Geosynthetic Reinforced Soil Integrated Bridge Systems

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Agenda GRS-IBS

- Introduction
- Key Materials
- Design Concepts
- Installation

What Is GRS-IBS?

- **GRS – Geosynthetic Reinforced Soil:**

  An engineered, well-compacted granular fill with closely spaced (<12”) layers of geosynthetic reinforcement

- **IBS – Integrated Bridge System**

  A fast, cost-effective method of bridge support, blending the roadway into the superstructure using GRS technology

History

- **GRS**
  - The U.S. Forest Service used geotextiles in the ’70s to construct wrapped face walls (i.e., burrito walls).
  - The Colorado DOT frictionally connected modular blocks as the facing component in the early ‘80s.
- **GRS-IBS**
  - FHWA refined this method for load-bearing applications (bridges) in 1995.
  - GRS-IBS was selected as an EDC initiative in 2010.

FHWA GRS-IBS Website

www.fhwa.dot.gov/everydaycounts/technology/grs_ibs/

FHWA Home / Accelerating Innovation / Every Day Counts / GRS-IBS

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GRS-IBS

Instead of conventional bridge support technology, Geosynthetic Reinforced Soil (GRS) Integrated Bridge System (IBS) technology uses alternating layers of compacted granular fill material and fabric sheets of geotextile reinforcement to provide support for the bridge. GRS also provides a smooth transition from the bridge onto the roadway, and alleviates the "bump at the bridge" problem caused by uneven settlement between the bridge and approaching roadway. The technology offers unique advantages in the construction of small bridges, including:

- Reduced construction time and cost, with costs reduced 25 to 60 percent from conventional construction methods.
- Easy to build with common equipment and materials; easy to maintain because of fewer parts.
- Flexible design that's easily modified in the field for unforeseen site conditions, including unfavorable weather conditions.

Ancient Secrets, Modern Science: Geosynthetic Reinforced Soil (GRS) Integrated Bridge System (IBS)

The Federal Highway Administration's "Bridge of the Future" initiative took a wise look at the past before soaring ahead to the future. The result was the Geosynthetic Reinforced Soil (GRS) Integrated Bridge System (IBS), which combined cutting-edge geosynthetics with ancient building secrets. This radically simple construction method can lower costs, slash construction time, improve durability, and increase worker safety.

GRS-IBS BROCHURE

Download Brochure

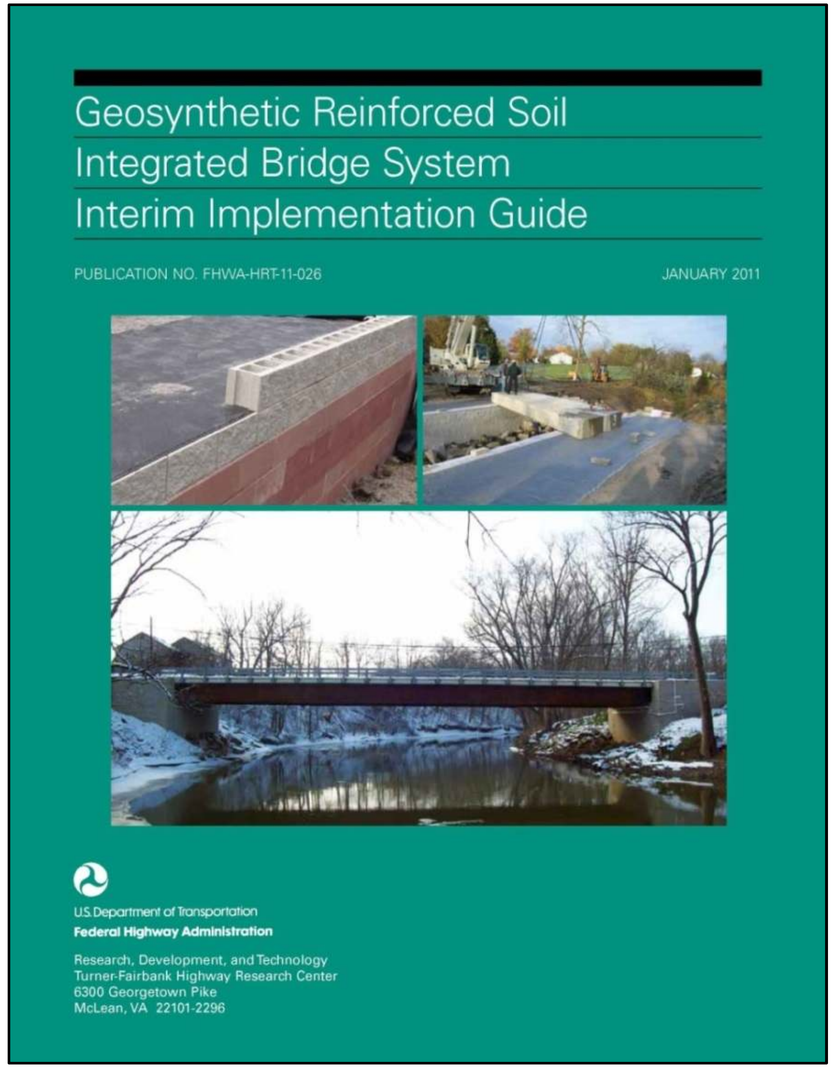
Printable/Foldable

Design: FHWA Manual

Geosynthetic Reinforced Soil
Integrated Bridge System
Interim Implementation Guide

