Performance of Geosynthetic Reinforced Soil Integrated Bridge Systems (GRS IBS)

October 24, 2016
TRB Webinar

Sponsor: Geosynthetics Committee (AFS70)
Cosponsor: Transportation Earthworks Committee (AFS10)

Jennifer Nicks, P.E., PhD – Federal Highway Administration
Christopher Meehan, P.E., PhD – University of Delaware
Derrick Dasenbrock, P.E. – Minnesota DOT
Peter Connors, P.E. – Massachusetts DOT
Daniel Alzamora, P.E. – Federal Highway Administration
# Agenda

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 min</td>
<td>Introduction and technology overview</td>
<td>Jennifer Nicks, P.E., PhD Federal Highway Administration</td>
</tr>
<tr>
<td>15 min</td>
<td>Chesapeake City Road, DE (2013)</td>
<td>Christopher Meehan, P.E., PhD University of Delaware</td>
</tr>
<tr>
<td>15 min</td>
<td>CR 55 over Minnesota Southern RR, MN (2013)</td>
<td>Derrick Dasenbrock, P.E. Minnesota DOT</td>
</tr>
<tr>
<td>15 min</td>
<td>RT 7A Over Housatonic RR, MA (2014)</td>
<td>Peter Connors, P.E. Massachusetts DOT</td>
</tr>
<tr>
<td>5 min</td>
<td>Summary of GRS IBS performance &amp; national deployment efforts</td>
<td>Daniel Alzamora, P.E. Federal Highway Administration</td>
</tr>
<tr>
<td>25 min</td>
<td>Questions and Answer Sessions</td>
<td>Panel</td>
</tr>
</tbody>
</table>
Introduction and technology overview

Jennifer Nicks, P.E., PhD – Federal Highway Administration
What is GRS IBS?

- Accelerated construction technique
- Utilizes compacted granular fill and geosynthetic reinforcement in alternating layers for bridge support
GRS – Composite Material

Concrete

- Aggregate
- Water
- Cement

GRS

- Aggregate
- Closely-spaced geosynthetics
Steel reinforcement (rebar) provides the tensile strength

Concrete

- Steel reinforcement (rebar) provides the tensile strength

- Geosynthetic reinforcement provides tensile strength (and added compressive strength)

\[ A_s = \beta_1 c \]

\[ C = 0.85 f'_cab \]

\[ d-a/2 \]

\[ T = A_s f_y \]

\[ S_v = 32'' 28'' 24'' 20'' 16'' 12'' 8'' 4'' \]

GRS

Concrete

Geosynthetic reinforcement provides tensile strength (and added compressive strength)

\[ S_v = 16'' \]

\[ S_v = 8'' \]
GRS IBS – Composite Design

**GRS Abutments**

- Spacing and properties of the reinforcement plays a role in strength and serviceability.
- The backfill and facing element also play a role in developing a unique composite with measurable properties that can be used in design.
Reinforced Backfill

Open Graded Fill

Well Graded Fill
Geosynthetics

Geogrids

Geotextiles
Facing Element
Why Consider the GRS IBS

- Lower costs (20-60%)
- Accelerated bridge construction
- Smooth transition alleviated the “bridge bump”
- Good performance
Where to Consider the GRS IBS

- **Grade separations**
  - Grade crossings of road, rail, trails

- **Water crossings**
  - Creeks, rivers, flood plains, tidal zones

- **Low volume local roads**

- **High volume and high loads**

- **Bridges under various load combinations**
  - e.g. seismic, lateral, thermal, uplift

- **Unusual geometries**
  - e.g. skew, longitudinal grades, transverse grades

- **Various superstructure types**
  - e.g. adjacent concrete boxes, steel girders with semi-integral abutment, timber bridges, trusses
Use of stone columns to improve foundation soils
ME - Knox County Beach Bridge (2013)
HI – Saddle Road Bridge (2012)

Designed for $\text{PGA} \times F_{\text{pga}}$ ground acceleration ($\text{PGA}=0.6\text{g} \quad F_{\text{pga}}=1.0$)

Taken October 2014, 2 years after construction
NY – CR 38
St. Lawrence County (2013)
Where not to Consider the GRS IBS

- Areas with deep scour estimates
- Areas with highly compressible foundation soils, unless considering ground improvement techniques
Performance of GRS-IBS

- First GRS IBS built in 2005 (24° skew, 7.6° superelevation, 0.006 ft/ft grade)
- An additional four bridges were instrumented and monitored, with the longest span of 140 feet.
- Results indicated good performance, small deformations, and no bump at the end of the bridge.
Key Performance Indicators of GRS-IBS

- **Vertical settlement**
  - (survey, LiDAR, etc.)

