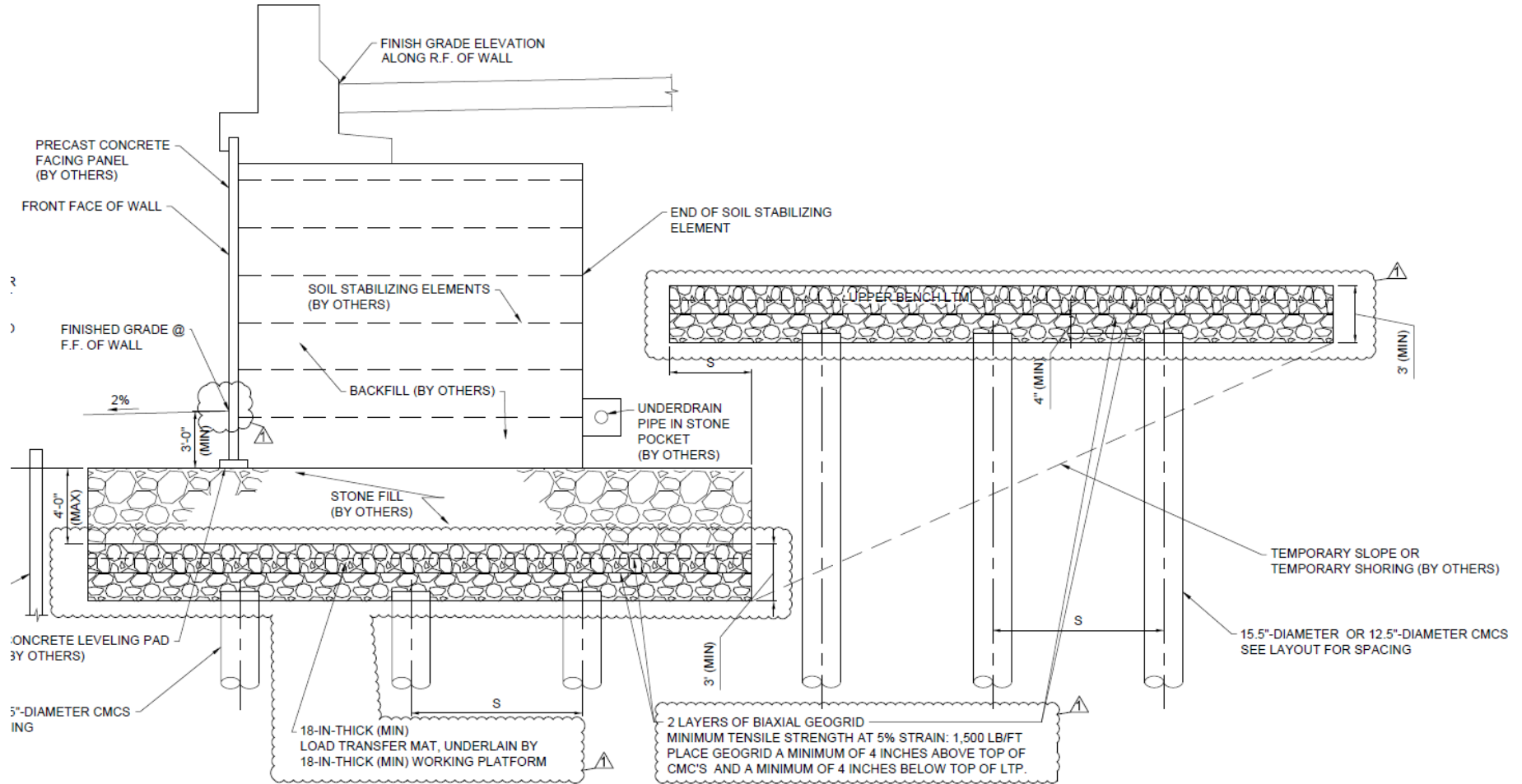
I-295 DIRECT CONNECT PROJECT

- **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





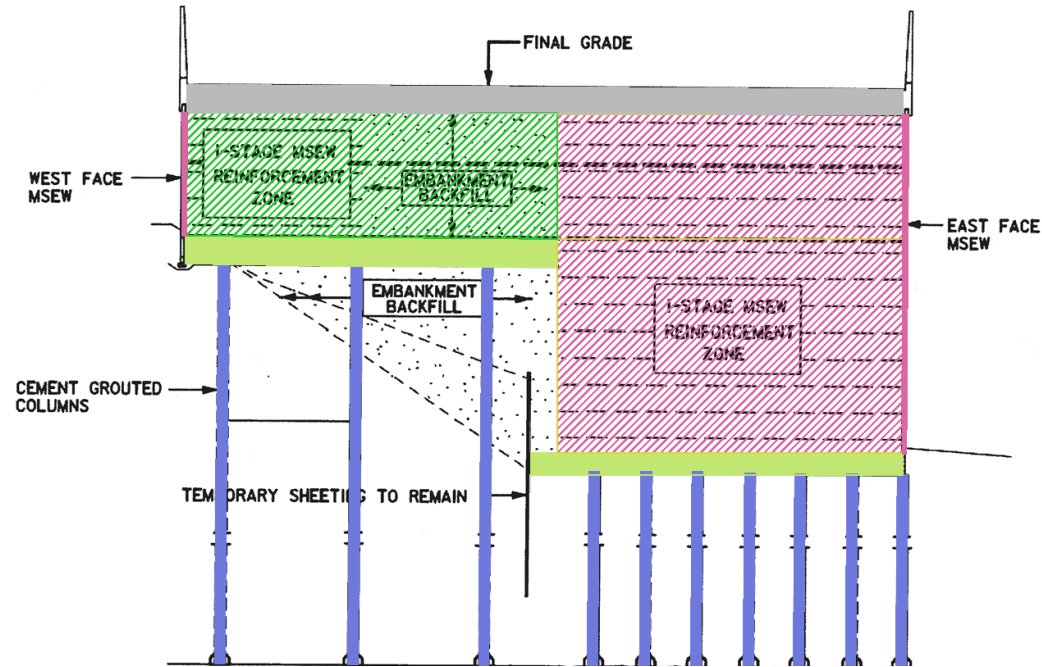
I-295 DIRECT CONNECT PROJECT



