Roadway and Approach Embankment Ground Improvement Applications

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Outline

- What is the Geopier® system?
- How do they behave?
- How are they constructed?
- What are potential applications?
- Recent Alabama DOT projects
What is the Geopier® system

- Ground modification system
- Comprised of gravel
- Behaves differently than deep foundation piles
- Geopier the only **Rammed** Aggregate Pier®
- Ramming makes the difference
What is the Geopier® system

- Multiple technologies to address a range of soil conditions
- Proven performance – Over 25 DOTs
- Accelerated construction schedules
- Cost-effective and Flexible solution
- Design-build capabilities
- Construction is clean – little to no mess to clean up
- Eliminates unfavorable design requirements
Roadway and Embankment Applications

- RAP transportation solutions for 25+ DOTs
- Over 50 projects and 100 MSE walls for DOTs
- **Only ground improvement technology with HITEC evaluation**
- High levels of quality control / verification testing
- In-house design build solutions by P.E.’s
Engineering Support

- Kord Wissmann, PhD, PE, D.GE – Chief Engineer
- Brian Metcalfe, MS, PE – VP of Engineering
- Rupesh Kadam, MS, PE – Area Manager
- Bill Beckler, MS, PE, GE – Region Engineer
- Mandi Petrella, MS, PE – Region Engineer

ROADWAY AND EMBANKMENT APPLICATIONS
Behavior
Increases lateral stress (lateral confinement) in the matrix soil to resist bulging of the Geopier® element when loaded.
The installation method pre-strains the soil.

Similar to surcharging the soil without the surcharge load or time duration.
Measure stiffness with modulus test
MODULUS TEST RESULTS

![Graph showing MODULUS TEST RESULTS]

- **Deflection**
  - 0.000
  - 0.200
  - 0.400
  - 0.600
  - 0.800
  - 1.000

- **Applied Geopier Stress (psf)**
  - 0
  - 5,000
  - 10,000
  - 15,000
  - 20,000
  - 25,000
  - 30,000

- **Roadway and Embankment Applications**

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**Legend**
- **Bottom of Geopier**
- **Top of Geopier**
- **Unload**
Construction
Roadway and Embankment Applications

**Rammed Aggregate Pier® Systems**

- **GP3® System**
- **Impact® System**
- **Rampact® System**
- **X1® System**
Rammed Aggregate Pier® Systems

GP3® System
Roadway and Embankment Applications

Excavate cavity

Open-graded stone

Tamp bottom bulb
Rammed Aggregate Piers

- Creation of stiff RAP in matrix soils.
- Undulated shape
- Lateral pressure increase along pier increases frictional shear resistance
Geopier drill
Geopier Tamper
Skid steer

Mobile crew (4 people, 3 to 4 machines)
Rapid installations (30 – 100 per day)
24-inch to 30-inch installation diameter
Rammed Aggregate Pier® Systems

Impact® System

Roadway and Embankment Applications
Clean dry method.
Well-suited for high-groundwater conditions.
Eliminates the need for casing.
Roadway and Embankment Applications

- Displacement method
- Depths up to 45 ft
- Dry process (no water jetting)
- No spoils (brownfield sites)
- Rapid installations (40 – 100 piers per day)
Positive lateral displacement:
Densifies and pre-stresses the matrix soil
Further stiffens the densely compacted lifts.
Rammed Aggregate Pier® Systems

X1® System

Roadway and Embankment Applications
Same soils as GP3® system.

 Depths up to 45 ft (no tripping out of hole).

 Rapid installations (30 – 50/ day)

 Good in mixed soils.

 Eliminate casing risk
Step 1. Drill hole.
Step 2. Backfill with 1 lift of clean stone.
Step 3. Build bottom bulb. Leave mandrel in the hole.
Step 4. Fill the hole partially.
Step 5. Raise mandrel and allow stone to pass through the head.
Step 6. Drive mandrel down to compact the aggregate.
Step 7. Repeat steps 5 and 6 to the top of pier elevation.
WHERE CAN RAP® ELEMENTS BE USED?
Roadway and Embankment Applications

**Embankment Support**
- Increased global stability
- Settlement control
- Accelerated settlement

**MSE Wall Support**
- Stability Improvement
- Bearing capacity increase
- Settlement control
- Accelerated settlement
• High friction angle of RAPs increase resistance
• Install at spacing to achieve design FoS
• $\phi_{\text{comp}} = \arctan [R_a \tan(\phi_g) + (1-R_a) \tan(\phi_{\text{soil}})]$
Roadway and Embankment Applications

- Highway Approach-Ramp Stabilization
- Reinforce unstable slopes
- Provide bearing support for MSE Walls
- Reduce bump at the end of bridges
- Support box culverts
Roadway and Embankment Applications

**Direct Results**

**Full-scale top-of-pier direct shear test results**  
(Fox and Cowell 1998)

Friction angle = 48 degrees (o/g stone)  
= 52 degrees (w/g stone)

**Laboratory triaxial shear tests**  
(White et al 2002)
Roadway and Embankment Applications

Birmingham Northern Beltline

*Birmingham, Alabama*

- 1700 ft MSE wall up to 32 feet high next to Self Creek.
- 1380 Geopier elements installed.
- 10 to 15 ft of very soft silty clay with isolated areas of 40 ft of very soft silty clay.

Owner: ALDOT
Geotechnical Engineer: AMEC
General Contractor: Wright Brothers Construction
I-59 / I-20 Interchange and Bridge Replacement

*Birmingham, Alabama*

- 6 ramps. Ramps 2, 3, 4, 10, 13, 14
- 4200 Geopier elements installed.
- Clay fill overlying fat clay.

Owner: ALDOT
Geotechnical Engineer: Terracon, AMEC,
General Contractor: Granite Joint Venture
**Roadway and Embankment Applications**

*I-65 Widening, Shelby Co, AL*

*I-40 / I-240 MSE Walls, Memphis, TN*

*Loop 363 at IH-35 MSE Walls, Temple, TX*

*US90 at SH6 MSE Walls, Sugarland, TX*

*Picardy Ave / I-10 MSE Walls, LA*

*US392 & I-25 MSE Wall & Embankment, CO*

*I-40 / I-55 Interchange, W. Memphis, AR*

*I-69 Mainline MSE Wall, IN*

*US169 & I-494, MN*

*Highway 880 MSE Wall, CA*

*I-235 / 50th St. MSE Walls, Des Moines, IA*

*I-70 / I-270 MSE Wall, St. Louis, MO*

*Route 162 MSE Walls, Troy, IL*