Published January 2011

Includes LRFD

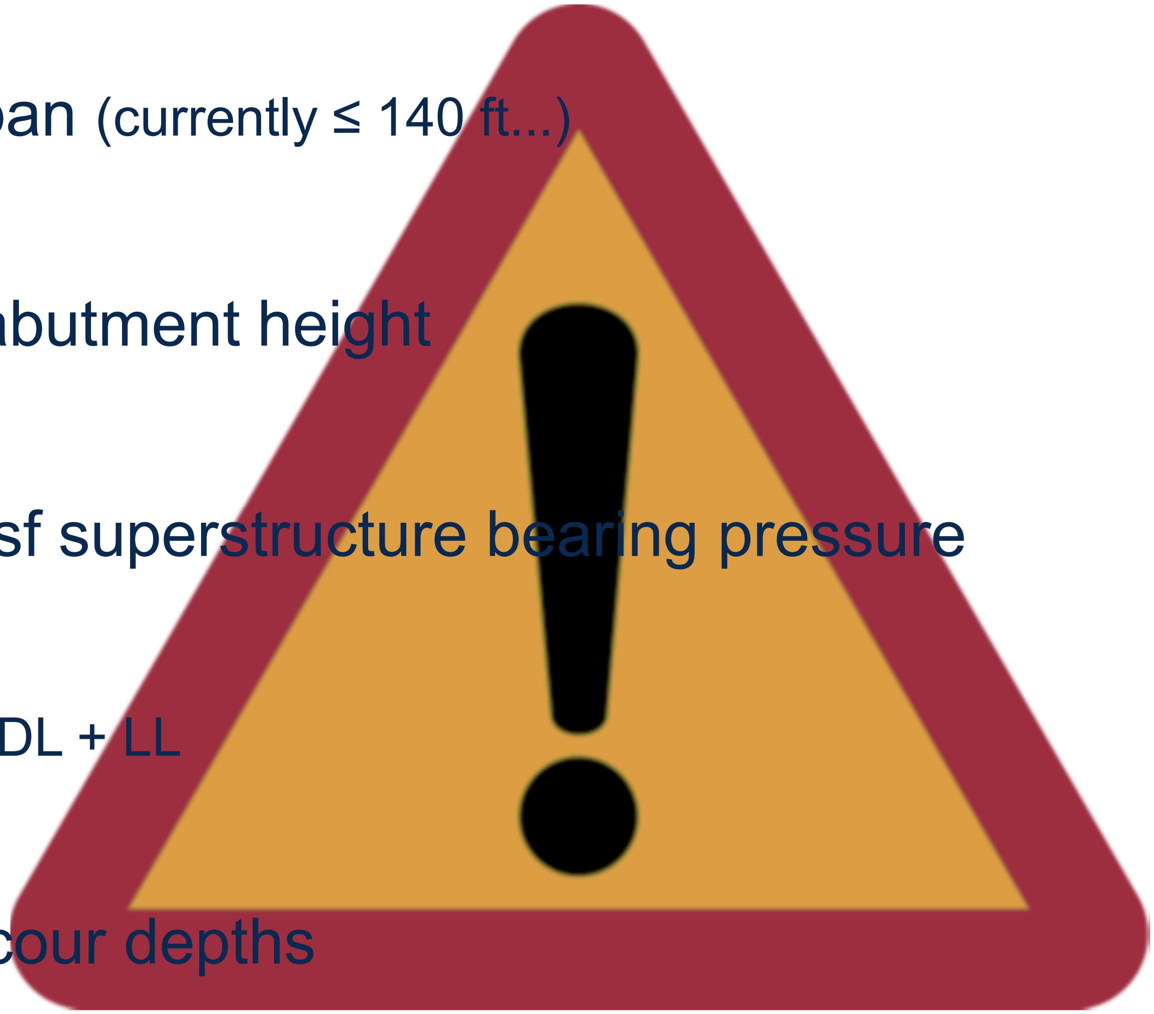


Why Use GRS-IBS?

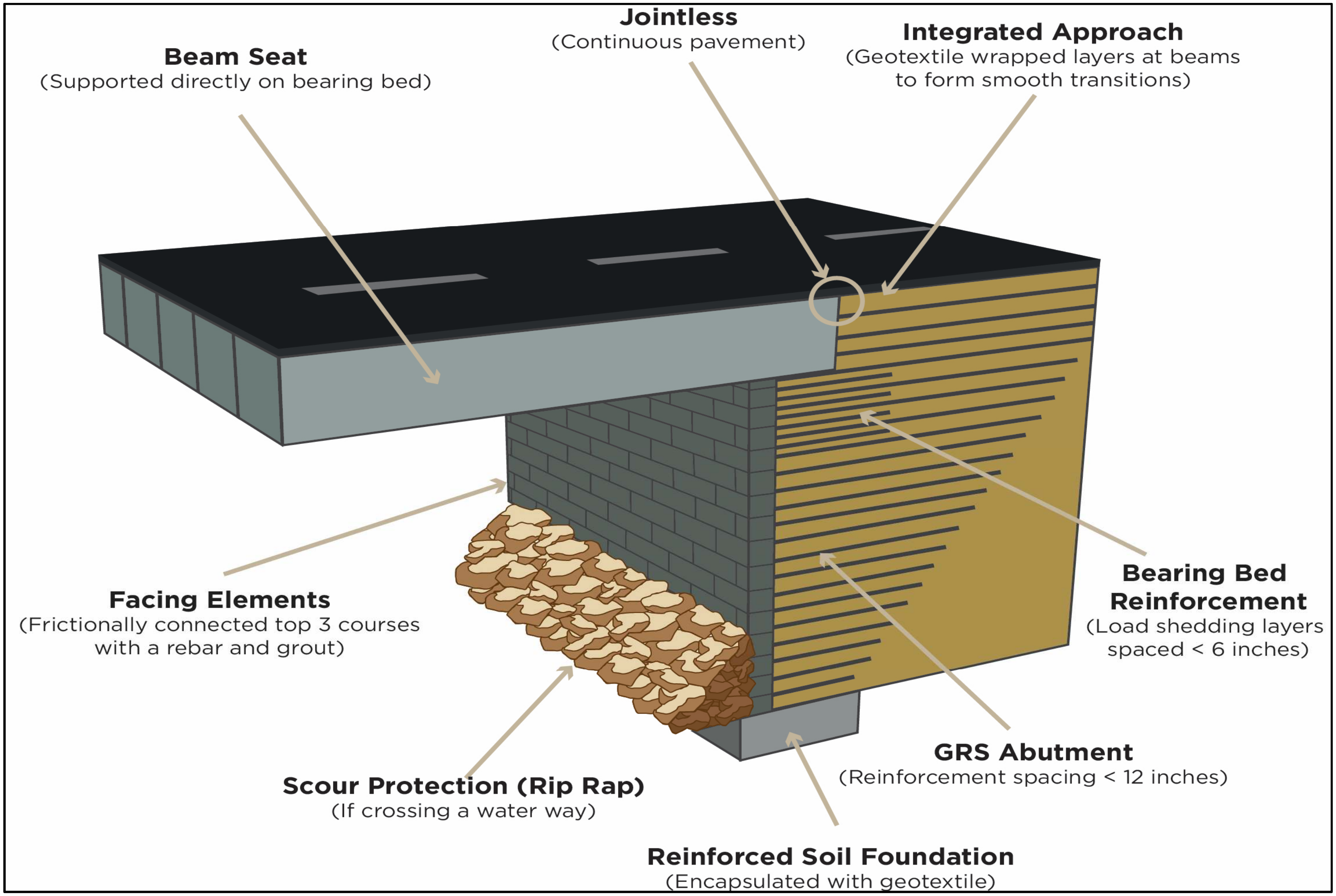
- Reduced construction time & costs (25 – 60%)
- Easy to build with common construction equipment; easy to maintain because of fewer parts
- Flexible design – easily field-modified for unforeseen site conditions, including utilities, obstructions, existing structures, variable soil conditions and weather
- Smooth transition from approach to bridge

Limitations to GRS-IBS

- Single span (currently ≤ 140 ft...)
- ≤ 30 ft...abutment height
- ≤ 4000 psf superstructure bearing pressure
    - Bridge DL + LL
- Deep scour depths

