U.S. Department of Transportation
Federal Highway Administration

GEOSYNTHETIC REINFORCED SOIL INTEGRATED BRIDGE SYSTEM

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Introduction

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EDC Web Site

www.fhwa.dot.gov/everydaycounts

- Taking effective, proven and market–ready technologies and getting them into widespread use

2012 Deployment Goals

- December 2012:
  - 30 bridges have been designed and/or constructed using GRS-IBS on the NHS within 20 states
  - 75 bridges have been designed and/or constructed using GRS-IBS off the NHS

The Current Bridge Situation

- Approximately 600,000 bridges in the U.S.
- Many have functional or structural deficiencies
- Most are small single span
- Budgets don't meet demand – Build more bridges for your dollar

GRS FUNDAMENTALS

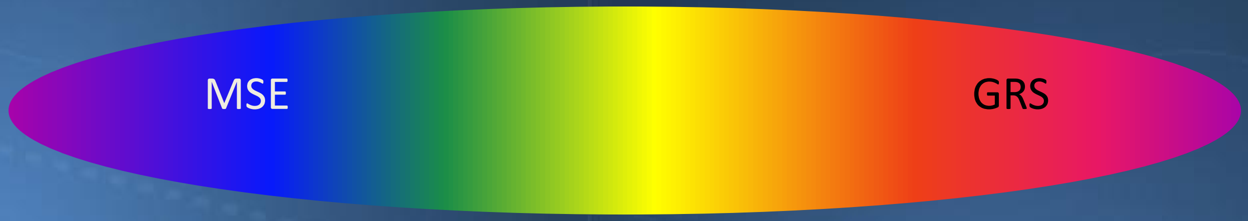
History

- Reinforced earth has been used for thousands of years. Ancient reinforcing materials have included:
  - Straw
  - Tree branches
  - Plant material
- Mechanically Stabilized Earth (MSE)
  - 1960s: Steel strips (Reinforced Earth®)
  - 1980s: Geosynthetic reinforcement

Definitions

- GRS - Geosynthetic Reinforced Soil
  - An engineered fill of closely spaced (< 12") alternating layers of compacted granular fill material and geosynthetic reinforcement
- IBS - Integrated Bridge System
  - A fast, cost-effective method of bridge support that blends the roadway into the superstructure using GRS technology

Degree of Composite Behavior

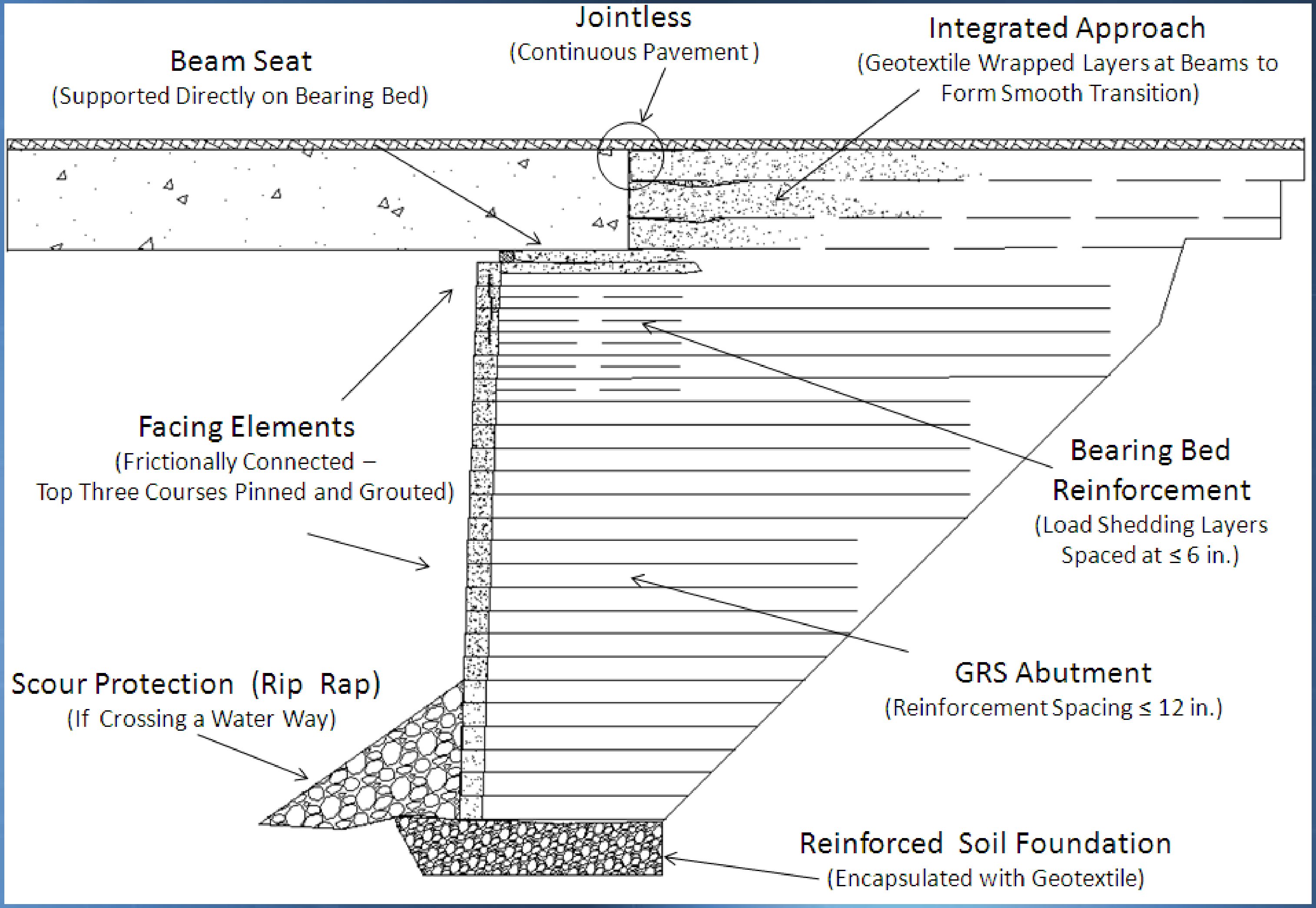


Reinforcement spacing

36”   30”   24”   18”   12”   6”

Cut-away of a GRS Mass

Cross-Section of GRS-IBS



Summary of Benefits

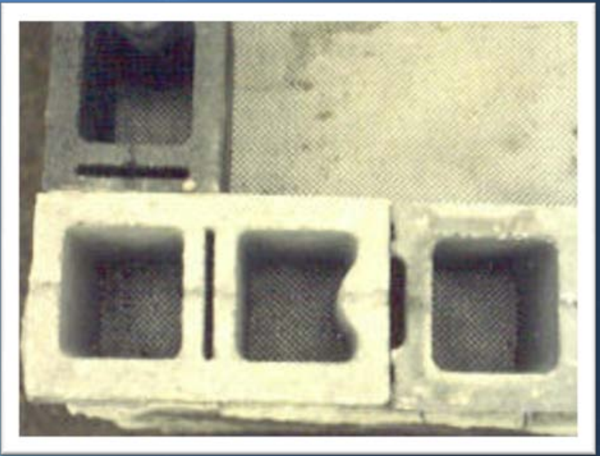
- Reduced construction cost (25 - 60%)
- Reduced construction time
- Construction less dependent on weather conditions
- Flexible design - easily field modified for unforeseen site conditions (e.g. obstructions, utilities, different site conditions)
- Easier to maintain (fewer bridge parts)
- QA/QC Advantages

Site Selection

- Single span (currently 140 ft)
- 30 ft abutment height
- Grade separation
- Water crossings with low scour potential
- Steel or concrete superstructures
- New or replacement structures

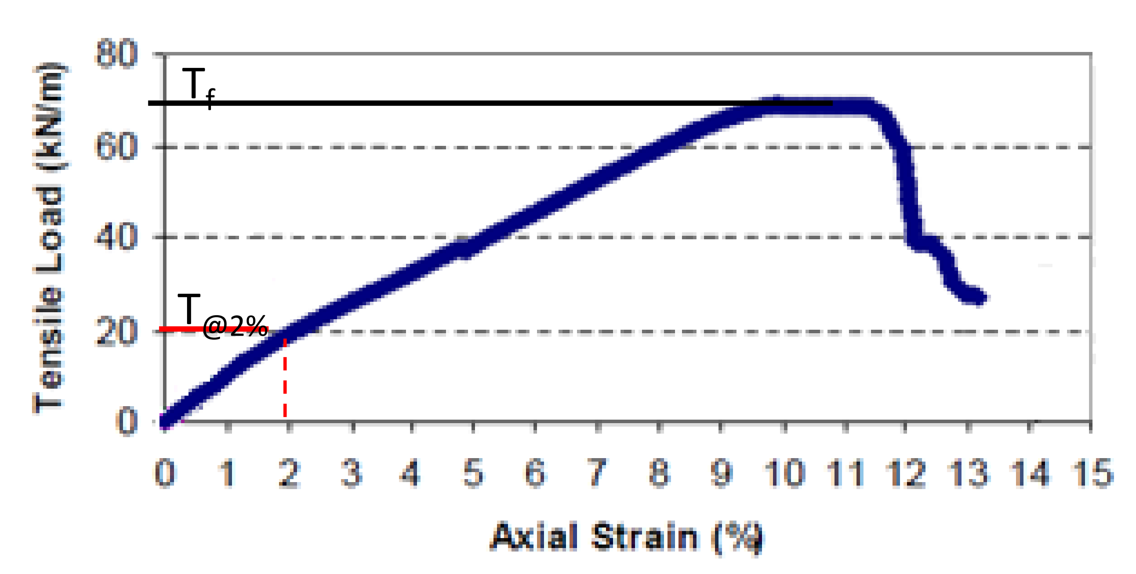
Facing Elements

- Split face CMU Block
  - Dimensions: 7-5/8” x 7-5/8” x 15-5/8”
  - Readily available
  - Inexpensive
  - Compatible with the frictional connection to the reinforcement
  - Material Specifications:
    - Compressive strength ≥ 4,000 psi
    - Water absorption limit: 5%
    - Must be designed for freeze-thaw protection (ASTM 1262-10)



Geosynthetic Reinforcement

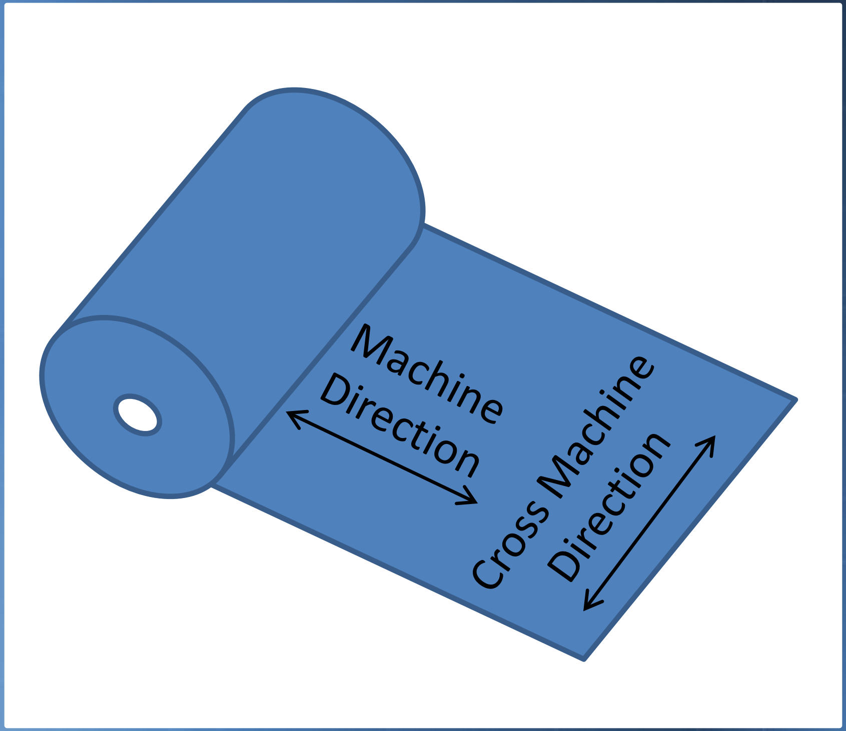
- Geosynthetic reinforcement material can include:
  - HDPE, PP, or PET Geogrids
  - PP or PET Woven geotextiles
- Ultimate Strength: Tf = 4800 lb/ft
- Strength at 2% Strain: T@ε=2%

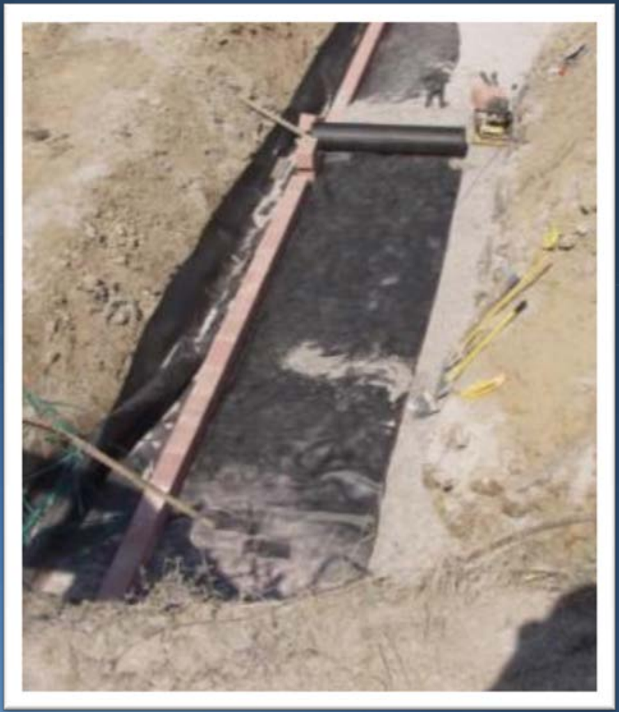


Geosynthetic Reinforcement

Continued

- Cross Machine vs. Machine Direction





- Uniaxial (strength in one direction)
- Biaxial (strength in both directions)

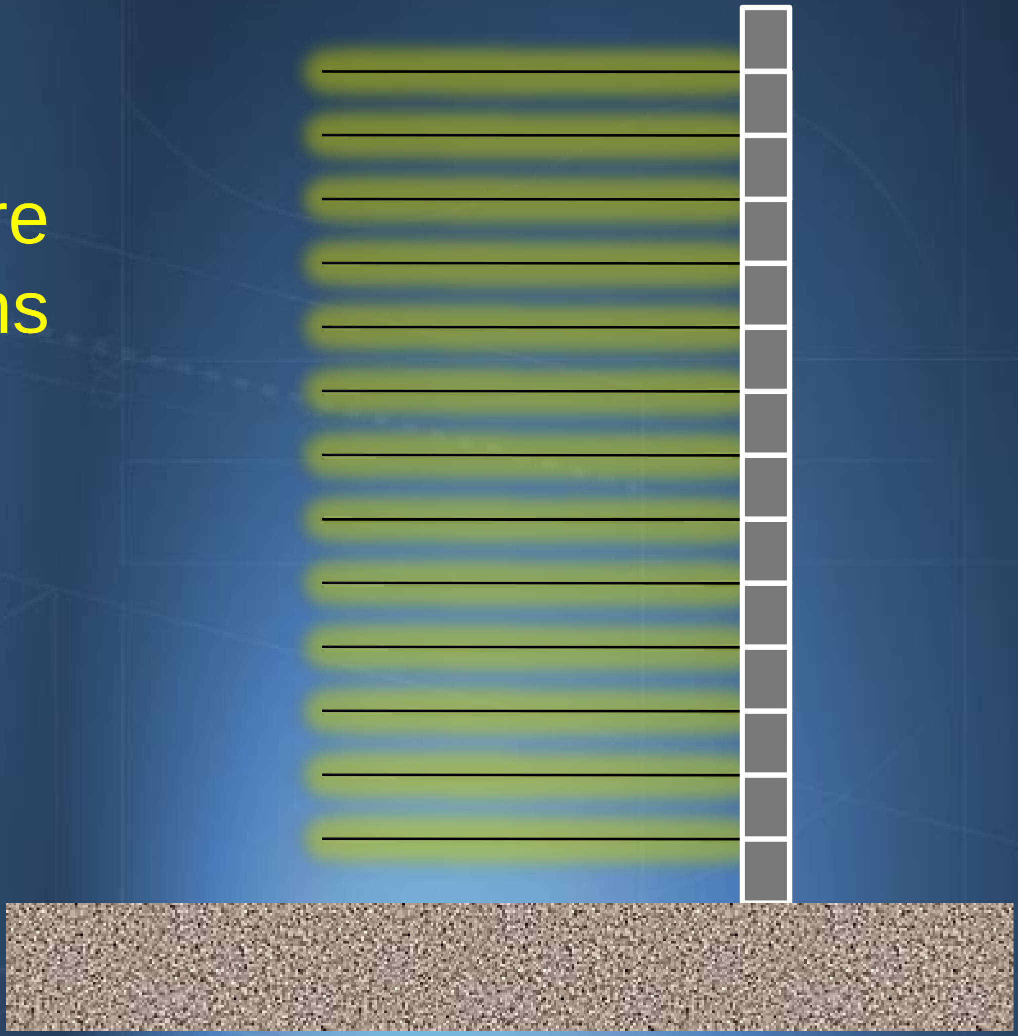
Granular Backfill

- Well graded
  - $d_{max} \leq 2"$
  - 200 sieve < 12% (PI ≤ 6)
  - $\phi \geq 38^o$
- Open graded
  - $0.5" \leq d_{max} \leq 1"$
  - 2" max. OK but more difficult to place
  - 200 sieve ≤ 5% (PI ≤ 6)
  - $\phi \geq 38^o$

Composite Behavior

GRS

- Composite Structure
- Friction Connections
- Close Spacing

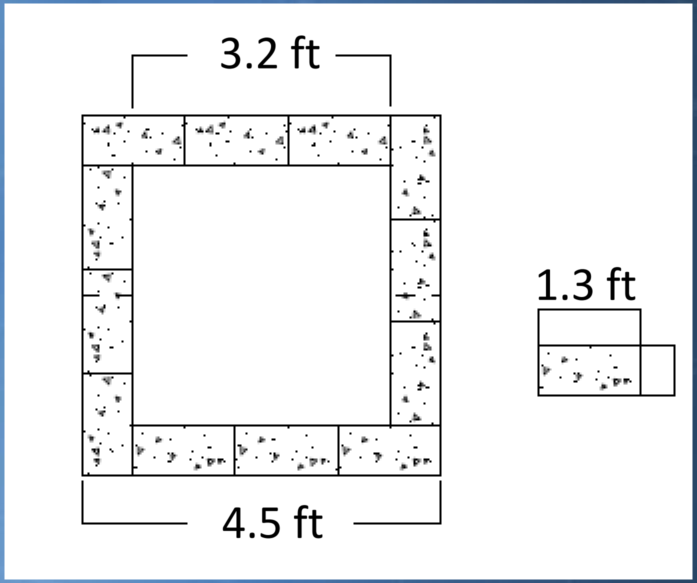


PERFORMANCE Testing and Monitoring

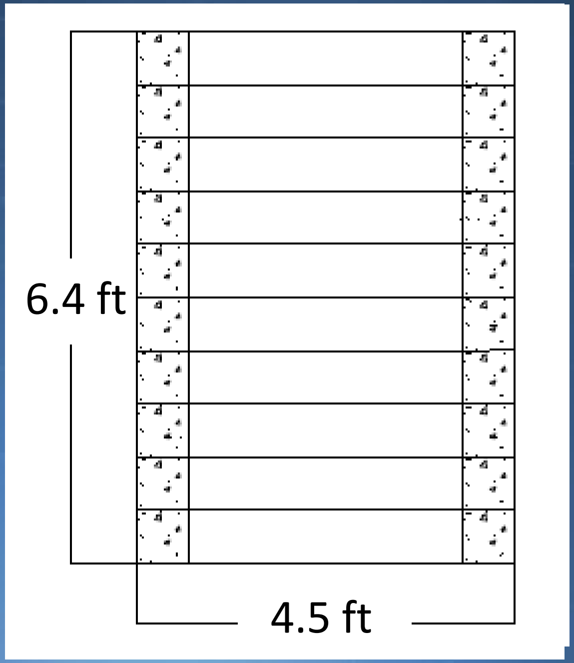
Performance Tests

- Also known as “Mini-Pier” experiments
- Provides material strength properties of a particular GRS composite
- Procedure involves axially loading the GRS mass to measure lateral and vertical deformation

Performance Tests *Continued*

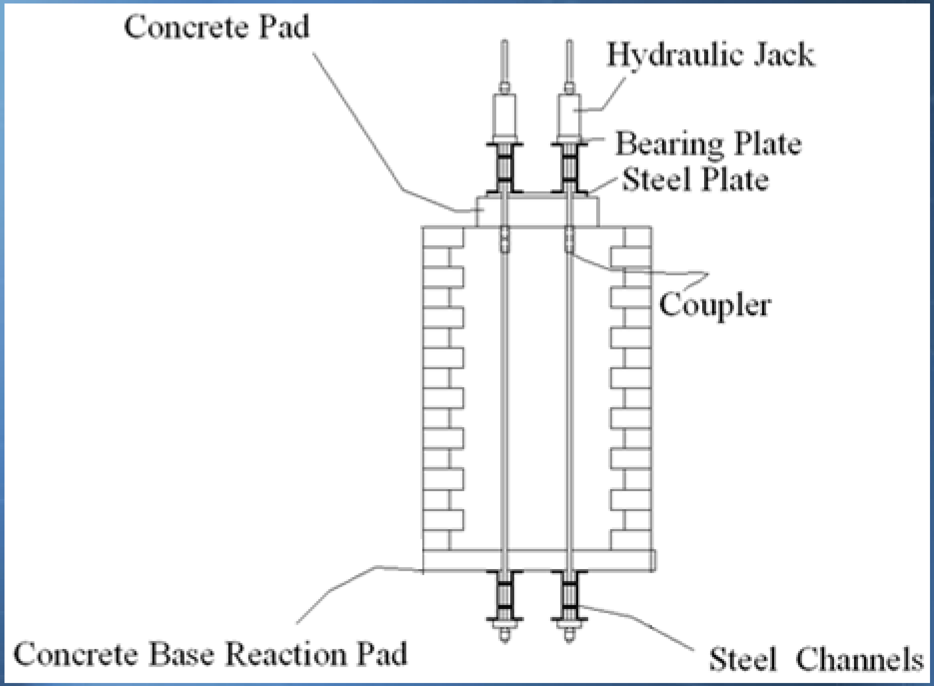


Top View



Side View

Performance Tests *Continued*



Performance Tests *Continued*

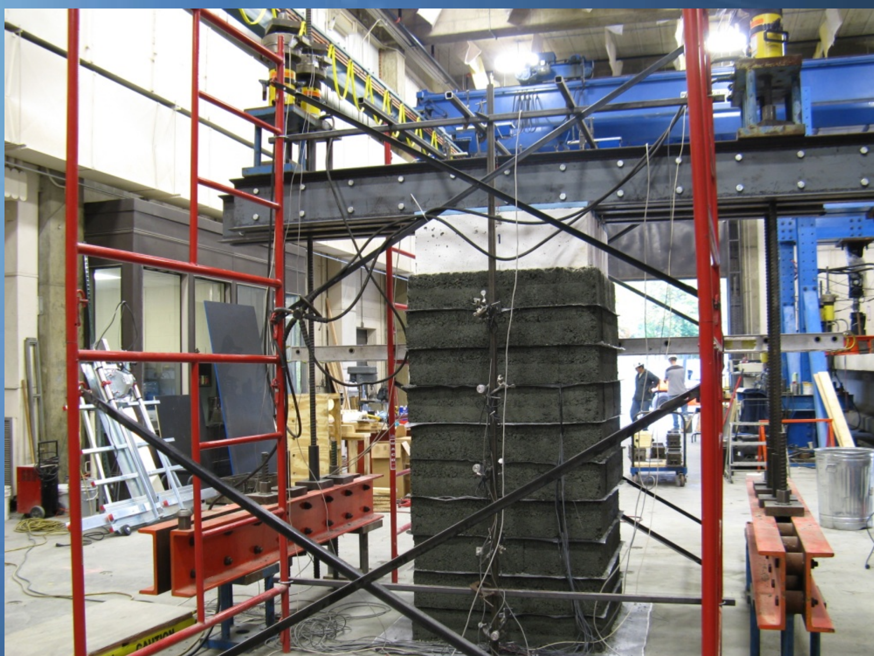
Before

After

Performance Test

2400 lb/ft @ 8” Spacing

Before



After


0.5 ksf
(25 kPa)


3.1 ksf
(148 kPa)


4.1 ksf
(196 kPa)
CAUTION


4.9 ksf
(235 kPa)


5.9 ksf
(282 kPa)


6.8 ksf
(326 kPa)


8.5 ksf
(407 kPa)


10.3 ksf
(493 kPa)

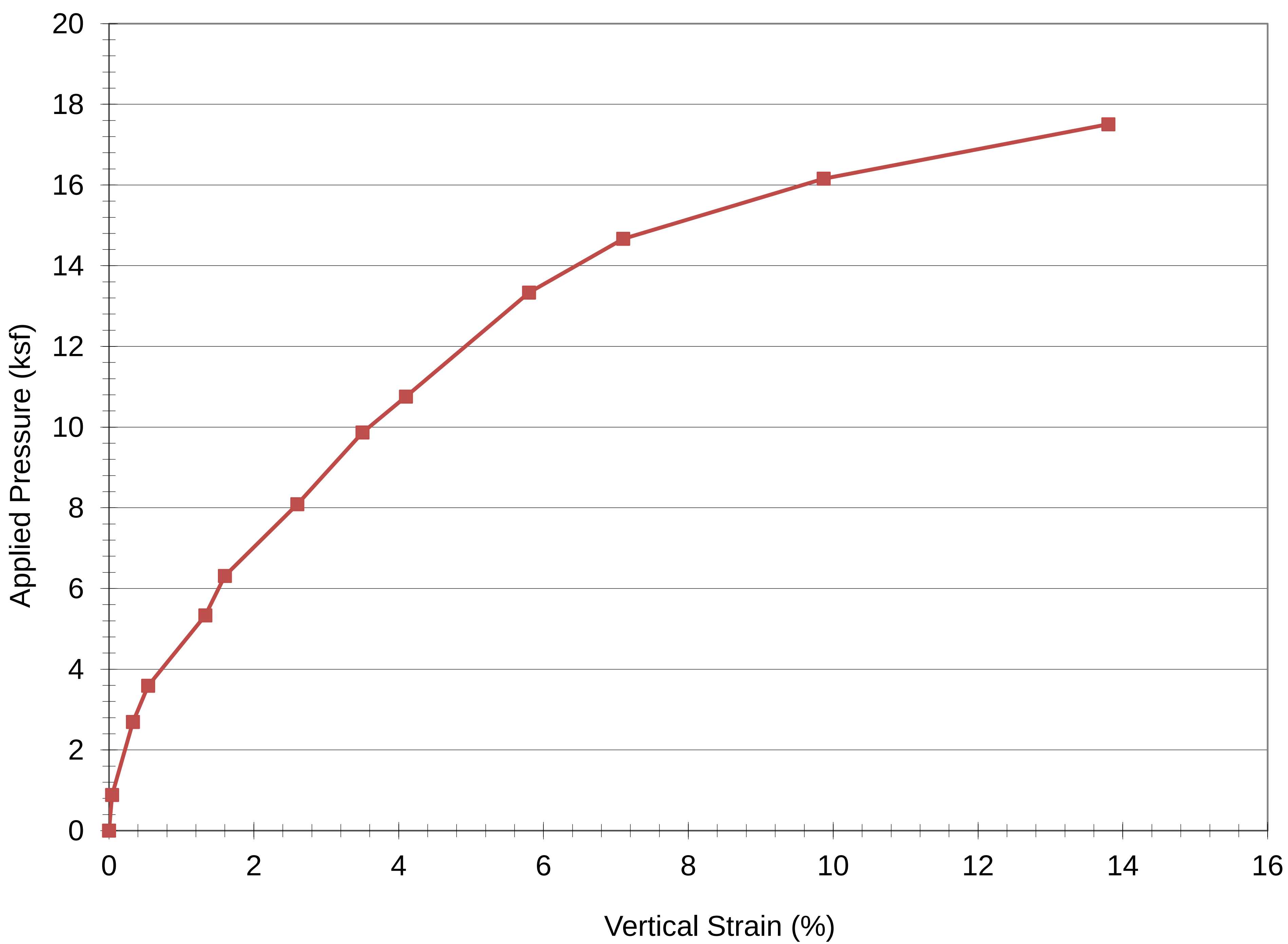

11.3 ksf
(541 kPa)


13.9 ksf
(666 kPa)

15.3 ksf
(733 kPa)

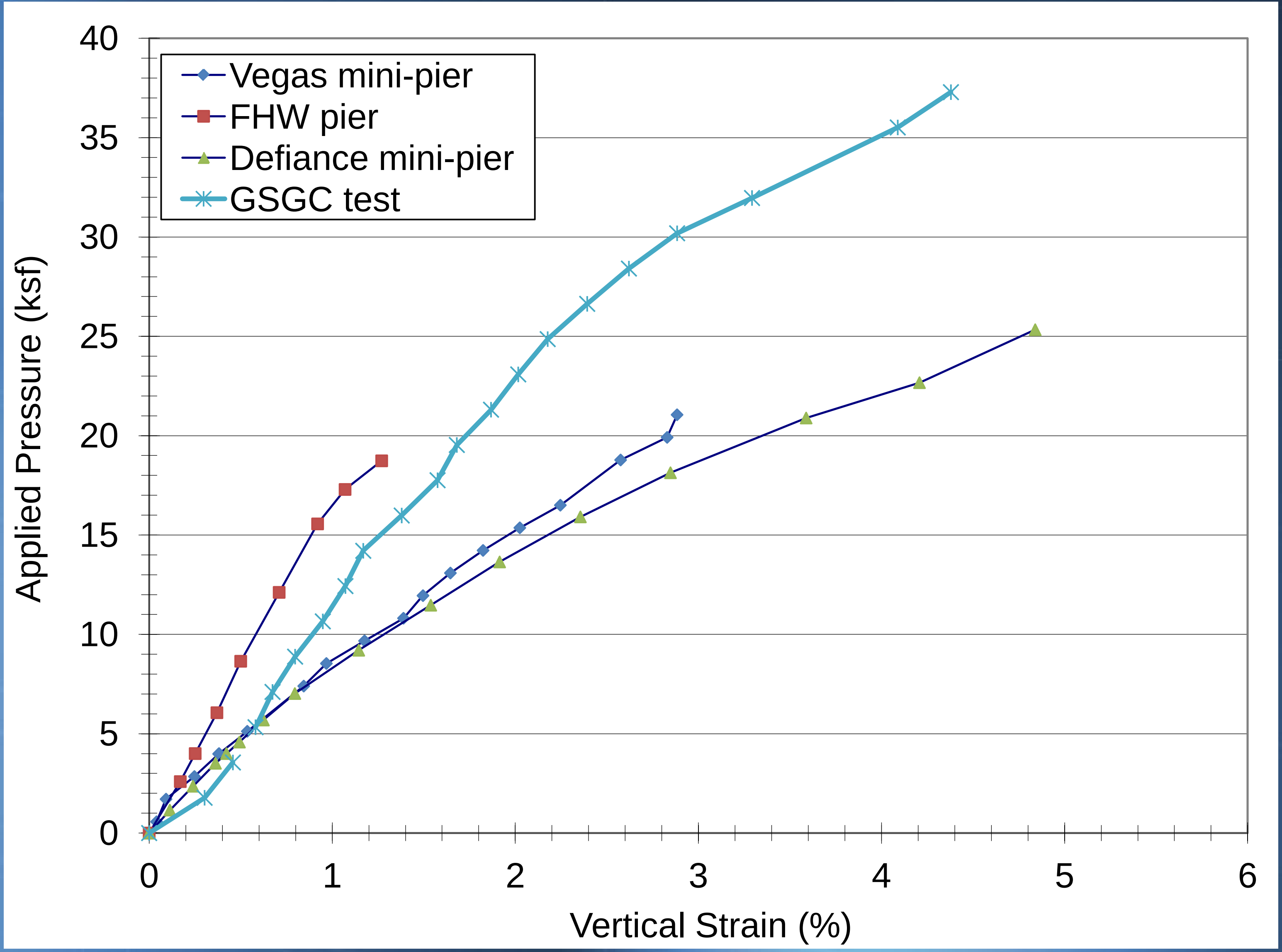

16.7 ksf
(800 kPa)