- **Lateral wall face deformations**
  - (survey, LiDAR, inclinometers, etc.)

- **Super-Substructure thermal interactions**
  - (visual observations, contact pressure cells, strain gauges, inclinometers, etc.)

- **Differential settlement between the bridge and approach**
  - (profilers, survey, etc.)

- **Differential settlement across the abutment length**
  - (survey, horizontal inclinometers, etc.)
Case Histories

Chesapeake City Road, DE

RT7A Over Housatonic RR, MA

CR 55 over Minnesota Southern RR, MN
Chesapeake City Road (2013)
Christopher Meehan, P.E., PhD – University of Delaware
Bridge 1-366 on Chesapeake City Road

存在的桥梁

- AADT = 2617
- 3/19/13-3/21/13: 存在桥梁拆除
- 3/22/13 – 4/5/13: 东端台基挖掘和施工
- 4/25/13: 桥梁梁体放置
Geometric Specifications for Project

![Diagram of a bridge design with specifications]

- East Abutment: 2.4 m, 3.7 m, 2.4 m
- Shoulder: 14.6 m
- Lane: 9.8 m, 8.7 m, 9.8 m
- Traffic Direction: 9.8 m, 8.7 m, 9.8 m

Measurements:
- 1.3 m
- 8.7 m
- 1.3 m
- 6.1 m
Geotechnical Conditions at the Site

- 2 HSA soil borings with SPT sampling – one through the center of each existing abutment
- In second boring, continuous Shelby tube sampling was performed over clay layer immediately beneath GRS-IBS
- Laboratory tests performed:
  - 41 soil classification tests – grain size analysis and Atterberg limits
  - 6 one-dimensional consolidation tests
  - 2 unconfined compression tests
  - 4 unconsolidated undrained triaxial tests
  - 11 organic content tests
Materials Used for GRS Abutment Construction

No. 8 Stone Backfill for Reinforced Zone

Polypropylene Woven Fabric Geotextile

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide Width Tensile Strength (Maximum)</td>
<td>ASTM D4595</td>
<td>70.0 x 70.0</td>
</tr>
<tr>
<td>Wide Width Tensile Strength (2% Strain)</td>
<td>ASTM D4595</td>
<td>14.0 x 19.3</td>
</tr>
<tr>
<td>Wide Width Tensile Strength (5% Strain)</td>
<td>ASTM D4595</td>
<td>35.0 x 39.4</td>
</tr>
</tbody>
</table>
Resulting GRS-IBS Design Section

- **External Stability Analysis**
  - Direct sliding
  - Bearing capacity
  - Global stability

- **Internal Stability Analysis**
  - Ultimate capacity
  - Vertical & horizontal deformation
  - Required reinforcement strength

Design was performed following the 2011 “Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide”, Publication No. FHWA-HRT-11-026
GRS-IBS CONSTRUCTION PROCESS
Construction

West Abutment
Bridge Superstructure Construction

Bridge Placement and Approach Road Construction
INSTRUMENTATION & MONITORING
Three Phases of Project Monitoring

Construction

Live Load Testing

Long Term Monitoring
Deflection of GRS-IBS Wall Facing Blocks

- The measurement precision and resolution for the utilized surveying system was 6 mm and 0.3 mm, respectively.
- The maximum facing wall lateral deflection at the abutment centerline is less than 10 mm.
Settlement of GRS-IBS Wall Facing Blocks

- The measurement precision and resolution for the utilized surveying approach was 6 mm and 0.3 mm, respectively.

- The maximum facing wall settlement at the abutment centerline is less than 12 mm.
Deformation in the GRS-IBS Foundation

- The maximum deflection in E-W and N-S directions are 10 mm and 7 mm respectively.
No “Bump at the End of the Bridge”

Construction of transition zone

Transition zone after two years of operation
Geosynthetic Strains Within the GRS Abutment

Long Strain Gauge

- The maximum strain in the abutment is less than 0.5%.
- The maximum creep in the abutment in less than 0.1%.
- No significant difference in long and short strain gauge measurements.
- No significant difference in the strains in the East and West abutments.
Temperature Within the GRS Abutment

- The temperature distribution in the abutment varies with the hot and cold weather.
- The upper elevations and the areas closer to the facing wall experience higher temperature changes due to being more exposed to the air temperature changes.