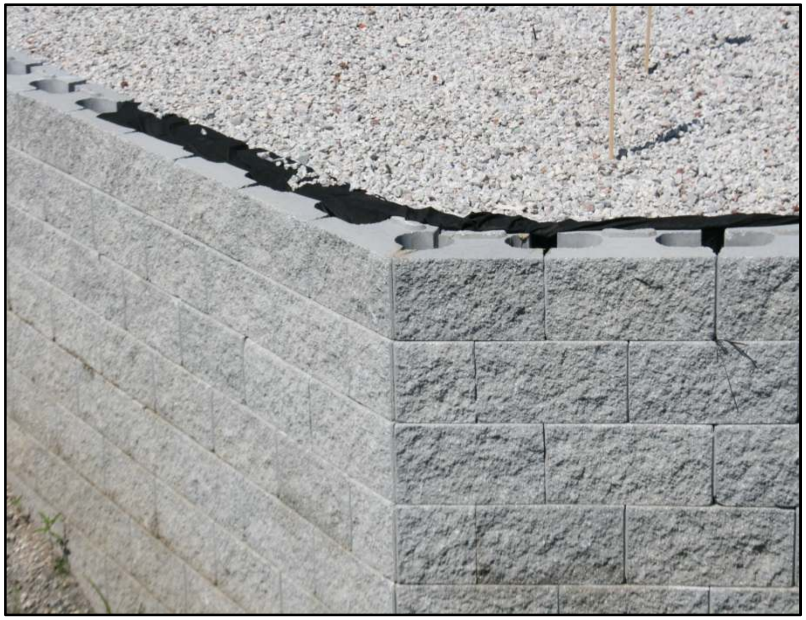


Section View of GRS IBS



Components of a GRS: Facing Elements

- Segmental block/CMU block
  - Readily available
  - Inexpensive
  - Integral colors
  - Works easily with reinforcement



- Material requirements
  - Compressive strength ≥ 4000 psi
  - Water absorption limit: 5%
  - Freeze thaw durability where required

Components of a GRS: Geosynthetic Reinforcement

- Geosynthetic reinforcement can include:
  - HDPE and PET Geogrids
  - PP or PET Woven Geotextiles

- Key Strength Requirements
  - Ultimate strength: $T_{ult} \geq$ 4800 lb./ft.
  - $T_{2\%}$ = Strength at 2% strain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HP570/15/300
NTPEP
SY1
Length (FT) 300.00
Width (Inches) 180.00
Area (Sq Yards) 500.00
Gross LBS 420.75
Date 20130206
AASHTO Class NTPEP LISTED
TenCate Mirafi®
HP570/15/300
NTPEP
SY1

Components of a GRS: Granular Backfill

- Well Graded
  - Graded aggregate base
  - Φ ≥ 38 degrees
- Open Graded
  - #57
  - #67
  - #89
  - Φ ≥ 38 degrees

