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Geotechnical Instrumentation and Monitoring System for I-20 Embankment Kershaw County, South Carolina

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SCDOT South Carolina Department of Transportation

GeoStellar Engineering

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Outline

- Introduction
- Project Background
- Instrumentation System
- Instrumentation Installation
- Online Automated Instrumentation Data Management System
- Remarks

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Introduction

- Types of Geotechnical Instruments
  - Lateral deformation – inclinometers (manual probe or in-place automated sensors)
  - Vertical deformation – settlement plates, settlement cells, and rod extensometers
  - Porewater pressure – piezometers
  - Stress in soil – earth pressure cells


Piezometer


Inclinometer Probe


Settlement Cell


Earth Pressure Cell

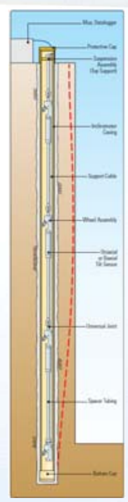
In-Place Inclinometer

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Photo source: www.slopeindicator.com

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Introduction

- Benefits of Geotechnical Instrumentation
  - Demonstration of Satisfactory Performance
  - Detection of Unusual Conditions or Impending Failure
  - Diagnosis of Unsatisfactory Performance
  - Quality Control of Construction and Operations
  - Prediction of Future Performance
  - Support of Litigation
  - Advancement of State-of-Knowledge

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Site Location

Site is located ~40 miles to the east of Columbia, SC on Interstate 20 (I-20).

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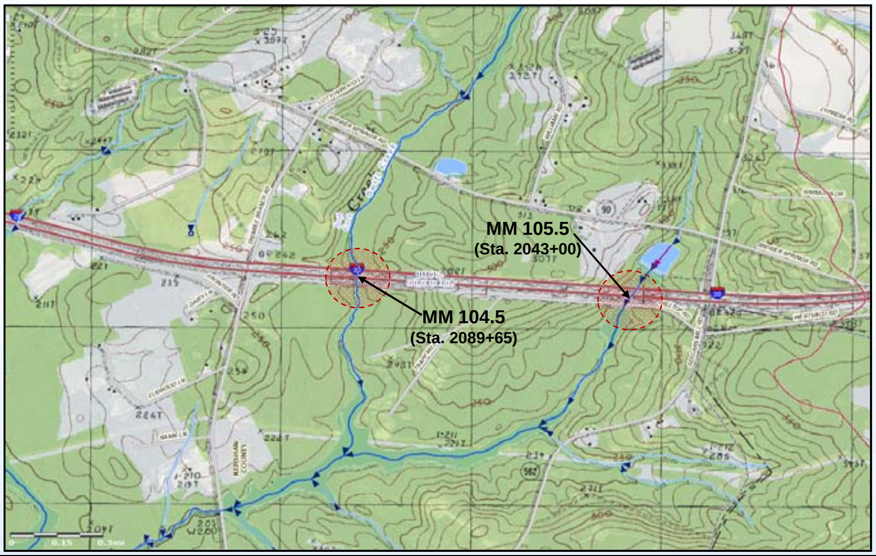
Project Site Topo



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Cracking

Photos were taken on Dec. 5, 2012.

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Organic Soil

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Scope of Services for Instrumentation

- Propose type and locations of geotechnical instrumentation
- Design, install, and maintain an automated centralized data management system capable of collecting, providing web based, real time geotechnical instrumentation data
- Analyze data collected (up to 3 years)

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Motivation of Geotechnical Monitoring

Cause of Pavement Distress

- Incomplete removal of peat layer (low shear strength)?
- Compression of peat layer (high compressibility)?
- Seasonal variation of water table?
- Imminent slope instability?
- Progressive creep?

Geotechnical mechanisms

- Settlement;
- Long-term creep;
- Slope instability; or
- A combination of above.