Temperature recorded by thermistors

Temperature recorded from accuweather.com
A two-wire Wheatstone bridge configuration was used to wire foil strain gauges – measured results can be affected by temperature.

A mathematical technique was developed for correcting strain gauge readings to account for temperature effects. Using this method, the temperature corrected strain ($\varepsilon_{cor}$) is determined using the measured strain ($\varepsilon_{uncor}$), air temperature ($T_a$), and average wire path temperature under the ground ($T_{s,avg}$).
Applied Bearing Pressure Beneath the Base of the RSF Wall

<table>
<thead>
<tr>
<th>Pressure, ( \sigma_z ) (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Horizontal Distance, ( x ) (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
</tr>
</tbody>
</table>

After Bridge Placement
Conclusions

Overall Conclusion: Satisfactory performance of the structure over the three phases of project monitoring.

- The maximum facing wall lateral deflection at the abutment centerline was less than 10 mm
- The maximum facing wall settlement at the abutment centerline was less than 12 mm
- Maximum strain in the abutments was less than 0.5%
- Maximum creep in the abutments was less than 0.1%
- Temperature had a direct influence on measured strain and should be corrected for
- No apparent scour issues
RAPID REPLACEMENT

To replace a two-lane bridge nearing the end of its design life, the Delaware Department of Transportation and an innovative approach. Britt 7-site, a precast beam installation and the 120m bridge superstructure elements, the composite bridge was constructed rapidly and has been equipped with a custom-designed instrumentation system to monitor long-term performance.

By Majid Talebi, P.E., S.M.ASCE,
Christopher L. Meehan, Ph.D., P.E.,
M.ASCE, Daniel V. Caccella, M.ASCE, and Matthew L. Becker, A.M.ASCE

A similar bridge project in the United States, the Delaware Department of Transportation (DelDOT) decided to deploy the effectiveness of this technology for use with its own bridge construction. By using a prefabricated bridge, the DelDOT project was able to deploy the bridge in a matter of months.

As the project nears completion, DelDOT managed the associated design and construction process for this GRSS-BSS project. Representations from the University of Delaware worked closely with DelDOT personnel during this process to provide technical guidance. They also designed an innovative system of sensors for the structure for an extended period. The project construction was performed by a local Delaware contractor—Mansfield and Miller Contractors, Inc., of Middletown—under the supervision of DelDOT personnel.

Rapid Replacement

(Continued from Page 43) content sensors were installed in the two-lane bridge to monitor load and stress in the superstructure elements. Fifteen surveying points were affixed to each abutment face to monitor settlement and wall deflections during the GRS-BSS construction process and while the structure is in service. This is the first GRS-BSS constructed in Delaware has expanded excellent performance. DelDOT personnel have been pleased with the straightforward nature of GRS-BSS construction, and the agency is looking for other projects suitable for this new technology.

Majid Talebi, P.E., S.M.ASCE, is a graduate student in the civil and environmental engineering department at the University of Delaware, and Christopher L. Meehan, Ph.D., P.E., M.ASCE, is an associate professor who holds the Horticulture Systems Transportation Chair Development at the University of Delaware, is a technical designer at pavement analytically licensed. Jeffrey Meehan, NIU, Matthew Becker, A.M.ASCE, is a fellow graduate student in the civil and environmental engineering department at the University of Delaware.

The authors note that the work reported here was supported by the Delaware Department of Transportation. This project was carried out using funds from the Federal Highway Administration’s Innovative Bridge Research and Deployment Program. The authors would also like to express their gratitude to Michael Angrist and Jennifer Nicky at the Federal Highway Administration’s Federal Highway Administration for their support and guidance during the project and to Michael Dannehl and Gary Winsor at the University of Delaware for their assistance in the laboratory and the field.
Rock County Road 55 over MN Southern Railway

Derrick Dasenbrock, P.E. – Minnesota DOT

Derrick Dasenbrock, PE
Geomechanics/LRFD Engineer
Minnesota Department of Transportation
Project Summary