18.1 ksf
(867 kPa)
CAUTION



Applied Pressure (ksf)
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
Vertical Strain (%)

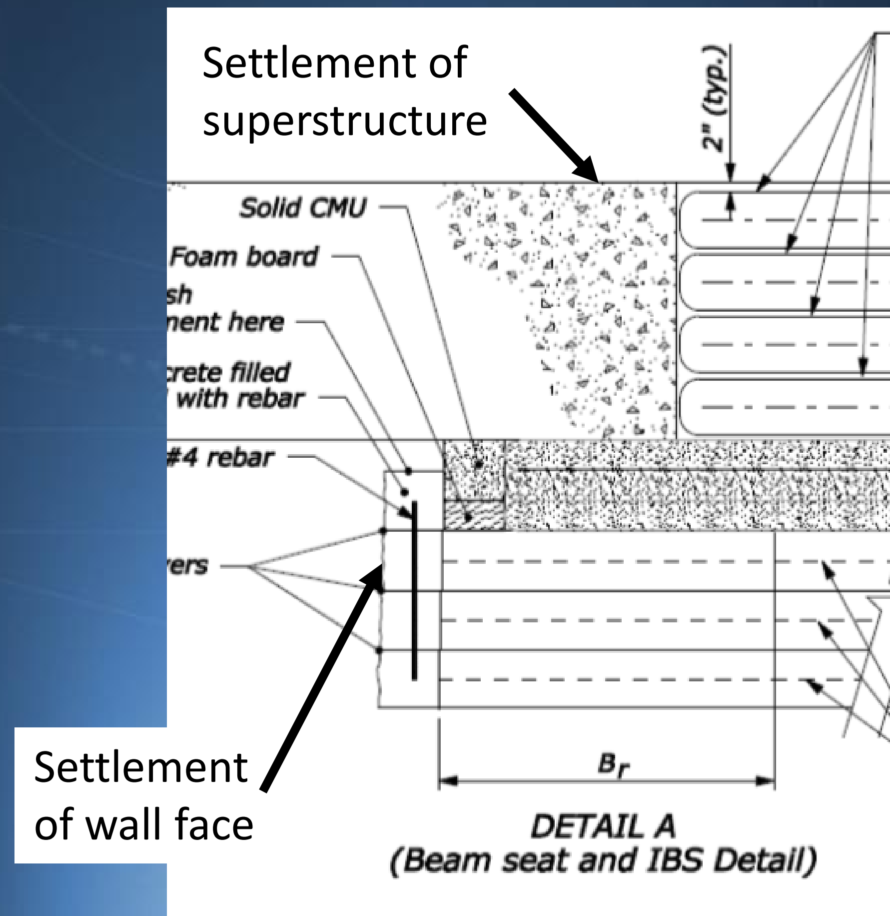
Performance Test Results



Settlement Monitoring *Continued*

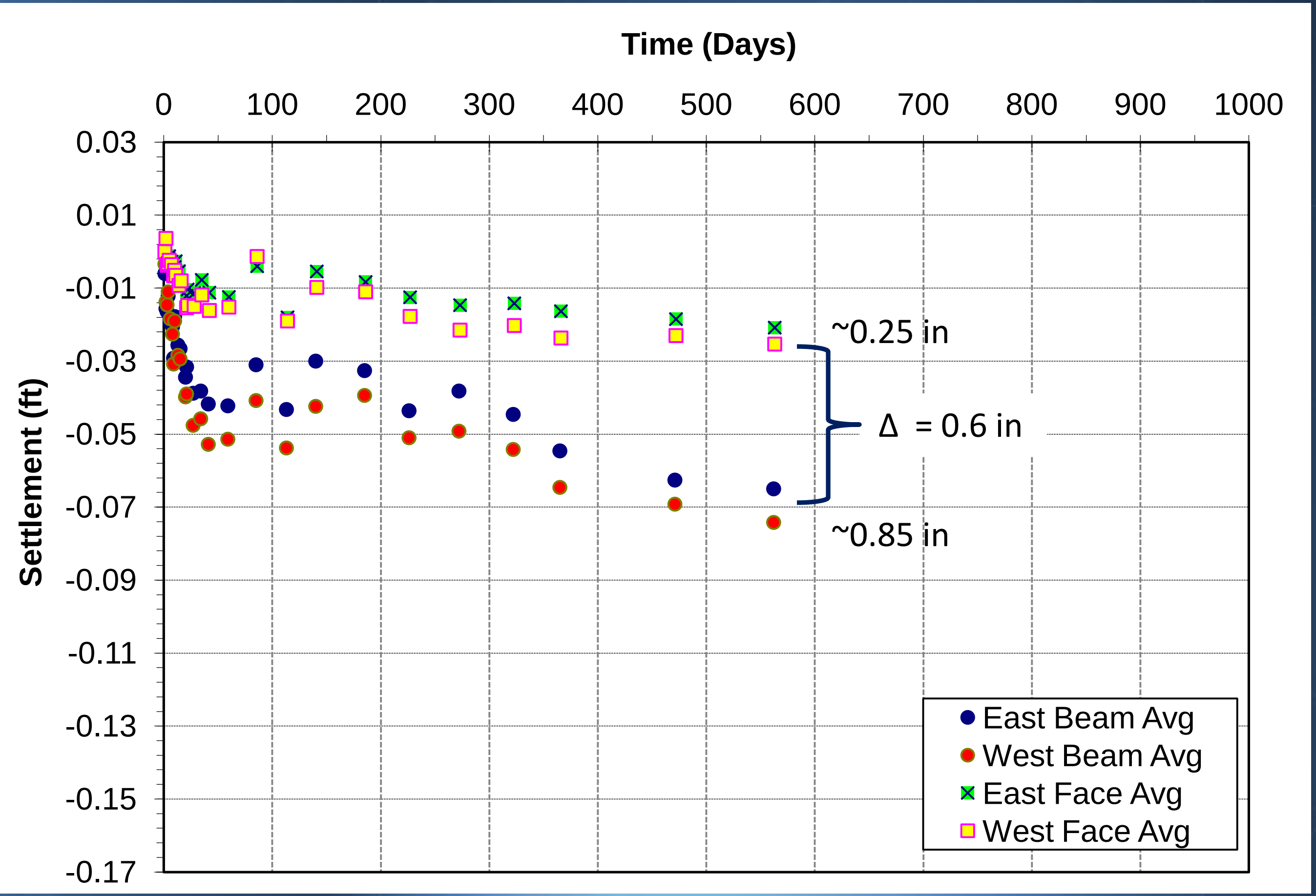
Settlement Monitoring *Continued*

- Settlement is recorded for both the wall face and the superstructure
- The difference between the settlement on the wall face and the settlement on the superstructure is the compression within the GRS mass



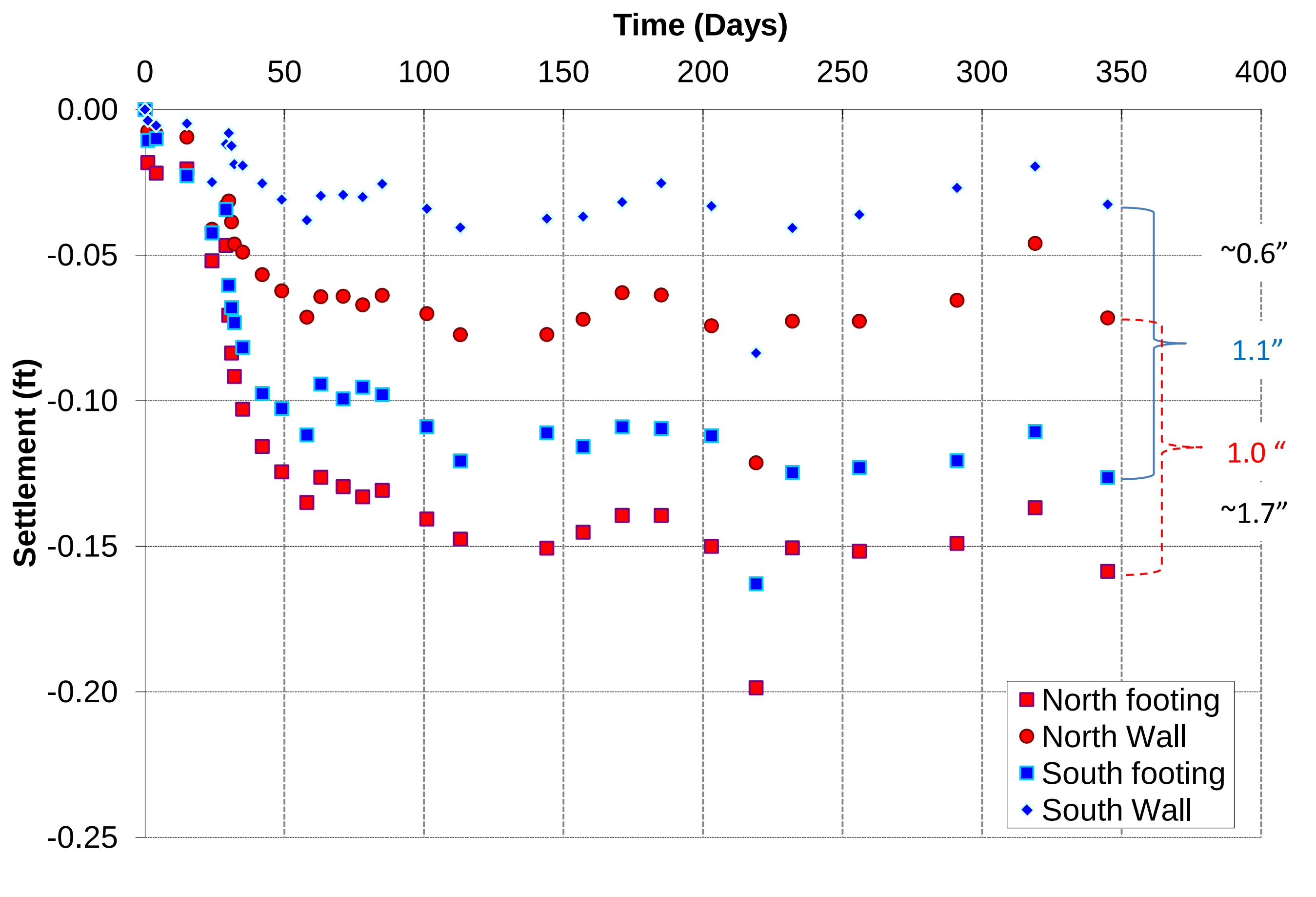
Settlement Monitoring *Continued*

- EDM survey
  - Bowman Road

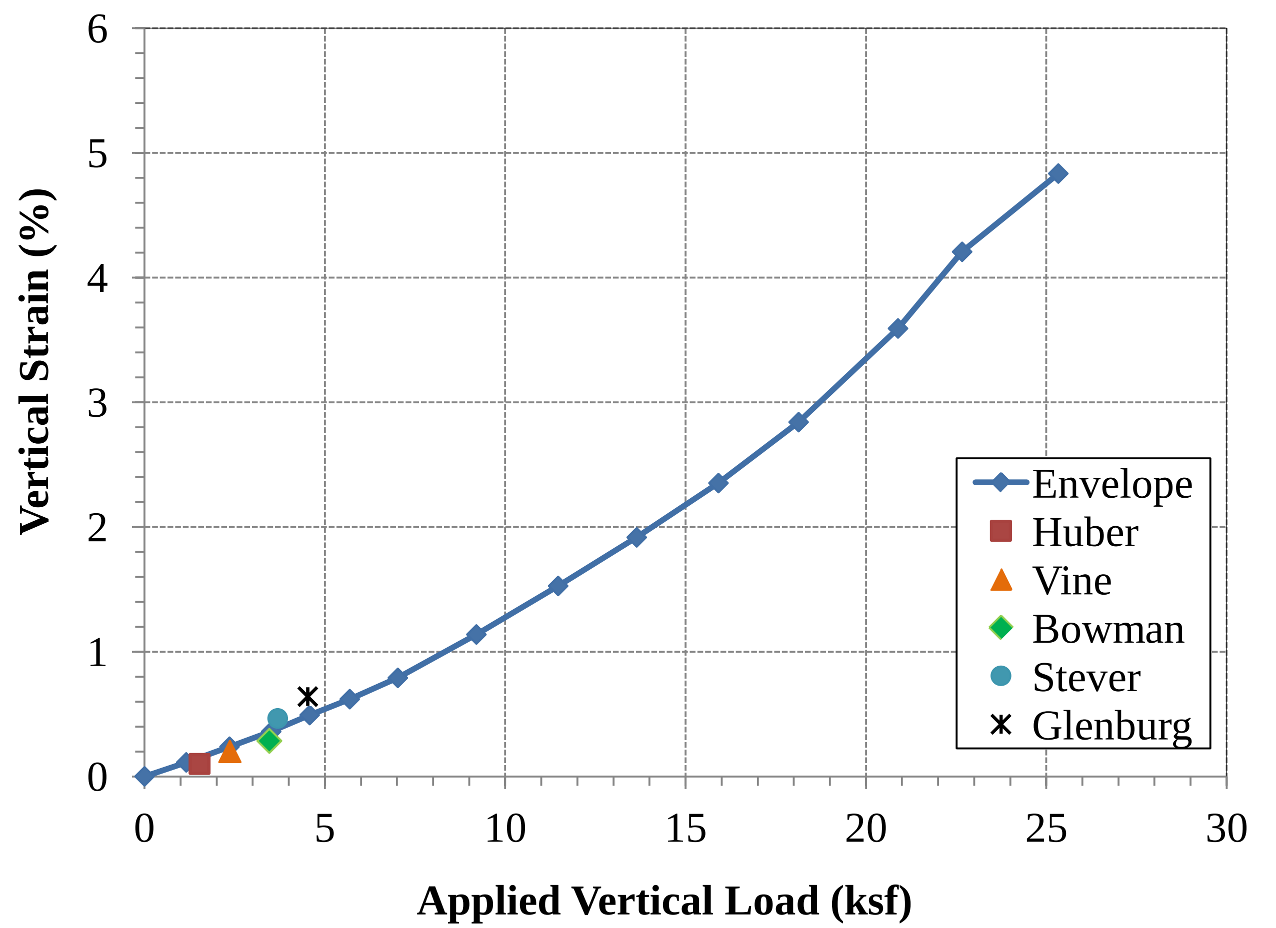


Settlement Monitoring *Continued*

- EDM survey
  - Tiffin River



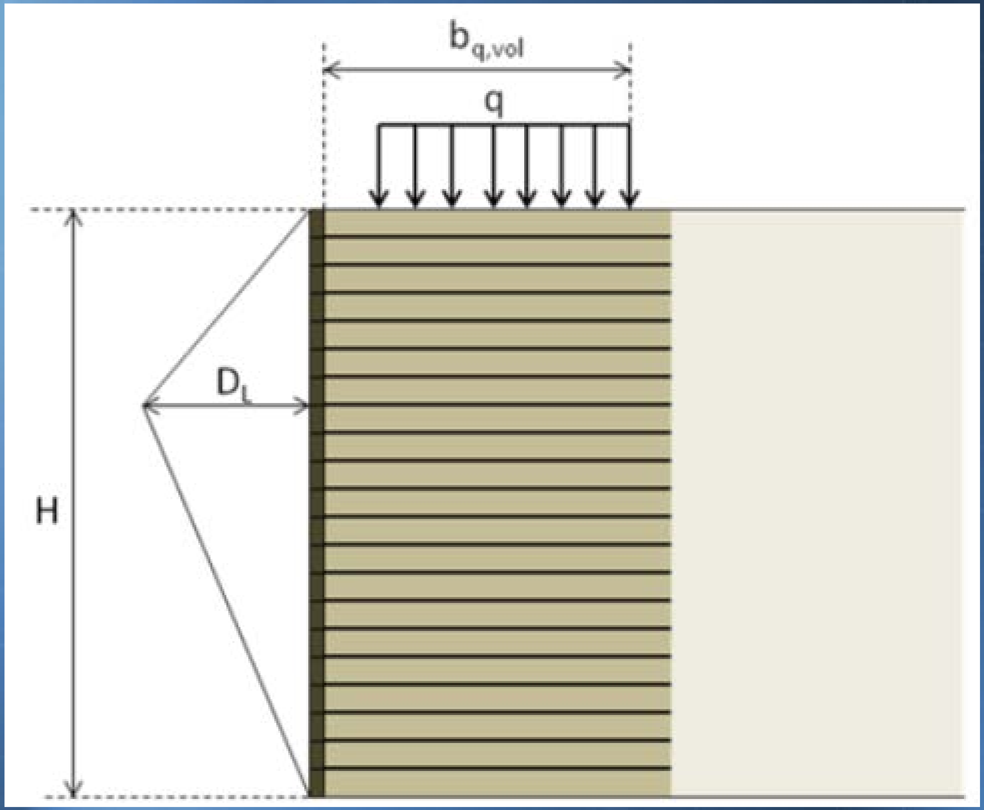
Vertical Deformation *Continued*



Lateral Deformation

- Estimated
  - Theoretically assuming no loss in volume
- Measured
  - Not frequently measured on bridges
  - Can use EDM, Slope inclinometer, etc.
- Lateral strain limited to 1% (of bearing area + setback)

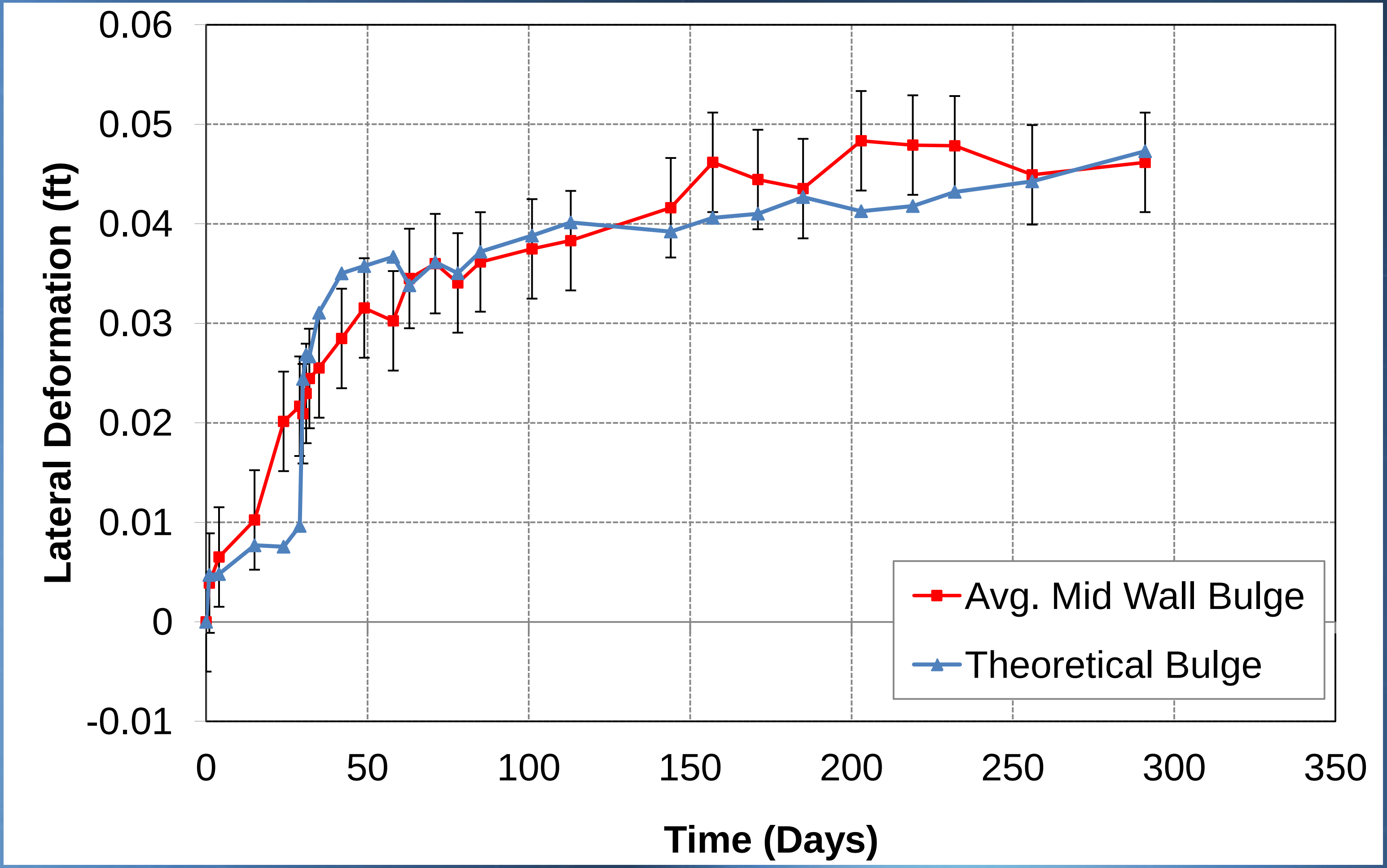
Lateral Deformation *Continued*



$$\Delta V_{top} = b_{q,vol} L D_v = \Delta V_{face} = \frac{1}{2} H L D_L$$

$$\varepsilon_L = \frac{D_L}{b_{q,vol}} = \frac{2D_v}{H} = 2\varepsilon_v$$

Lateral Deformation *Continued*

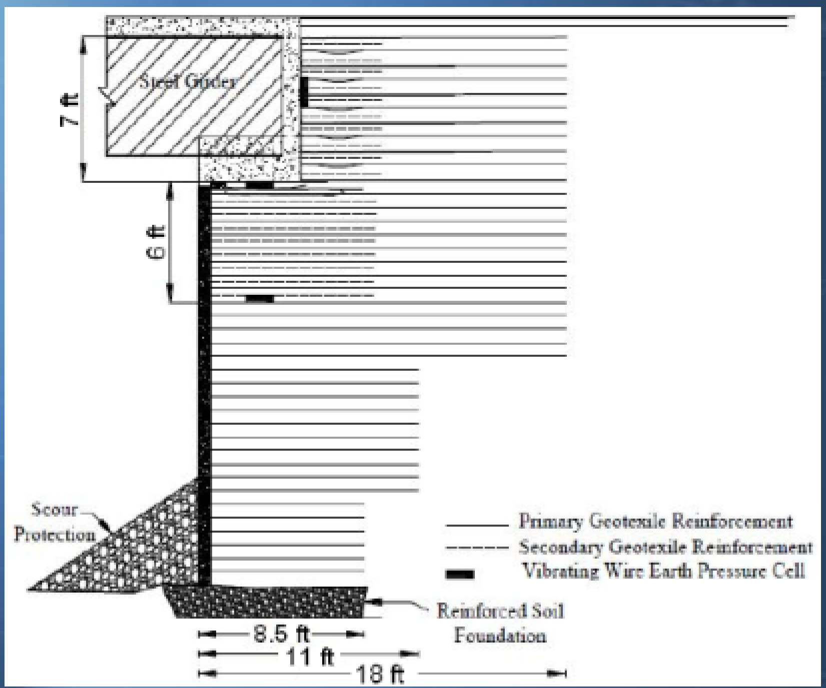


Thermal Cycles

- Compatible with thermal cycles
- Integrated transition behind the beam ends
- The wrapped face of the integrated approach:
  - Confines the soil
  - Prevents soil sloughing behind the beam ends
  - Limits development of excess pressures behind the beams

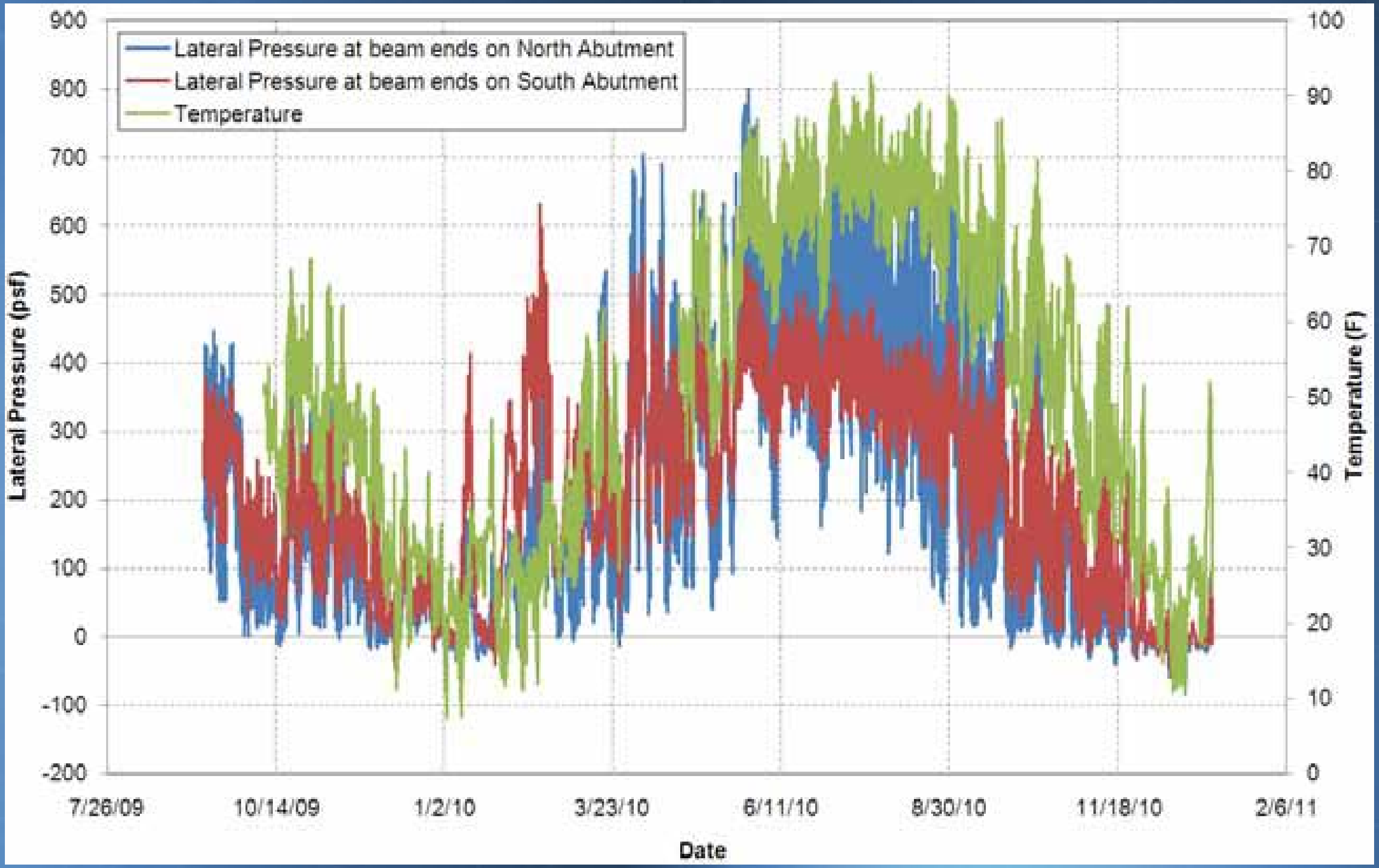
Thermal Cycles *Continued*

- To measure lateral pressure behind beam end, place vibrating wire vertical pressure cells behind the beam end and connect to a data logger



Thermal Cycles *Continued*

- Tiffin River Bridge:



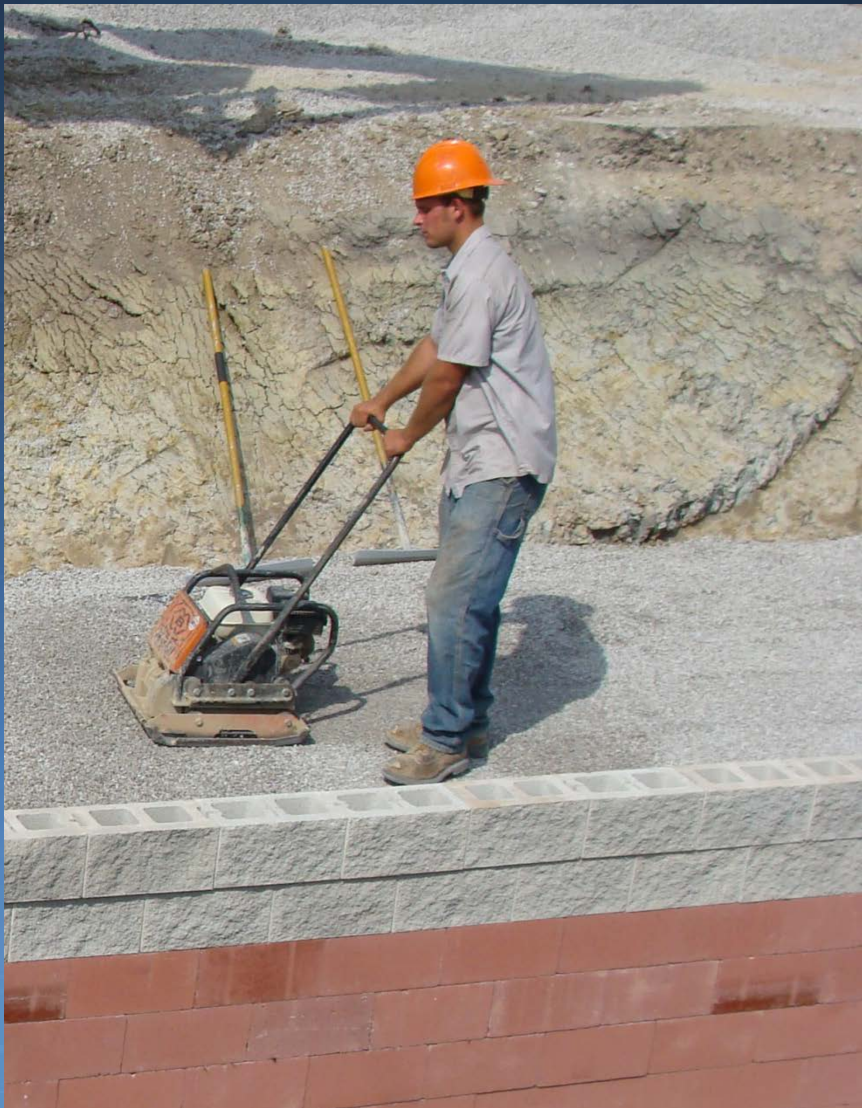
CONSTRUCTION OF GRS-IBS

Quality Assurance/Quality Control

- Block alignment
- Compaction
- Reinforcement placement
- Quality of construction materials
- Scour protection
- Drainage details

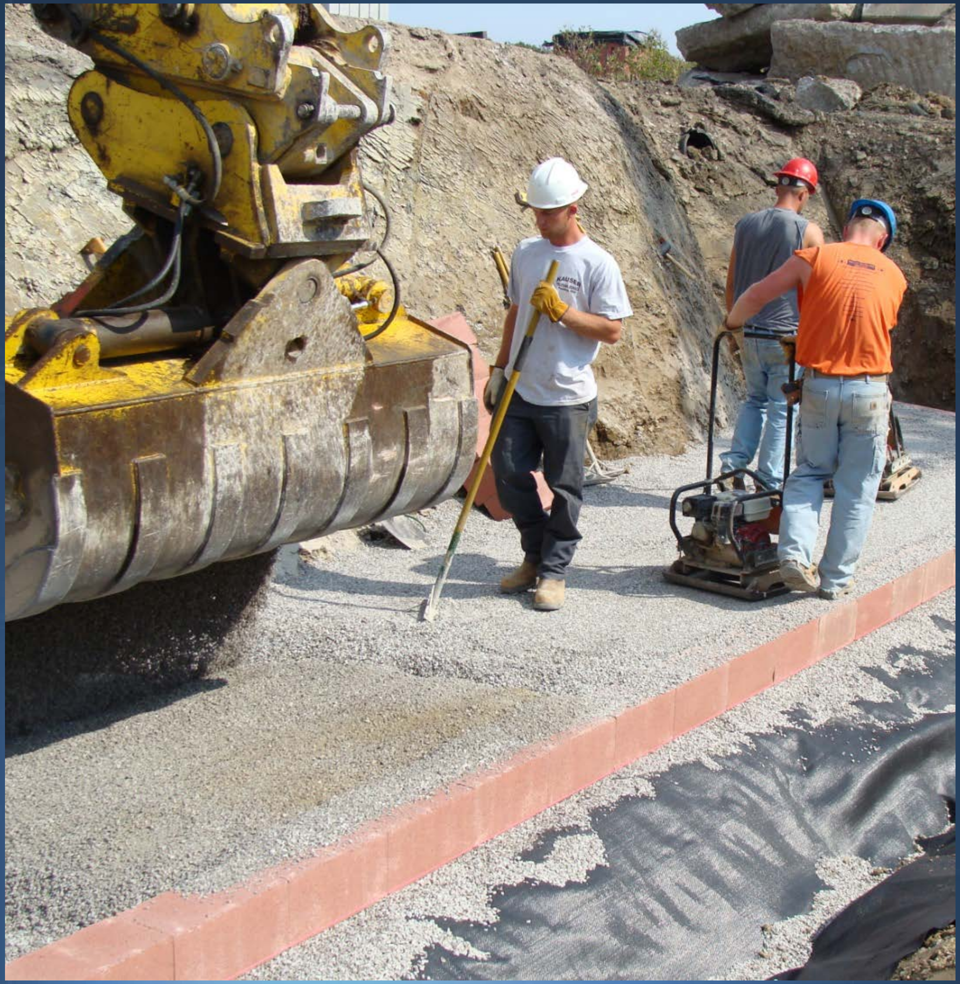
Compaction

- Compaction of the fill is extremely important
- Compact to 95% of standard proctor
- Vibratory roller to within approximately 3 ft. of face
- Light vibratory plate compactor near the face