Efficient Rehabilitation

- Monitor and maintain
- Reduce driving forces
- Increase strength
- Decrease compression
- Remove and reconstruct

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Instrumentation Components

- 4 In-place Inclinometers (ShapeAccelArray or SAA)
  - Each inclinometer is installed to a depth of ~60 ft.
- 2 Vibrating Wire Extensometers
  - Each extensometer has 4 anchors, installed at depths of 3 ft, 20 ft, 35 ft, and 60 ft.
  - Each anchor is connected to a rod, which is monitored by a sensor at the ground surface.
  - The 20-ft and 35-ft rods bracket the soft organic layer, capturing the settlement of the organic layer.
- 4 Piezometers
  - Each piezometer is installed at a depth of ~60 ft.
- 67 Fixed Monuments

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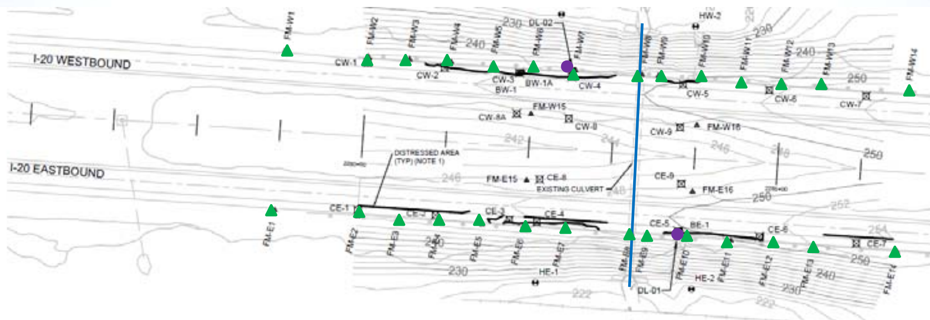
MM 104.5 Instrumentation Plan



- ▲ Fixed monument
- ● Automated instrument cluster
- — Culvert

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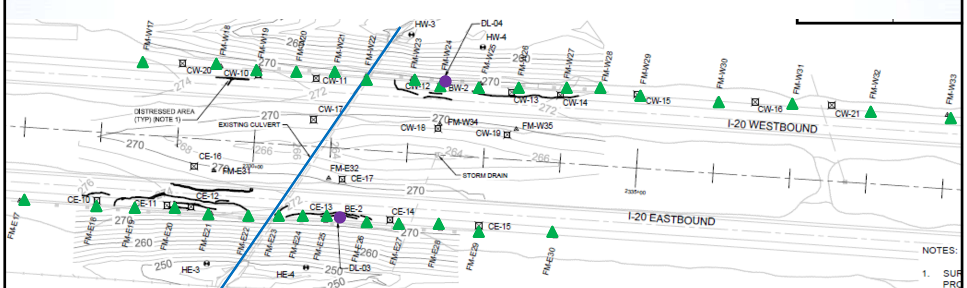
MM 105.5 Instrumentation Plan



- ▲ Fixed monument
- ● Automated instrument cluster
- — Culvert

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Datalogger System

- The datalogger system automatically collects data from the piezometers, inclinometers and rod extensometers.
- 4 datalogger systems (CR1000 dataloggers)
  - @ MM 104.5 EB and WB
  - @ MM 105.5 EB and WB
- RF401 Radio
  - Allows datalogger stations to communicate with each other
- RAVENXTV Airlink Modem
  - Allows remote access to the dataloggers
  - Allows datalogger stations to upload data to an online FTP site

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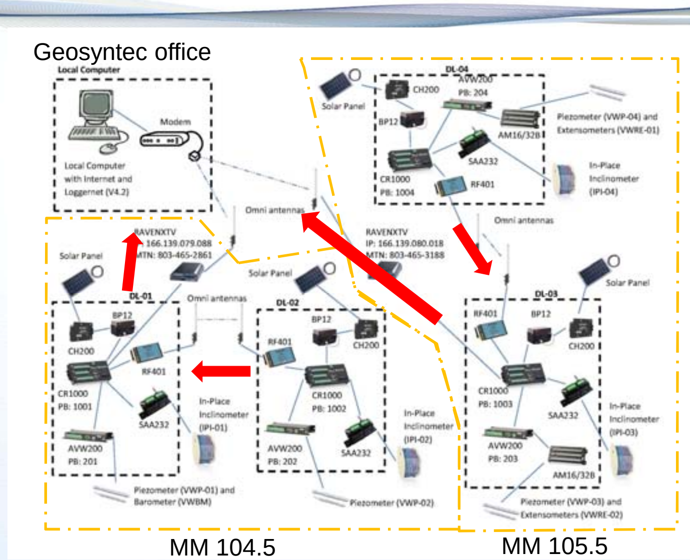
Network Diagram