• Rock County (County State Aid Highway) Bridge 67564
• 5.3% grade (largest grade of an IBS built to date)*
• Length: 82.5’ (clear span 77.5’)
• Face height of 22’
• Width: 33’
• ADT 135

• Instrumentation Program Evaluated:
  o Construction behavior
  o *Reaction of GRS wall to bridge constructed at this grade
  o Deformation and movement during thermal cycles
  o 3-year post-construction monitoring
Instrumentation Layout Plans + X-Sec

Targets

Beam EPCs

Foundation EPCs

H. SAA

V. SAA
Instrumentation Sensors and Equipment

• Each Abutment (N/S)
• 1 Vertical ShapeAccelArray @ center behind wall (2)
• 1 Horizontal ShapeAccelArray behind front face (2)
• 3-5 Earth Pressure Cell below reinforced soil foundation (8)
• 3 Fat Back EPC at back interface of bridge beams (6)
• 1 AMTS: NE*, SW (2 initially; *1 long-term)
• Optical Prisms on Face and on exterior beams (about 60)
• Support Equipment
  o Weather Station + Cameras + Solar Panels
  o Radios + Cell Modems + Batteries
  o Cabinets + Conduit + Cables
  o Back-sight Reference Prisms and Posts

Total numbers in ()
Internal + External Instrumentation

Sensors and targets installed throughout construction of the bridge

Many comments were received with respect to the number of strange looking devices
Site Location (Winter Before Construction)
Early Project Work

• Trenching & Excavation
• Horizontal SAAs and EPCs installed
• Posts for AMTS and solar panels were drilled
• Cabinet Hardware + Sensor Conduit + Cabling

And Snow!
Beginning Wall Block Placement

Horizontal SAA and Earth Pressure Cells are Installed and Acquiring Data
AMTS System: Targets Placed as Wall Progresses

Some targets will be buried after initial construction.
Vertical Wall Deformation and Beam Pressure

• SAA installed about 3’ from edge of box beams
• Installed after backfill is placed up to beams
  o Access available for rig and full wall height established
• June 4, 2013 (compare to AMTS target data from mid-May)
• 3 Fat Back EPC sensors installed on box beams (each end)
North Abutment Construction Pressure/Fill

North Abutment Foundation Earth Pressure Cells

- **EPC Pressure (5 Cells)**
- **Fill Height**
- **Beams Placed**
South Abutment Construction: Pressure/Fill

South Abutment
Foundation Earth Pressure Cells

Beams Placed

Fill Height

EPC Pressure
(3 Cells)
North Abutment Long-Term Earth Pressure

Ambient Temp. Peak  EPC Temp. Peak  EPC Max Pressure

5 Cells
South Abutment Long-Term Earth Pressure

Behavior consistent with North Abutment (long term trends and pressure range)
Lateral (N/S) Wall Deflection Measurements:

AMTS (scanning center and east/west wing wall faces: 60+ optical prism targets)
Vertical SAA sensors at center of both abutments

2013 Looking East
Nearing End of Construction
Vertical Wall Deformation 2013-2016

Largest movements at the lower portion of the wall above embedded portion

Sloped Backfill
Base of Wall

Top EL.: 1546' +/-
Pt of Max Displ. @ EL 1526' +/-
Approx. Layer 7 of GRS

Top EL.: 1550.5'
Pt of Max Displ. @ EL 1526.5' +/-
Approx. Layer 2 of GRS
(negative movement out from wall face)
North Abutment Translation: (-0.2” to -0.9”N)

North Abutment Center Prism Column Northward Movement ('-' = Southern Movement)

AMTS service interruption

LONG TERM

Lower targets covered by fill

SAA Installation

Construction
South Abutment Translation: (-0.2” to 0.4” N)

South Abutment Center Prism Column Northward Movement (’-’ = Southern Movement)

[Graph showing movement over time with markers for AMTS service interruption and SAA Installation]

LONG TERM

Construction
North SAA + Prism Settlement

Prism Settlement Generally < SAA
Good Match at Center (Gray Lines)

"Fuzzy" target data
Horizontal SAA
South SAA + Prism Settlement

Prism Settlement Generally > SAA
Good Match at Center (Green Lines)
Sensor/Prism Monitoring Summary (2016)

- **Lateral movement:** -0.2 to 0.9 inch at both abutments
  - Larger movement at wall base (bulging)
  - Distinct short-term generally outward movements; longer-term creep movement
  - Behavior is different than rigid tilt (active pressure on retaining wall)