Labor and Equipment

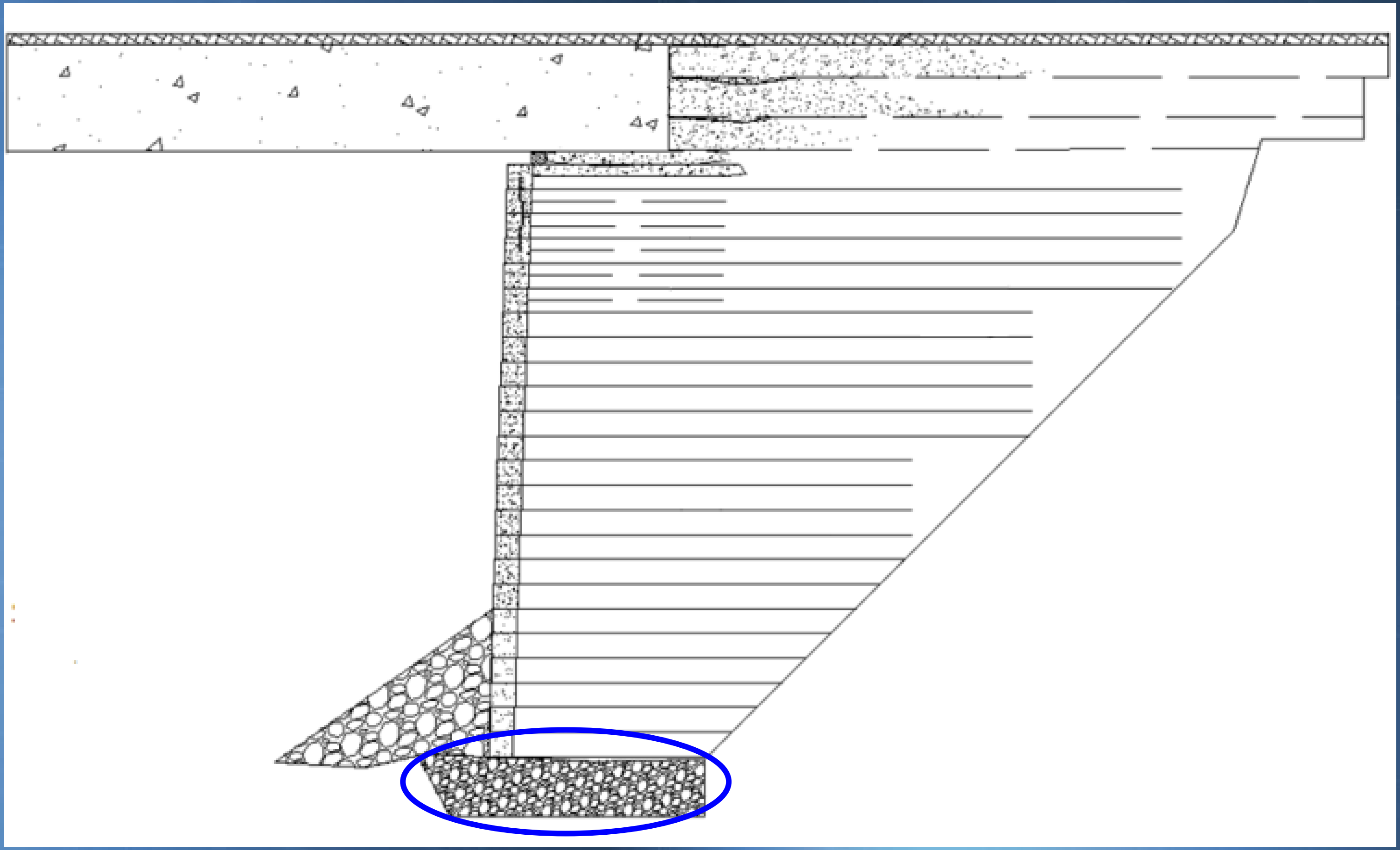
- Common labor
- Equipment: Non-specialized
  - Hand tools
  - Measuring devices
  - Heavy equipment



Excavation

Reinforced Soil Foundation (RSF)

- Provides embedment and increased bearing area

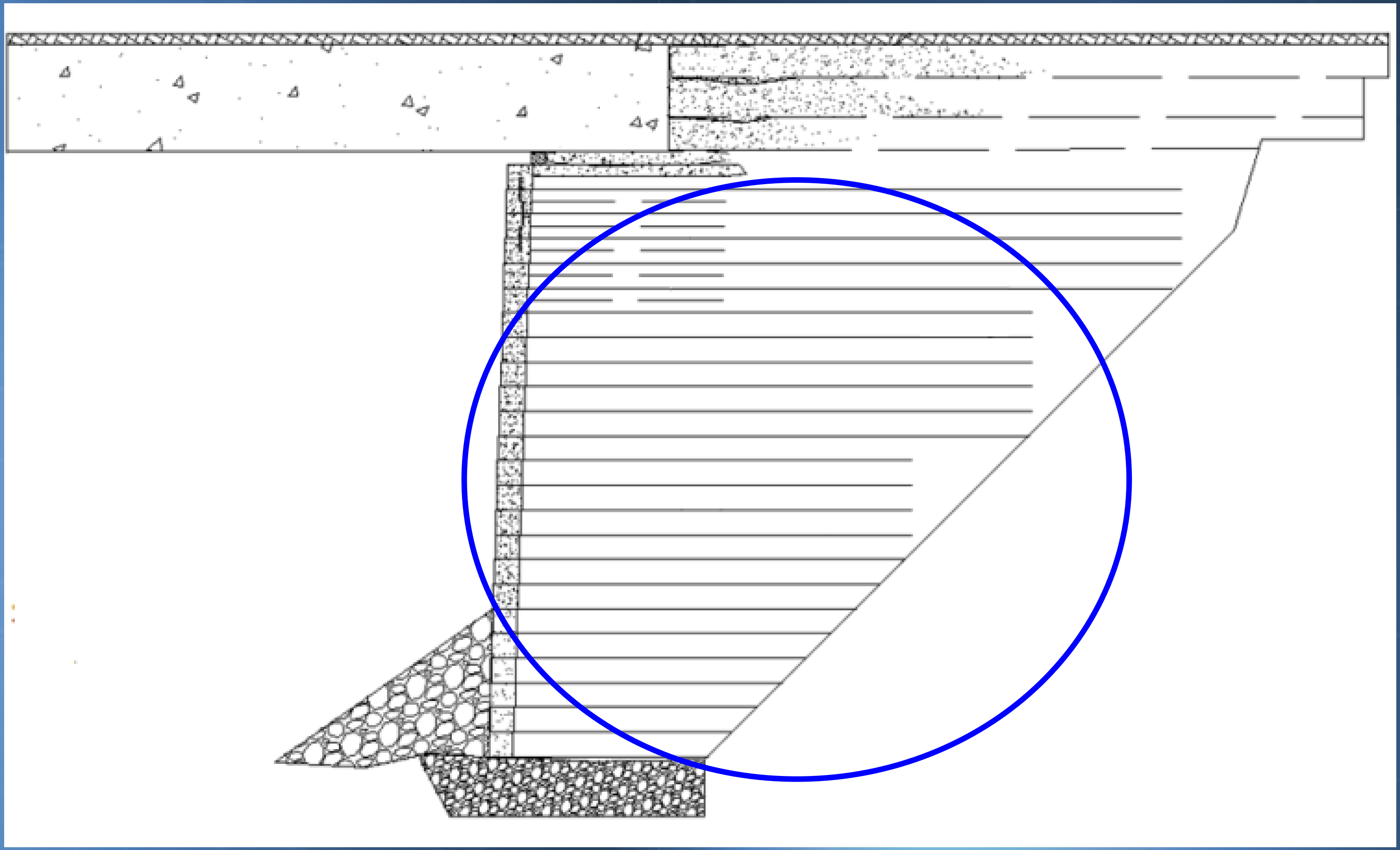



10/04/2005


MARK

GRS Abutment

- The first layers are important for leveling and alignment



GRS Abutment *Continued*

- Wall Corners:
  - Right angle wall corners constructed with CMU corner blocks that have architectural detail on two sides
  - Walls with angles ≠ 90 degrees require cutting of the corner blocks resulting in a vertical seam or joint. Fill with a dry concrete mix and install bent rebar

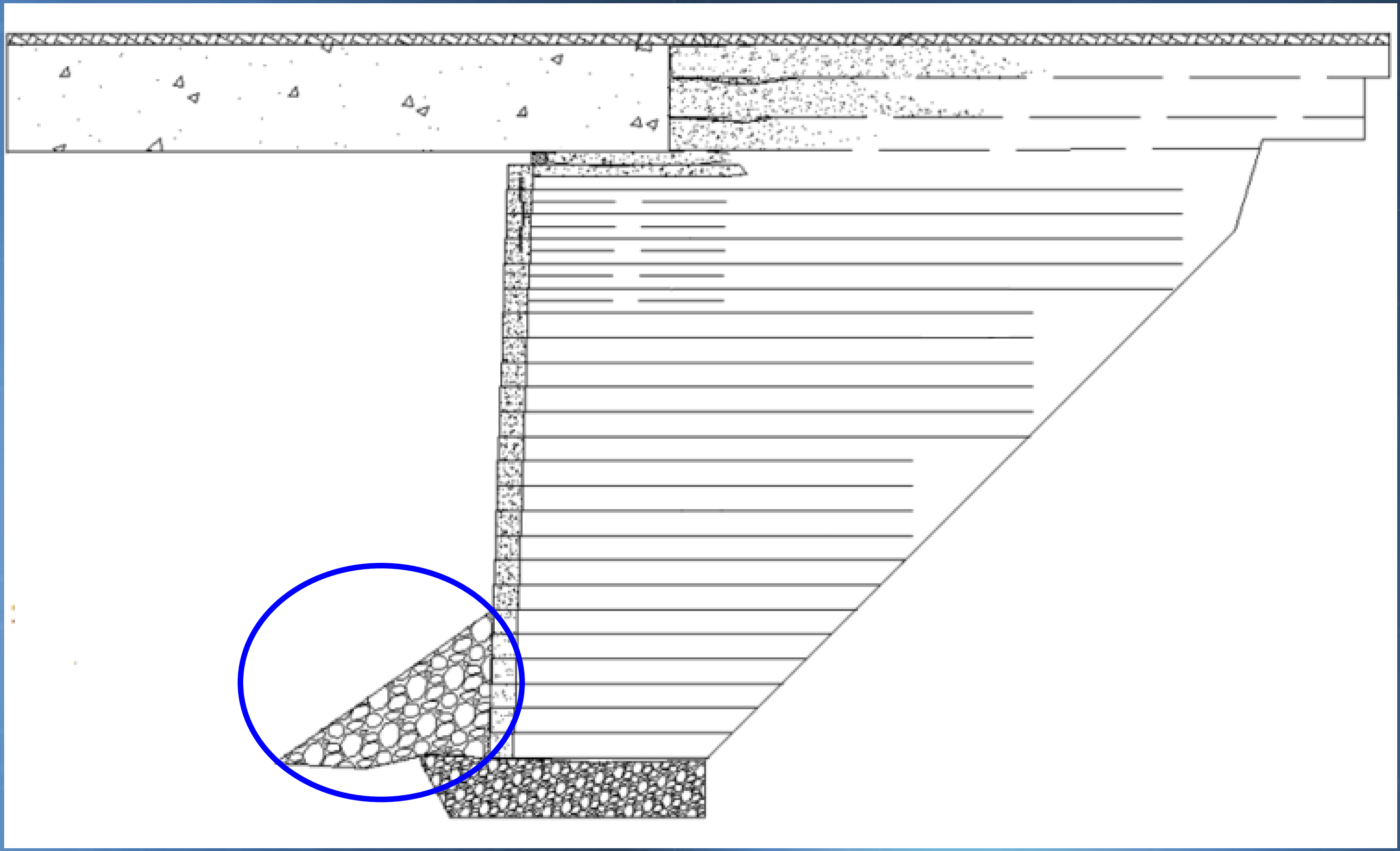
GRS Abutment *Continued*

- Top of Facing Wall:
  - The top three courses of CMU block are filled with concrete wall mix and pinned together with No. 4 rebar
  - The reinforcement between the top two courses needs to be removed with a razor knife or burning to open the core for placement of concrete wall fill

GRS Abutment *Continued*

- Coping:
  - After filling the top three courses of block, a thin layer of the same concrete mix is placed on top of the block, to form the coping cap
  - Then hand trowel the coping either square or round and sloped to drain

GRS Abutment *Continued*

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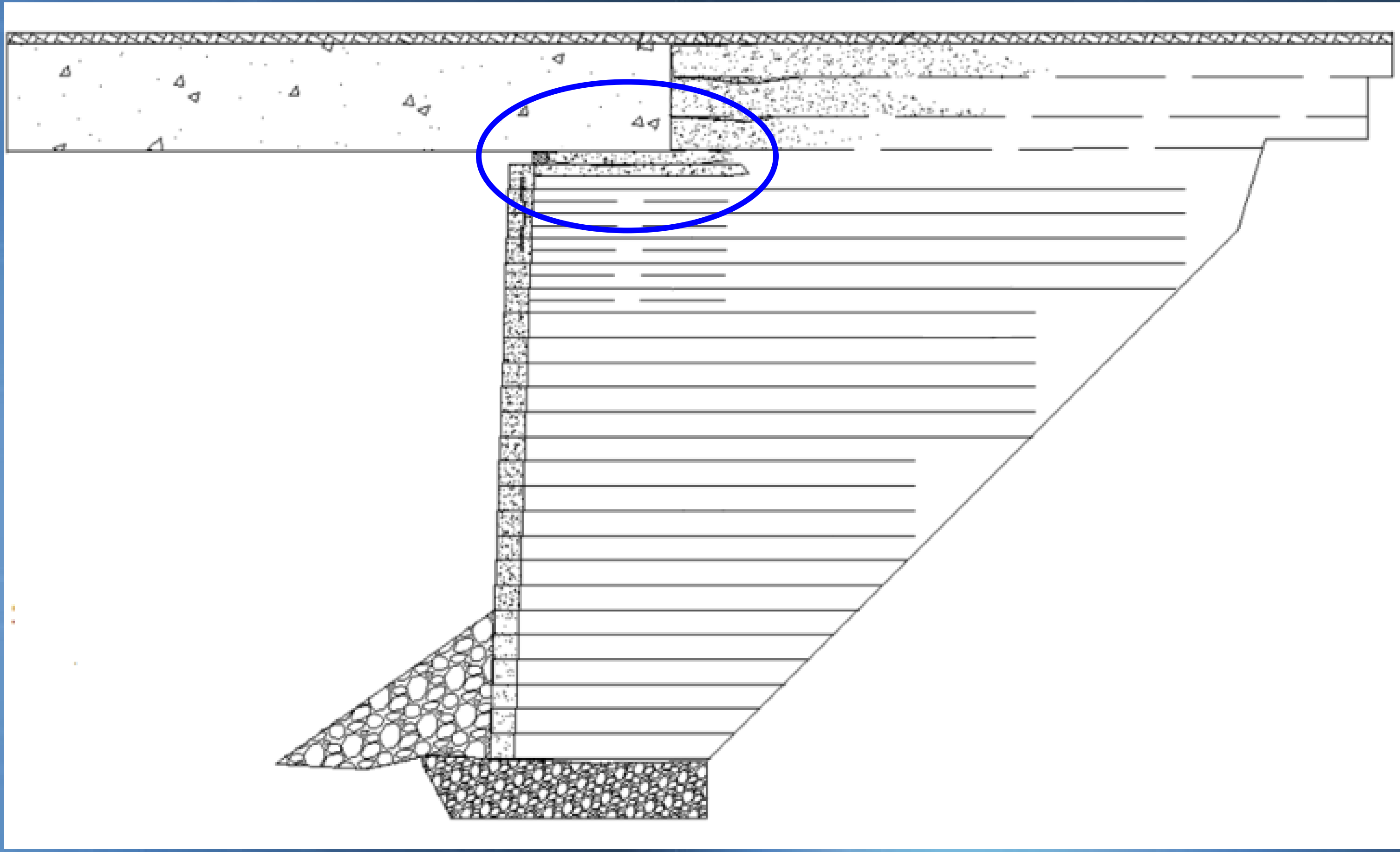
GRS Abutment *Continued*



GRS Abutment *Continued*

- Beam Seat Procedure:
  1) Place pre-cut foam board of 4 in” thickness on the top of the bearing bed reinforcement. The foam board should be butted against the back face of the CMU block.

GRS Abutment *Continued*

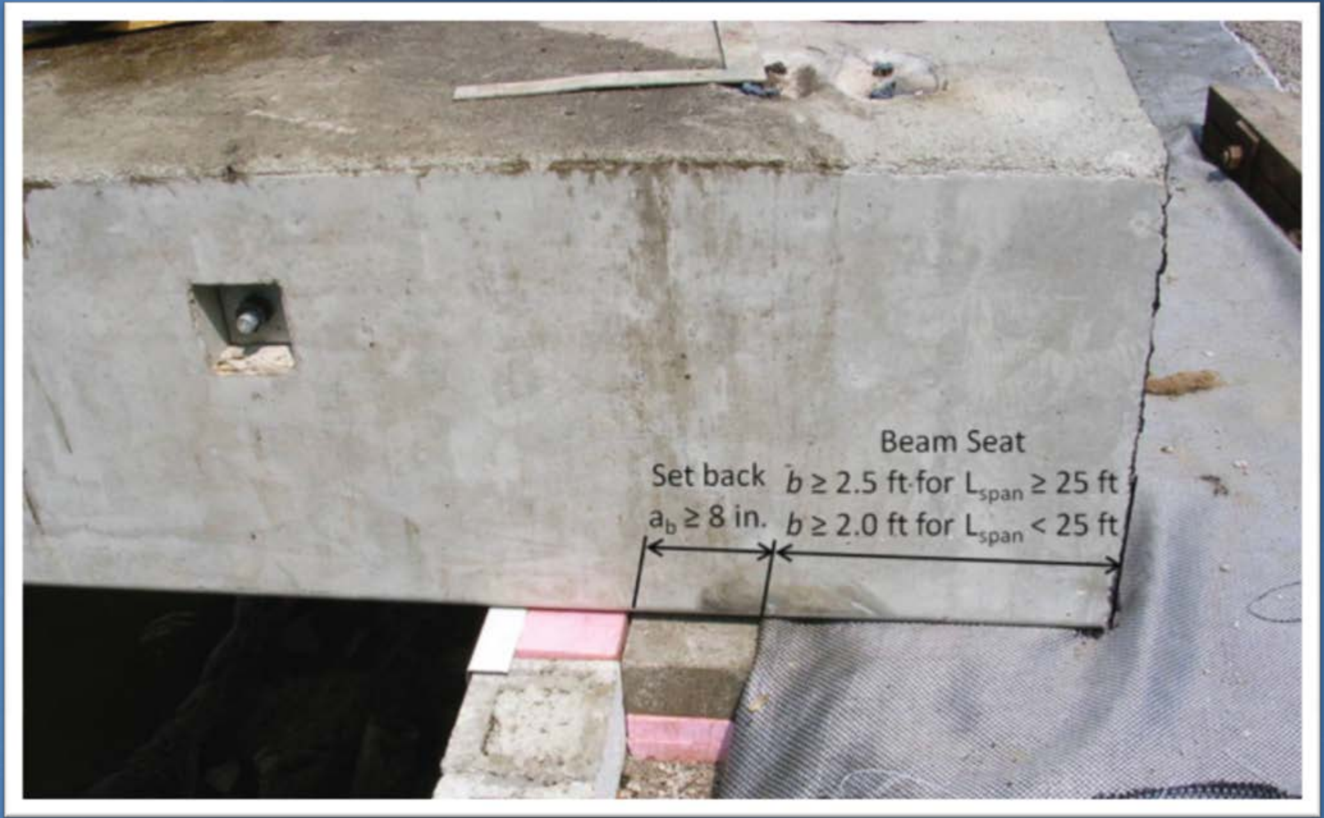
- Beam Seat Procedure:
  2) Set a 4” solid concrete block on top of the foam board, across the entire length of the bearing area.

GRS Abutment *Continued*

- Beam Seat Procedure:
  3) The first 4” wrapped layer of compacted fill is the thickness to the top of the foam board
  4) The second 4” wrapped layer of compacted backfill is to the top of the 4” solid block creating the clear space
  5) Grade the surface aggregate of the beam seat slightly high (to about 0.5”) to seat the superstructure level and maximize contact with the bearing area

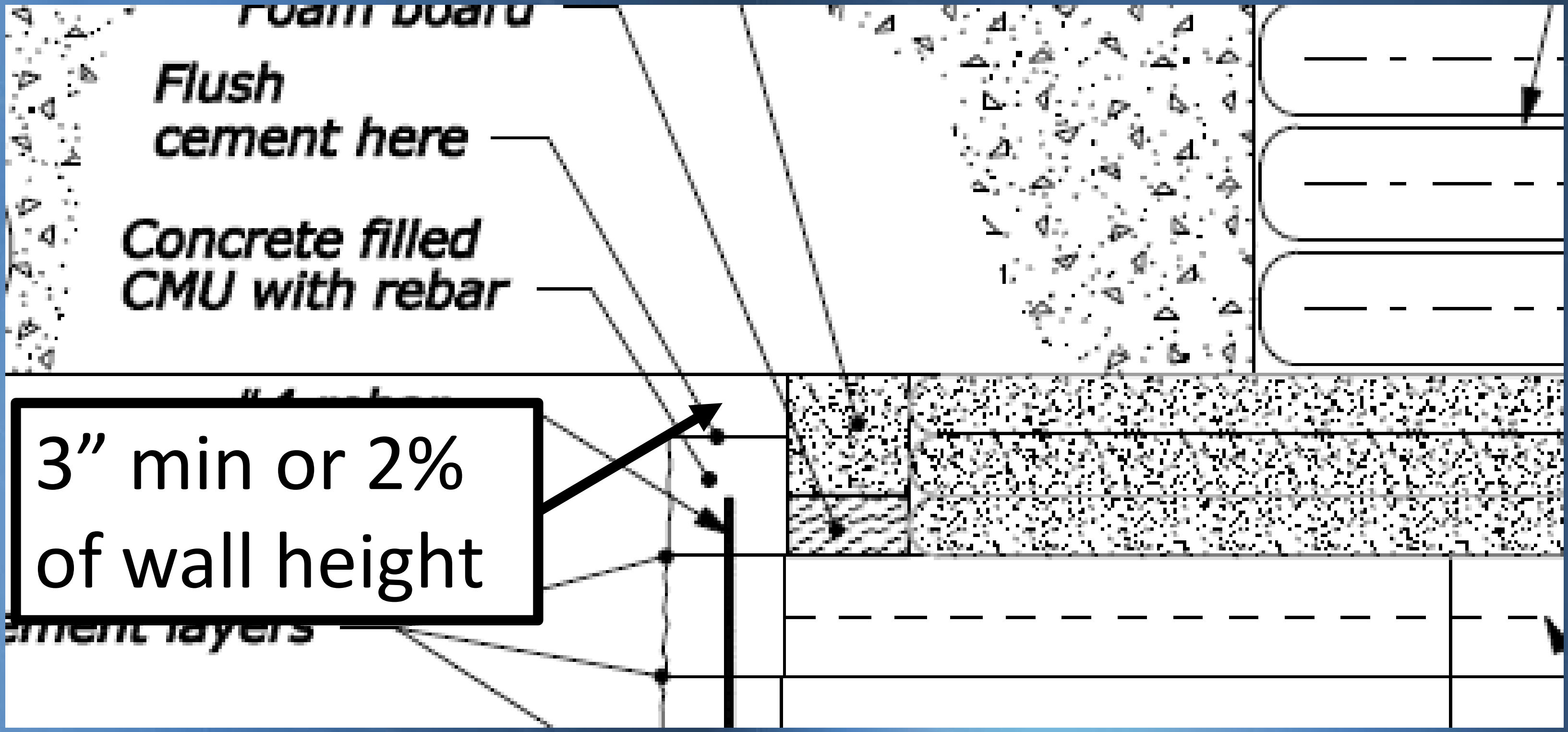
GRS Abutment *Continued*

- Set Back: The distance between the back of the facing block and the front of the beam seat

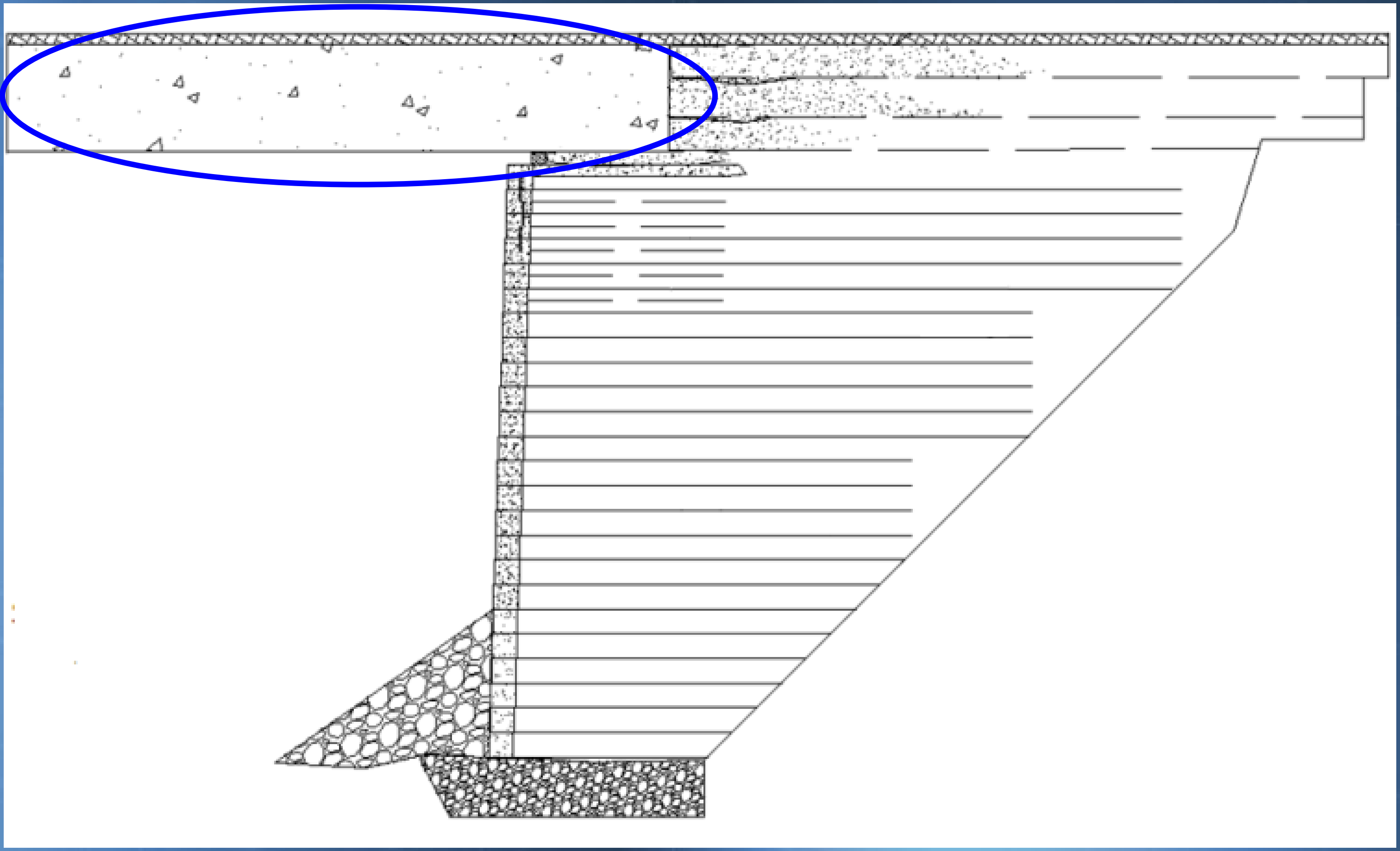


GRS Abutment *Continued*

- Clear Space: The distance between the top of the wall face and the bottom of the superstructure

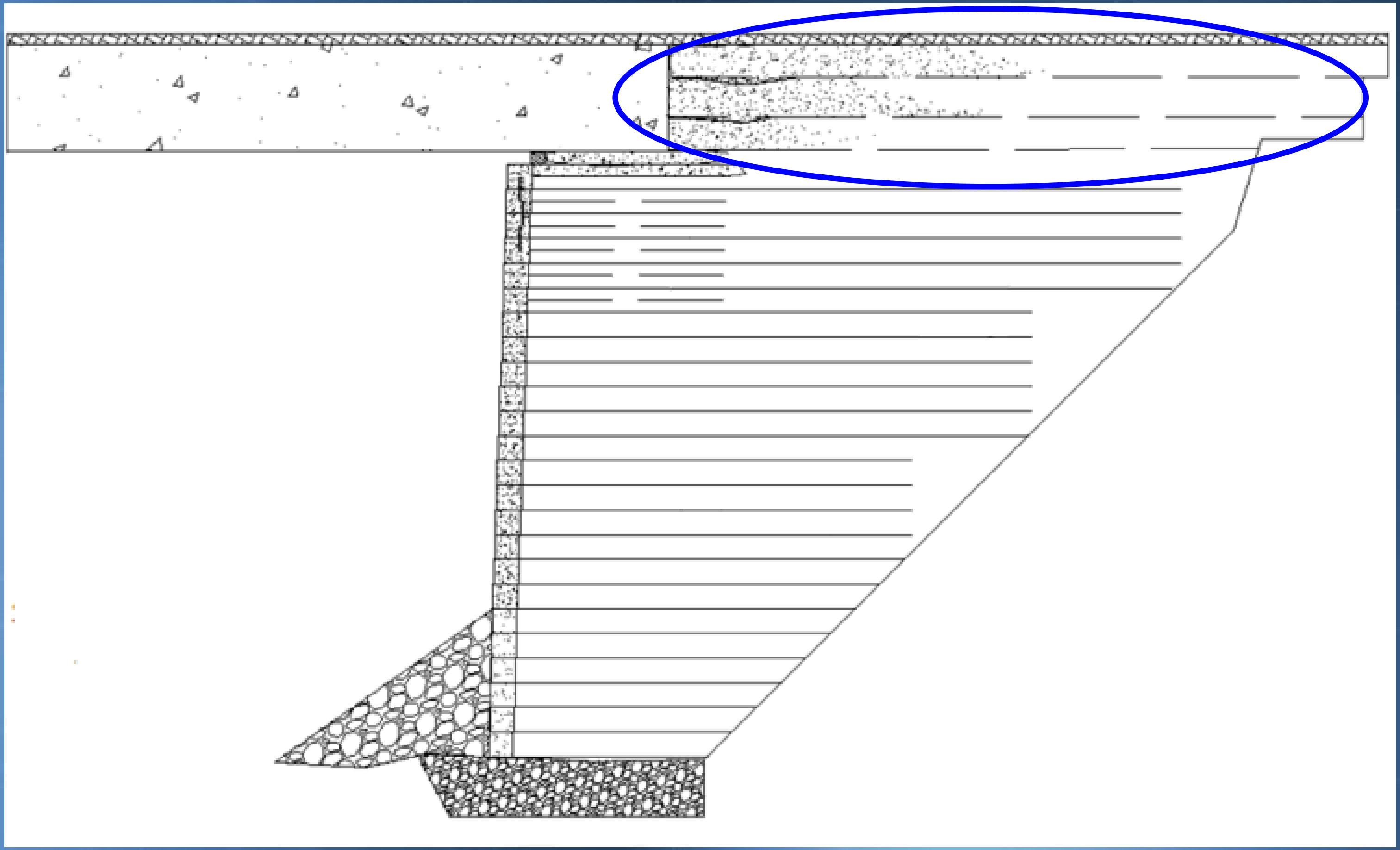


Superstructure



innovation ingenuity Every Day Counts imagination invention

Approach Integration



Approach Integration *Continued*

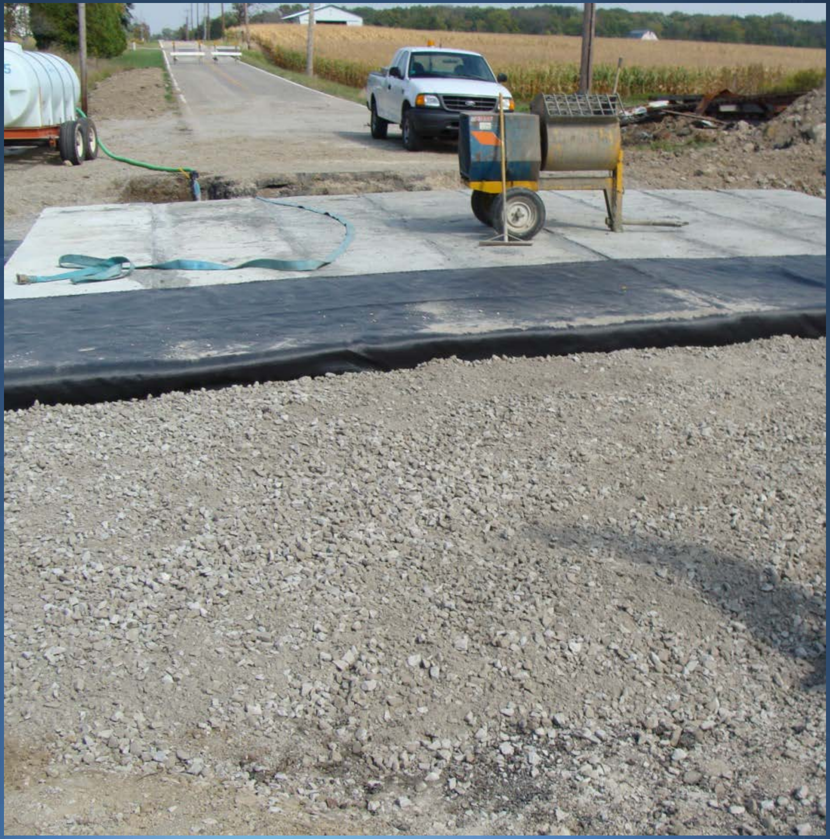
1) Trim reinforcement sheet to provide planned length after it is wrapped and place behind the beam end. The width of the sheet should allow for wrapping of the sides after the fill layer is placed and compacted. Wrapping of the sides prevents migration of the fill laterally.