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Field Installation

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Installed Datalogger Stations

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Datalogger Programming

1. Take readings from instruments every 6 hours
2. Convert readings to engineering units and calculate rates
3. Store readings in tables
4. Compare readings and rates to pre-established thresholds
5. If threshold is exceeded, take a new reading and send out an alert email
6. Store alert status and any new readings in alert tables

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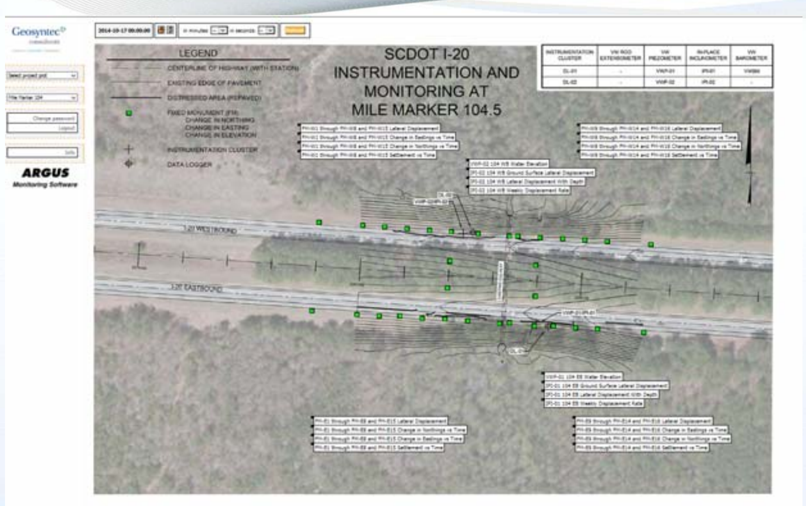
Online Automated Instrumentation Data Management System (AIDMS) Interface



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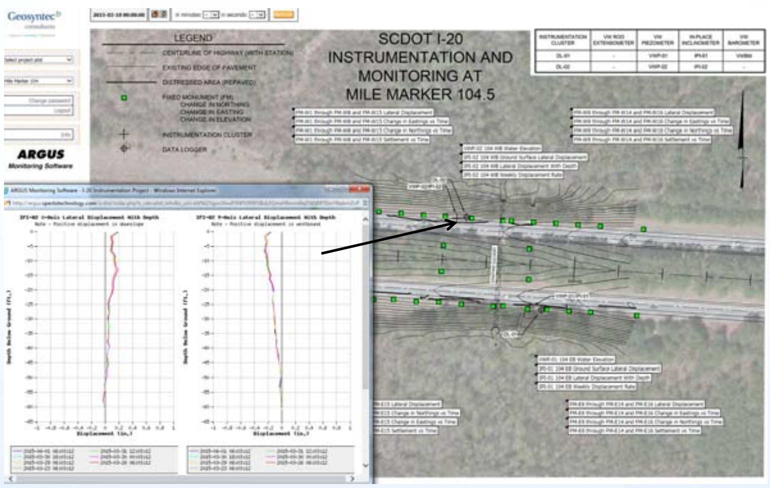
Inclinometers – Lateral Deformation Profiles



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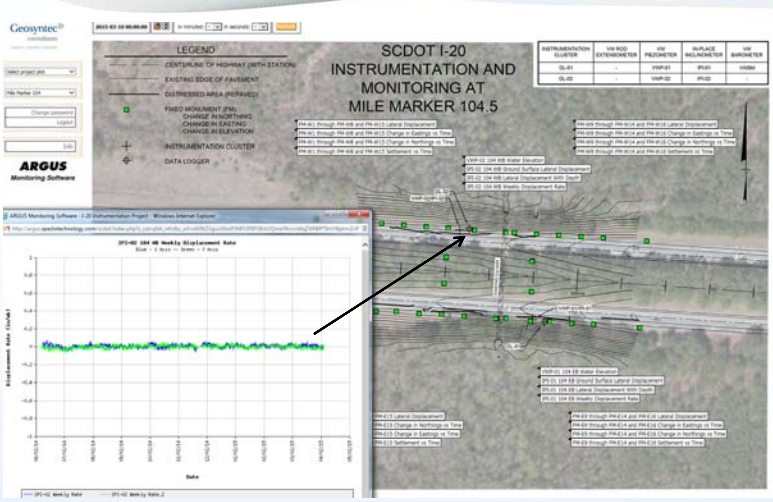
Inclinometers – Weekly Displacement Rate vs. Time