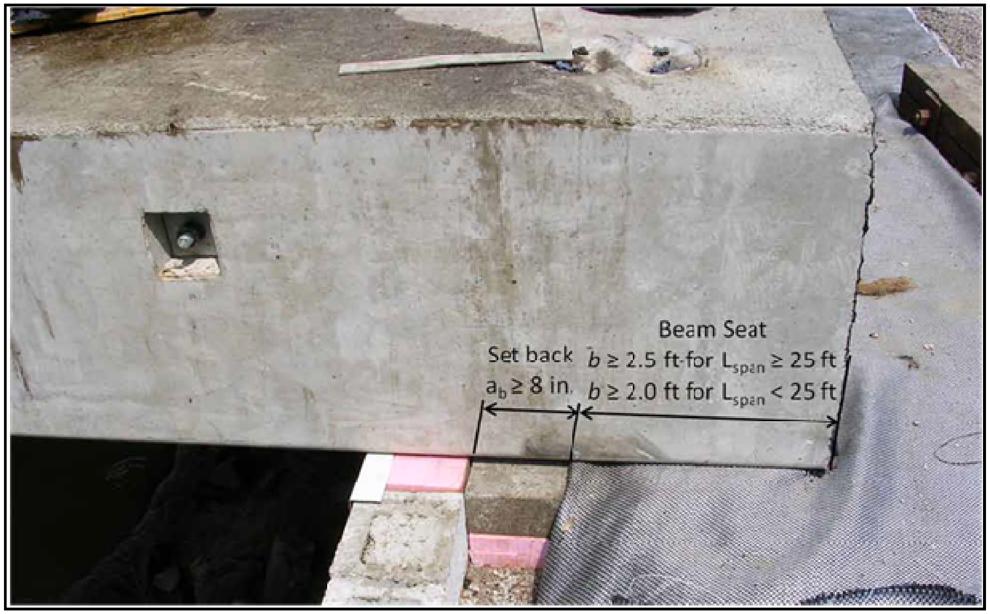
Performance Demonstration

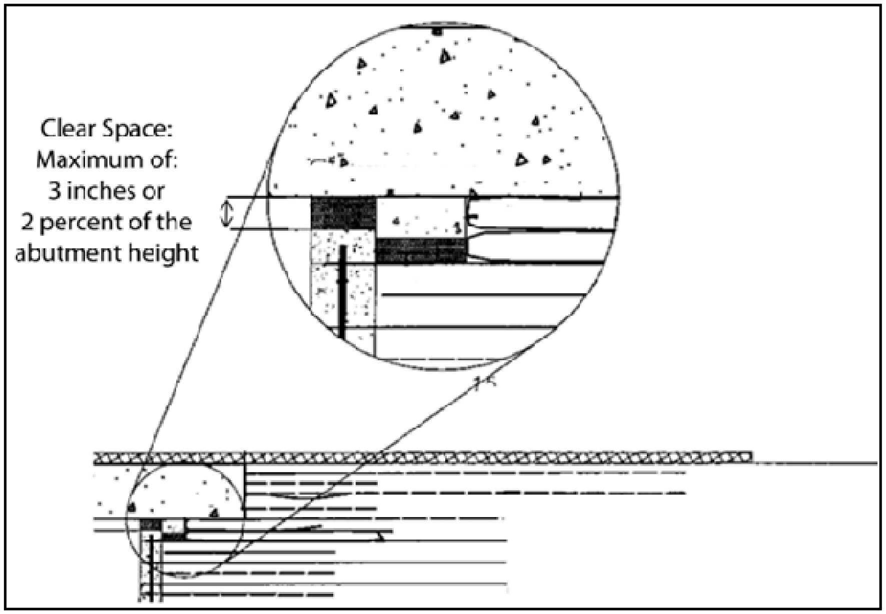
Performance Demonstration

Performance Demonstration

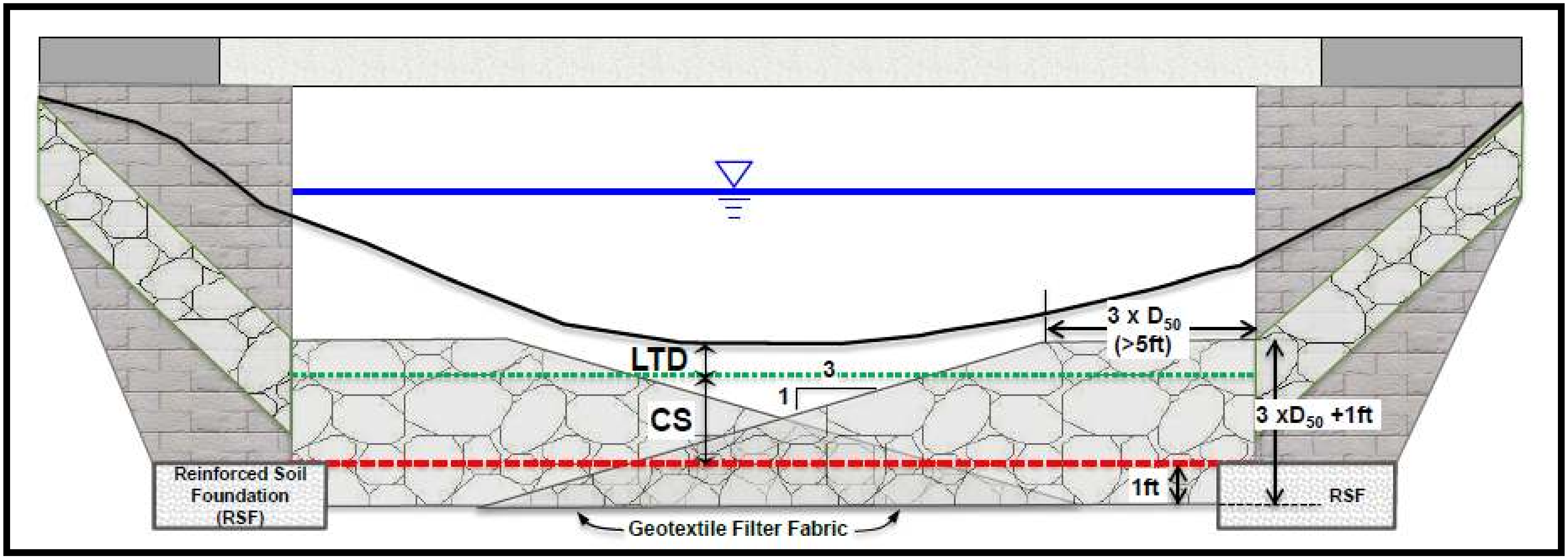
Basic Design Steps:
Determine Layout of GRS-IBS

- Define geometry of abutment face/wing walls
- Layout abutment with respect to superstructure





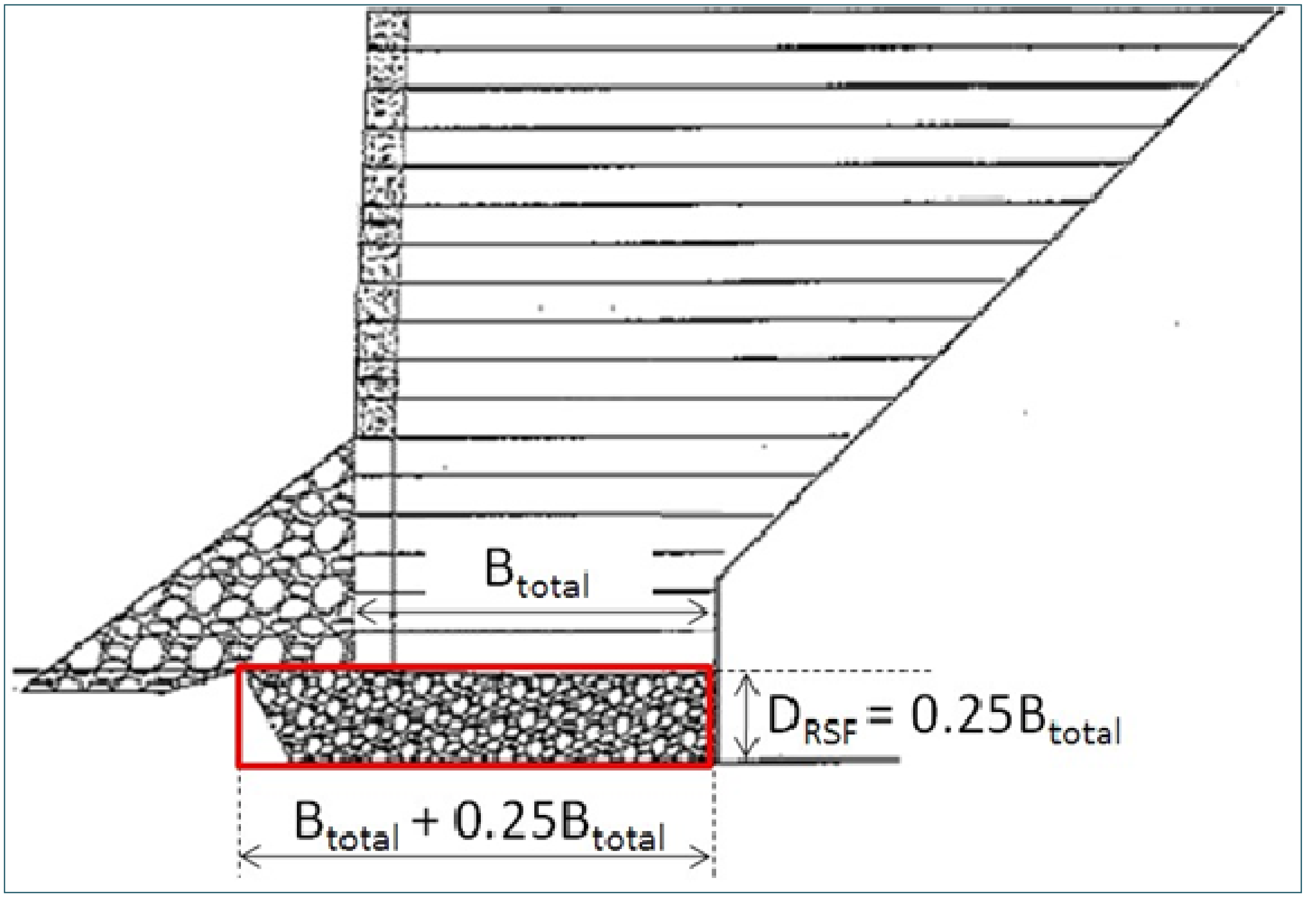
Basic Design Steps:
Perform Site Evaluation



- If a stream crossing - Evaluate hydraulic scour conditions

Basic Design Steps: Dimension of Reinforced Soil Foundation (RSF)