Approach Integration *Continued*

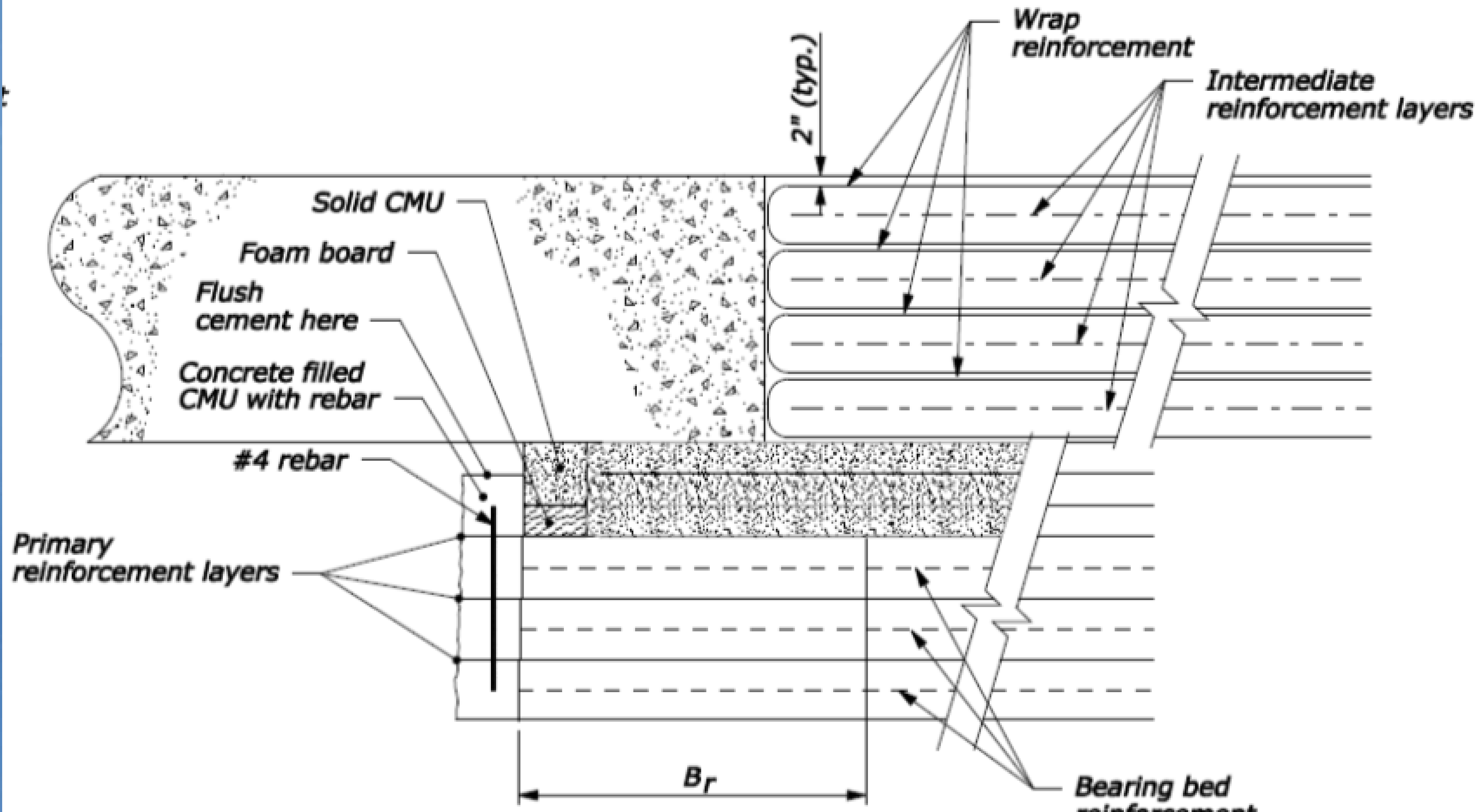
2) Place a 6” lift of fill and compact per compaction specifications for road base.
3) Add a secondary layer of reinforcement on top of the 6” lift, and then place another 6” lift of fill and compact

Approach Integration *Continued*

- In order to prevent lateral spreading of the fill material at the road/bridge interface, the reinforcement sheets comprising the wrapped layers should be folded over along the sides and perpendicular to the bridge



Approach Integration *Continued*

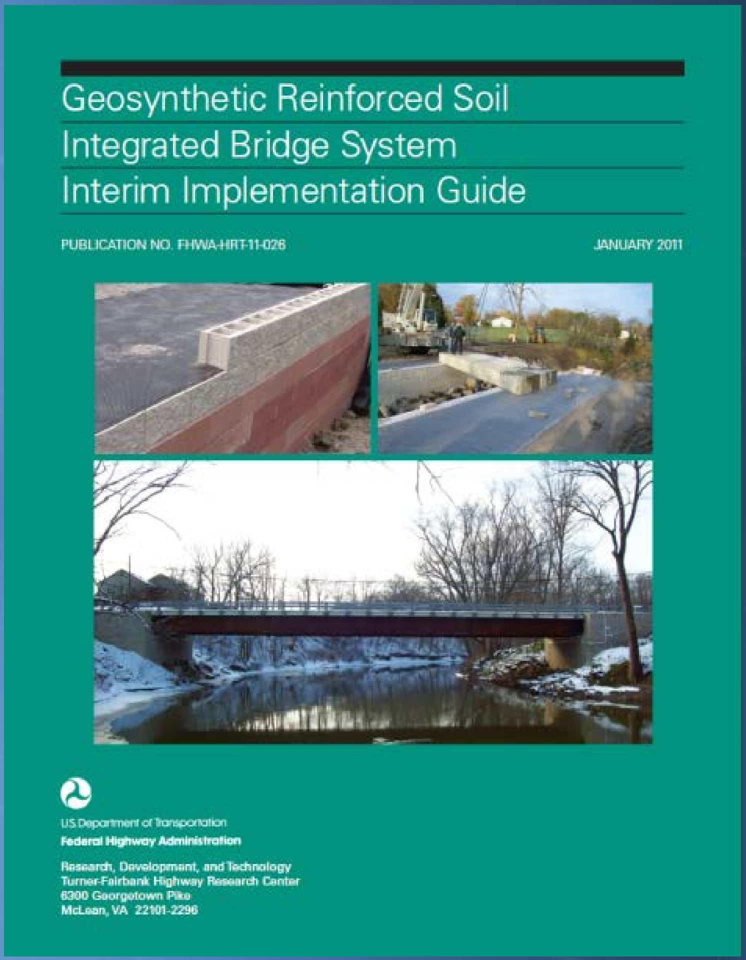


DETAIL A
(Beam seat and IBS Detail)

Construction Video

DESIGN OF GRS-IBS

GRS IBS Reports

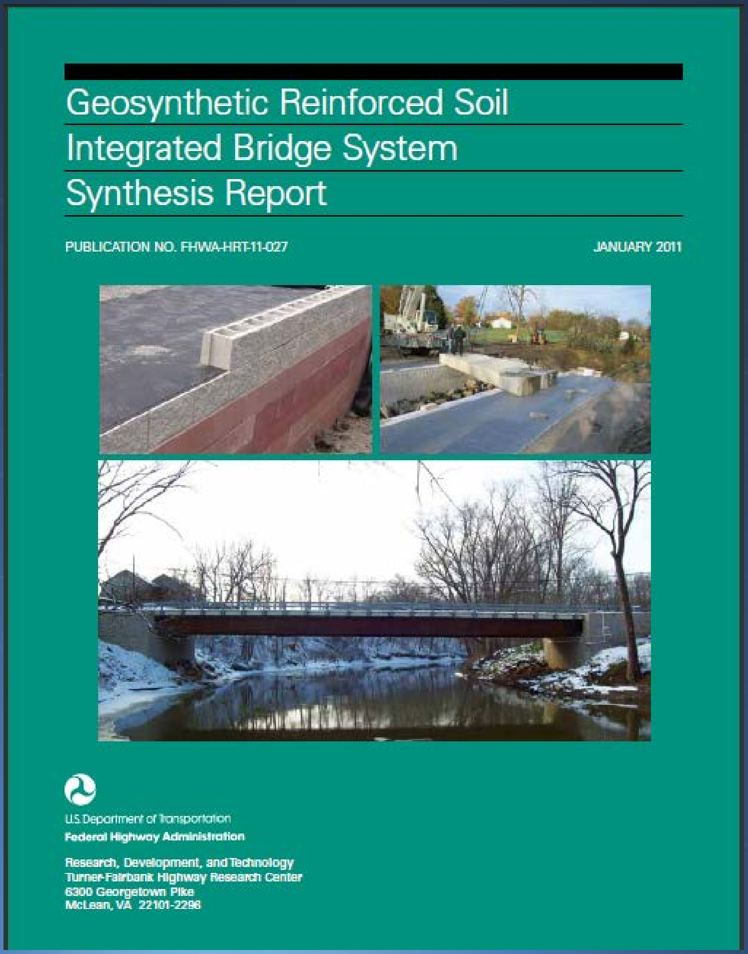


Geosynthetic Reinforced Soil
Integrated Bridge System
Interim Implementation Guide

PUBLICATION NO. FHWA-HRT-11-026 JANUARY 2011

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296



Geosynthetic Reinforced Soil
Integrated Bridge System
Synthesis Report

PUBLICATION NO. FHWA-HRT-11-027 JANUARY 2011

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

Design Process

1) Establish project requirements
2) Perform a site evaluation
3) Evaluate project feasibility
4) Determine layout of GRS-IBS
5) Calculate loads
6) Conduct an external stability analysis
7) Conduct an internal stability analysis

DESIGN OF GRS-IBS
Step 1: Establish Project Requirements

Design Requirements

- Geometry
  - Bridge layout (length, width, skew, grade, super-elevation)
  - Wall layout (height, length, batter, geometry)
- Materials
  - Facing
  - Fill
  - Reinforcement
- Loading Conditions
  - Surcharges (soil, traffic)
  - Bridge loads (dead load, live load)
  - Seismic
- Performance Criteria
  - Design format (ASD, LRFD)
  - Design life
  - Tolerable deformations (vertical, lateral, differential)
  - Factors of Safety/Resistance Factors

DESIGN OF GRS-IBS
Step 2: Perform a Site Evaluation

Perform a Site Evaluation

- Conduct a subsurface evaluation for the foundation soil: (1 boring per abutment)
  - Density (γ_f)
  - Friction Angle (ϕ_f)
  - Cohesion (c_f)
  - Undrained Shear Strength (c_u)
  - Groundwater conditions
- Refer to:
  - AASHTO (2003): "Standard Practice for Conducting Geotechnical Subsurface Investigations"
  - FHWA (2006): Soils and Foundations Manual

Perform a Site Evaluation *Continued*

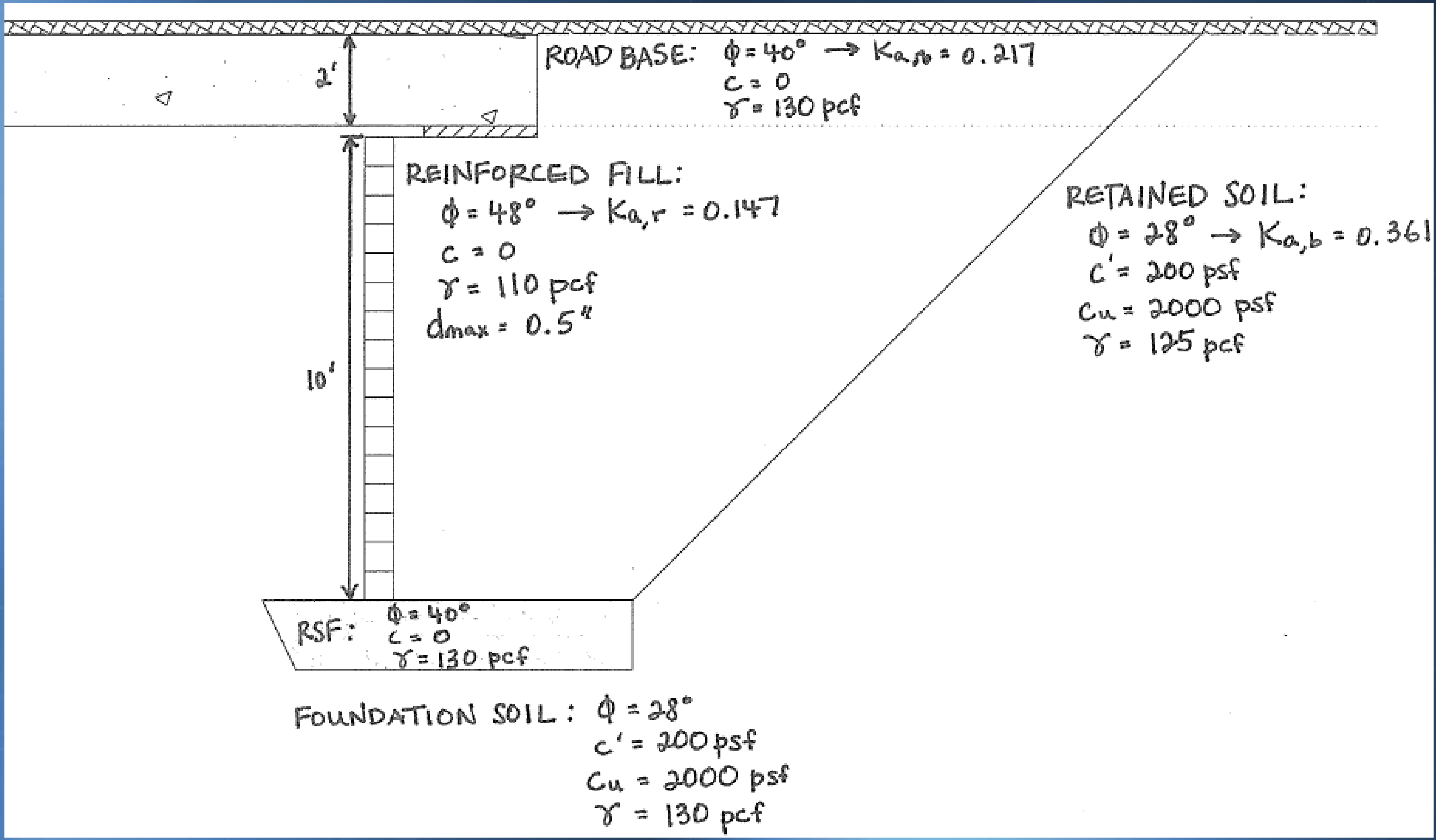
- Evaluate soil properties for the retained earth (soil behind the abutment)
  - Density (γ_b)
  - Friction Angle (ϕ_b)
  - Cohesion (c_b)

Perform a Site Evaluation *Continued*

- Evaluate soil properties for the reinforced fill
  - Density (γ_r)
  - Friction Angle (ϕ_r)
  - Cohesion (c_r): *Assume cohesionless soil*
  - Maximum aggregate size: (d_{max})

Design Example

Design Soil Parameters

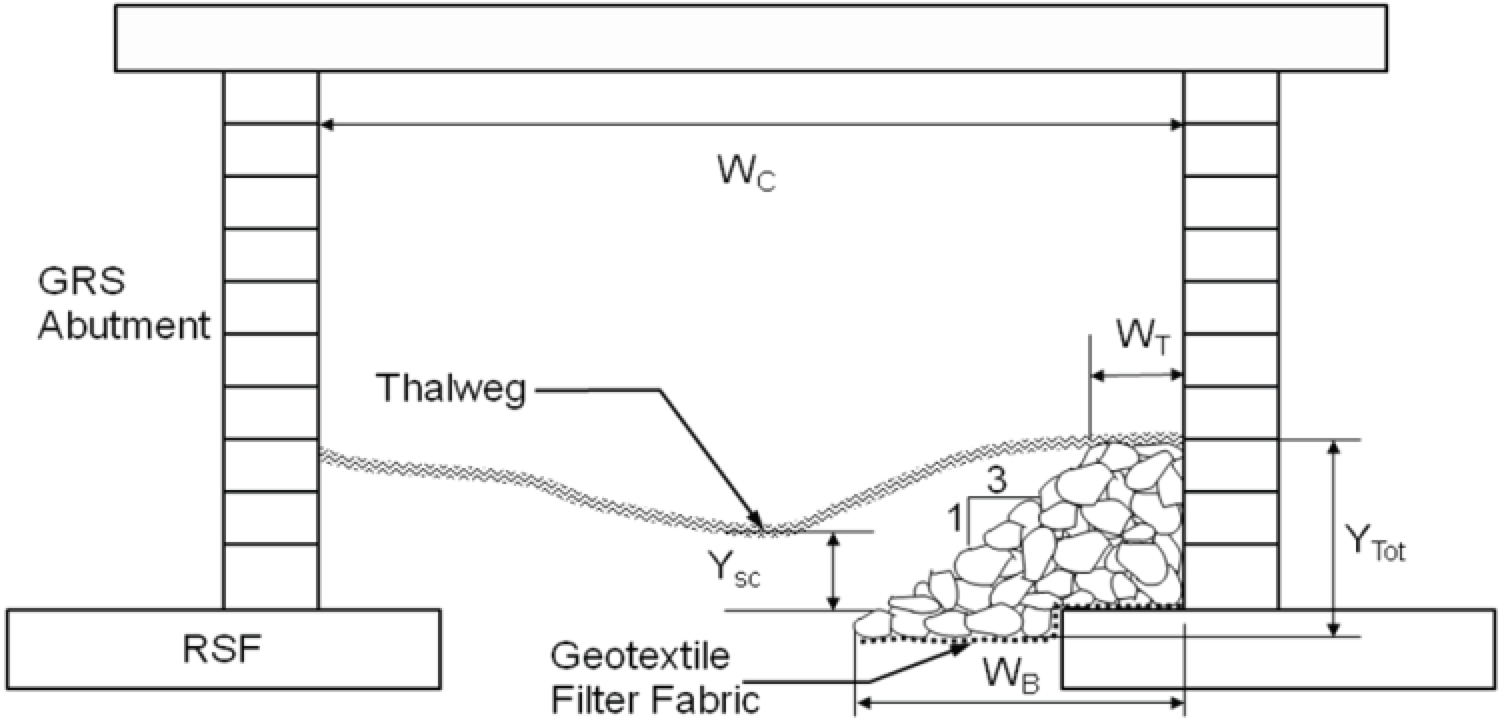


DESIGN OF GRS-IBS
Step 3: Evaluate Project Feasibility

Project Feasibility

- Is the proposed structure within the limits of the manual
  - Bridge Span < 140 ft
  - Wall height < 30 ft
  - Are the foundation materials competent
- Project cost
- Technical requirements
- Performance objectives
- Scour and/or channel instability

Scour Design



Constructed Sloping Rock

Y_{sc} = Contraction scour plus long-term degradation referenced to the thalweg.

Y_{Tot} = Distance from top of riprap to bottom of riprap (3 x $D_{50riprap}$ minimum and keyed at least 1 ft (0.3 m) below top of RSF).

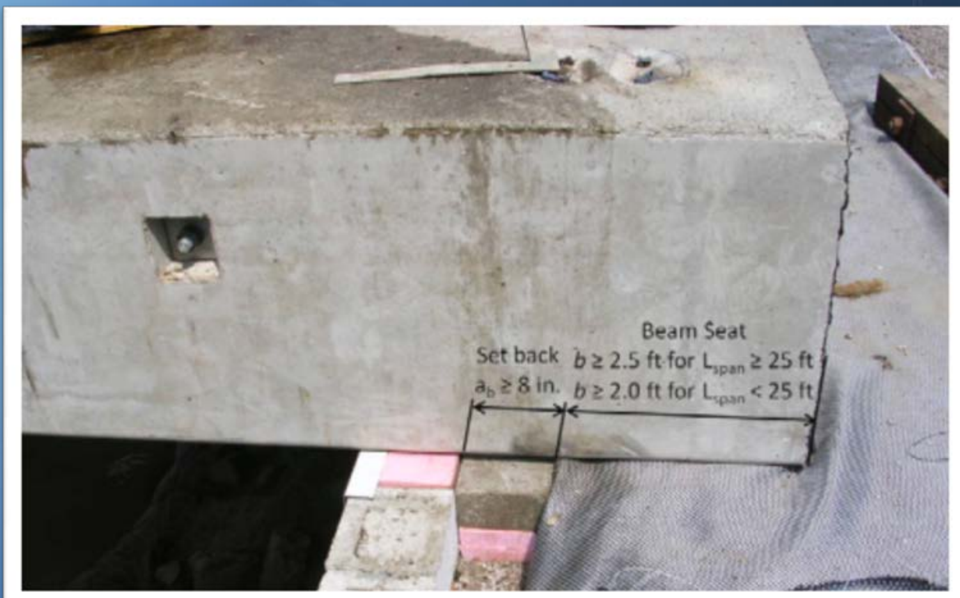
W_T = 3 x $D_{50riprap}$ or 5 ft (1.5 m), whichever is greater.

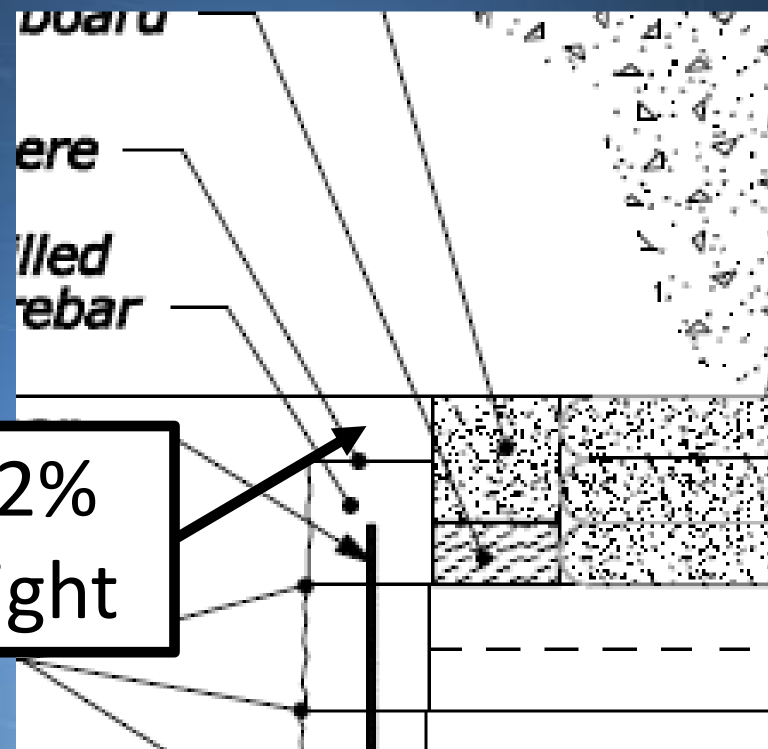
$W_B = W_T + 3Y_{Tot}$

Top of RSF (footing) elevation at Y_{sc} (or deeper) as recommended in HEC-18.