I-295 DIRECT CONNECT PROJECT

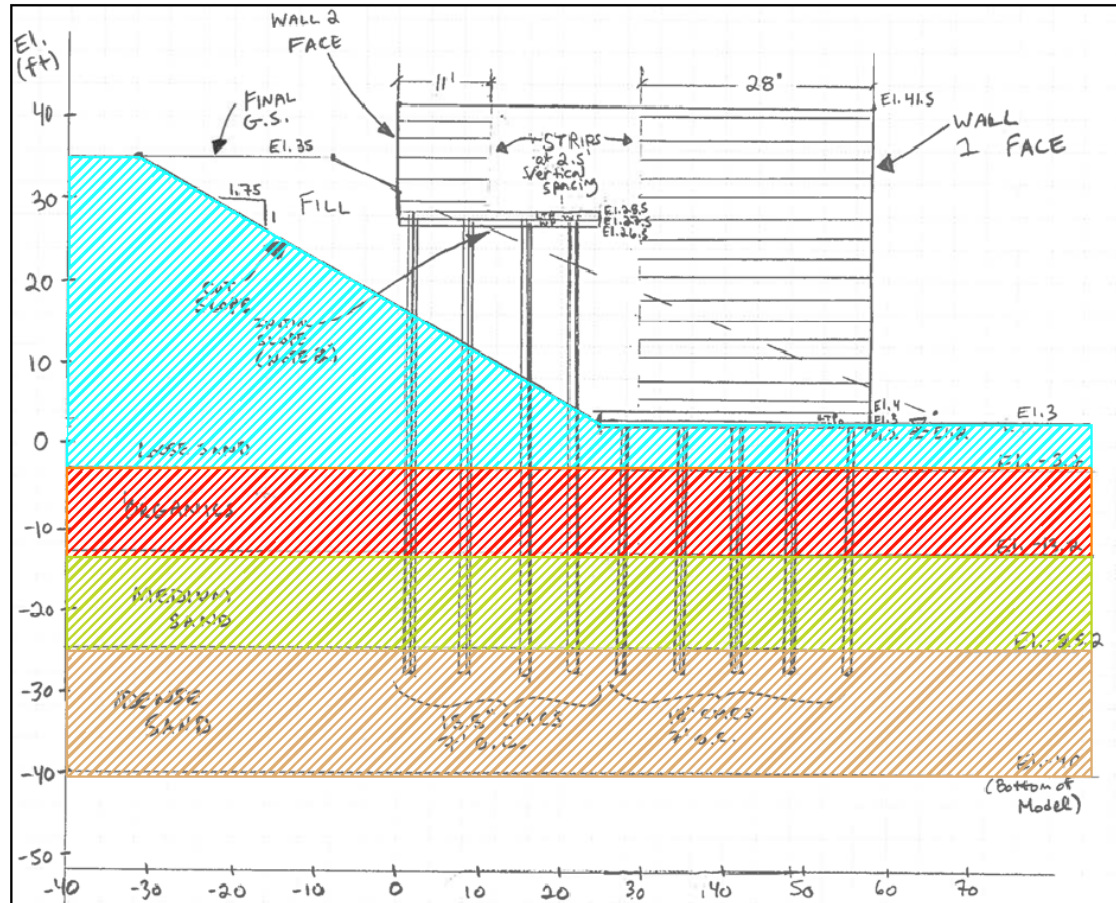
Construction Staging

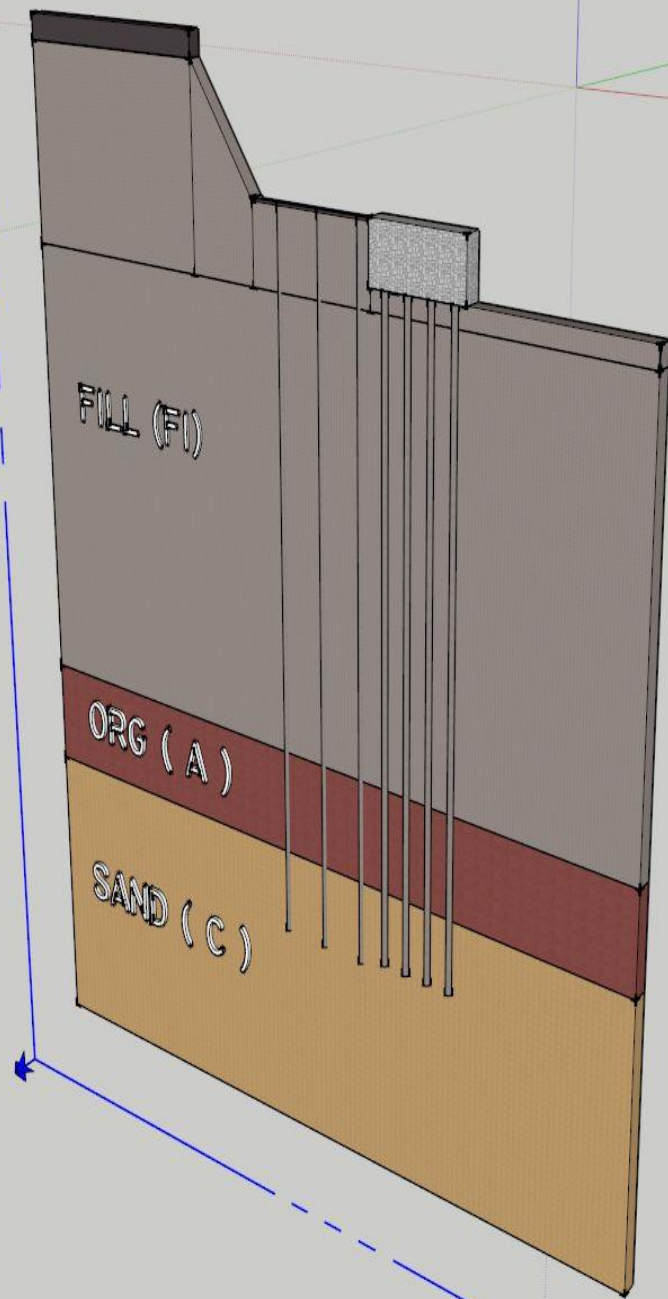
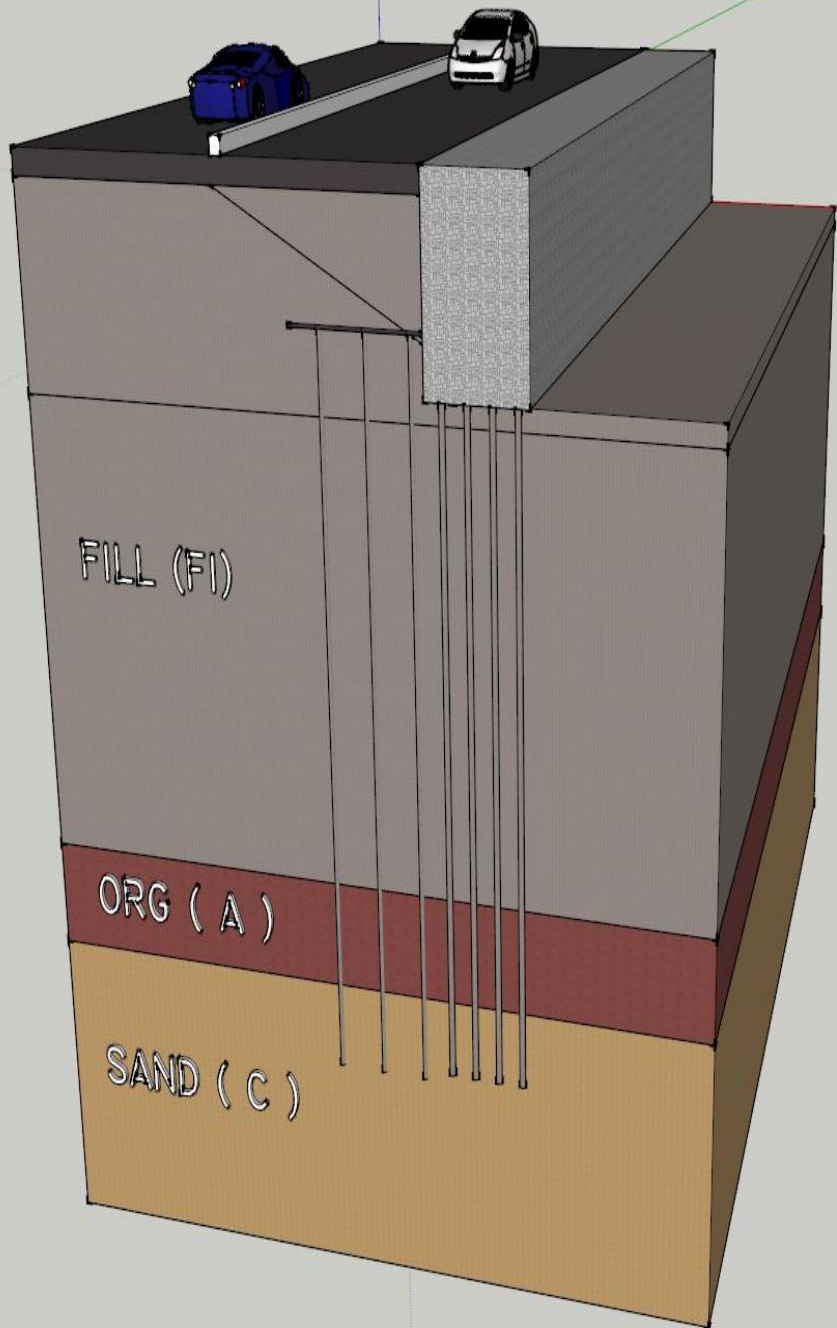
- Cut slope to lower working pad
- Install temporary sheeting, lower working pad
- Install CMCs for lower wall
- Backfill lower wall to upper bench elevation
- Install CMCs for upper wall
- Backfill upper wall to roadway elevation
- Finish grade, place pavement