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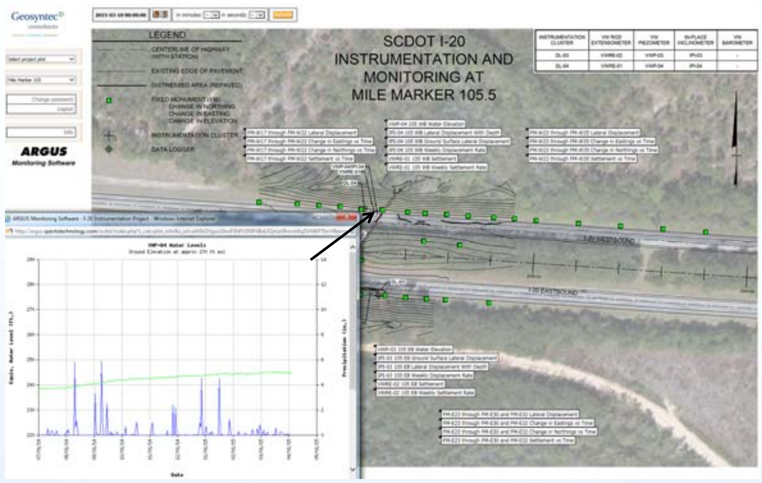
Piezometer Readings and Precipitation



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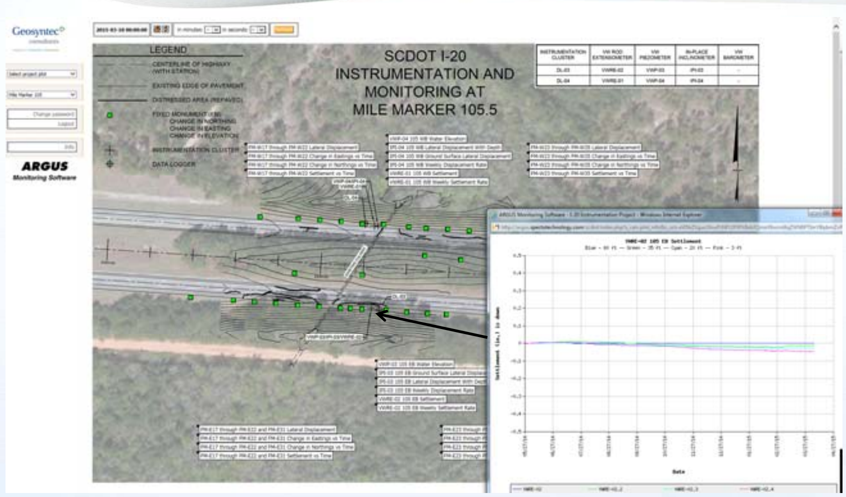
Extensometer Readings



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Remarks

- The total cost of the automated system is about $330k, including equipment, materials, installation, data collection and reporting, and system maintenance for a period of 3 years (readings every 6 hours).
- It was estimated that a manual system would cost approximately $390k for the same monitoring period (readings 1 to 2 times a week).
- An automated system provides continuous, reliable, nearly real-time data, and automatic early warnings. Several factors should be considered to select an automated system or a manual system, including site conditions and accessibility, availability of staff, monitoring requirements (period and frequency), data quality, consequence of failure, and availability of funding.

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Remarks

- Lesson learned #1 – continuous data collection can drain the battery quicker than expected:
  - Dataloggers are only turned on four times a day to collect data and relay information to the host computer.
  - Ensure solar panels are installed at an orientation that maximizes sunlight.
  - Backup batteries
- Lesson learned #2 – adequate water drainage in instrumentation vaults is needed to protect non-waterproof sensors:
  - Replace clayey soil with coarse material and/or use drainage pipes.

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Thanks!

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