- **Settlement:** 0.5 to 2.0 inches at both abutments
  - Majority occurred during initial construction and backfilling (steep curve)
  - Several years of small magnitude creep appears to be present (shallow, long-term, curve)
  - Long-term settlement magnitude is minimal
  - Targets showed largest settlement at center of structure

- **Base EPCs showed regular increase during construction**
  - Show jumps when new loads are applied (fill/beams) some creep between loading events

- **Earth pressure at beams was most dynamic sensor reading**
  - Large daily and seasonal temperature variations

- **North EPC Beam Pressures (lower elevation) were somewhat higher than those observed at South side (higher elevation)**
Monitoring Program Technical Support

Field problems were both technical and rodent-based*

*Field mice (south system cabinet) snacked on antenna wiring
Performance Monitoring and Instrumentation Challenges

• Coordination: Several different crews installed site sensors
• Remote site location (4.5 hours from Twin Cities)
• Power and Communications (radio + cellular modem)
• Correlation of data from instruments installed at different times and loading points during construction sequence
• Large amounts of data/frequency could have been reduced
  - Intermittent construction activity made this somewhat challenging
  - Data presentation (different sensor installation start times, additive movement)
• Very small movements are very difficult to measure*
  - Fixed datum is required- often hard to come by at a construction site
• *Temperature effects on equipment and data
• Several types of error associated with different sensors
Bridge In Service (looking west)

A summary of technical, measured, performance has been discussed
Qualitative Fascia Distress

- Some block cracking
- Some chipping
- Some movement at joints
Pavement Cracks (2016 Observations)

- Distinct, uniform, crack in pavement at beam ends
3 Year Project Study Conclusions

• No significant movement appears related to the 5.3% grade of the bridge- distortions are 0.5” to 2.0”
  o Movements toward the south (high side) appear comparatively large
  o Wall movement is complex and appears to include aspects of settlement (both initial and creep), bulging, tilt/rotation, and translation
  o Movements are small; temperature effects are comparatively large

• Distress is present in pavement and some blocks
  o Pavement cracks observed across entire roadway at beam ends
  o Pavement cracks are the most noticeable performance feature
  o Small amounts of minor block distress- cracks, chips, gap at construction joint

• Studying performance is challenging
  o Maintaining AMTS systems required effort and many field trips
  o Power and cell modem issues arose several times during study
  o Project partners (design, construction, monitoring) did a great job
Special Thanks to:
Dan Mattison,
Joel Swenson,
Gene Bryant,
Aaron Grosser
RT 7A Over Housatonic RR (2014)
Peter Connors, P.E. – Massachusetts DOT
SHEFFIELD
Bridge No. S-10-023

Route 7A (Ashley Falls Road) over Housatonic Railroad
Sheffield S-10-023
Route 7A/Housatonic Railroad

Before

August 2016

Built 1935
Summary Details

- 105’ single span
- 30° skew
- 24’ to 28’ high walls (RR clearance)
- Steel girders w/ CIP deck
- Concrete footings for superstructure
- Cut down existing piers for RR protection
- FHWA instrumentation monitoring program
- 49% cost savings over original design!
Bridge Plan

- ABP
- Collins/GEI
- Maximilian
- District 1

Dimensions:
- 105± ft
- 24± ft
- 28± ft
Construction Timeline

- April to June, 2014 - GRS abutments built
- June - MassDOT showcase
- FHWA instrumentation
- July to August - beams set and cast back wall
- FHWA instrumentation
- September - CIP Deck
- October - Approaches and pavement
- November 18, 2014 – Complete and in service
GRS Construction
GRS Construction

- Standard CMU Blocks
- Woven Geotextile
- Open graded Fill (46-48° lab)
2014 Showcase

- 60 participants
- 1 day: class & site
- MassDOT Districts
- NE DOTs
- Local DPWs
- FHWA
- ACEC
- CIM
GRS Construction

Beams on footings  Crane loading
FHWA Instrumentation

- Installed by FHWA
- 36 months monitoring
- Soil Structure Interaction
- Response to 30° skew
- Compare to other GRS and traditional bridges
ASHLEY FALLS RD GRS-IBS - SHEFFIELD, MA
As-Built Layout of Instrumentation
Installed 6/2014 to 8/2014