I-295 DIRECT CONNECT PROJECT

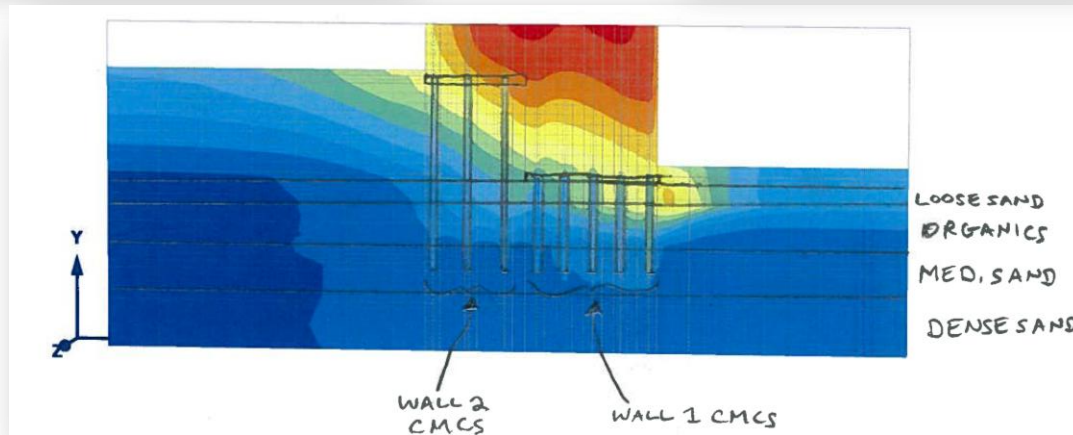
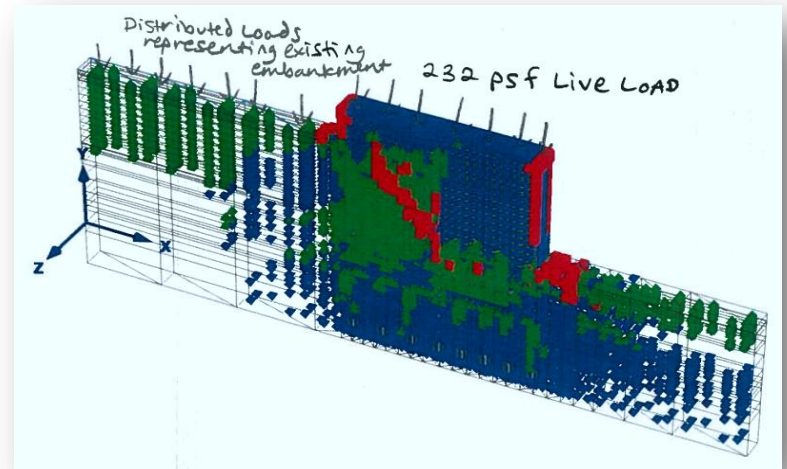
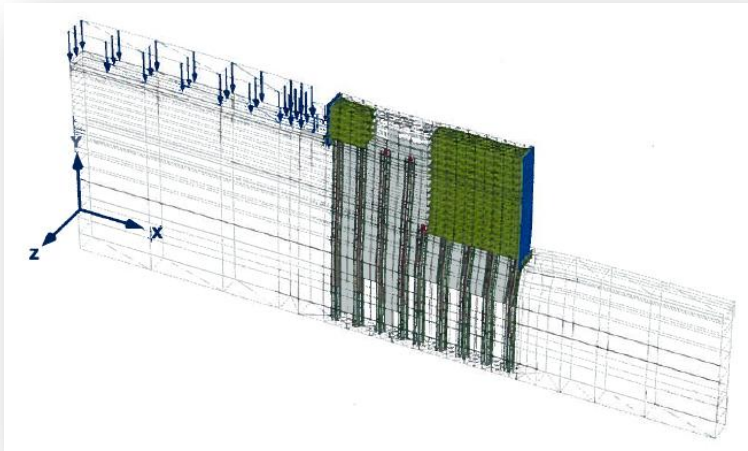
Modeled Soil Profile