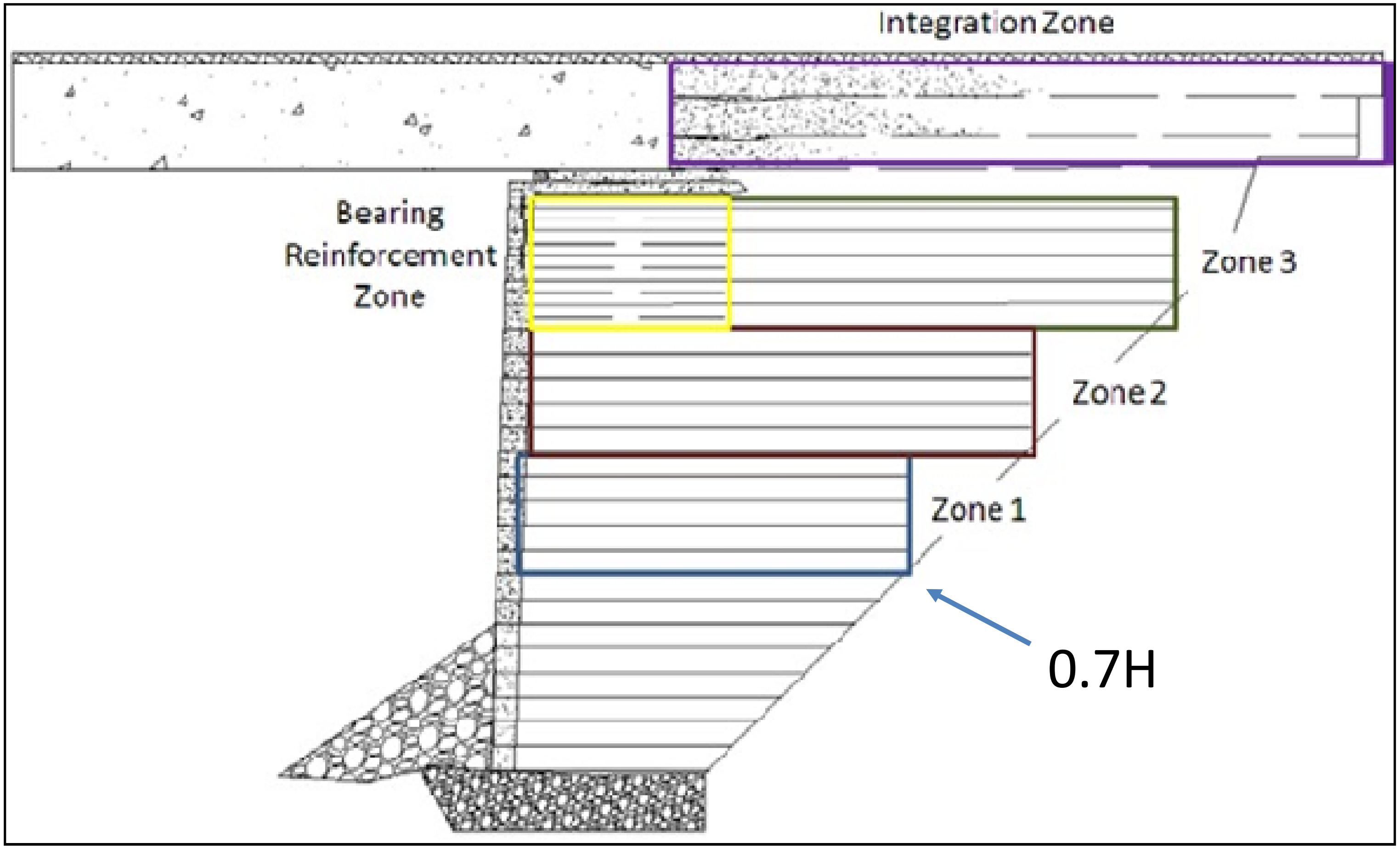
Determine Depth and Volume of Excavation



