ACCELERATED ROADWAY CONSTRUCTION:
Rigid Inclusions for Support of Embankments and MSE Walls in Soft Ground

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First Things First
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
• **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

100% of the load in the piles. No load in the soil.

Share of the load between column and soil.
Uniform Load (building/embankment)

- Load Transfer by Arching
  - 5 - 30% of load on soil

- Load Transfer by skin friction
- Limited settlement

- 70 to 95% of load in CMC

Controlled Modulus Columns

Load Transfer Platform
REMINDER FROM THE PAST

BEFORE SETTLEMENT

Arrows show direction of flow of water to and from vertical Sand Drains during filling and overloading period.
WICK DRAINS

INSTALLATION OF PREFABRICATED VERTICAL DRAINS

- Mast
- Crane
- Drain Roll
- Drain
- Casing (mandrel)
- Anchor plate
- 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.
CONSTRUCTION SEQUENCE FOR WICK DRAINS & ROG inclusion 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 seven days prior to installation of the rigid inclusions to allow the interface zone to expand. Additional time may be required to ensure potential additional swelling lead to the rigid inclusions.
3. The embankment fill on top of the wick drains shall be placed with a temporary HV slope at the interface zone.
4. Rigid inclusions adjacent to the "Wick Drain/ROG inclusion interface zone" shall be installed 90 days after completion of the construction of wick drains and embankment fill on top of the wick drains.
QUALITY CONTROL – COMPUTER MONITORING
### Job Site Data:

- **Project Name:** I-29 (67)
- **Location:** Area 5
- **Client:** 1119
- **Contract Number:** Hawkins Construction
- **Drill Rig:** Enteco 050 #3

### Data for CMC No: STB

- **Date:** 10/7/2014
- **Start Time:** 4:15:51 PM
- **End Time:** 4:20:43 PM
- **Total Time:** 00:00:52
- **Pause Time:** 00:00:00

- **CMC Length:** 28.67 ft
- **CMC Diameter:** 10 inch
- **Theo. Volume:** 50.7 ft³
- **Act. Volume:** 58.8 ft³
- **Overbreak:** 12 %

### Timediagram

![Timediagram](image)

**Legend:**
- Depth
- **P_Crown** (bar)
- **P_Rotary Head** (bar)
- **Torque** (lbf-ft)
- **Speed** (rpm)

**Graph:**
- Graph shows depth progression over time, indicating pumping volume and speed changes.

### Depthdiagram

![Depthdiagram](image)

**Legend:**
- Downwards
- Upwards

**Graphs:**
- Various graphs showing depth changes with time and associated parameters such as pump strokes and torque.
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
**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

![Diagram of Modeled Soil Profile](image-url)
Mullica River
Typical section
3D Model Plan View – Slice Through Entire Embankment
I-295 DIRECT CONNECT PROJECT

Plaxis Results
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

Adjusted Shape Array 2 between CMCs at El. 3.1

Distance back from face of wall (ft)

Settlement (in)
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.
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
Thanks to STGEC and ALDOT!