DESIGN OF GRS-IBS
Step 4: Determine Layout of GRS-IBS

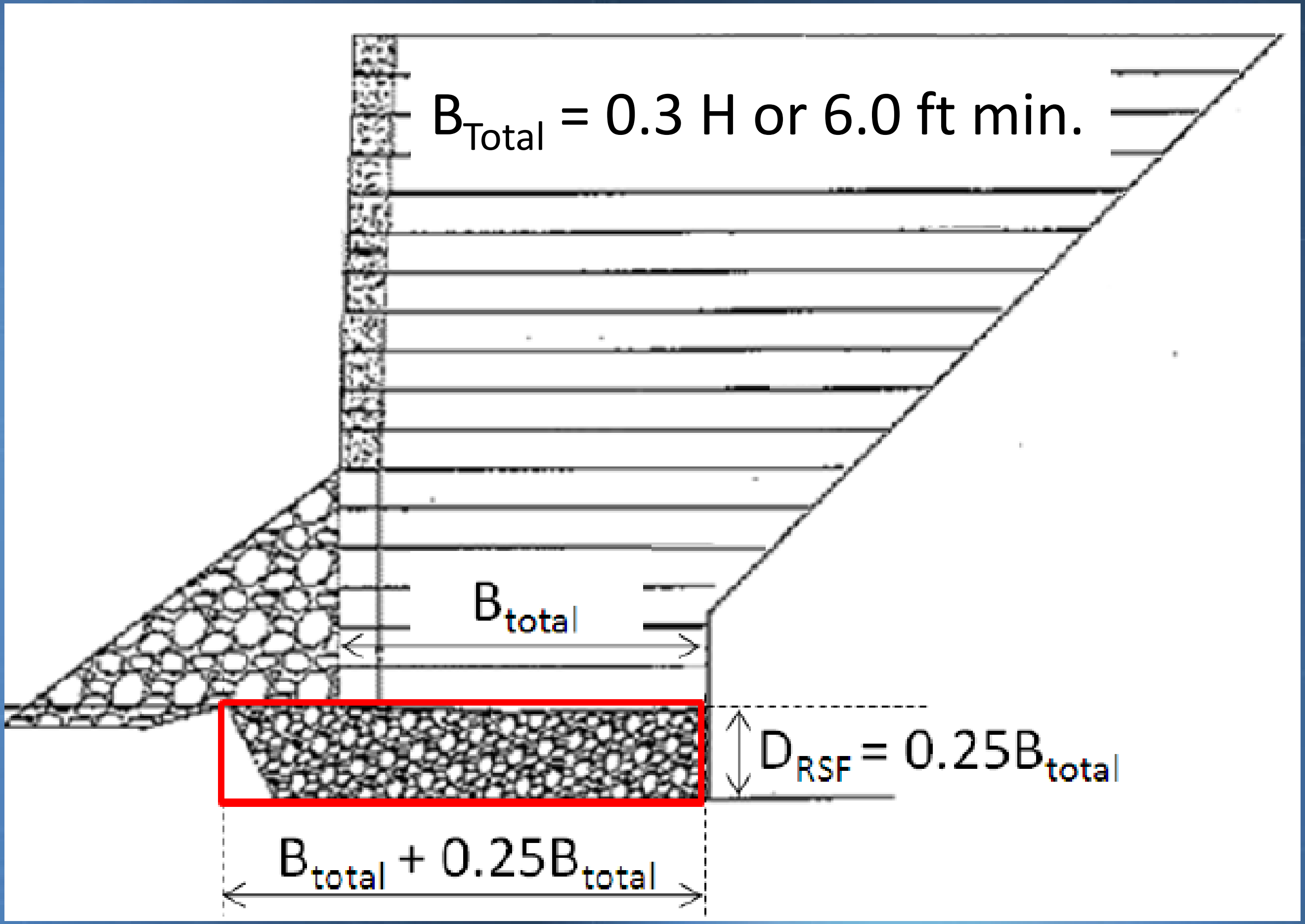
Beam Seat, Set Back and Clear Space





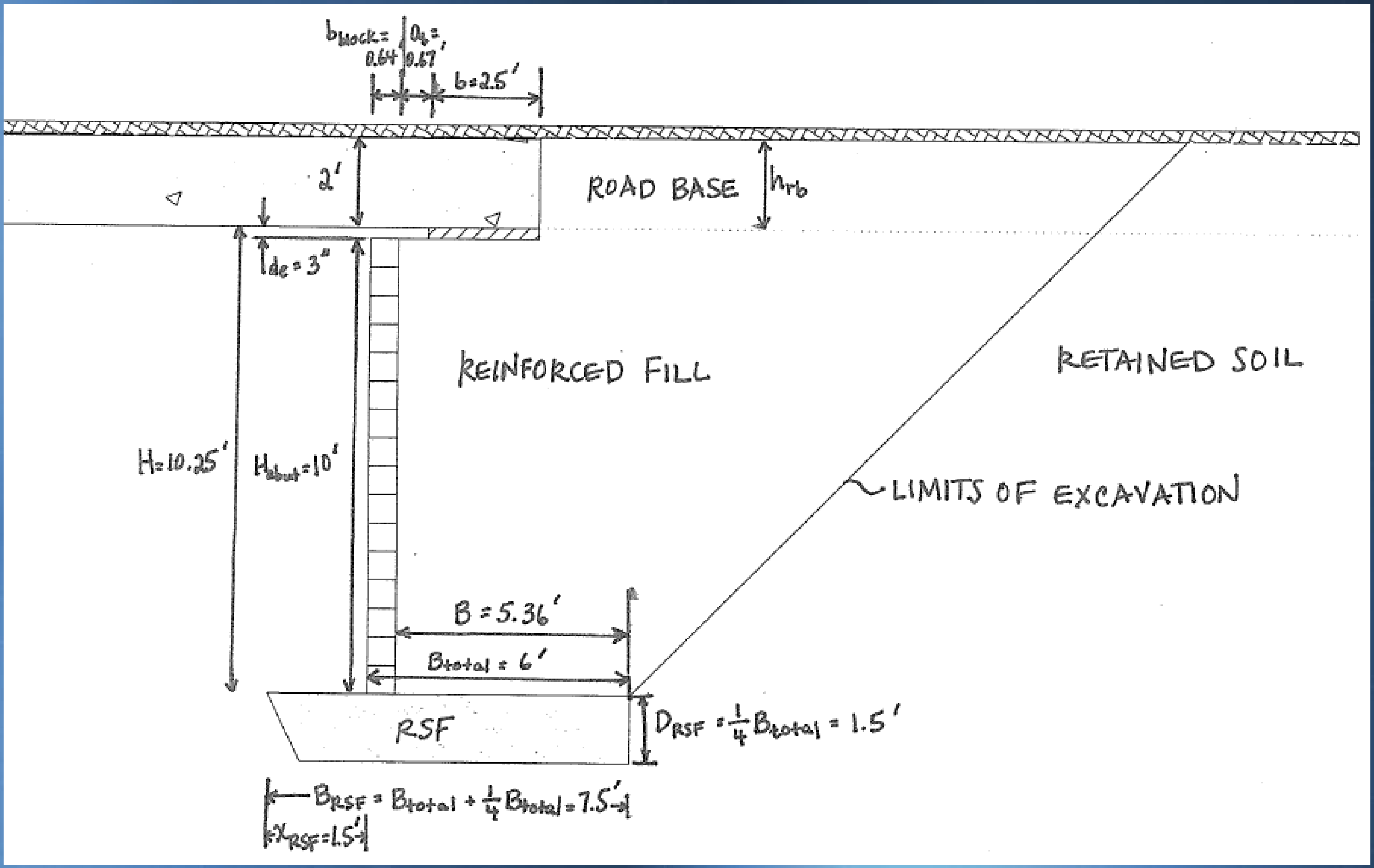
3” min or 2% of wall height

Reinforcement embedment length



Design Example

GRS-IBS Layout



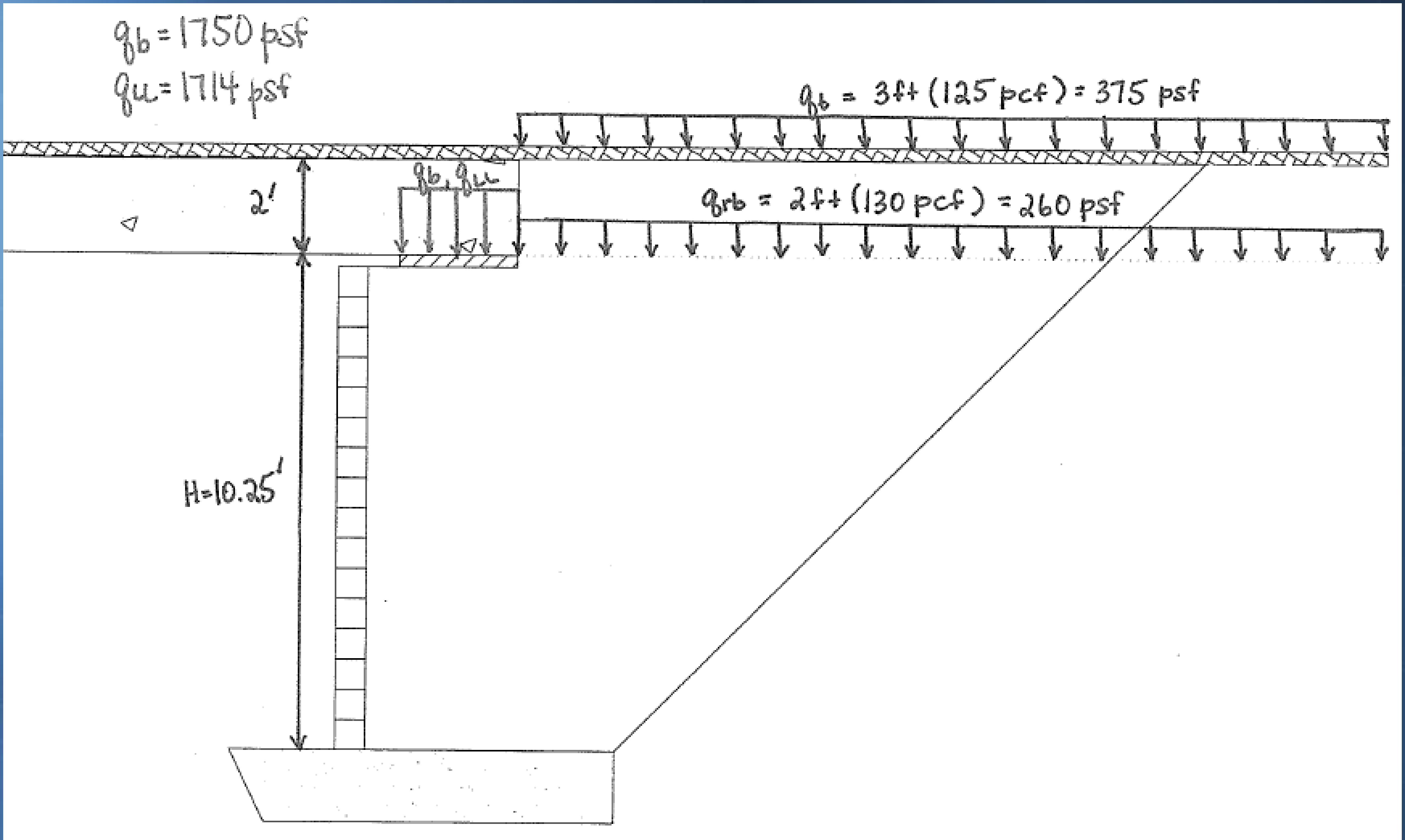
DESIGN OF GRS-IBS
Step 5: Calculate Applicable Loads

Calculate Loads

- Traffic live loads above embankment
- Road base above GRS abutment
- Bridge loads (from Bridge engineer)
  - Dead loads from superstructure
  - Live loads from deign vehicle

Design Example

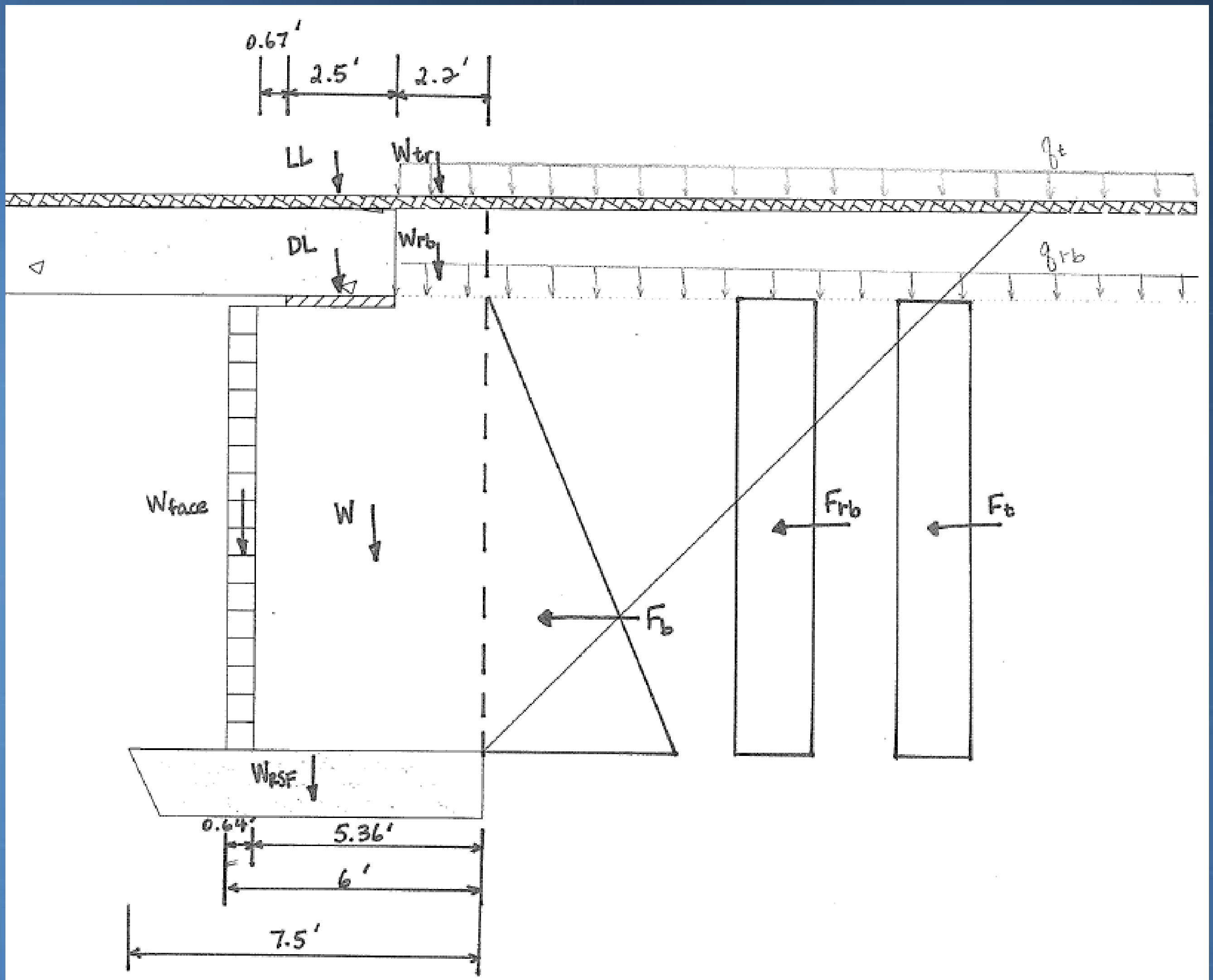
Design Loads



DESIGN OF GRS-IBS
Step 6: Conduct an External Stability Analysis

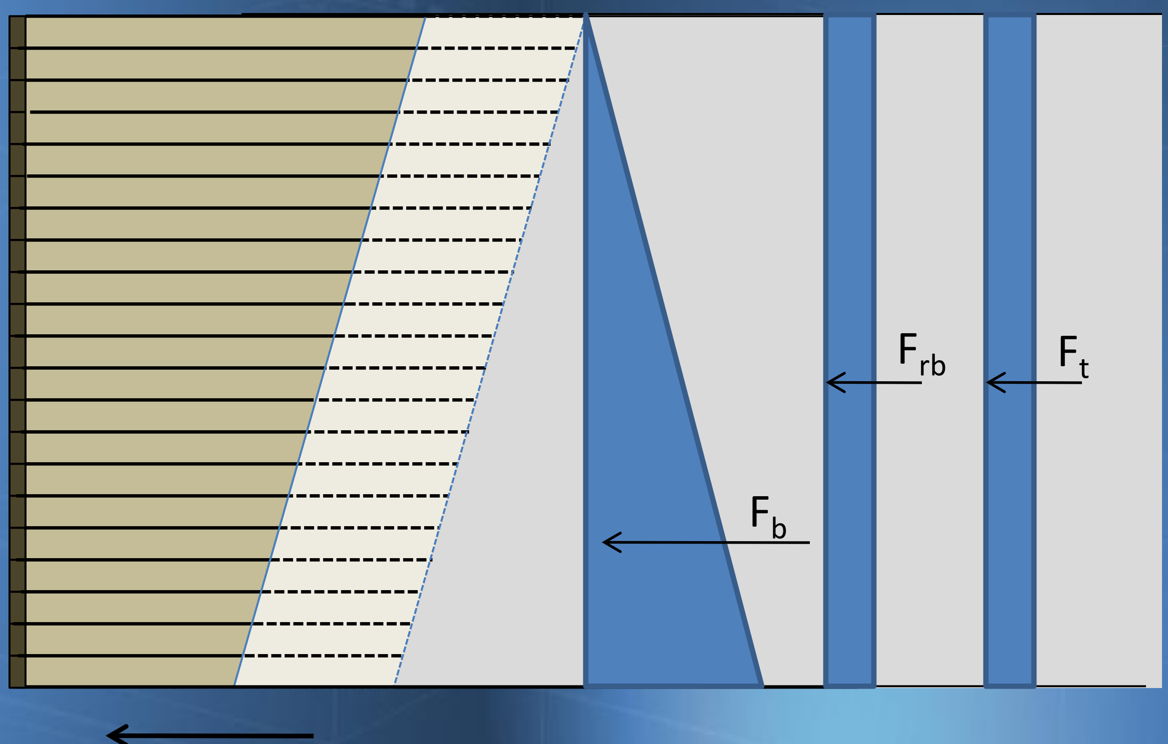
Design Example

External Stability – Forces *Continued*



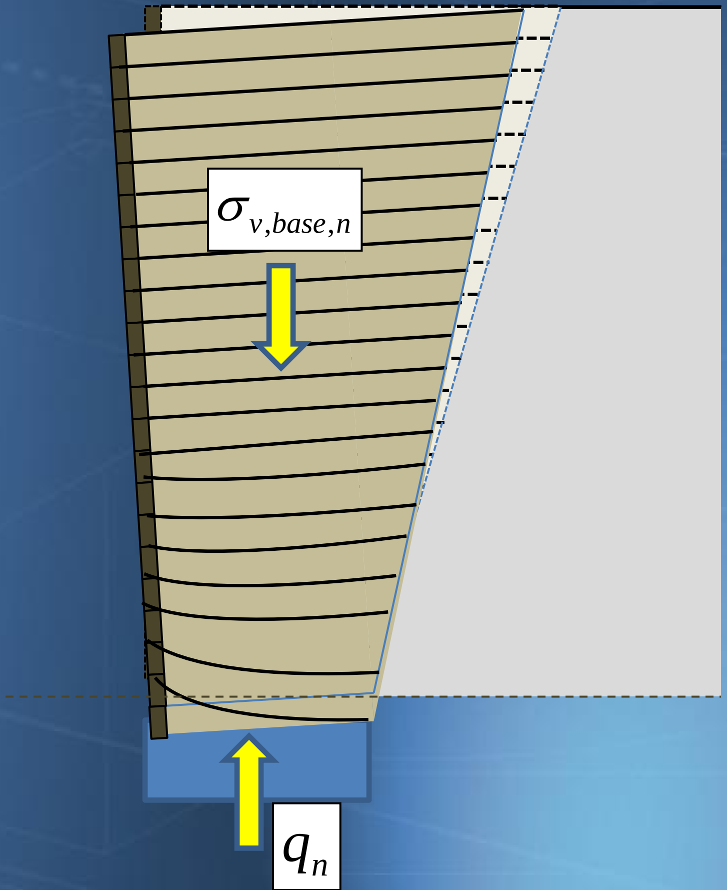
Direct Sliding

$$FS_{slide} = \frac{R_n}{F_n} \geq 1.5$$



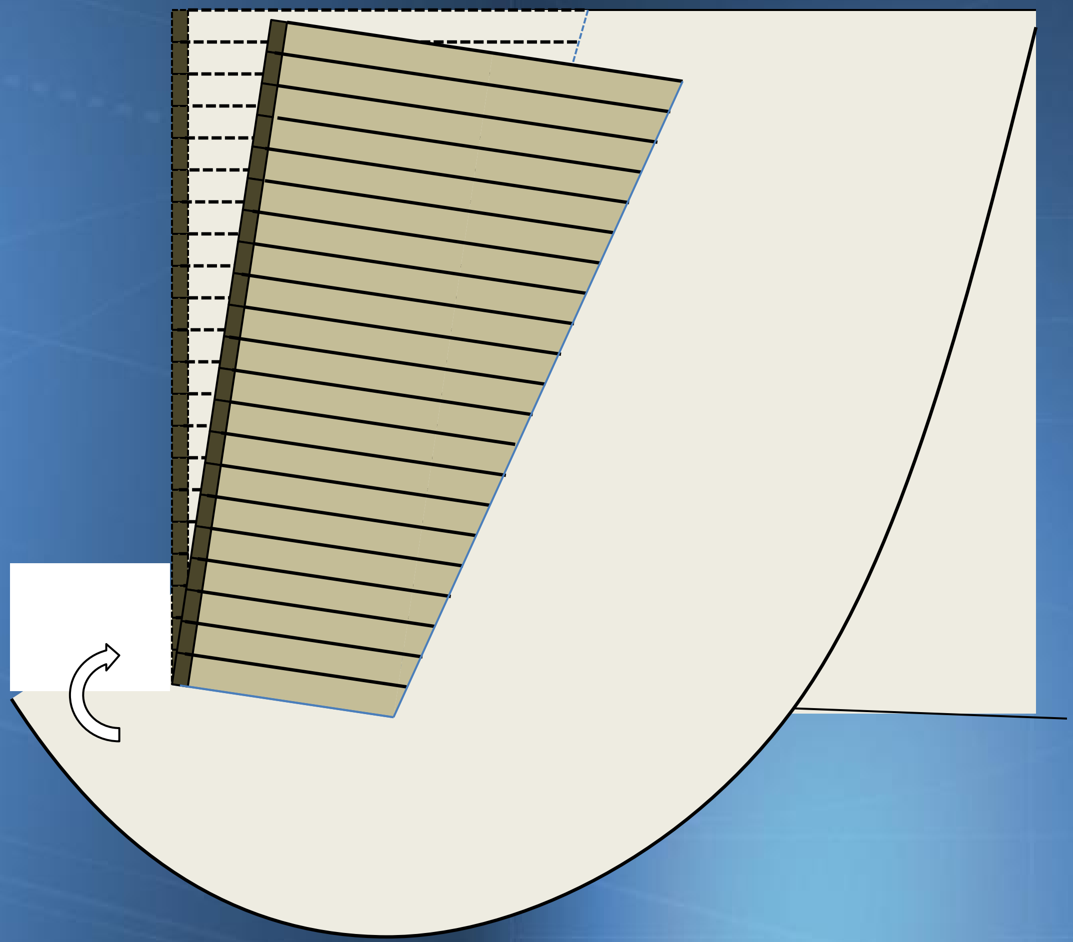
Bearing Capacity

$$FS_{bearing} = \frac{q_n}{\sigma_{v,base,n}} \geq 2.5$$



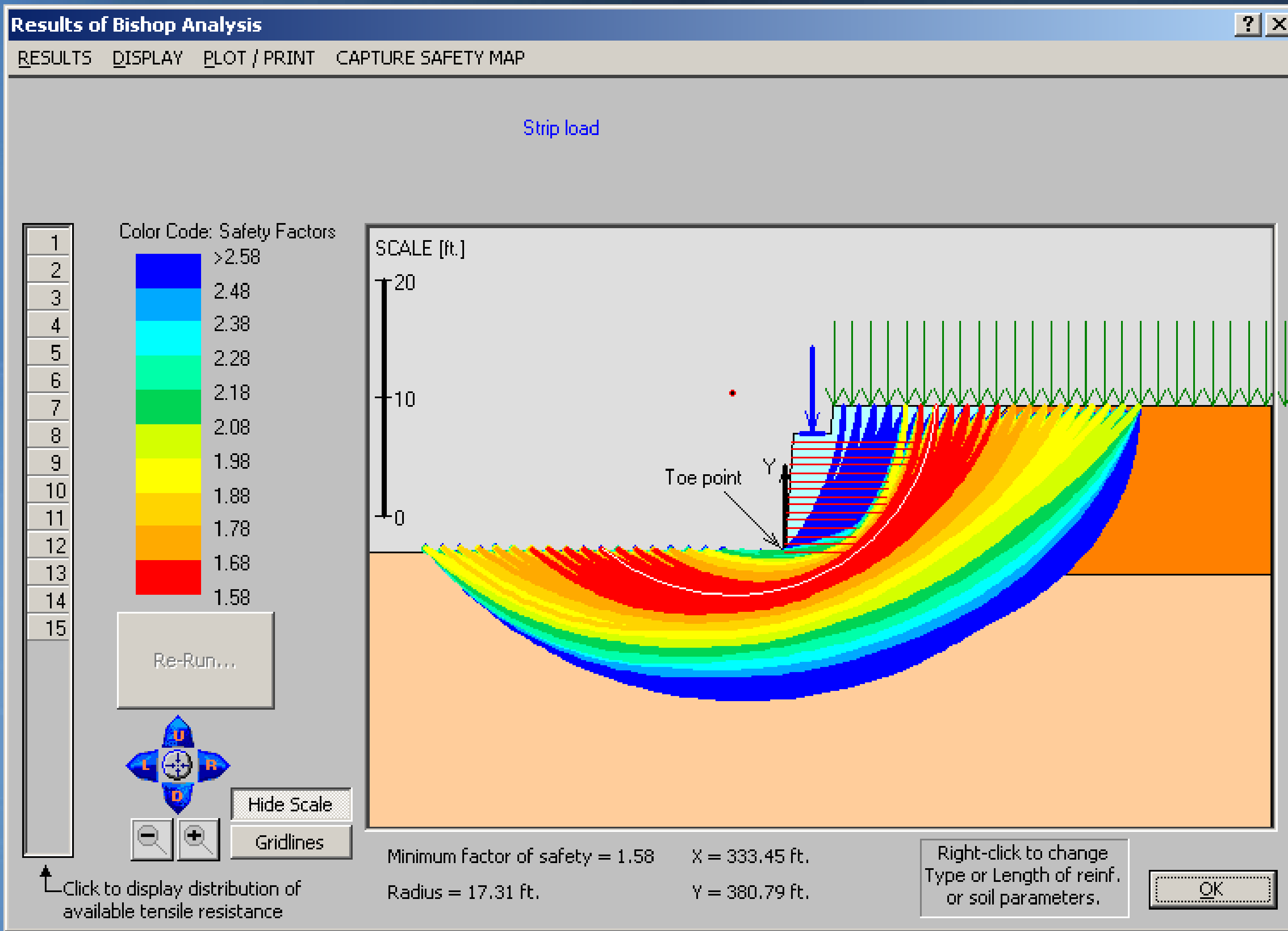
Global Stability

$$FS_{global} \geq 1.5$$



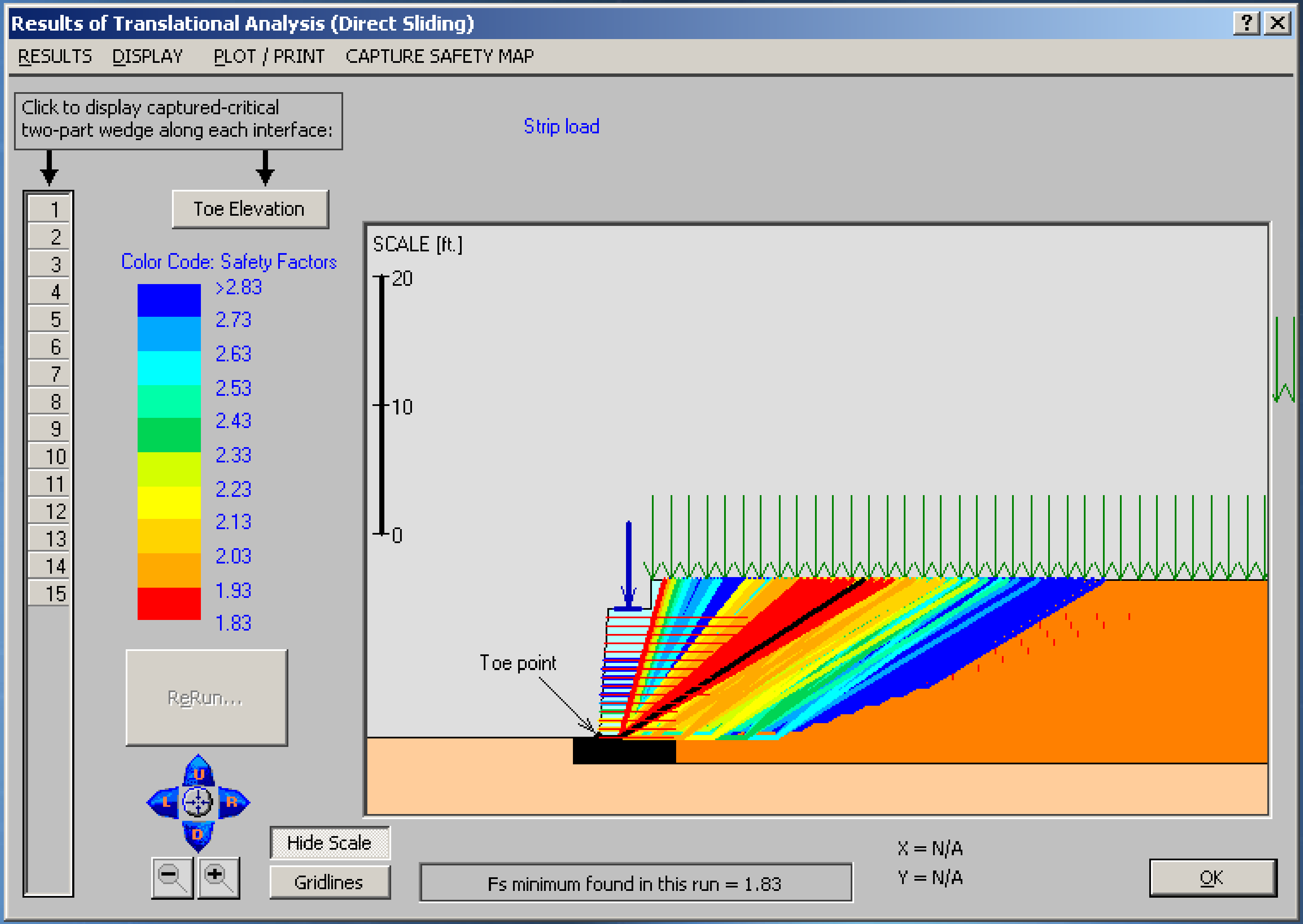
Design Example

Global Stability *Continued*



Design Example

Global Stability *Continued*



DESIGN OF GRS-IBS
Step 7: Conduct an Internal Stability Analysis

Internal Stability Analysis

- Ultimate Capacity (Empirical and Analytical)
  - Empirical Method
  - Analytical Method
- Deformations
  - Vertical
  - Lateral
- Required Reinforcement Strength

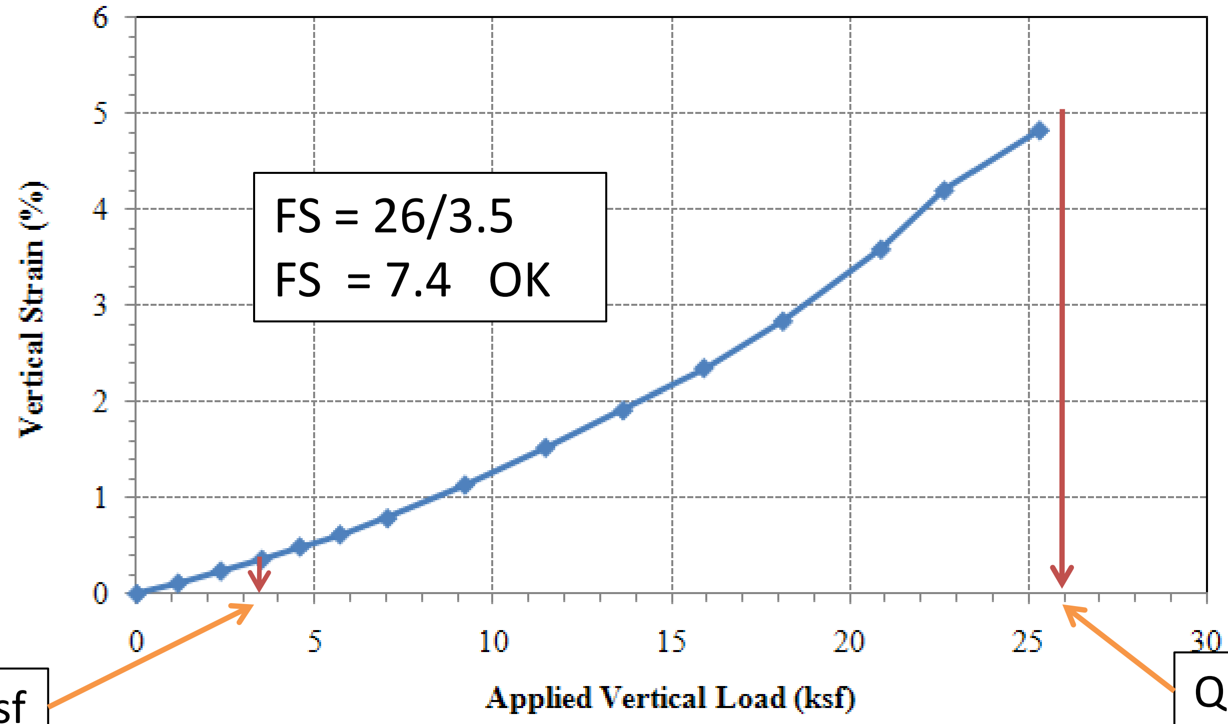
Ultimate Capacity

- Empirical Method
  - Use results from performance test
    - $q_{ult,emp}$ = Stress at 5% vertical strain
  - Check that applied load ($V_{applied} = q_b + q_{LL}$) is less than allowable load ($V_{allow,emp}$)

$$V_{allow,emp} = \frac{q_{ult,emp}}{FS_{capacity}} = \frac{q_{ult,emp}}{3.5}$$

Design Example

Ultimate Capacity *Continued*



$V_{applied}$ = 3.5 ksf

Q_n = 26 ksf

Figure 4-17 - Design Envelope for Vertical Strain at 8 in. Reinforcement Spacing

Ultimate Capacity *Continued*

- Analytical Method
  - Function of:
    - Confining stress (σ_c)
    - Reinforcement spacing (S_v)
    - Ultimate reinforcement strength (T_f)
    - Maximum aggregate size (d_{max})
    - Aggregate friction angle (ϕ)
  - Check that applied load ($V_{applied} = q_b + q_{LL}$) is less than allowable load ($V_{allow,an}$)

$$q_{ult,an} = \left[0.7^{\frac{S_v}{6 d_{max}}} \frac{T_f}{S_v} \right] K_p$$

$$V_{allow,an} = \frac{q_{ult,an}}{FS_{capacity}} = \frac{q_{ult,an}}{3.5}$$

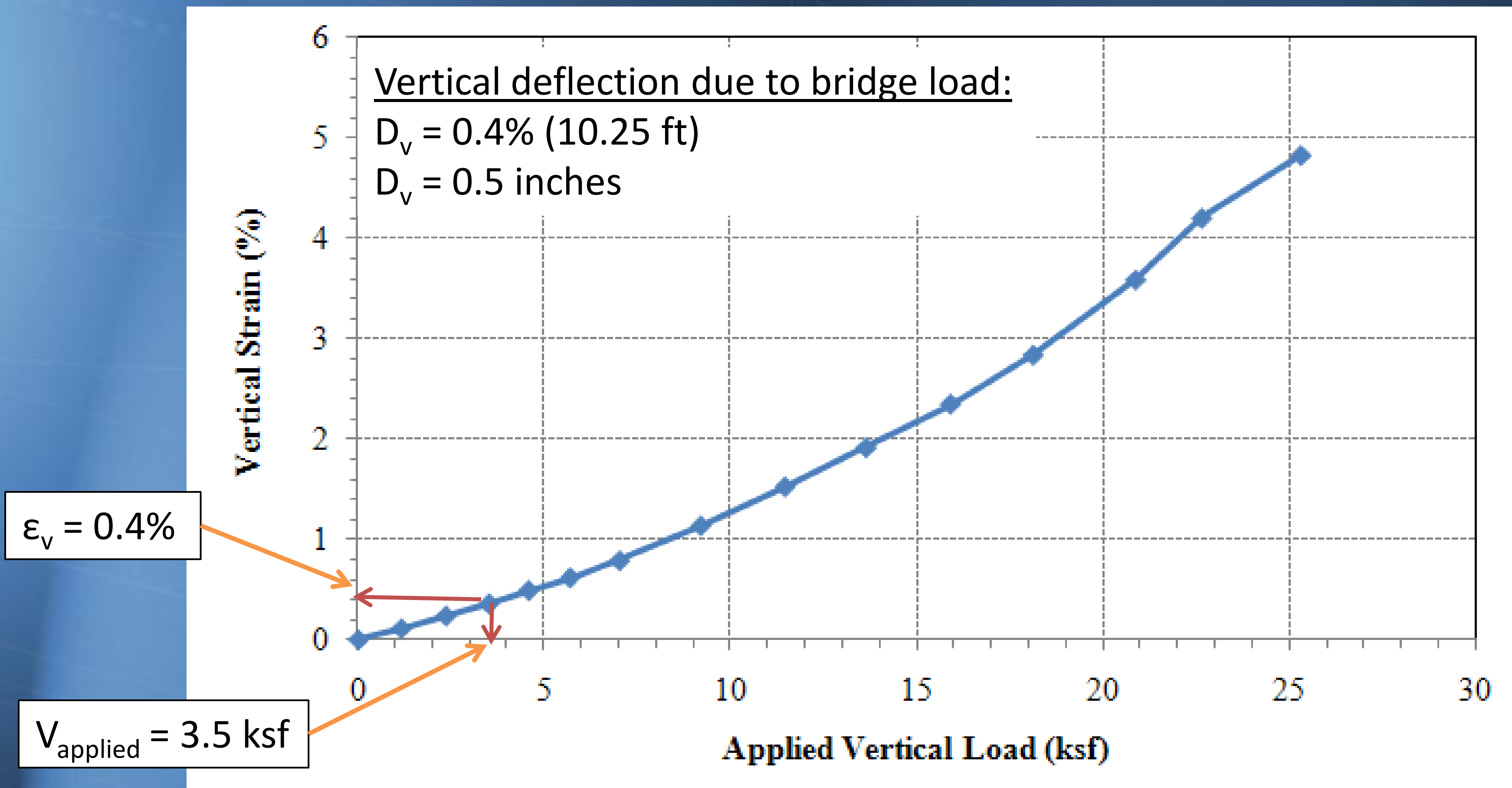
Vertical Deformation

- Use results from performance test
- Find corresponding vertical strain (ε_v) for applied dead load (q_b)
- Multiply by the height to estimate vertical deformation (D_V) within GRS abutment