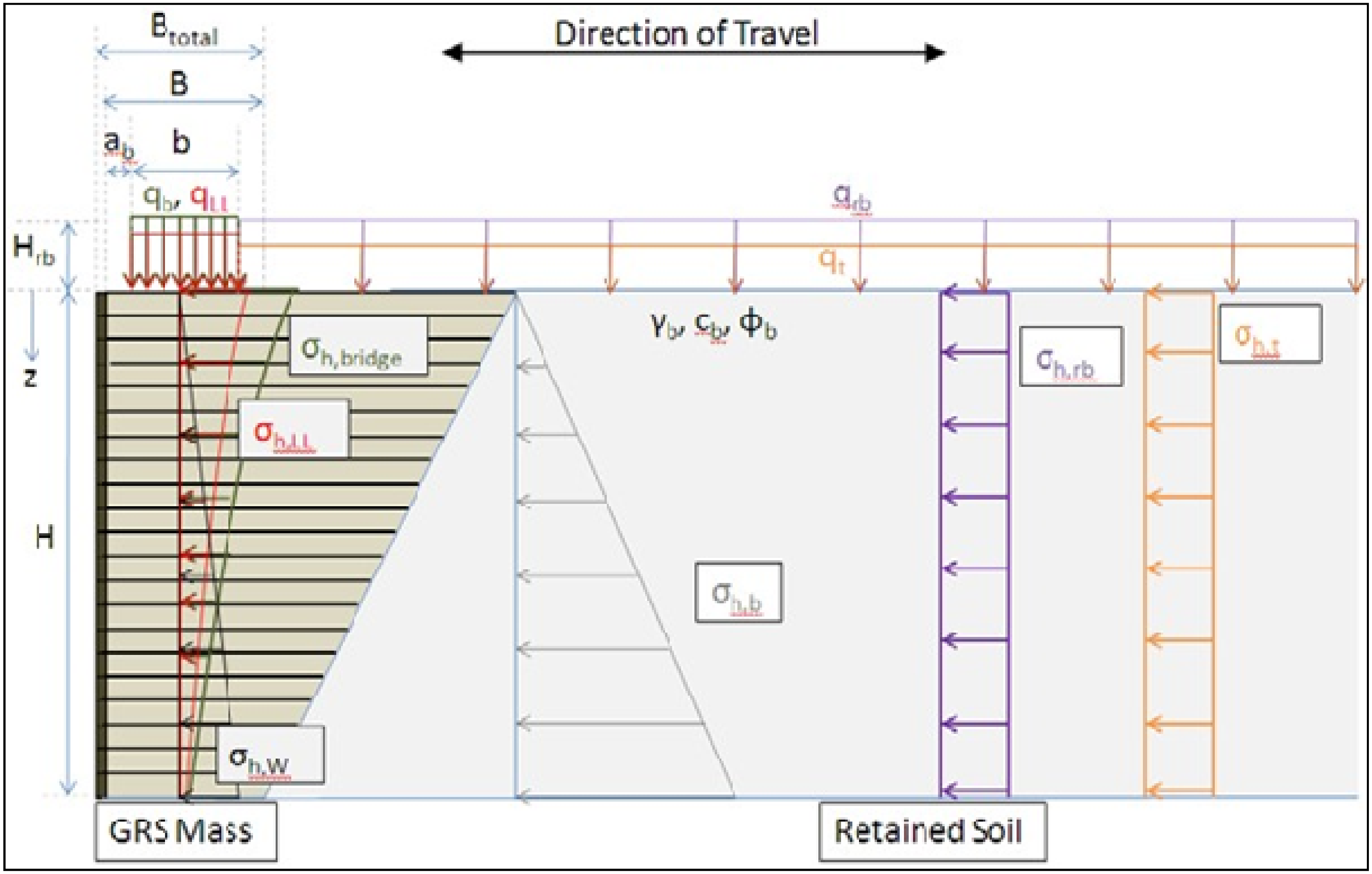
$B_{total} \geq 0.3H$

Basic Design Steps:
Determine Layout of GRS-IBS

Estimate Reinforcement Layout

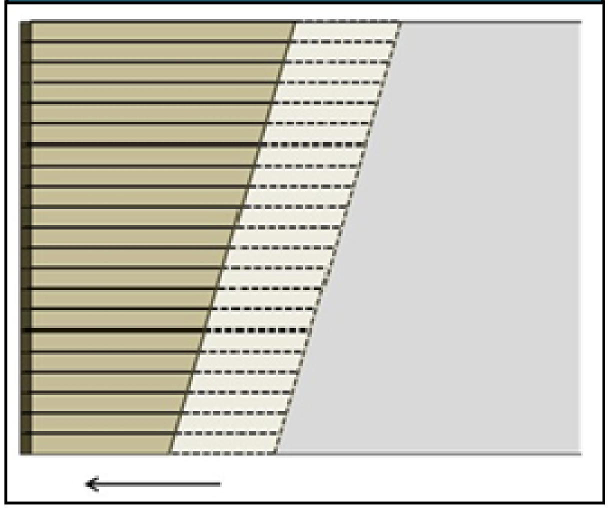


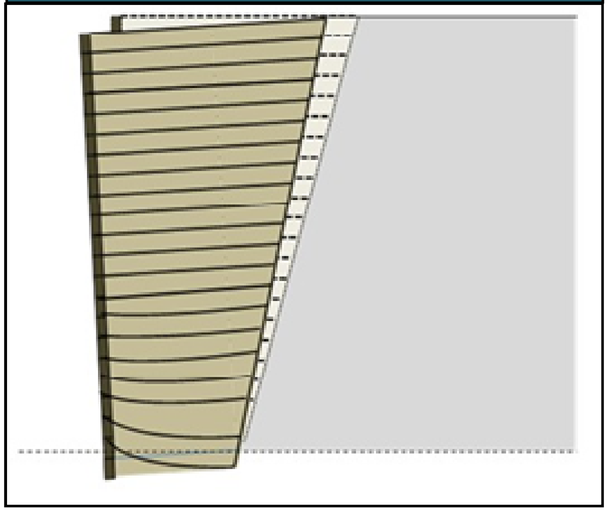
Basic Design Steps: Determine Loads

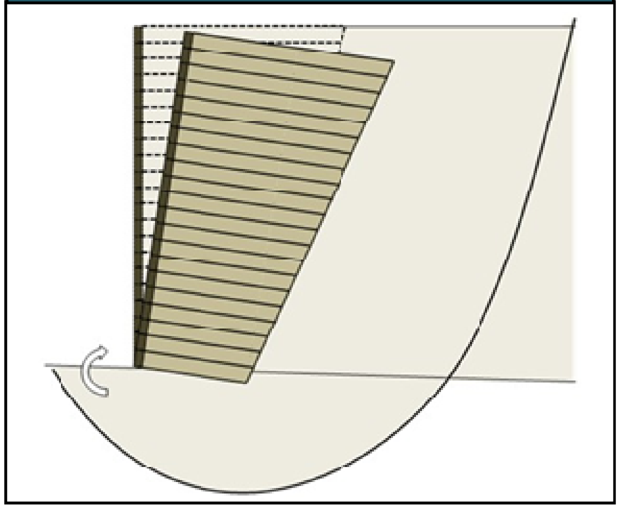


Basic Design Steps:
Check External Stability Analysis (LRFD)

Direct Sliding	Bearing Capacity	Global Stability
$\Phi_r = 1.0$	$\Phi_{bc} = 0.65$	$\Phi_{gs} = 0.65$

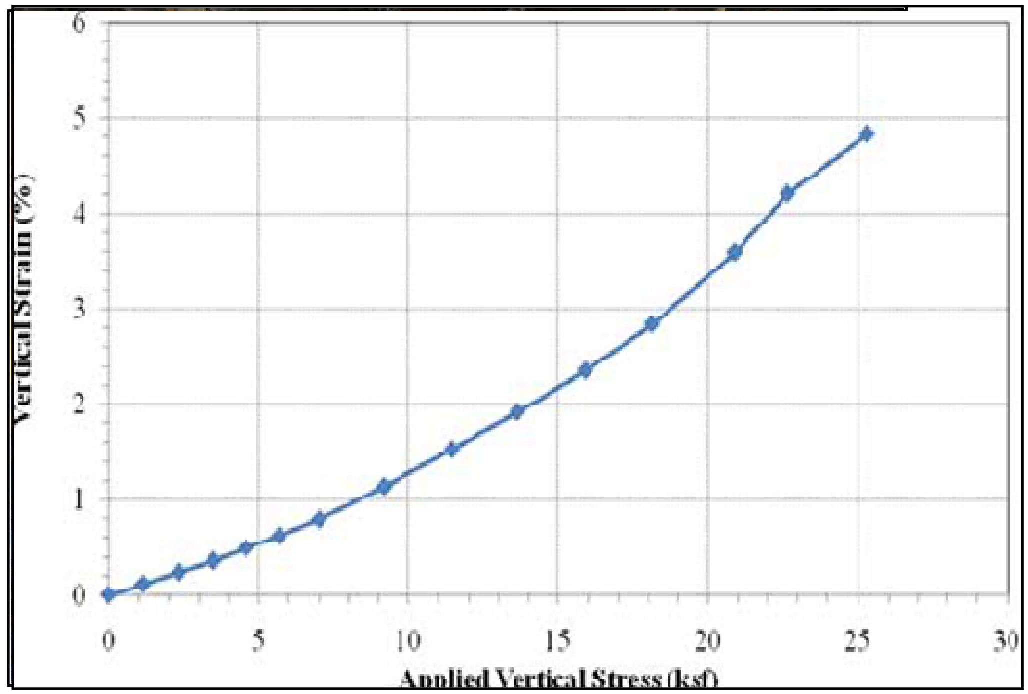






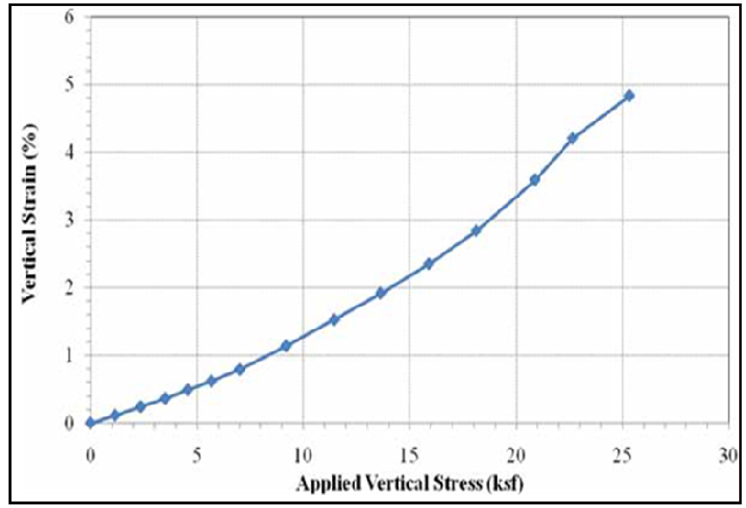
Basic Design Steps: Internal Stability Analysis