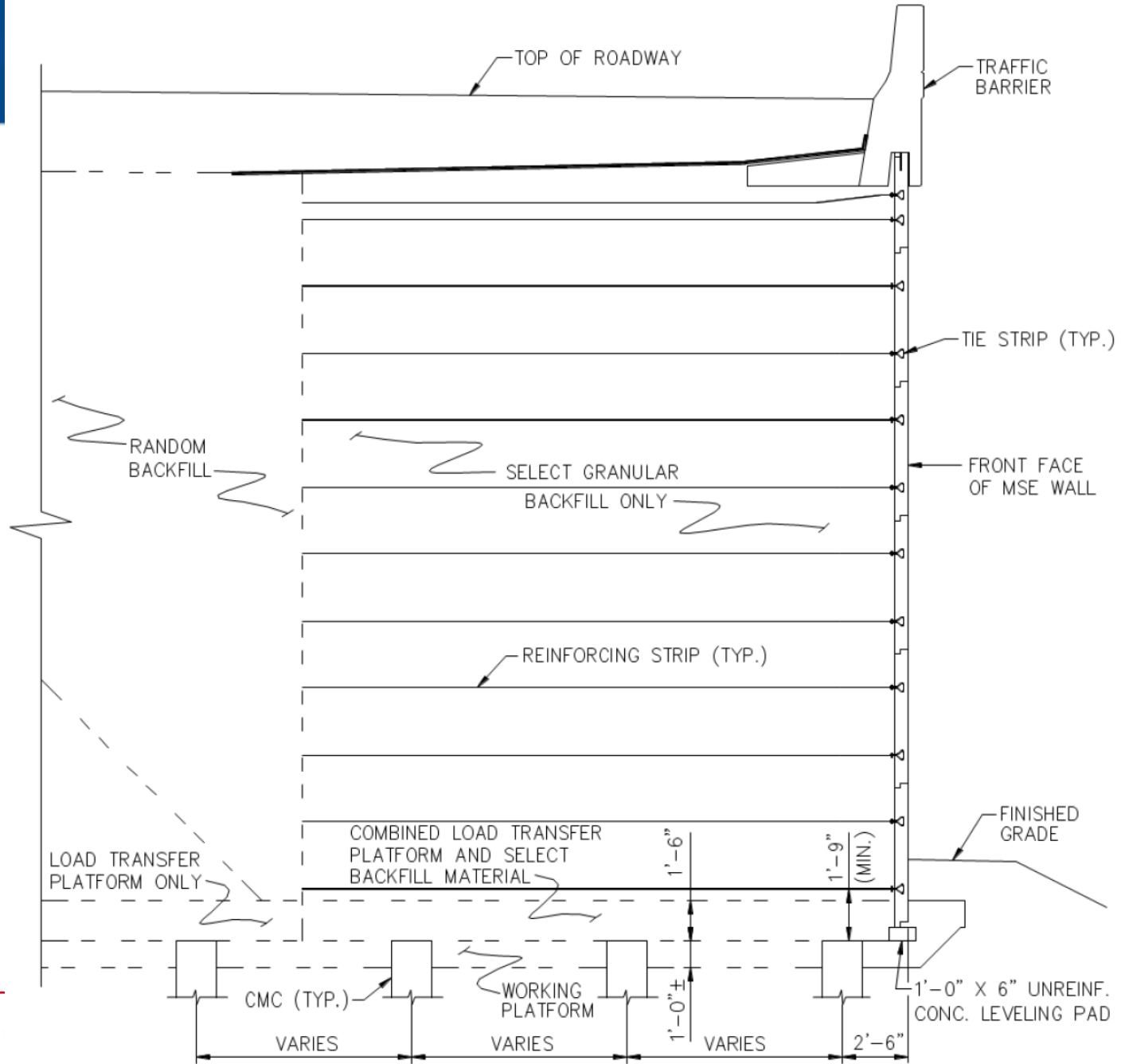


I-295 DIRECT CONNECT PROJECT

Plaxis Results



I-295 DIRECT