$$D_V = \varepsilon_v H$$

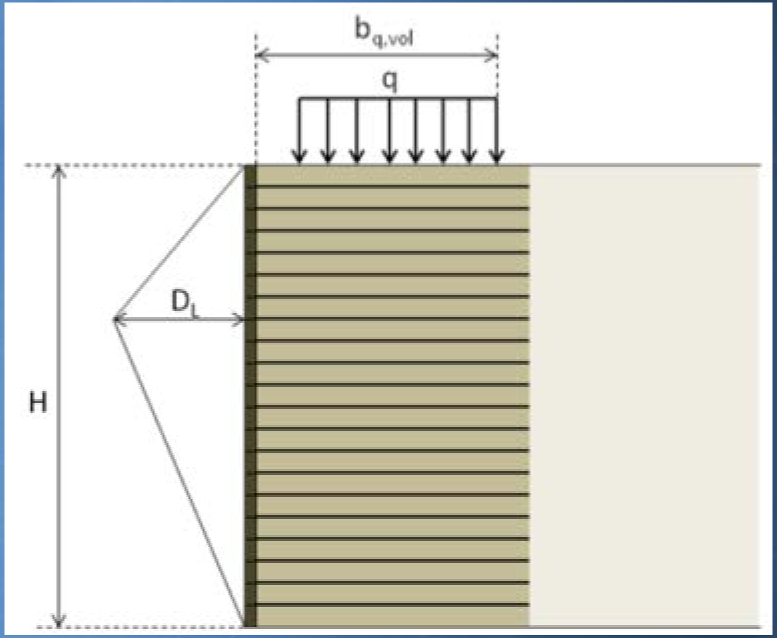
Design Example

Vertical Deformation *Continued*



Lateral Deformation

- Estimate from vertical deformation
- Based on concept of zero volume change

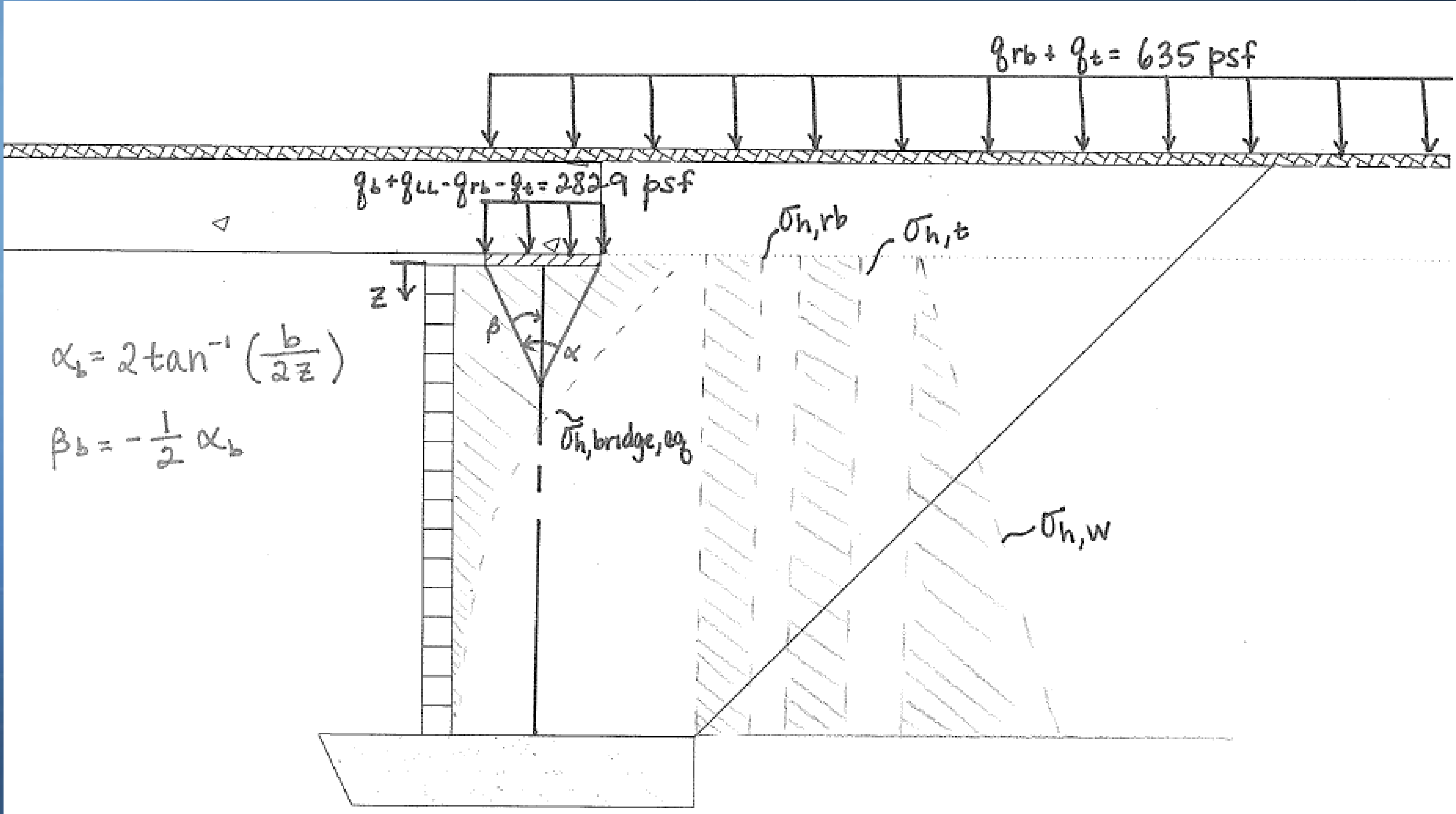


$$\Delta V_{top} = b_{q,vol} L D_v = \Delta V_{face} = \frac{1}{2} H L D_L$$

$$D_L = \frac{2 b_{q,vol} D_V}{H}$$

$$\varepsilon_L = \frac{D_L}{b_{q,vol}} = \frac{2 D_V}{H} = 2\varepsilon_V$$

Design Example
Required Reinforcement Strength
Continued



Required Reinforcement Strength

- Use analytical equation
- Function of:
  - Lateral stress (σ_h)
    - Measured beneath the centerline of the bridge load
  - Reinforcement spacing (S_v)
  - Maximum aggregate size (d_{max})
  - Aggregate friction angle (ϕ)

$$T_{req} = \left[\frac{\sigma_h}{0.7^{\frac{S_v}{6d_{\max}}}} \right] S_v$$

Required Reinforcement Strength

Continued

- The required reinforcement strength must satisfy two criteria:
    1) It must be less than the allowable reinforcement strength (T_{allow})

$$T_{allow} = \frac{T_f}{FS_{\text{reinf}}} = \frac{T_f}{3.5}$$

    2) It must be less than the strength at 2% reinforcement strain ($T_{@\varepsilon=2\%}$)

Standard Plans

STATE	PROJECT	SHEET NUMBER
	FHWA GRS-IBS	A

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

GRS-IBS
DESIGN DRAWINGS
2011

INDEX TO SHEETS

GENERAL NOTES

PURPOSE: These example plan Sheets A through D were prepared to illustrate the typical contents of a set of drawings necessary for a GRS-IBS project. Presented in these plans are the assumptions for the bridge and GRS-IBS systems with typical wall heights (H) ranging from 10 to 24 feet. Two conditions were prepared for the quantity estimate Sheet B: "poor soil conditions" and "favorable soil conditions". INTENDED USE: These plans are not associated with a specific project. All dimensions and properties should be confirmed and/or revised by the Engineer of Record prior to use. Project specifications should be prepared to supplement this plan set.

DESIGN

DESIGN LOADS AND SOIL PROPERTIES

Combined load: Superstructure (qLL + qB) 2 TSF maximum (service load, allowable stress design). Roadway live load surcharge: 250 psf uniform vertical

Road Base unit weight = 140 pcf, thickness = 34-inches

"Poor" Soil Conditions:

Retained backfill: Unit weight= 125 pcf, friction angle= 34°, cohesion = 0 psf, (Cohesion $\geq$ 200 psf assumed for temporary back slope cut conditions during construction.)
$d_{max} \geq 1.0$ inches
Reinforced fill: Unit weight=115 pcf, friction angle = 38°, cohesion = 0 psf
RSF backfill: Unit weight = 140 pcf, friction angle = 38°, cohesion = 0 psf
Foundation soil: Unit weight = 125 pcf, friction angle = 30°, cohesion = 0 psf

"Favorable" Soil Conditions:

Retained backfill: Unit weight = 125 pcf, friction angle = 40°, cohesion = 100 psf
$d_{max} \geq 0.5$-inches
Foundation soil: Unit weight = 125 pcf, friction angle = 40°, cohesion = 100 psf
Reinforced fill: Unit weight = 120 pcf, friction angle = 42°, cohesion =0 psf
RSF backfill: Unit weight = 120 pcf, friction angle = 42°, cohesion = 0 psf

DESIGN SPECIFICATIONS

1. *Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide, FHWA-HRT-11-026, January 2011.*
2. *Design methods follow the ASD design methods presented in Chapter 4 of the reference Manual. No seismic design assumed.*
3. *Conduct a subsurface investigation in accordance with "Soils and Foundations", FHWA-NHI-06-088 (2006) and "Subsurface Investigations", FHWA-NHI-01-031, (2006).*
4. *Design factor of safety against sliding is $\geq$ 1.5; Factor of safety against bearing failure is $\geq$ 2.5.*
5. *A global stability analysis must be performed for each site. Factor of safety against global failure is to be $\geq$ 1.5.*
6. *Performance criteria: tolerable vertical strain = 0.5% of wall height (H): tolerable lateral strain = 1.0% of b and a_b (bearing width and setback)*
7. *Settlement below the RSF is assumed to be negligible. No differential settlement between abutments is assumed.*
8. *Sliding checks were conducted at the top and bottom of the RSF to meet the minimum factors of safety in the reference manual.*
9. *Road base thickness (h_{rb}) assumes a 32-inch structure and 2-inch pavement thickness.*

CONSTRUCTION SPECIFICATIONS

1. *Site Layout/Survey: Construct the base of the GRS abutment and wingwalls within 1.0 inch of the staked elevations. Construct the external GRS abutment and wingwalls to within ±0.5 inches of the surveyed stake dimensions.*
2. *Excavation: Comply with Occupational Safety and Health Administration (OSHA) for all excavations.*
3. *Compaction: Compact backfill to a minimum of 95 percent of the maximum dry density according to AASHTO-T-99 and ± 2 percent optimum moisture content In the bearing reinforcement zone, compact to 100 percent of the maximum dry density according to AASHTO-T-99. Only hand-operated compaction equipment is allowed within 3-feet of the wall face. Reinforcement extends directly beneath each layer of CMU blocks, covering $\geq$ 85% of the full width of the block to the front face of the wall.*
4. *Geosynthetic Reinforcement Placement: Pull the geosynthetic taught to remove any wrinkles and lay flat prior to placing and compacting the backfill material. Splices should be staggered at least 24-inches apart and splices are not allowed in the bearing reinforcement zone. No equipment is allowed directly on the geosynthetic. Place a minimum 6-inch layer of granular fill prior to operating only rubber-tired equipment over the geosynthetic at speeds less than 5 miles per hour with no sudden braking or sharp turning.*
5. *RSF Construction: The RSF should be encapsulated in geotextile reinforcement on all sides with minimum overlaps of 3.0 feet to prevent water infiltration. Wrapped corners need to be tight without exposed soil. Compact backfill material in lifts less than 6-inches in compacted height. Grade and level the top of the RSF prior to final encapsulation, as this will serve as the leveling pad for the CMU blocks of the GRS abutment.*
6. *GRS Wall Face Alignment: Check for level alignment of the CMU block row at least every other layer of the GRS abutment. Correct any alignment deviations greater than 0.25 inches.*
7. *Beam Seat Placement: Generally, the thickness of the beam seat is approximately 8 to 12 inches and consists of a minimum of two 4-inch lifts of wrapped-face GRS. Place precut 4-inch thick foam board on the top of the bearing bed reinforcement butt against the back face of the CMU block. Set half-height or full height (depending on wall height and required clear space) solid CMU blocks on top of the foam board. Wrap two approximately 4-inch lifts across the beam seat. Before folding the final wrap, it may be necessary to grade the surface aggregate of the beam seat slightly high, to about 0.5 inches, to aid in seating the superstructure and to maximize contact with the bearing area.*
8. *Superstructure Placement: The crane used for the placement of the superstructure can be positioned on the GRS abutment provided the outrigger pads are sized for less than 4,000 psf near the face of the abutment wall. Greater loads could be supported with increasing distance from the abutment face if checked by the Engineer of Record. An additional layout of geosynthetic reinforcement can be placed between the beam seat and the concrete or steel beams to provide additional protection of the beam seat. Set beams square and level without dragging across the beam seat surface.*
9. *Integrated Approach Placement: Following the placement of the superstructure, geotextile reinforcement layers are placed along the back of the superstructure, built in maximum lift heights of 6-inches (maximum vertical spacing of reinforcement $\leq$ 6-inches). The top of the final wrap should be approximately 2-inches below the top of the superstructure to allow at least 2-inches of aggregate base cover over the geosynthetic to protect it from hot mix asphalt.*

REINFORCING STEEL

Provide reinforcing steel conforming to ASTM A615, GR. 60.

CMU BLOCK

In colder climates, freeze-thaw test (ASTM C1262-10) should be concluded to assess the durability of the CMU and ensure it follows the standard specification (ASTM C1372). Additives can be used to reduce efflorescence at the face of the blocks if they are at locations subject to de-icing chemicals.

Compresive strength = 4,000 psi minimum
Water absorption limit = 5 %
H_{block} = 7⅝" L_{block} = 15⅝" b_{block} = 7⅝"
Note: In many construction applications CMU blocks are placed with a ⅜" mortar joint to create an in place nominal dimension of 8" x 8" x 16".

REINFORCED BACKFILL GRADATION

Reinforced Backfill Gradation = See Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide, Table 1 or Table 2. Consider GRS CMU minimal dimensions to be the same.

GEOSYNTHETIC REINFORCEMENT TENSILE PROPERTIES

Required ultimate tensile strength = 4,800 lb/ft by (ASTM D 4595 (geotextiles) or ASTM D 6637 (geogrids))
Tensile strength at 2% strain = 1,370 lb/ft

POLYSTYRENE FOAM BOARD

Provide polystyrene foam board conforming to AASHTO M230, type VI.

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GRS-IBS
COVER SHEET

NO.	DATE	BY	REVISIONS	NO.	DATE	BY	REVISIONS	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	PROJECT TEAM LEADER	BRIDGE DRAWING	DATE	DRAWING NO.
	03/25/11		Rev. 0		04/04/11		Rev. 1	FHWA	C. TUTTLE	R. BARROWS, B. COLLINS, M. DODSON, M. ELIAS A. ALZAMORA, J. NICKS	NTS	M. ADAMS	1 of 4	04/2011	
	03/29/11														

STATE	PROJECT	SHEET NUMBER
	FHWA GRS-IBS	B

GRS-IBS Poor Soil Condition Quantites Per Abutment [1/]

HEIGHT (H) (FT)	ROAD BASE h_{rb} THICKNESS (IN)	GEOSYNTHETIC REINFORCEMENT (SQYD) [6/]	CMU BLOCK HOLLOW (EA)	CMU BLOCK SOLID (EAC H)	#4 REBAR (FT)	GRS BACKFILL (CUYD)	RSF FILL (CUYD)	FOAM BOARD (SQFT) [2/]	ROAD BASE AGGREGATE (CUYD)	CONCRETE BLOCK WALL FILL (CUYD)
10.42	34	1200	710	349	652	287	52	18	54	1.4
12.32	34	1700	950	365	698	399	73	18	63	1.5
14.31	34	2100	1165	373	721	509	94	18	68	1.6
16.22	34	2700	1455	389	766	655	123	18	77	1.7
18.21	34	3200	1700	397	789	793	154	36	82	1.7
20.12	34	4000	2030	413	835	973	187	36	92	1.8
22.1	34	4600	2305	421	858	1139	220	36	96	1.9
24.01	34	5600	3280	437	904	1354	267	36	106	2

GRS-IBS ABUTMENT Favorable Soil Condition Quantities Per Abutment [1/]

HEIGHT (H) (FEET)	ROAD BASE h_{rb} THICKNESS (IN)	GEOSYNTHETIC REINFORCEMENT (SQYD) [6/]	CMU BLOCK HOLLOW (EACH)	CMU BLOCK SOLID (EACH)	#4 REBAR (FEET)	GRS BACKFILL (CUYD)	RSF FILL (CUYD)	FOAM BOARD (SQFT) [2/]	ROAD BASE AGGREGATE (CUYD)	CONCRETE BLOCK WALL FILL (CUYD)
10.42	34	1000	710	349	652	176	24	18	54	1.4
12.32	34	1400	950	365	698	242	26	18	63	1.5
14.31	34	1700	1165	373	721	305	27	18	68	1.6
16.22	34	2200	1455	389	766	394	29	18	77	1.7
18.21	34	2700	1700	397	789	483	35	36	82	1.7
20.12	34	3400	2030	413	835	606	43	36	92	1.8
22.1	34	4000	2305	421	858	715	50	36	96	1.9
24.01	34	4800	3280	437	904	865	60	36	106	2

GRS-IBS Poor Soil Condition DESIGN DIMENSIONS

WALL HEIGHT (H)	WINGWALL LENGTH, L_{ww}	d_e [7/]	a_b	b	b_r	B_{total}	B	B_{RSF}	D_{RSF}	x_{RSF}	ABUT WIDTH	WINGWAL L HEIGHT
(FT)	(FT)	(IN)	(IN)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)
10.42	15.63	3	7.6	2.5	3.83	9.5	8.86	11.88	2.38	2.38	37.76	14.00
12.32	18.23	3	7.6	2.5	3.83	11.0	10.36	13.75	2.75	2.75	37.76	15.89
14.31	19.53	4	7.6	2.5	3.83	12.5	11.86	15.63	3.13	3.13	37.76	17.79
16.22	22.14	4	7.6	2.5	3.83	14.0	13.36	17.50	3.50	3.50	37.76	19.70
18.21	23.44	5	7.6	2.5	3.83	15.5	14.86	19.38	4.00	3.88	37.76	21.60
20.11	26.04	5	7.6	2.5	3.83	17.0	16.36	21.25	4.25	4.25	37.76	23.51
22.10	27.34	6	7.6	2.5	3.83	18.5	17.86	23.13	4.63	4.63	37.76	25.42
24.01	29.95	6	7.6	2.5	3.83	20.0	19.36	25.00	5.00	5.00	37.76	27.83

GRS-IBS Favorable Soil Condition DESIGN DIMENSIONS

WALL HEIGHT (H)	WINGWALL LENGTH, L_{ww}	d_e [7/]	a_b	b	b_r	B_{total}	B	B_{RSF}	D_{RSF}	x_{RSF}	ABUT WIDTH	WINGWALL HEIGHT
(FT)	(FT)	(IN)	(IN)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)
10.42	15.63	3	7.6	2.5	3.83	6.0	5.36	7.50	1.50	1.50	37.76	14.00
12.32	18.23	3	7.6	2.5	3.83	6.0	5.36	7.50	1.50	1.50	37.76	15.89
14.31	19.53	4	7.6	2.5	3.83	6.0	5.36	7.50	1.50	1.50	37.76	17.79
16.22	22.14	4	7.6	2.5	3.83	6.0	5.36	7.50	1.50	1.50	37.76	19.70
18.21	23.44	5	7.6	2.5	3.83	6.5	5.86	8.13	1.63	1.63	37.76	21.60
20.11	26.04	5	7.6	2.5	3.83	7.0	6.36	8.75	1.75	1.75	37.76	23.51
22.10	27.34	6	7.6	2.5	3.83	7.5	6.86	9.38	1.88	1.88	37.76	25.42
24.01	29.95	6	7.6	2.5	3.83	8.0	7.36	10.00	2.00	2.00	37.76	27.83

FOOTNOTES:

1/ The estimated materials quantities correspond to the dimensions on the accompanying plan sheets. Deviation from the dimensions on the plan sheets will void the quantities.

2/ Foam board thickness is 4-inches (typ.).

3/ Wingwall length = B total + H + 3-feet.

4/ CMU block assumptions: solid blocks at the base of the GRS abutment from estimated scour elevation to 100-year flood event elevation (5-feet assumed here): solid blocks in setback location to beam seat (1-row assumed): hollow blocks for remaining wall height and guardrail height: concrete-filled blocks assumed 3 rows deep below bearing pad and at the top of the wall of guardwall and at all corners: wet cast coping at the top row of exposed CMU at abutment wall and wingwall: flush concrete fill in the CMU's at the top of the abutment wall under the beam seat below the clear zone. See Sheet C and D for illustrations of these details.

5/ Maximum vertical spacing of reinforcement = height of 1 CMU block (H_{block}) in reinforced backfill zone. Maximum vertical spacing of reinforcement ≤ 6-inches in bearing bed zone and integrated approach.

6/ No overlaps in geosynthetics measured for quantities.

7/ Design clear space (d_e) rounded up to the nearest 1.0 inch.

8/ Geosynthetic reinforcement quantity includes RSF and IBS geotextile quantities.

ABREVIATIONS:

- a_b = Set back distance between back of facing element and beam seat
- B = Base length of reinforcement not including the wall face
- b = Bearing width for bridge, beam seat
- B_b = Width of the bridge
- b_{block} = Width of CMU
- b_r = Length of bearing bed reinforcement
- B_{RSF} = Width of RSF
- B_{total} = Total width at base of GRS abutment including the wall facing
- CMU = Concrete masonry unit
- d_e = Clear space from top of wall to bottom of superstructure.
- d_{max} = Maximum partical diameter in reinforced backfill
- D_{RSF} = Depth of RSF below bottom of wall elevation
- GRS = Geosynthetic Reinforced Soil
- H = Wall height measured from top of RSF to top of beam seat
- H_{block} = Height of CMU
- h_{rb} = Height of road base (equals height of super structure and pavement thickness)
- IBS = Integrated Bridge System
- L = Length of geosynthetic reinforcement
- L_{abut} = Abutment width
- L_{block} = Length of CMU
- L_{ww} = Wingwall length.
- RSF = Reinforced soil foundation
- X_{RSF} = Length of RSF in front of the abutment wall face

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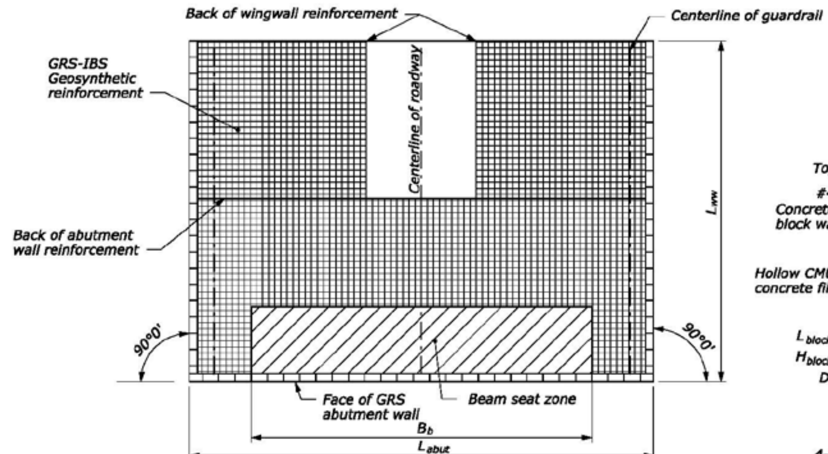
GRS-IBS

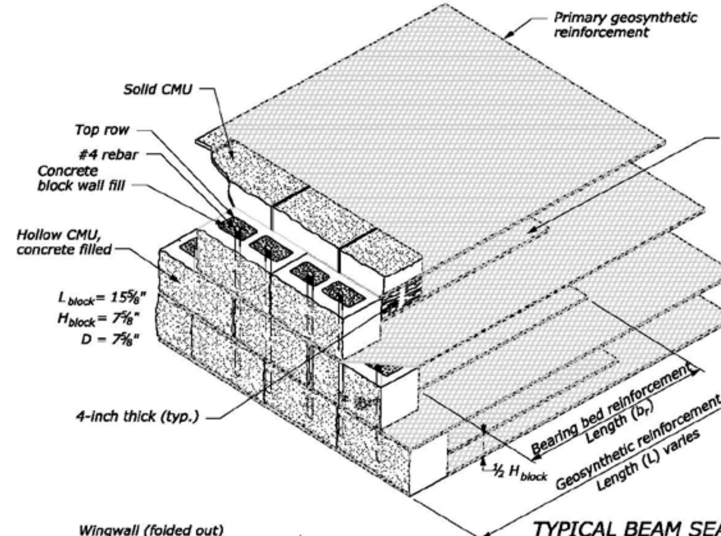
DESIGN DIMENSION QUANTITIES

NO.	DATE	BY	REVISIONS	NO.	DATE	BY	REVISIONS	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	PROJECT TEAM LEADER	BRIDGE DRAWING	DATE	DRAWING NO.
	03/25/11		Rev. 0					FHWA	C. TUTTLE	R. BARROWS, B. COLLINS, M. DODSON, M. ELIAS A. ALZAMORA, J. NICKS	NTS	M. ADAMS	2 of 4	04/2011	
	03/29/11														

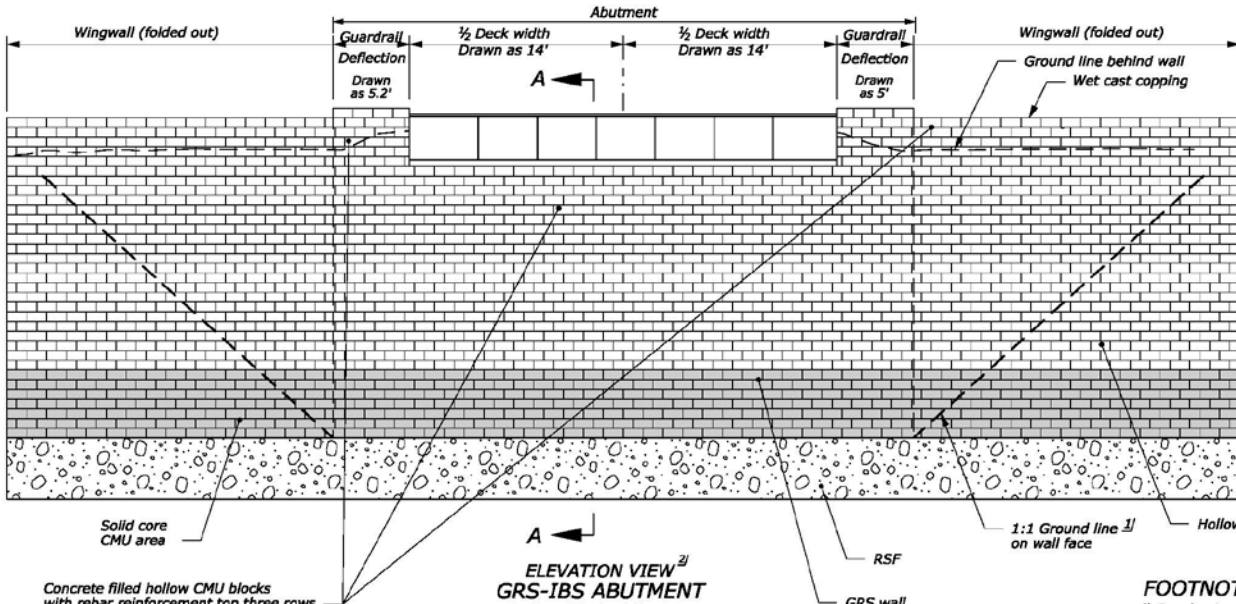
STATE	PROJECT	SHEET NUMBER
	FHWA GRS-IBS	C



PLAN VIEW
GRS-IBS ABUTMENT
Facing Block Schedule
SCALE: ⅛" = 1'-0"



TYPICAL BEAM SEAT
(ISOMETRIC VIEW)



ELEVATION VIEW [2]
GRS-IBS ABUTMENT
Facing Block Schedule
SCALE: ⅛" = 1'-0"

NOTE:

1. Insert #4 rebars into the top 3 rows of CMU's and corner CMU's and fill with concrete.
2. Adjust length and angle of wingwalls for site specific conditions and quantities in Sheet B accordingly.
3. If RSF is not used beneath the wingwalls, then additional independent retaining wall calculations should be performed to determine the stability of the wingwalls.
4. Superelevation of the roadway is assumed to have a crest at the centerline of the roadway, which corresponds to the maximum design clear space (d).
5. No skew angle of the bridge to the stream channel is assumed.
6. No angular distortion between abutments is assumed.
7. Solid core CMU's placed up to the riprap height (5 feet typ.).
8. CMU blocks are staggered, including corners, so there are no vertical joints greater than 1 CMU block height.
9. Guardrail type and location to be designed by others in accordance with required safety standards.

FOOTNOTE:

1/ Bench wingwall as necessary.

2/ Wingwalls folded out for elevation view.