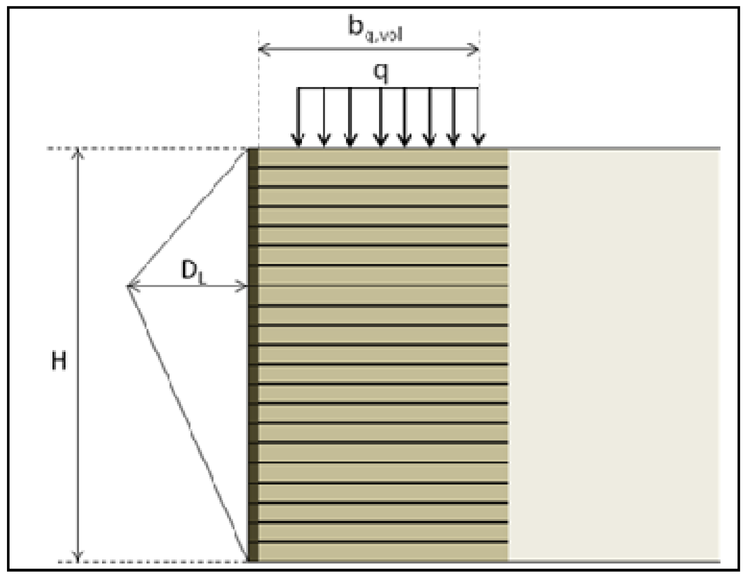
- Ultimate capacity
  - Empirical method
    - Performance test
  - Analytical method
    - $\Phi_{cap}(q_n)/V_{applied} \geq 1.0$



Basic Design Steps: Internal Stability Analysis

- Deformations
  - Vertical
    - Performance test curve
    - Limit vertical strain to 0.5%
    - $D_v = \varepsilon_v H$
  - Lateral
    - $D_L = (2D_v/H)(b + a_b)$





Required Reinforcement Strength, T_{req}

- T_{req} is the required tensile strength of an individual reinforcement layer and is a function of the sum of the horizontal stresses, the reinforcement spacing & backfill gradation (Equation 31)

- The geosynthetic strength (Lower of T_{allow} or $T_{2\%}$) ≥ T_{req}
  - where $T_{allow} = T_f/3.5$ and T_f is the ultimate geosynthetic tensile strength ($T_f \geq 4800$ lb/ft)
  - $T_{2\%}$, geosynthetic strength at 2% strain

- If necessary increase geosynthetic strength or decrease spacing to meet criteria

Component of a GRS:
Geosynthetic Reinforcement

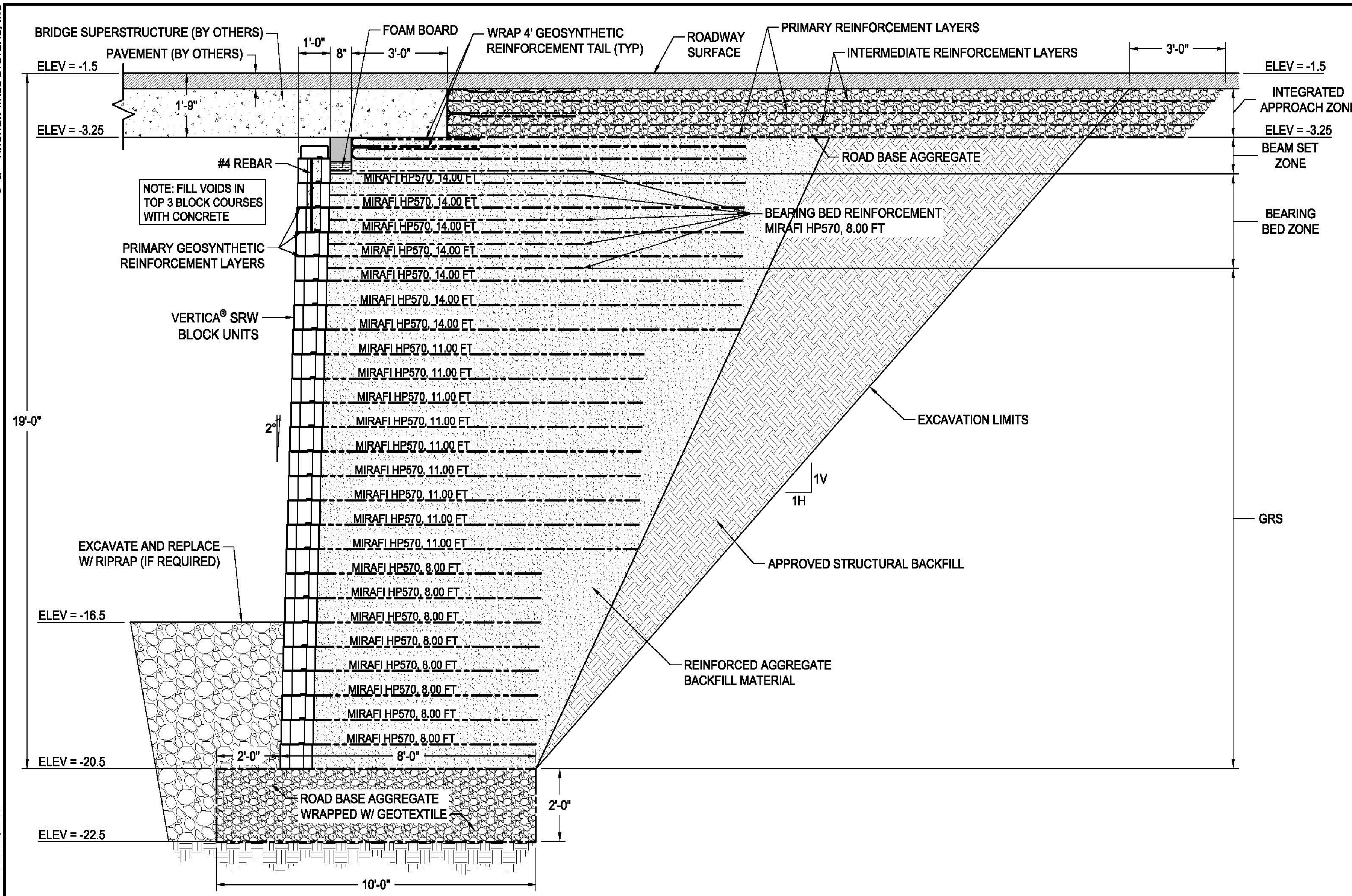
Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	CD
Tensile Strength (at ultimate)	ASTM D4595	lbs/ft (kN/m)	4800 (70.0)	4800 (70.0)
Tensile Strength (at 2% strain)	ASTM D4595	lbs/ft (kN/m)	960 (14.0)	1320 (19.3)
Tensile Strength (at 5% strain)	ASTM D4595	lbs/ft (kN/m)	2400 (35.0)	2700 (39.4)
Tensile Strength (at 10% strain)	ASTM D4595	lbs/ft (kN/m)	4800 (70.0)	---
			Minimum Roll Value	
Flow Rate	ASTM D4491	gal/min/ft^2 (l/min/m^2)	30 (1222)	
Permittivity	ASTM D4491	sec^{-1}	0.40	
			Maximum Opening Size	
Apparent Opening Size (AOS)	ASTM D4751	U.S. Sieve (mm)	30 (0.60)	
			Typical Test Value	
Pore Size O_{95}[1]	ASTM D6767	microns	465	
Pore Size O_{50}[1]	ASTM D6767	microns	632	
			Minimum Test Value	
Factory Sewn Seam	ASTM D4884	lbs/ft (kN/m)	3000 (43.8)	
UV Resistance (at 500 hours)	ASTM D4355	% strength retained	80	

[1] Based on Third Party Testing

Physical Properties	Unit	Roll Size
Roll Dimensions (length x width)	ft (m)	15 x 300 (4.5 x 91)
Roll Area	yd^2 (m^2)	500 (418)

Basic Design Steps: Finalize GRS-IBS

- Develop scaled drawings to include:
  - Reinforcement layout
  - Block layout
  - Extents of backfill
  - Other details specific to project



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SCALE: 3/8" = 1'-0"

0 1

VERIFY THAT THE BAR ABOVE IS 1". IF NOT, ADJUST THE SCALE ACCORDINGLY.