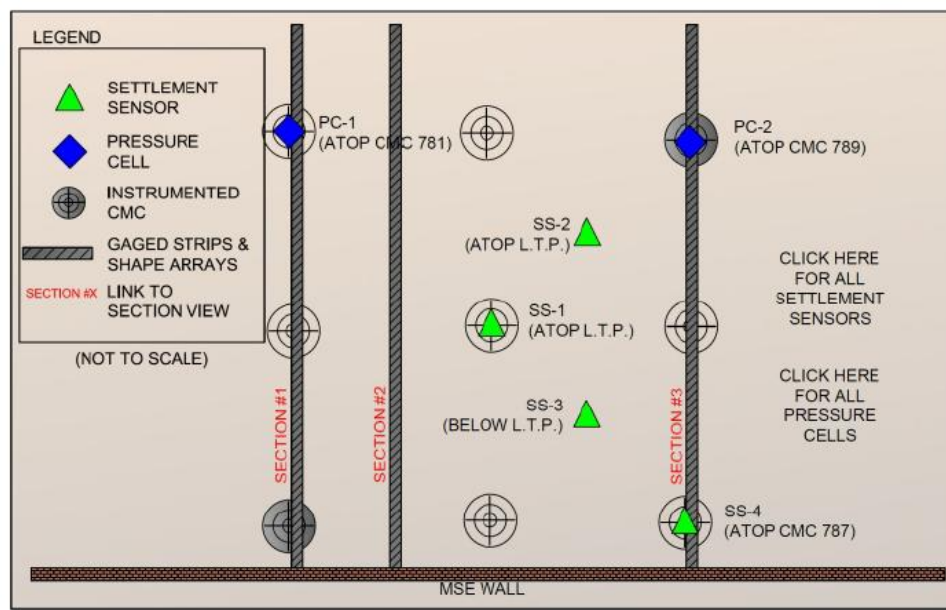


Figure 4. Plan view of the instrumentation

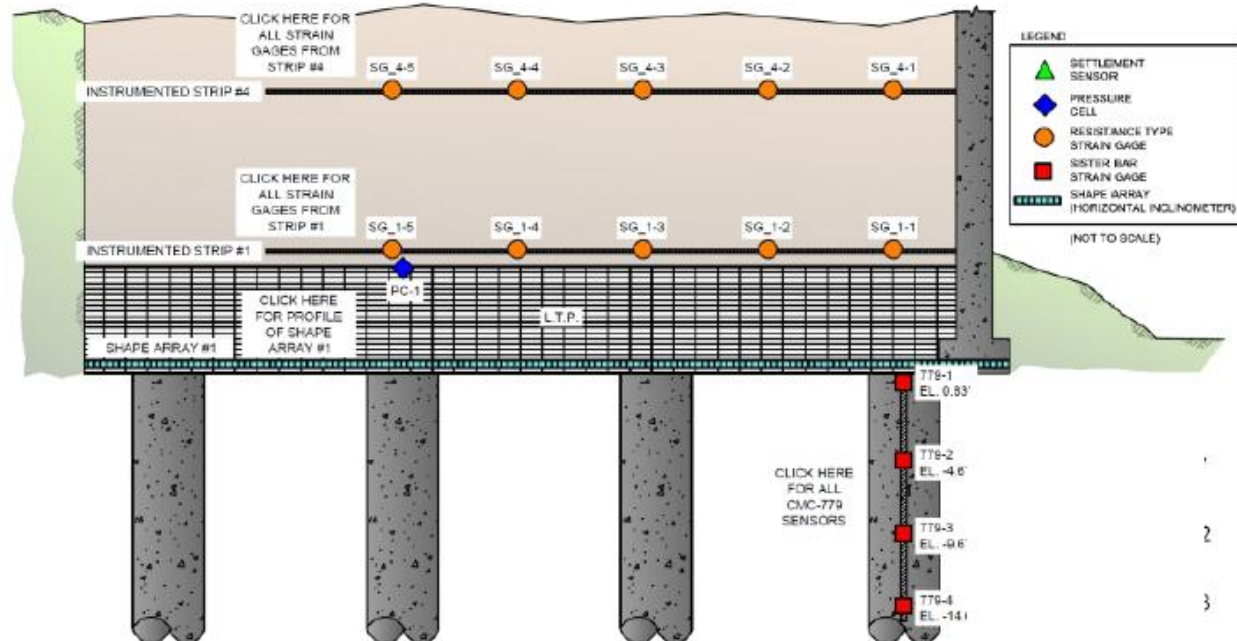