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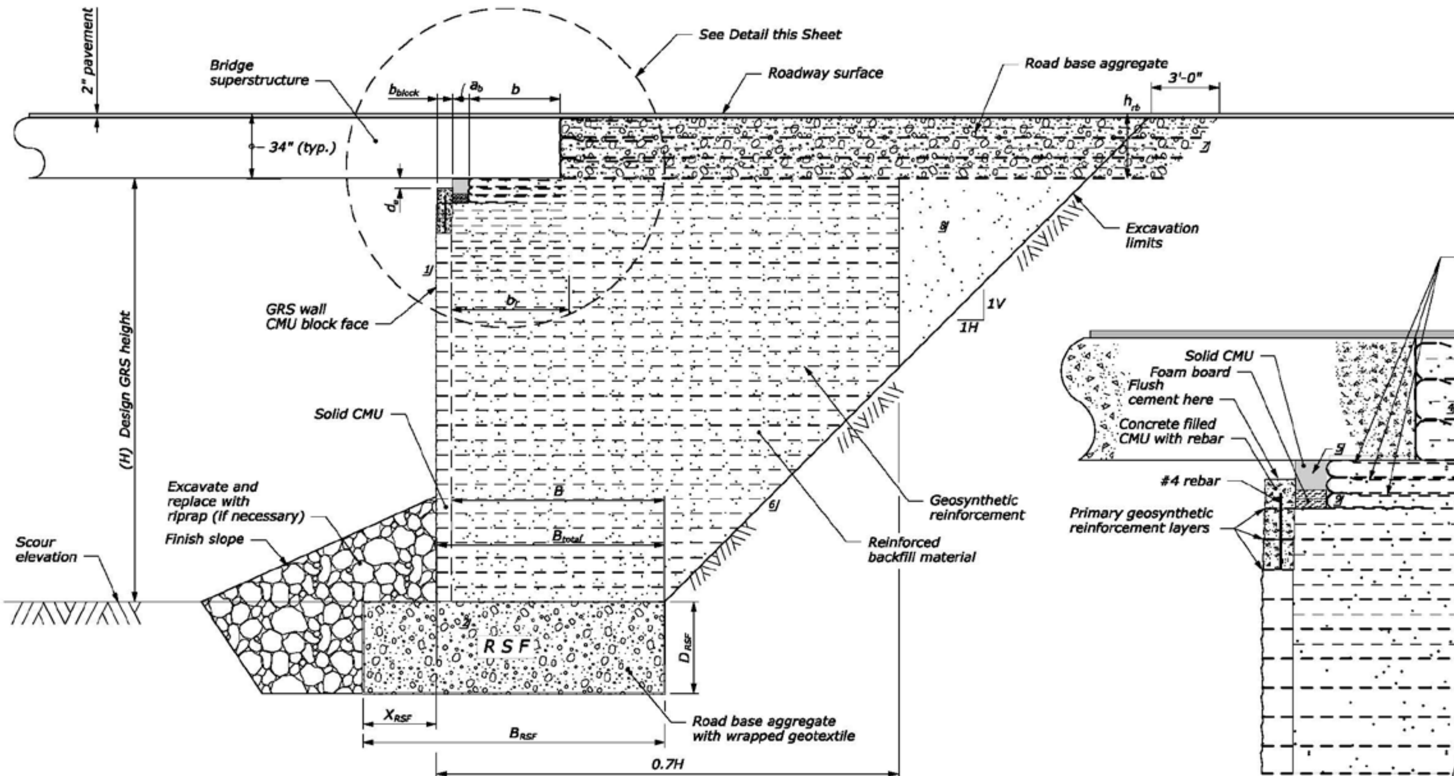
GRS-IBS
PLAN AND ELEVATION
FACING BLOCK SCHEDULE

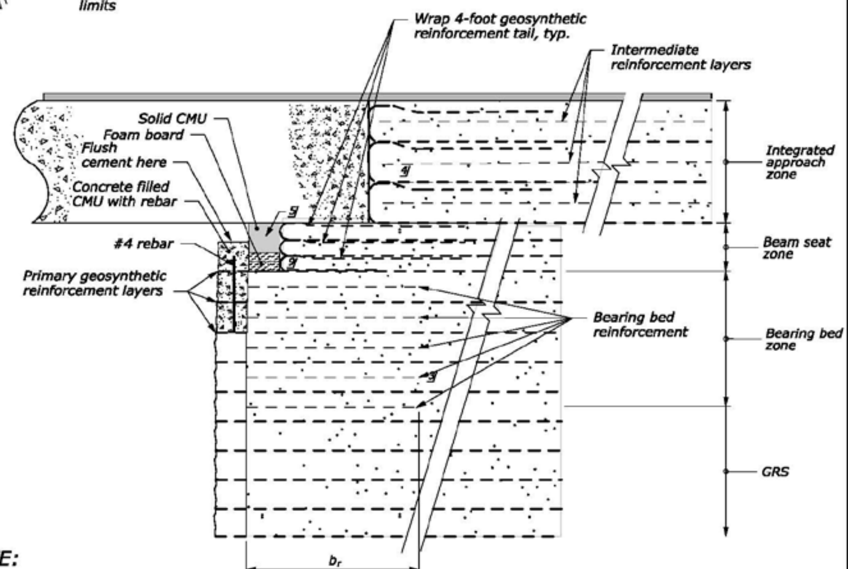
NO.	DATE	BY	REVISIONS	NO.	DATE	BY	REVISIONS	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	PROJECT TEAM LEADER	BRIDGE DRAWING	DATE	DRAWING NO.
	03/25/11		Rev. 0		04/04/11		Rev. 1	FHWA	C. TUTTLE	R. BARROWS, B. COLLINS, M. DODSON, M. ELIAS A. ALZAMORA, J. NICKS	AS SHOWN	M. ADAMS	3 of 4	04/2011	
	03/29/11														

STATE	PROJECT	SHEET NUMBER
	FHWA GRS-IBS	D



SECTION A-A

Vertical Scale: 3/16" = 1'-0"
Horizontal Scale: NTS



DETAIL
(Beam seat and integrated approach Detail)

Vertical Scale: 3/8" = 1'-0"
Horizontal Scale: NTS

LEGEND:

- Reinforced backfill material
- Road base aggregate
- Pavement
- Riprap
- Hollow concrete masonry unit (CMU)
- Colored solid concrete masonry unit (CMU)
- Concrete filled concrete masonry unit (CMU)

NOTE:

1. Insert #4 rebars in to the top 3 rows of CMU's and corner CMU's and fill with concrete.
2. Strike CMU concrete fill flush with top of CMU's under bridge girders slope to drain.
3. On the top row of CMU's create a mortar capping approx. 3/4-inch thick.
4. Typical sections represent a wall height (H) equal to 18.21-feet.

FOOTNOTE:

1/ Vertical wall face batter = 0°.

2/ Solid CMU's behind riprap.

3/ Minimum of 5 layers of bearing bed reinforcement.

4/ Primary wrap reinforcement vertical spacing for the integrated approach is a maximum of 12-inches.

5/ Full height block is typical in front of bearing seat but a half height block and a special foam board thickness may be required in some applications.

6/ Short term back slope ratio per OSHA Safety Regulations (29CFR, Part 1926, Subpart P, excavation). Shoring may be required if the short term back slope will be open more than 30 days or if the required short term back slope ratio specified cannot be obtained.

7/ Extend integration zone layers past cut slope.

8/ Insure that high quality fill is placed in this area.

9/ The first beam seat reinforcement layer length is a maximum of 6-feet with a conventional 4-foot tail.

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
WESTERN FEDERAL LANDS HIGHWAY DIVISION

GRS-IBS

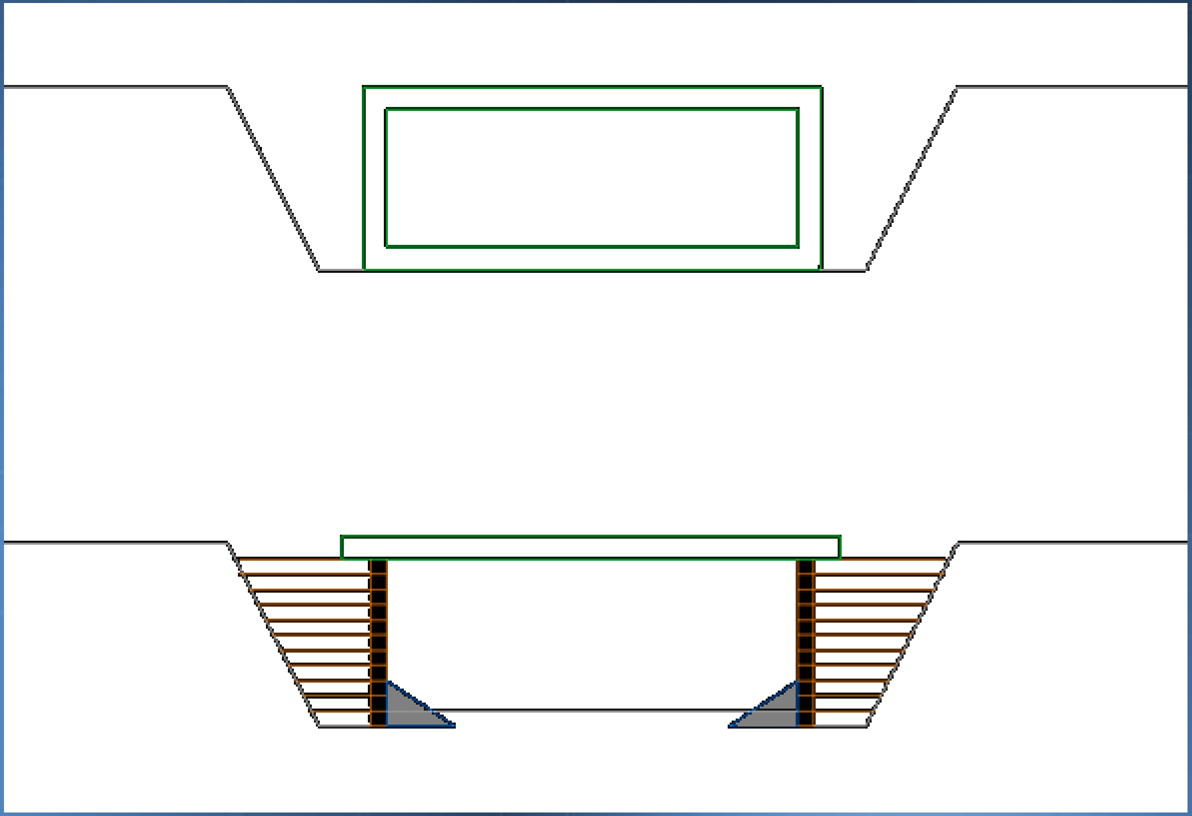
DETAILS

NO.	DATE	BY	REVISIONS	NO.	DATE	BY	REVISIONS	DESIGNED BY	DRAWN BY	CHECKED BY	SCALE	PROJECT TEAM LEADER	BRIDGE DRAWING	DATE	DRAWING NO.
	03/25/11		Rev. 0		04/04/11		Rev. 1	FHWA	C. TUTTLE	R. BARROWS, B. COLLINS, M. DODSON, M. ELIAS A. ALZAMORA, J. NICKS	AS SHOWN	M. ADAMS	4 of 4	04/2011	
	03/29/11														

User Perspective

Defiance County, Ohio

Some Design History



- Same excavation, less expensive materials, lighter weight components and less weather sensitive construction

Trying it out
05/02/2005

Attractive and Flexible


Construction Costs:
80’x32’-$266,000 - 2005
Open to Traffic:
47 days


Construction Costs:
28’x20’-$68,000 - 2008


Construction Costs
28’x20’-$88,000 - 2

Construction Costs:
32’x10’-$51,000 - 2010


Construction Costs:
28’x20’-$70,000 - 2010


Construction Costs:
28'x20'-$65,000 - 2010


Construction Costs:
28’x32’-$85,000 - 2010

Construction Costs:
36’x20’-$71,000 - 2010


GROVE
Crane loading
right against
beam ends


Construction Cost:
140’x40’-$620,000 - 2009

User Perspective

St. Lawrence County, NY

CR 12 - 40’x33’- Material Cost $160,000
Construction costs $240,000

CR 24 - 47’x33’- Material Cost $110,500

CR 31 - 56’x33’- Material Cost $165,000

CR 35 - 67’x33’- Material Cost $180,500
Construction Cost $310,000

CR 38 - 63’x32’- Material Cost $175,000

2009 BRIDGE

CR12 o. Malterna Creek – 40’-6” Span

2010 Bridges

CR24 o. Leonard Brook – 47’ Span

CR35 o. Trout Brook – 66’-8” Span

CR31 o. Brandy Brook – 55’-8” Span

CR38 o. Plum Brook – 63’-6” Span

2011 Bridges

CR60 o. Little River – 65’-8” Span

CR27 o. N. Br. Grasse River – 71’-8” Span

Fraser Road o. Oswegatchie River – 85’ Span

CR25 o. Little River – 87’-8” Span

CR40 o. Hutchins Creek – 51’-2” Span

CR3 o. Chippewa Creek – 95’ Span -

River Road o. Trout Brook – 89’ +/- Span

2012 Bridges

CR47 o. Trout Brook (IBRD) – 110’-0” Span

CR20 o. Tanner Creek – 65’-0” Span Proposed

Project cost and time examples

- CR27 o. N. Br. Grasse River – 71’-8” Span
  - Material Cost - $238,256
  - Labor and Equip. Cost - $82,508
  - Schedule – Closed May 16, 2011 – Open June 23, 2010

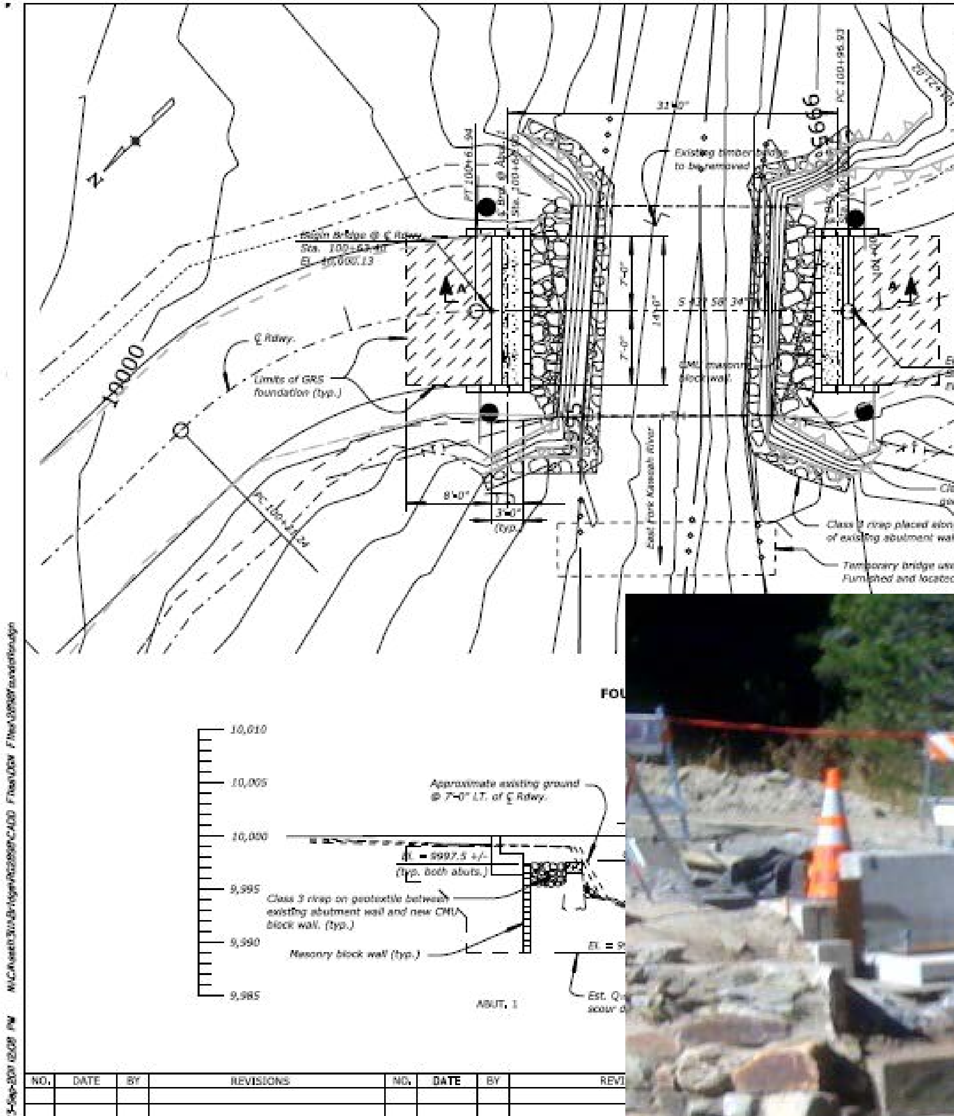
- CR40 o. Hutchins Creek – 51’-2” Span
  - Material Cost - $197,156
  - Labor and Equip. Cost - $55,206
  - Schedule – Closed June 6, 2011 – Open July 7, 2011

Project cost and time examples

- CR3 o. Chippewa Creek – 95’-0” Span
  - Material Cost - $275,319
  - Labor and Equip. Cost - $97,791
  - Schedule – Closed August 8, 2011 – Open Sept. 20, 2010
- CR24 o. Leonard Brook – 47’-0” Span
  - Material Cost - $158,470
  - Labor and Equip. Cost – $73,652
  - Schedule – Closed June 1, 2010 – Open June 24, 2010

User Perspective
National Park Service

Disney Bridge in Sequoia NP



Disney Bridge in Sequoia NP

Strawberry Creek
Great Basin National Park - NV

User Perspective
Huston Township, Pennsylvania

Huston Township, Clearfield County
Mount Pleasant Road Bridge
Presented By G. Randy Albert, PE
Municipal Services Supervisor, 2-0


07/18/2011 15:22


10/12/2011 10:25


10/14/2011 14:35


11/07/2011 16:06


11/07/2011 16:08

Cost Data

Huston Township Actual Project Costs

"Soup to Nuts"

Permitting:	$5,273.75
Excavation Contractor (removal, disposal, excavation, backfilling)	$12,364.00
Timber Superstructure	$28,165.00
Concrete Blocks (including delivery)	$3,696.15
Geotextile	$2,850.00
Aggregate (2RC and AASTO 8)	$8,807.40
Aggregate (Rip Rap)	$4,509.00
Miscellaneous (filter bags, filter sock, concrete, coffer dam, tool rental, rebar, lumber, plastic, tools)	$5,282.70
Bituminous Paving	$15,429.84
Guide Rail (contracted out)	$6,290.40
Township Labor	$ 9,225.67
Total Cost	$101,893.91

Comparable Cost Data

PENNDOT Box Culvert and Bridge Beam Projects $150,000

District 2-0 Maintenance Force Project

2011 Costs vary from $95,000 to $265,000

District 2-0 is using $185,000 for 2012 estimates

Actual Cost: $133,000 (without paving costs)

Comparable Cost Data

Local Project Box Culvert (no paving costs) $194,000

Locally bid and built with local forces

Actual project in Genesee Township, Potter County

Contracted Design and Construction Box Culverts $500,000+

Time Savings

Huston Township: 35 Days

Actual abutment construction time: 6 days!

Total time of road closure: 112 days


02/27/2009 00:05

U.S. Department of Transportation
Federal Highway Administration

Every Day Counts

innovation ingenuity invention imagination

PROGRESS TOWARD 2012 EDC GRS IBD GOALS

GRS IBS Implementation policy memos

Florida DOT

Florida Department of Transportation
605 Suwannee Street
Tallahassee, FL 32399-0450

RICK SCOTT
GOVERNOR

OFFICE OF THE
SECRETARY

FROM: Robert V. Robertson, P. E., State Structures De

COPIES: Brian Blanchard, David Sadler, David O'Hagar
Charles Boyd, Tom Andres, Sam Fallaha, Denn
Jonathan Van Hook, Garry Roufa, Peter Lai, Rc
Chris Richter (FHWA), Jeffrey Ger (FHWA), F

SUBJECT: Mandatory Evaluation of Suitability of Geosynt
Abutments for Single Span Bridges

DESIGN REQUIREMENTS

1. Section 3.12 of the **January 2011 Structures Design Guideline**
   3.12.12 Geosynthetic Reinforced Soil (GRS) Walls and Abutme
   A. GRS abutments are a shallow foundation and retaining wall
   significantly reduce the construction time and cost of single
   B. GRS walls and abutments, like MSE walls, are very adaptabl
   conditions and can tolerate a greater degree of differential settlement than CIP walls.
   GRS walls, however, are also not appropriate for all sites.

foundations and/or other wall types may be required.

2. Section 3.13.2 of the **January 2011 Structures Design Guidelines** is expanded as follows:
   P. GRS Walls and Abutments
   Commentary: **FHWA Publication No.** FHWA-HRT-11-026 "Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide" (GRS Guide) contains background information and design steps for GRS walls and abutments. (Refer to this guide for Figures referenced below)

Colorado DOT

COLORADO DEPARTMENT OF TRANSPORTATION STAFF BRIDGE BRIDGE DESIGN MANUAL	Subsection: 7.4 Effective: May 15, 2011 Supersedes: New
GEOSYNTHETIC REINFORCED SOIL (GRS) ABUTMENTS	
POLICY	COMMENTARY

7.4.1 GENERAL

Mechanically Stabilized Earth (MSE) or Geosynthetic Reinforced Soil (GRS) abutments are acceptable alternatives for deep foundations and are required by Item 5 in subsection 19.1.3B to be considered in the structure type selection report. See Figure 7.4-1 for an illustration of a GRS abutment. (C1)

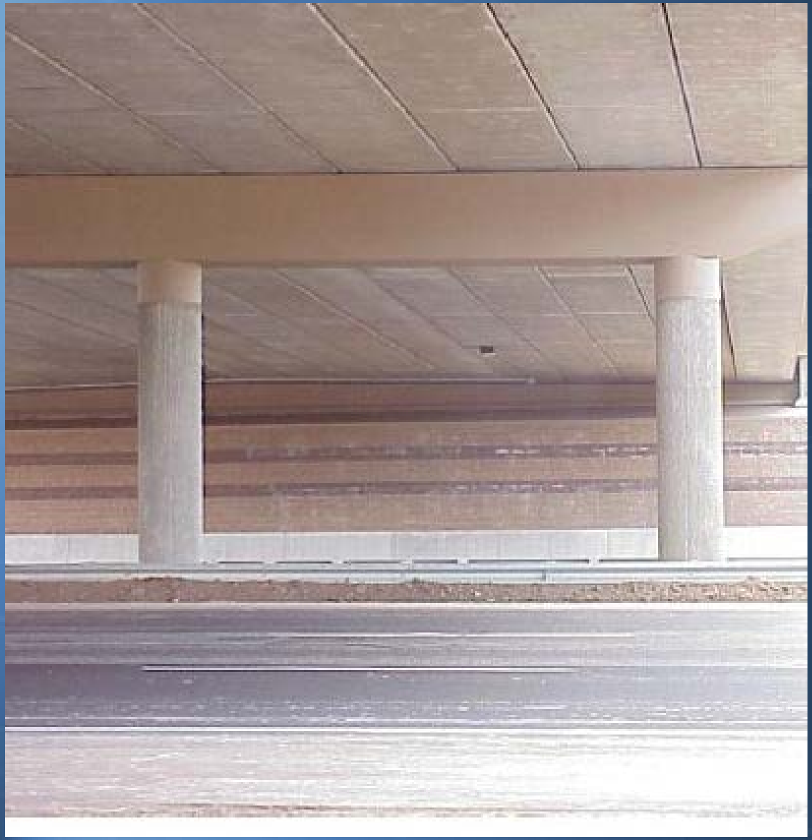
- Both single or continuous span bridges where competent foundation is near the surface

n alternative to

- Both single or continuous span bridges where competent foundation is near the surface
- Single span bridges where foundation short-term settlement from sandy gravel can be calculated and compensated for by adjusting the girder seat elevation to meet vertical clearance requirement
- Single span bridges where

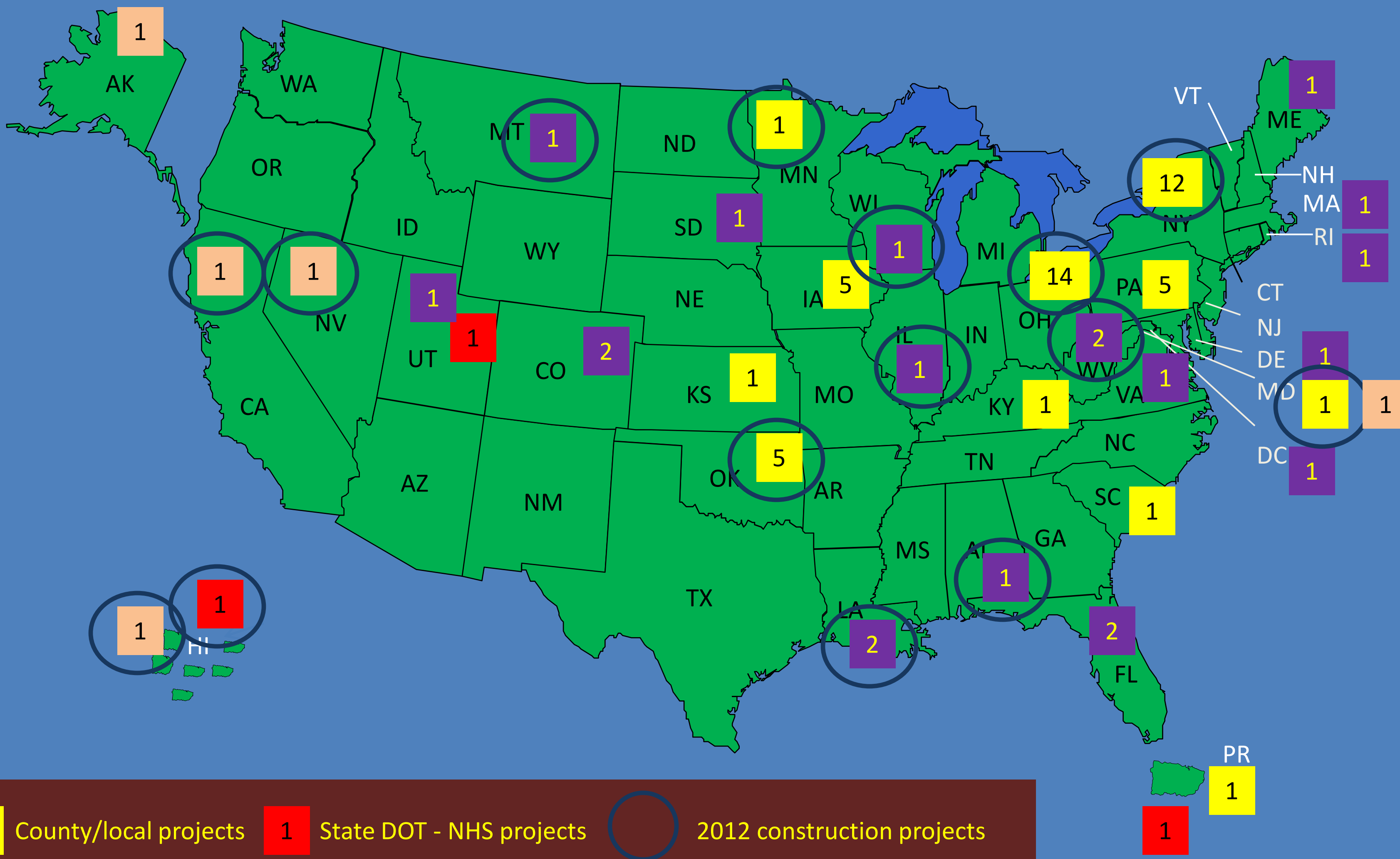
To assure the clearance for bridge underpass meets the minimum requirement, avoid lengthy interaction processes between structural depths, roadway vertical profile, and hydraulic freeboard and anticipate allowable long-term settlement from geotechnical engineer, deep foundation is usually utilized. In general deep foundation is straight forward in design process than spread footing. Deep foundation such as caissons at pier for water crossing is more economic and easier than shallow

Founders Meadows Bridge Over I-25 – Castle Rock, CO Constructed in 1999



GRS IBS Progress Towards Goals

Total of 74 project in 31 states at some stage of design and construction

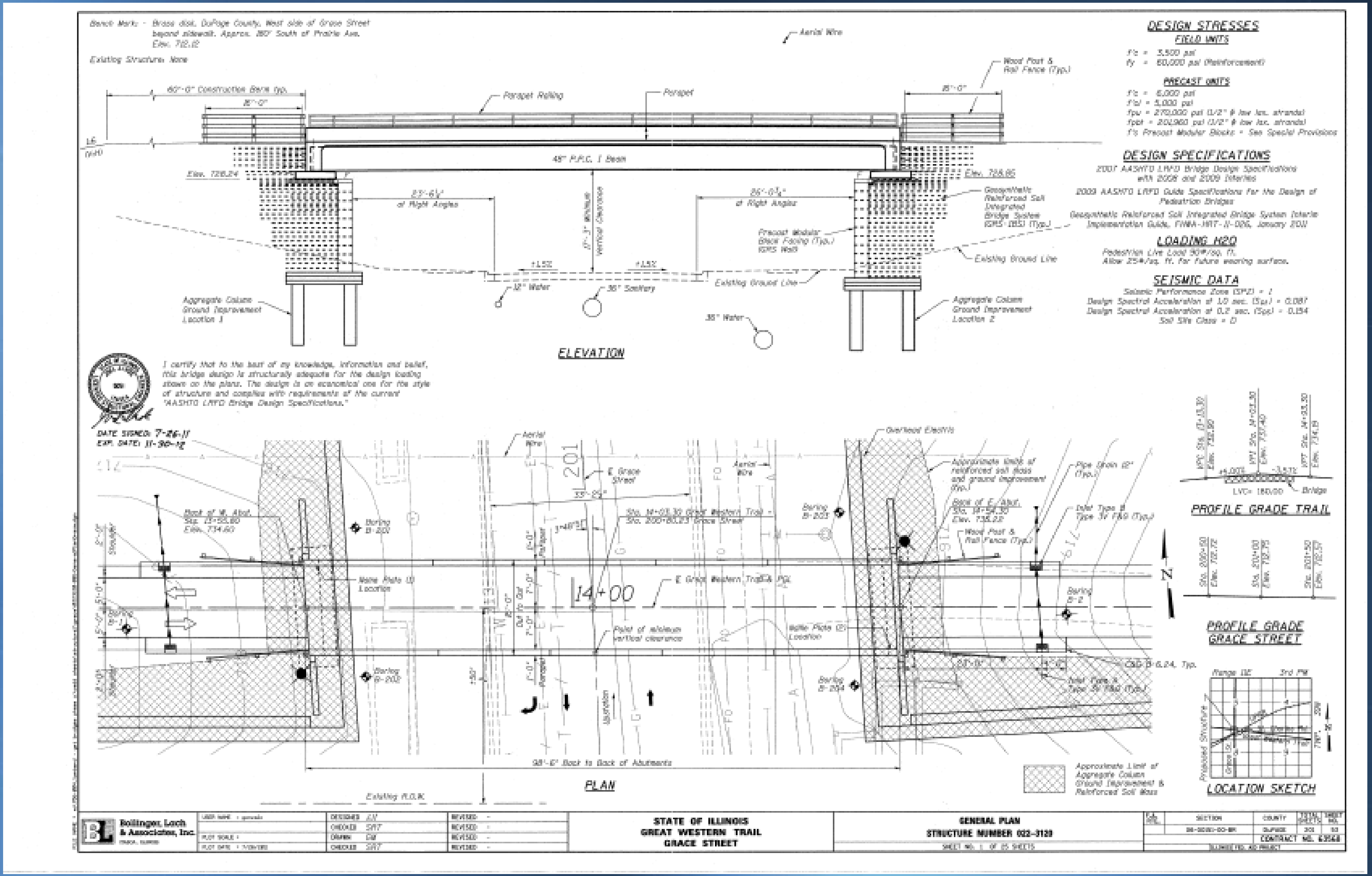


1 County/local projects
1 State DOT projects
1 State DOT - NHS projects
1 Federal Land Projects
2012 construction projects

IBRD Projects

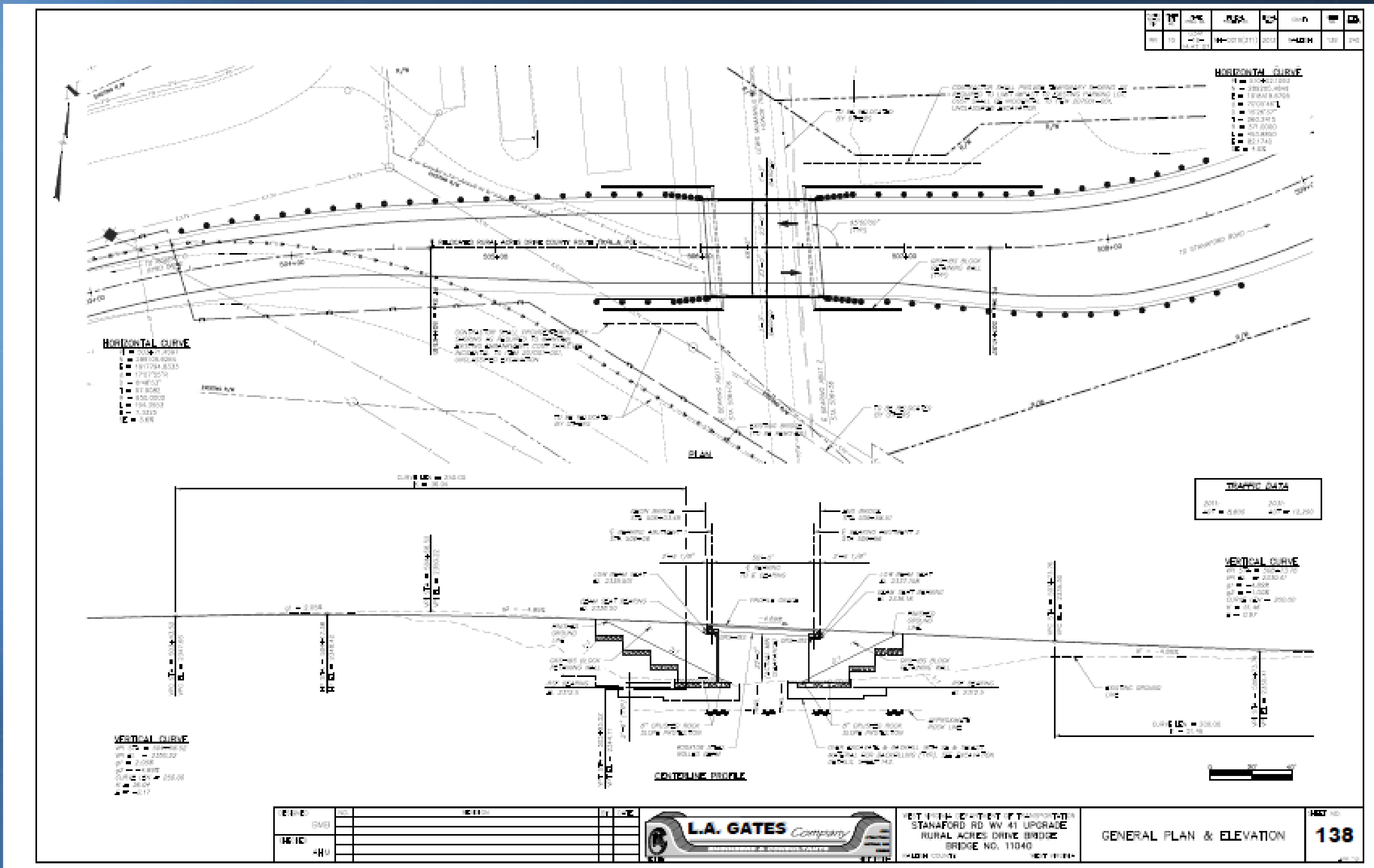
- 2010 IBRD awards
  - 7 projects at $1.85 million
- 2011 IBRD awards
  - 8 projects at $2.00 million
  - Rhode Island received $350,000
- 2 HFL projects