PROPOSED GRS-IBS ABUTMENT WALLS
DAYTONA AVENUE BRIDGE REPLACEMENT
HOLLY HILL, FLORIDA

OLDCASTLE COASTAL — TAMPA, FL

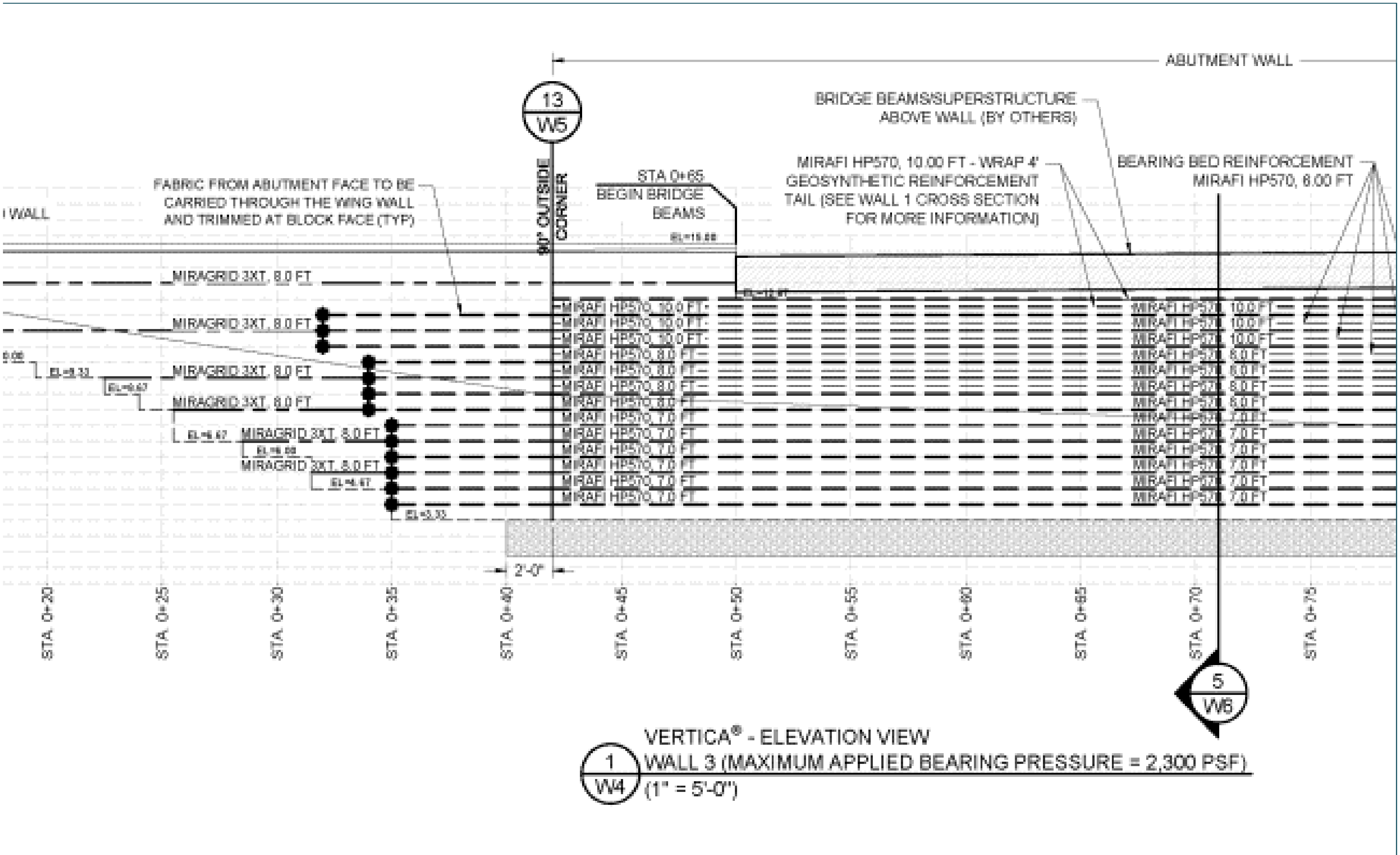
PROJ. NO:	AF 12-27	REVIEWED BY:	AWE
DATE:	04/02/12	DRAWN BY:	AWE

REVISION DATES (SEE SHEET W1 FOR REVISION HISTORY):

CROSS SECTION

SHEET W1 OF 1

Basic Design Steps:
Finalize GRS-IBS



GRS-IBS Installation (Sunshine Hill Bridge): Original Bridge

GRS-IBS Installation (Sunshine Hill Bridge): Placement of RSF

GRS-IBS Installation (Sunshine Hill Bridge): Placement of GRS

GRS-IBS Installation (Sunshine Hill Bridge): Placement of GRS

GRS-IBS Installation (Sunshine Hill Bridge): Placement of Beam Seat/Beams

GRS-IBS Installation (Sunshine Hill Bridge): Placement of Beam Seat/Beams

GRS-IBS Installation (Sunshine Hill Bridge): Placement of Beam Seat/Beams

GRS-IBS Installation (Sunshine Hill Bridge): Bridge Deck/Integrated Approach

GRS-IBS Installation (Sunshine Hill Bridge): Completed GRS-IBS

GRS-IBS Installation (Sunshine Hill Bridge): Completed GRS-IBS

FDOT Orange Avenue Case History

Time Lapse Rhode Island DOT GRS-IBS

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What about Alabama DOT?

- First GRS-IBS project installed in 2017 in Marshall County (Cochran Road over Turkey Creek)
  - This is a County Project
- Being evaluated by Auburn University team
- Sees them best utilized on moderate to low volume county road bridges

Summary

- GRS-IBS technology offers unique advantages in the construction of small bridges, including:
  - Reduced construction time and cost, with costs reduced 25 to 60% from conventional construction methods
  - Easy to build with common equipment and materials, easy to maintain because of fewer parts
  - Flexible design that's easily modified in the field for unforeseen site conditions, including unfavorable weather conditions

For More Information

Guide Specifications, Details, Test Reports, etc. available upon request or at www.belgardcommercial.com

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