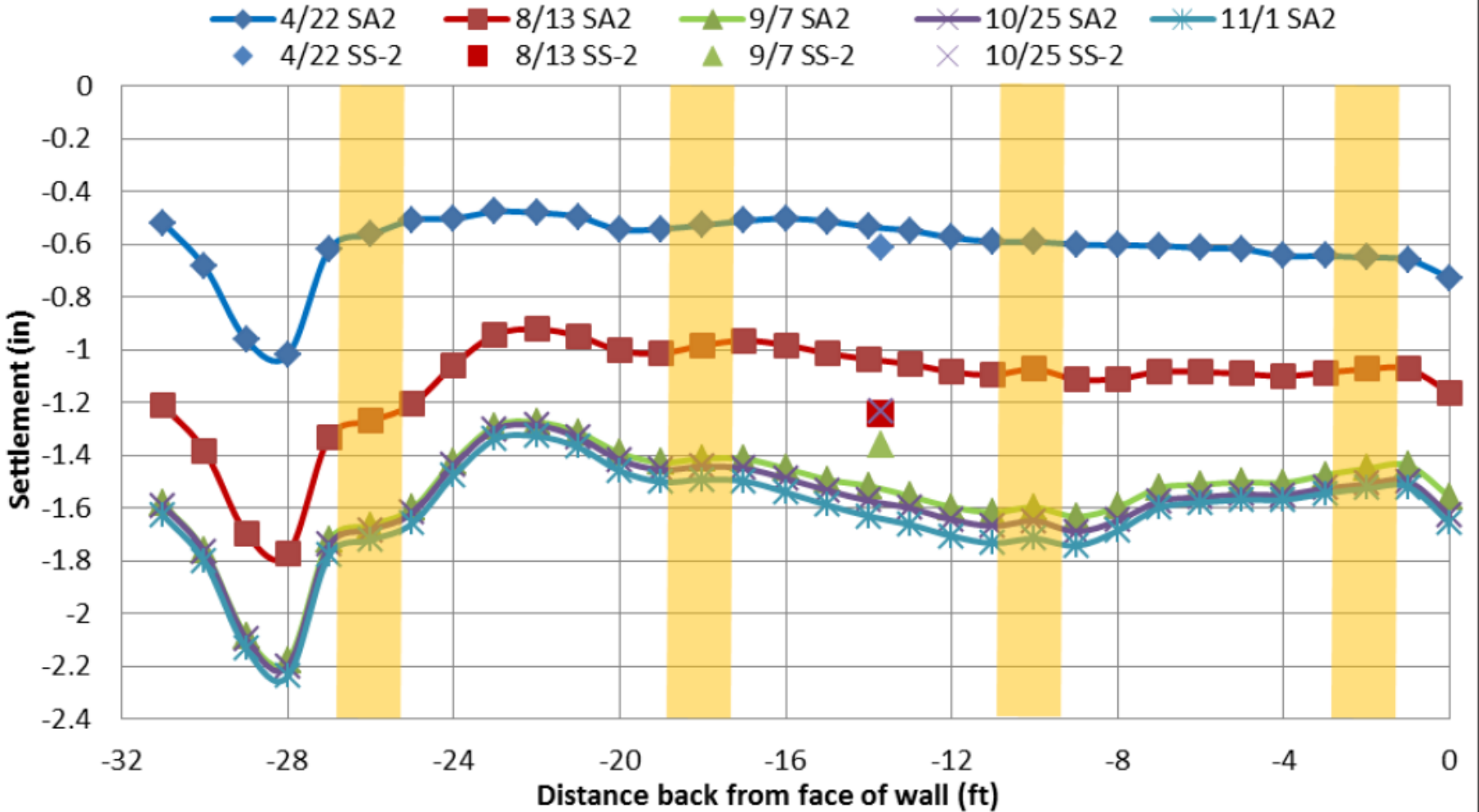


Figure 5. Section #1 of the instrumentation.