Illinois

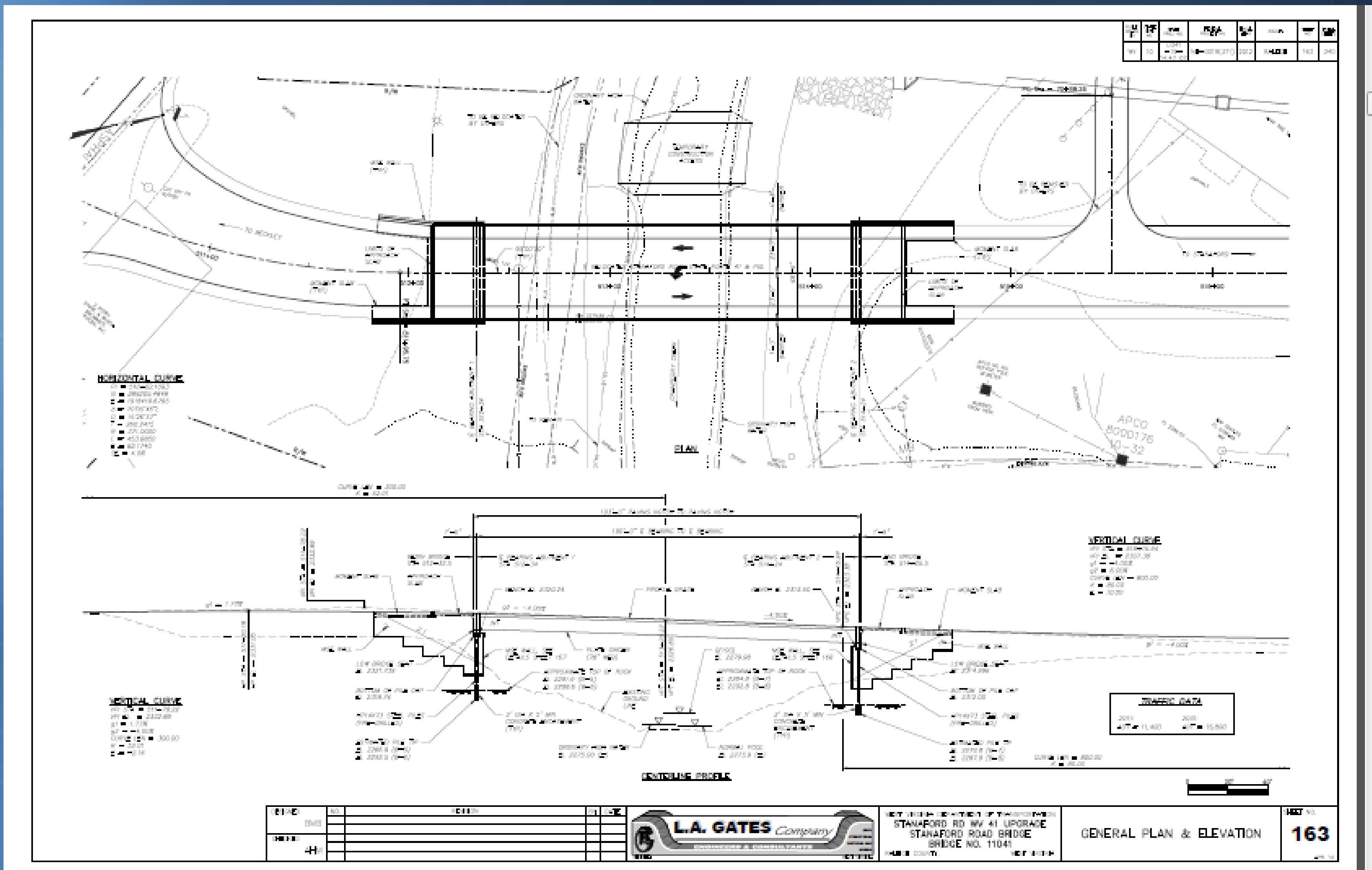


DESIGN STRESSES
FIELD UNITS
PRECAST UNITS
DESIGN SPECIFICATIONS
LOADING H20
SEISMIC DATA
48" P.P.C. I Beam
ELEVATION
14+00
PLAN
PROFILE GRADE TRAIL
PROFILE GRADE GRACE STREET
LOCATION SKETCH
STATE OF ILLINOIS
GREAT WESTERN TRAIL
GRACE STREET
GENERAL PLAN

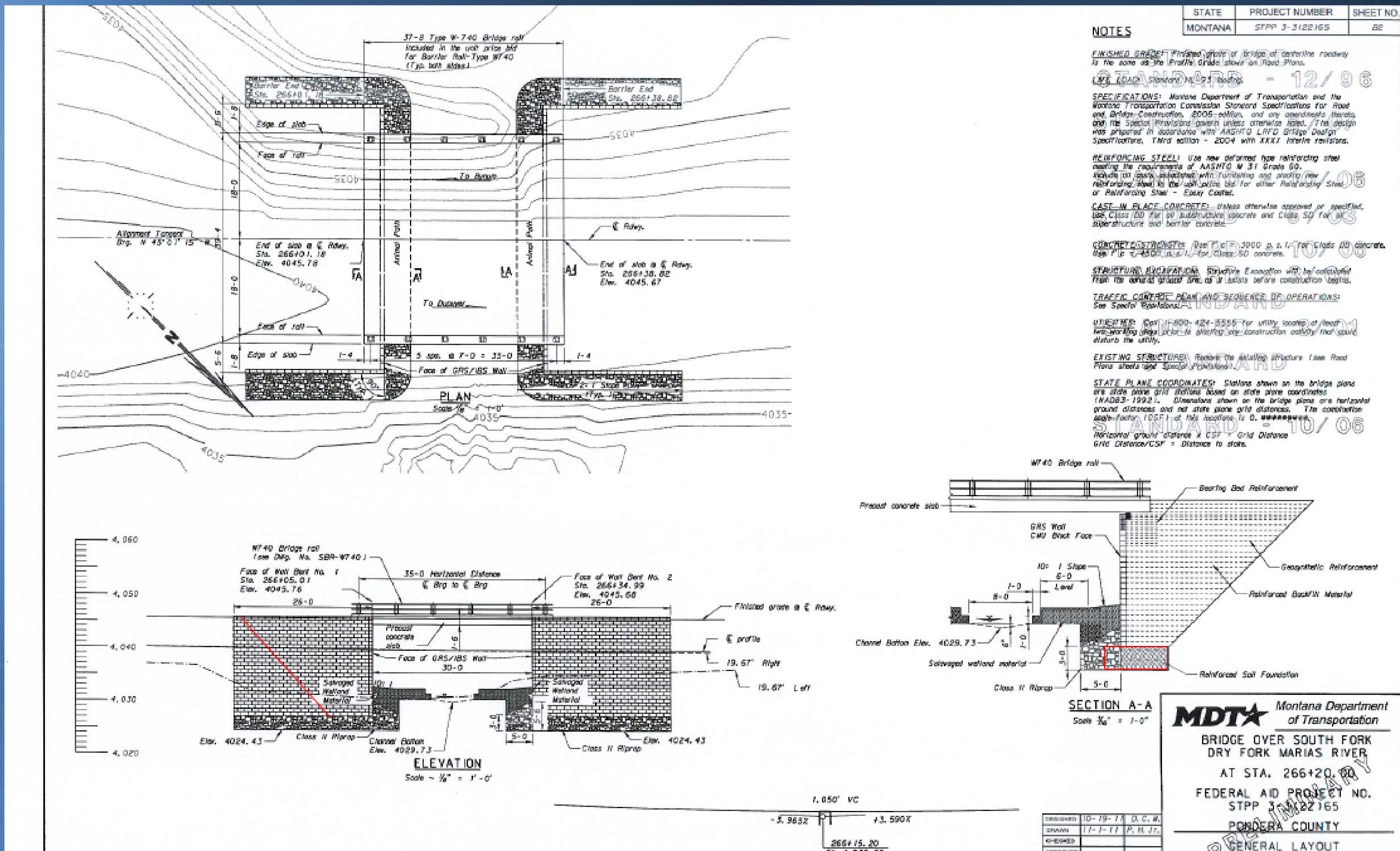
West Virginia



West Virginia

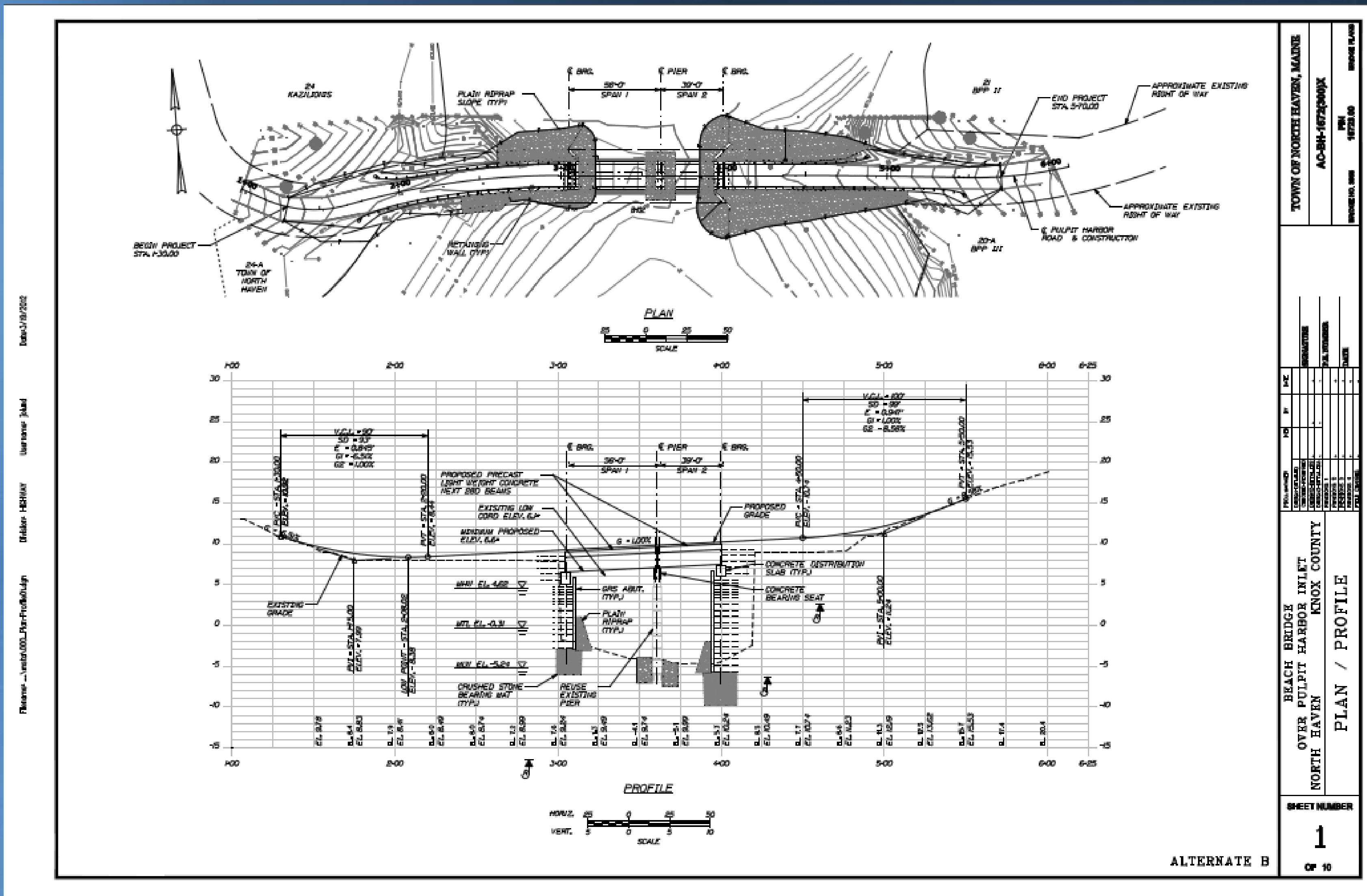


Montana

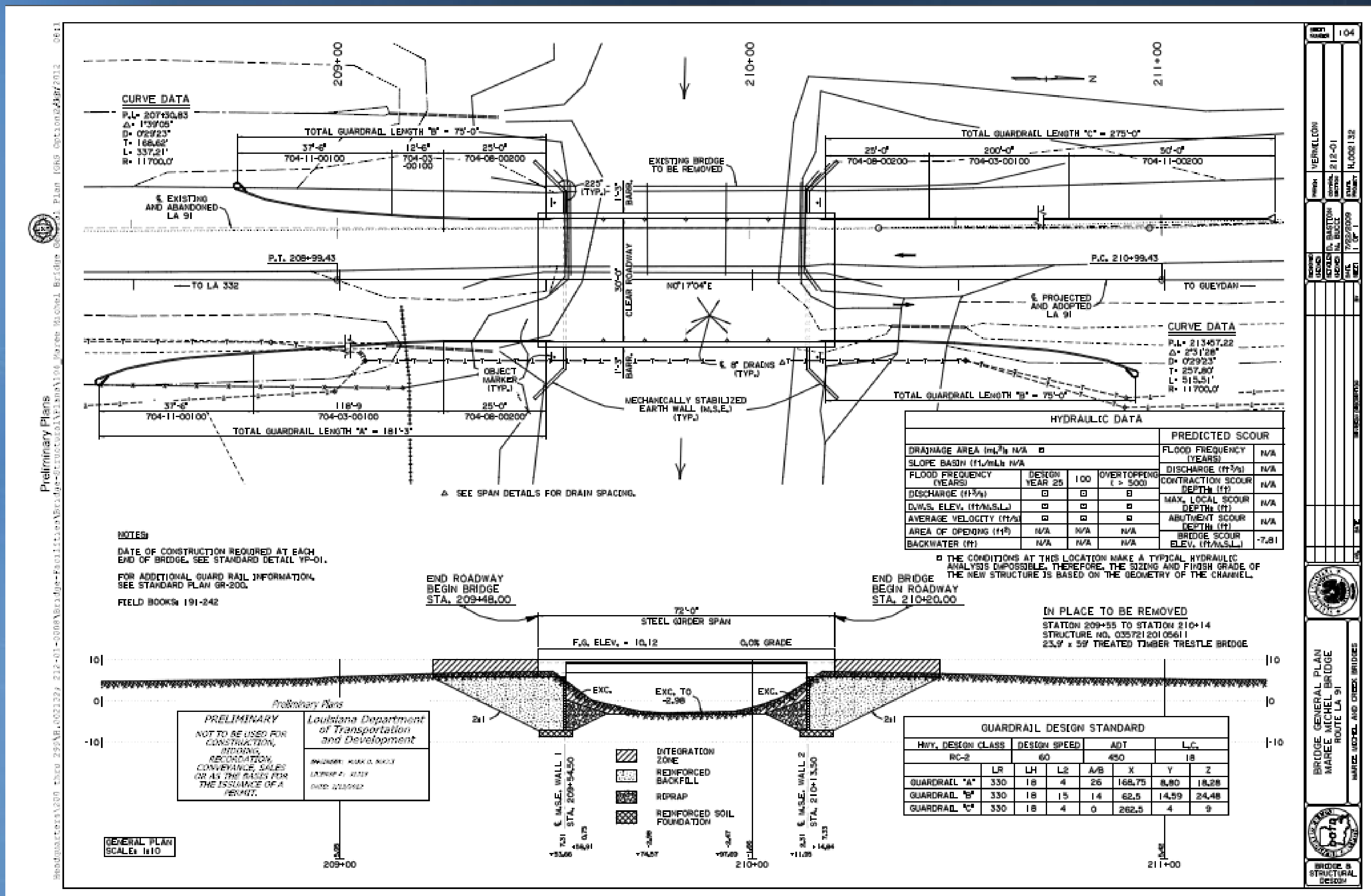


STATE
PROJECT NUMBER
SHEET NO.
MONTANA
NOTES
PLAN
ELEVATION
SECTION A-A
WT40 Bridge rail
Precast concrete slab
GRS Wall CMU Block Face
Bearing Bed Reinforcement
Geosynthetic Reinforcement
Reinforced Backfill Material
Reinforced Soil Foundation
Class II Riprap
Salvaged wetland material
Finished grade @ ℄ Rdwy.
℄ profile
MDT Montana Department of Transportation
BRIDGE OVER SOUTH FORK
DRY FORK MARIAS RIVER
AT STA. 266+20.00
FEDERAL AID PROJECT NO.
STPP 3-3(22)65
PONDERA COUNTY
GENERAL LAYOUT
PRELIMINARY

Maine

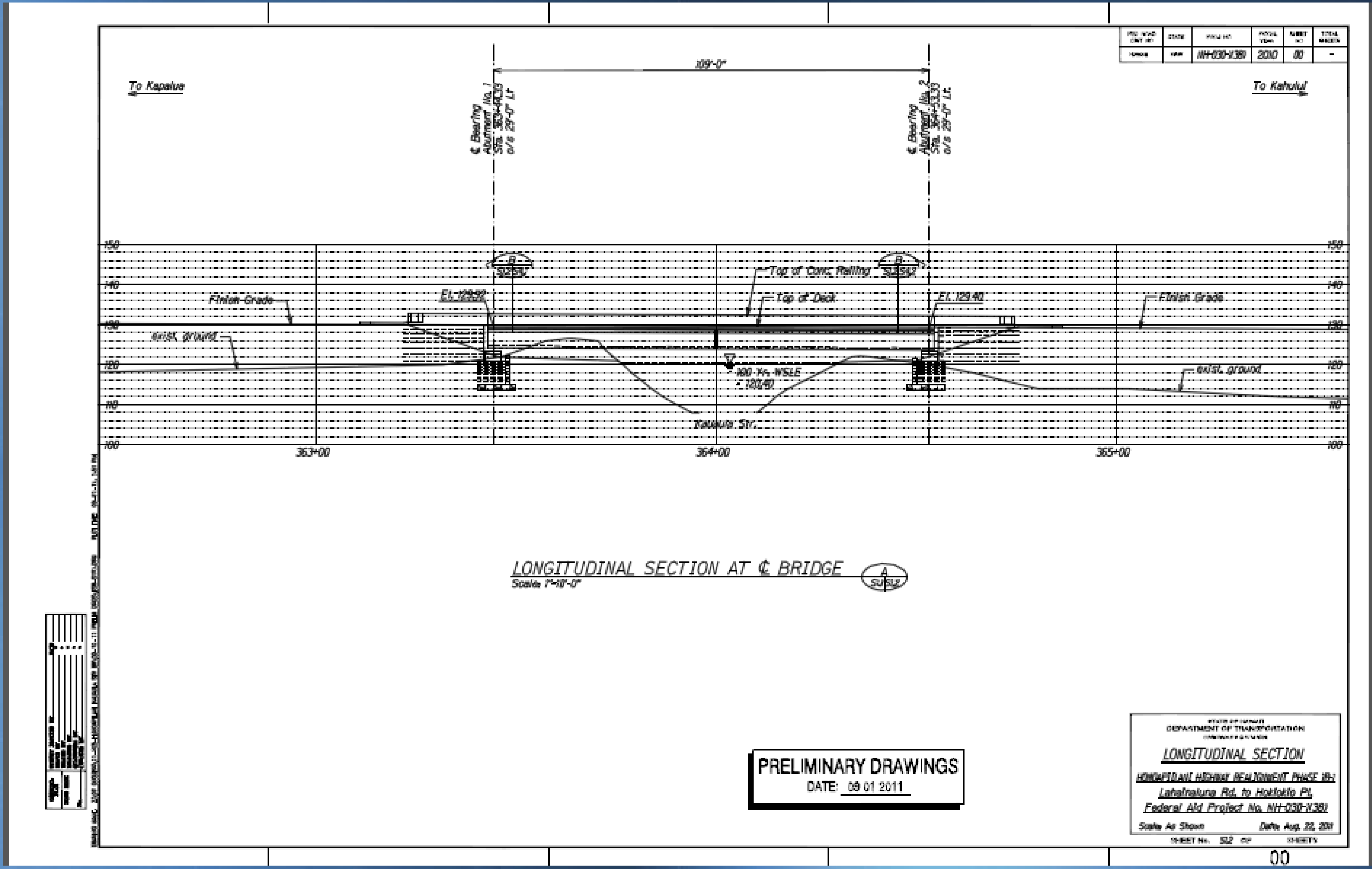

TOWN OF NORTH HAVEN, MAINE
BEACH BRIDGE
OVER PULPIT HARBOR INLET
NORTH HAVEN KNOX COUNTY
PLAN / PROFILE
SHEET NUMBER
1
OF 10
ALTERNATE B
PLAN
SCALE
PROFILE
HORIZ.
VERT.
SCALE
BEGIN PROJECT STA. 1+30.00
END PROJECT STA. 5+70.00
APPROXIMATE EXISTING RIGHT OF WAY
PLAIN RIPRAP SLOPE (TYP.)
RETAINING WALL (TYP.)
SPAN 1
SPAN 2
PROPOSED PRECAST LIGHT WEIGHT CONCRETE NEXT BEAMS
PROPOSED GRADE
EXISTING GRADE
GRS ABUT. (TYP.)
CONCRETE DISTRIBUTION SLAB (TYP.)
CONCRETE BEARING SEAT
CRUSHED STONE BEARING MAT (TYP.)
REUSE EXISTING PIER

Louisiana



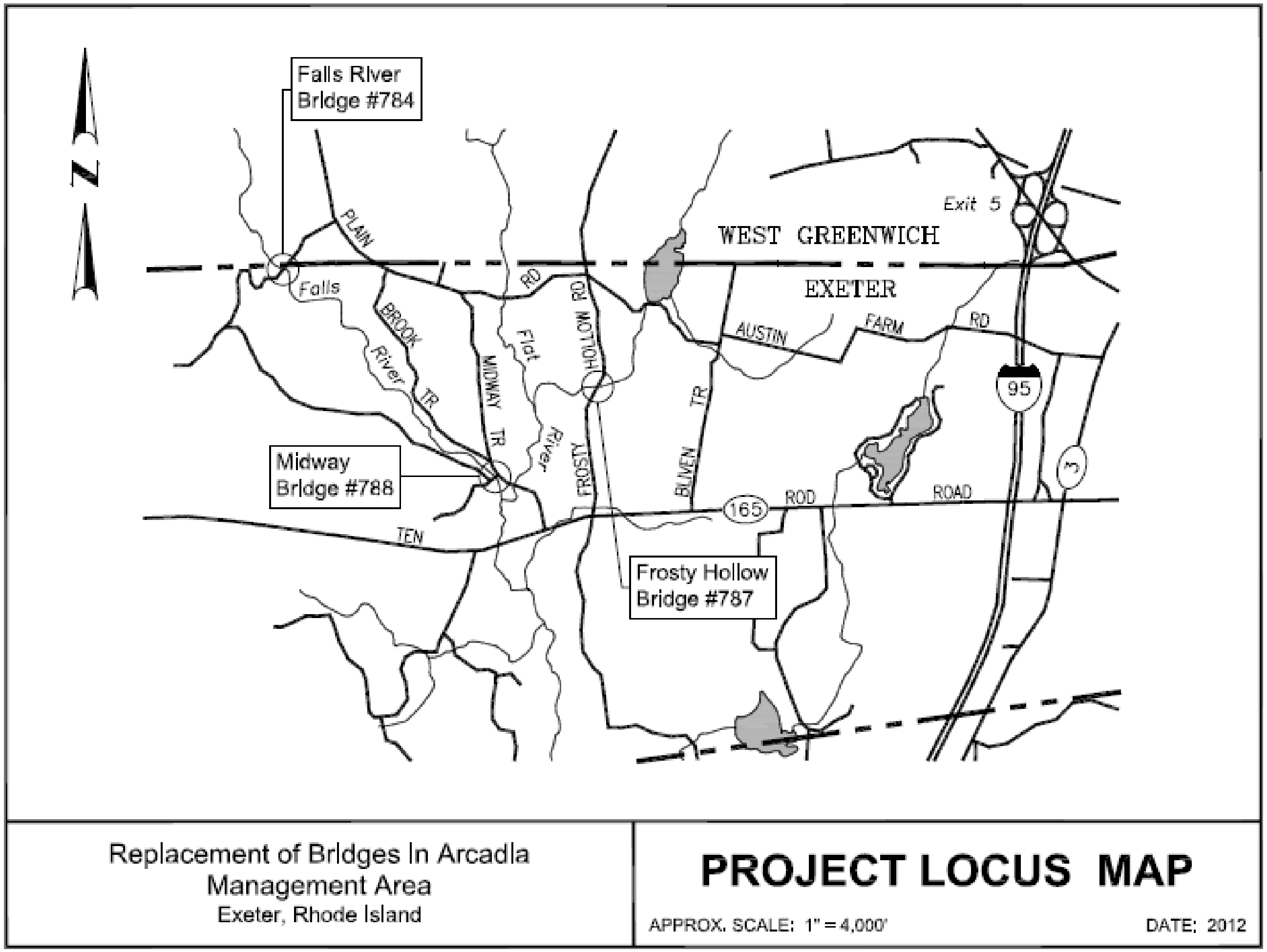
CURVE DATA
TOTAL GUARDRAIL LENGTH "B" = 75'-0"
TOTAL GUARDRAIL LENGTH "C" = 275'-0"
EXISTING BRIDGE TO BE REMOVED
℄ EXISTING AND ABANDONED LA 91
P.T. 208+99.43
P.C. 210+99.43
TO LA 332
TO GUEYDAN
30'-0" CLEAR ROADWAY
℄ PROJECTED AND ADOPTED LA 91
OBJECT MARKER (TYP.)
MECHANICALLY STABILIZED EARTH WALL (M.S.E.) (TYP.)
TOTAL GUARDRAIL LENGTH "A" = 181'-3"
SEE SPAN DETAILS FOR DRAIN SPACING.
HYDRAULIC DATA
PREDICTED SCOUR
NOTES:
DATE OF CONSTRUCTION REQUIRED AT EACH END OF BRIDGE. SEE STANDARD DETAIL YP-01.
FOR ADDITIONAL GUARD RAIL INFORMATION, SEE STANDARD PLAN GR-200.
FIELD BOOKS: 191-242
END ROADWAY BEGIN BRIDGE STA. 209+48.00
END BRIDGE BEGIN ROADWAY STA. 210+20.00
72'-0" STEEL GIRDER SPAN
IN PLACE TO BE REMOVED
STATION 209+55 TO STATION 210+14
23.9' x 59' TREATED TIMBER TRESTLE BRIDGE
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION, BIDDING, RECORDATION, CONVEYANCE, SALES OR AS THE BASIS FOR THE ISSUANCE OF A PERMIT.
Louisiana Department of Transportation and Development
INTEGRATION ZONE
REINFORCED BACKFILL
RIPRAP
REINFORCED SOIL FOUNDATION
GUARDRAIL DESIGN STANDARD
GENERAL PLAN SCALE: 1:10
Preliminary Plans
BRIDGE GENERAL PLAN MAREE MICHEL BRIDGE ROUTE LA 91

Hawaii



To Kapalua
To Kahului
109'-0"
℄ Bearing Abutment No. 1
℄ Bearing Abutment No. 2
Top of Conc. Railing
Top of Deck
Finish Grade
exist. ground
100-Yr. WSLE
363+00
364+00
365+00
LONGITUDINAL SECTION AT ℄ BRIDGE
PRELIMINARY DRAWINGS
LONGITUDINAL SECTION

Rhode Island Project

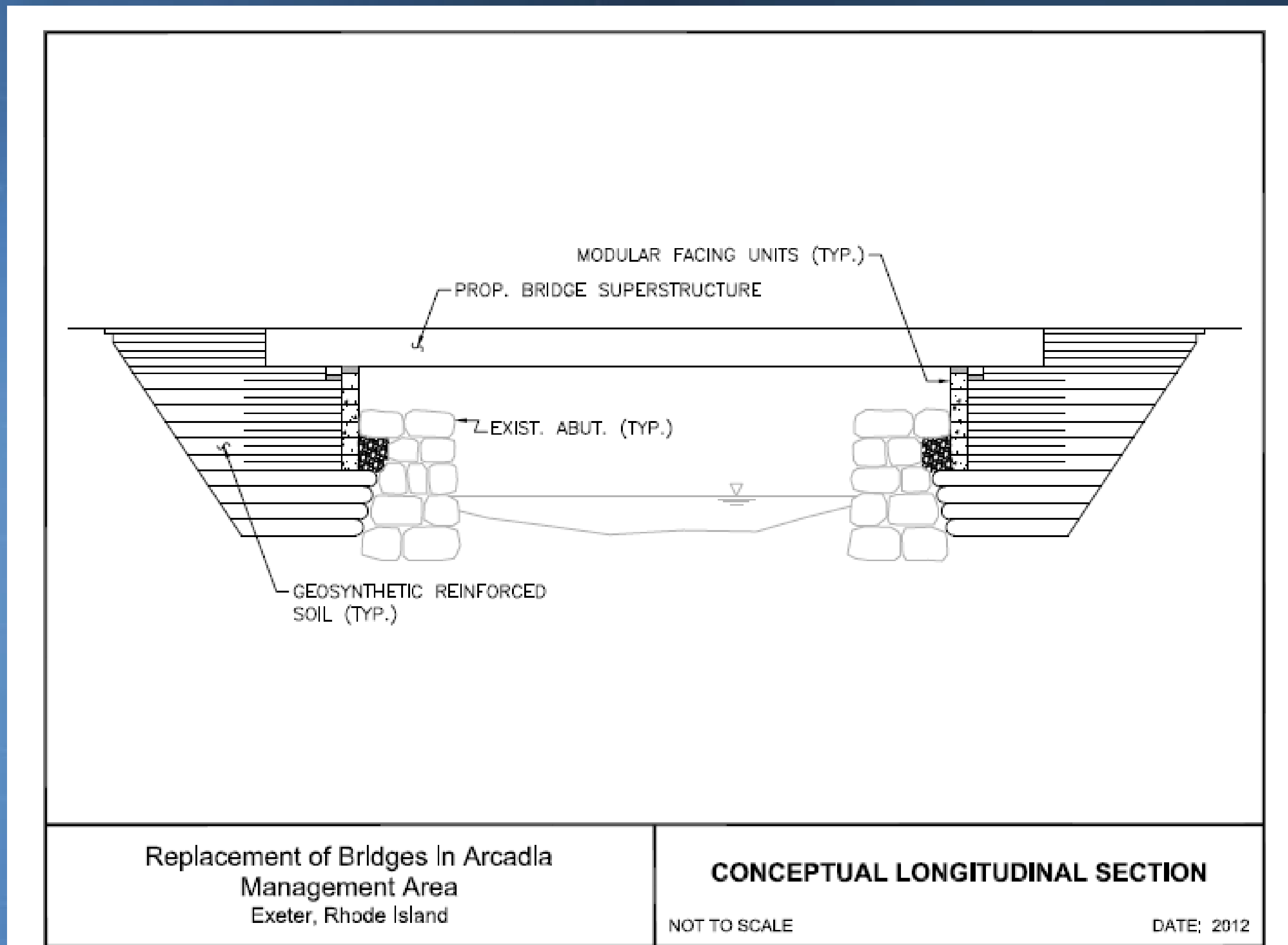


Midway Bridge

Frosty Hollow Bridge

Falls River Bridge

Conceptual Longitudinal Section



U.S. Department of Transportation

Federal Highway Administration

Every Day Counts

innovation ingenuity invention imagination