As Built (both abutments)

- In-place inclinometer casing (2.75 inch ID)
- Concrete (Fatback) Pressure Cell (25-psi) – Geokon 4810
- Earth pressure cell (50-psi) – Geokon 4800

Typical Instrumentation Layout for both abutments
West Abutment Instrumentation

- Concrete Pressure Cell (25-psi)
- Earth Pressure Cells (50-psi)
- Concrete pressure cell on cheek wall (25-psi)
- Survey target
- In place inclinometer

- Center of Bearing
- Mid Height of Abutment Stem Wall
- Bottom of IPI casing embedded in bedrock ~1ft
- RSF is 1.5 ft due to bedrock in excavation

Dimensions:
- 23 ft
- Embedded in bedrock ~1 ft

Notes:
- RSF (Reinforcement Spacing Factor) is 1.5 ft due to bedrock in excavation.
Concrete Pressure Cells
Stem Wall
Concrete Pressure Cells
Cheek Walls
Instrumentation Panel

Battery Power from Solar

A/D Board and Modem
West Abutment Lateral Pressures

Daily Average Lateral Pressure - West Abutment

- 7/15/14 Beams Placed
- 7/30/14 Beam Seat/Backwall Poured
- 8/25-8/28/14 Approach Construction
- 9/4/14 Bridge Deck Poured
Daily Average Temperature
Pressure cells – East Abutment

Sheffield

Daily Average Temperature of Lateral Pressure Cell - East Abutment

Temperature (°F)

8/16/14  9/15/14  10/15/14  11/14/14  12/14/14

LP_SE_End, DgF
LP_SE, DgF
LP_CE, DgF
LP_NE, DgF

Vertical Pressure Cell
Lateral Pressure Cell
In-place Inclinometer
West Abutment In-Place Inclinometer

Season Backwall Movement = 0.17 in
East Abutment In-Place Inclinometer

Season Backwall Movement = 0.2in
Pavement Sawcut
Survey Targets for Settlement
East Abutment Survey Settlement

Survey Targets - East Abutment Wall and Beams

Total Abutment Height = 19.92 ft.

y = -0.468ln(x) + 1.2274
R² = 0.9435

100 Year GRS Settlement
3.7 inch - 1.5% strain
West Abutment Survey Settlement

Survey Targets - West Abutment Wall and Beams

- South Beam Target
- Middle Beam Target
- North Beam Target

Regression equation: 
\[ y = -0.425 \ln(x) + 1.0827 \]
R\(^2\) = 0.9416

Key dates:
- 7/17/2014: Beams Installed
- 8/4/2014: Seat Cast
- 9/5/2014: Deck Cast

Significant targets:
- TARGET 31
- TARGET 32
- TARGET 33
- TARGET 28
- TARGET 29
- TARGET 27
- TARGET 30

Targets disturbed during beam installation.
Abutment Face 2016
Conclusions

- Monitoring ongoing
- Small longitudinal movements observed
- Horizontal Earth Pressure controlled by thermal effects
- GRS Settlement within FHWA guidelines
GRS IBS performance & deployment efforts
Daniel Alzamora, P.E. – Federal Highway Administration

Chesapeake City Road, DE (2013)
RT7A Over Housatonic RR, MA (2014)
CR 55 over Minnesota Southern RR, MN (2013)
OH – Bowman Rd Bridge (2005)
OH – Tiffin River Bridge (2009)
HI – Kauaula Stream Bridge (2012)
WI – STH 40 Bloomer, WI (2012)
Project Example: UT – I-84 Echo Bridge (2013)

First G RS IBS on the Interstate; utilized SIBC

- Constructed summer 2013
  - No approach slab
  - ADT > 8,000
  - Truck ~ 40%

Image source: FHWA
NY – CR47 in St. Lawrence County, NY (2013)
PR – Yauco PR2 (2014)

ADT: 40,000
MO – Rustic Road Project (2015)
Legend

<table>
<thead>
<tr>
<th>Number</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>None constructed</td>
</tr>
<tr>
<td>2</td>
<td>None constructed but state has been looking for projects on local roads</td>
</tr>
<tr>
<td>5</td>
<td>Projects in designed and/or going out to bid</td>
</tr>
<tr>
<td>41</td>
<td>Projects Constructed</td>
</tr>
</tbody>
</table>
Questions?