I-29 and US 275 INTERCHANGE PROJECT

Adjusted Shape Array 2 between CMCs at El. 3.1

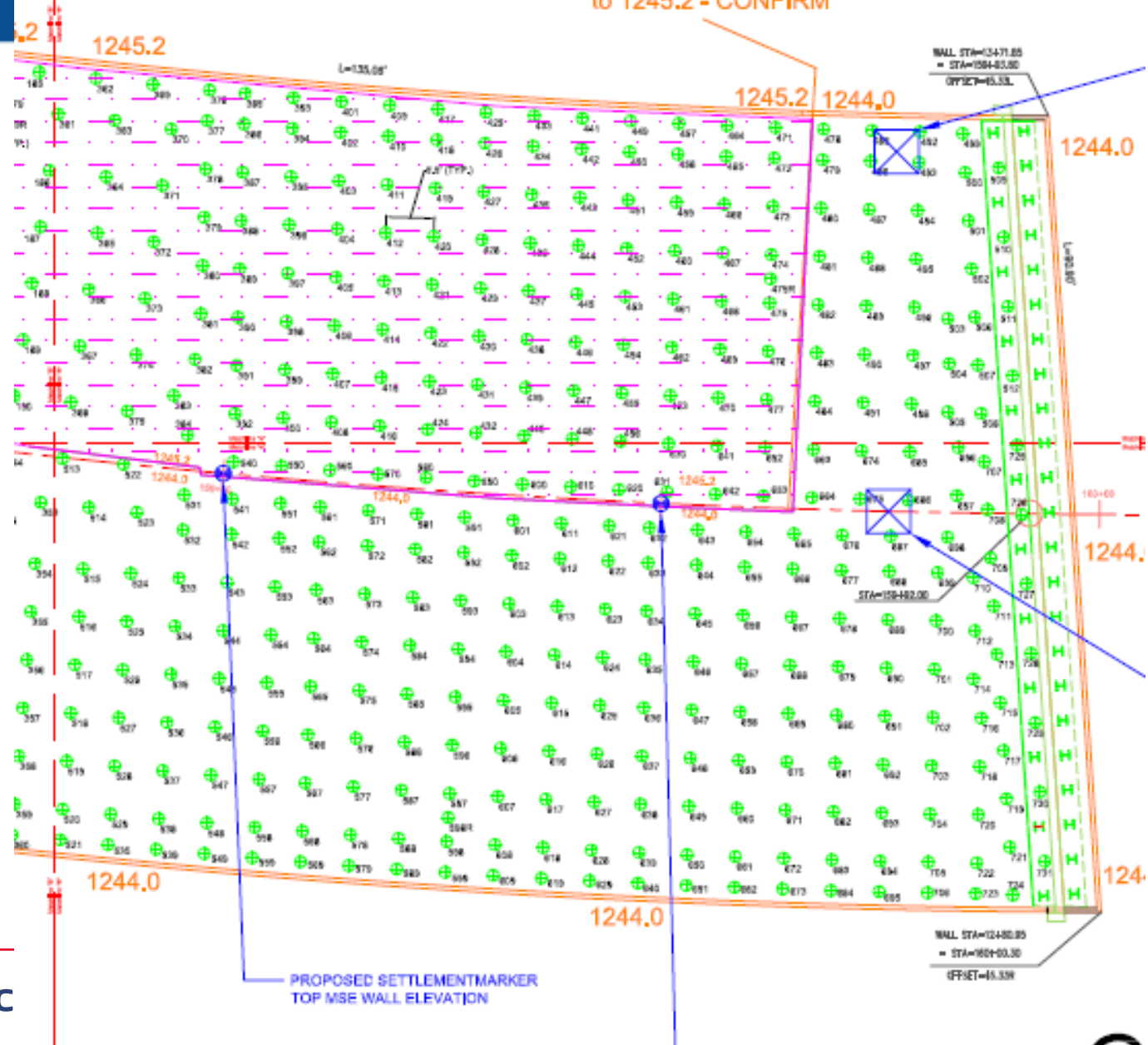


ERICSON AVENUE PROJECT

- **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

Sta. 13+99
Proposed raise of
working pad from 1244
to 1245.2 - CONFIRM



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!**