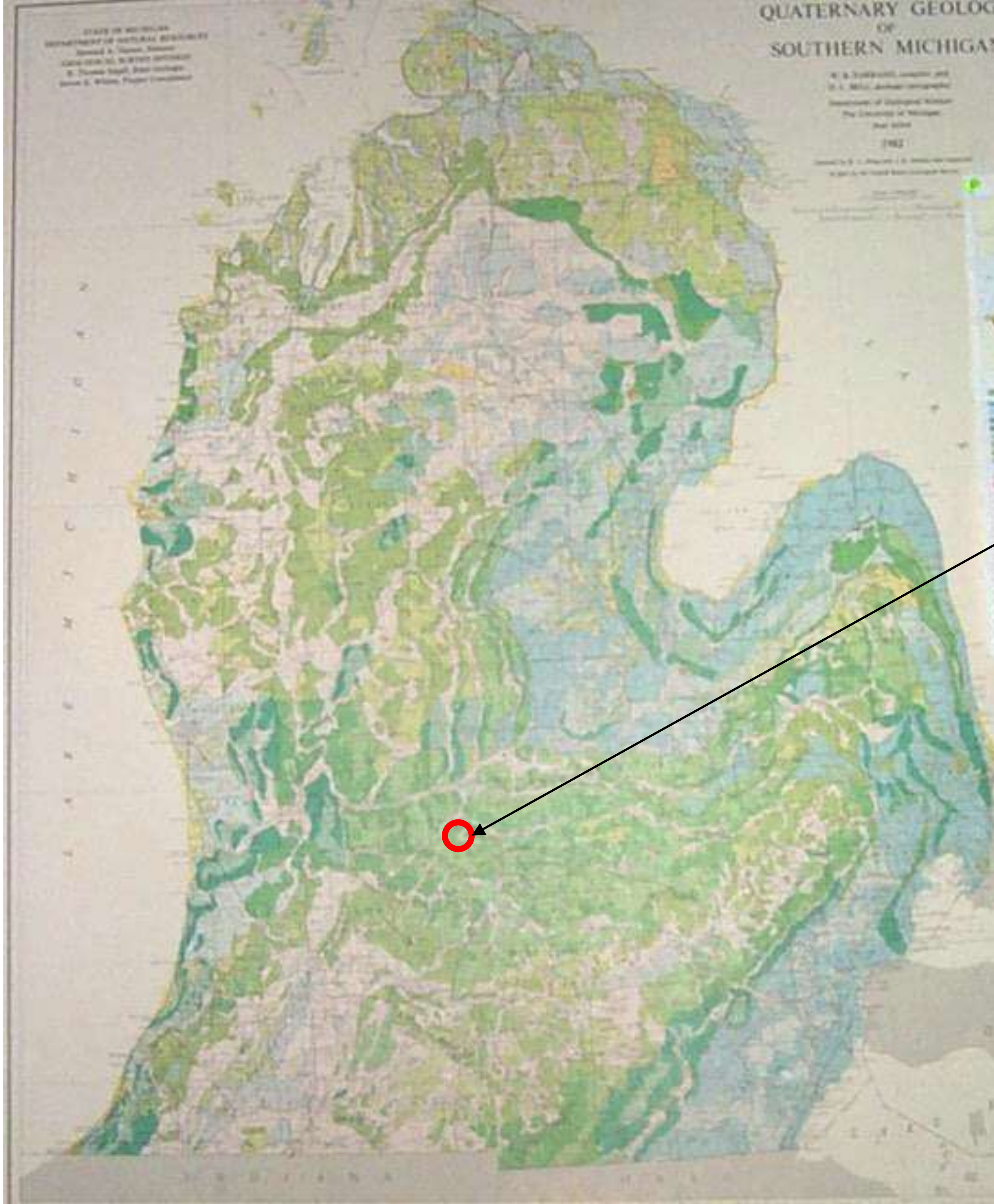
Keefer Highway over Sebewa Creek: Geotechnical Considerations Abutment Design and Construction

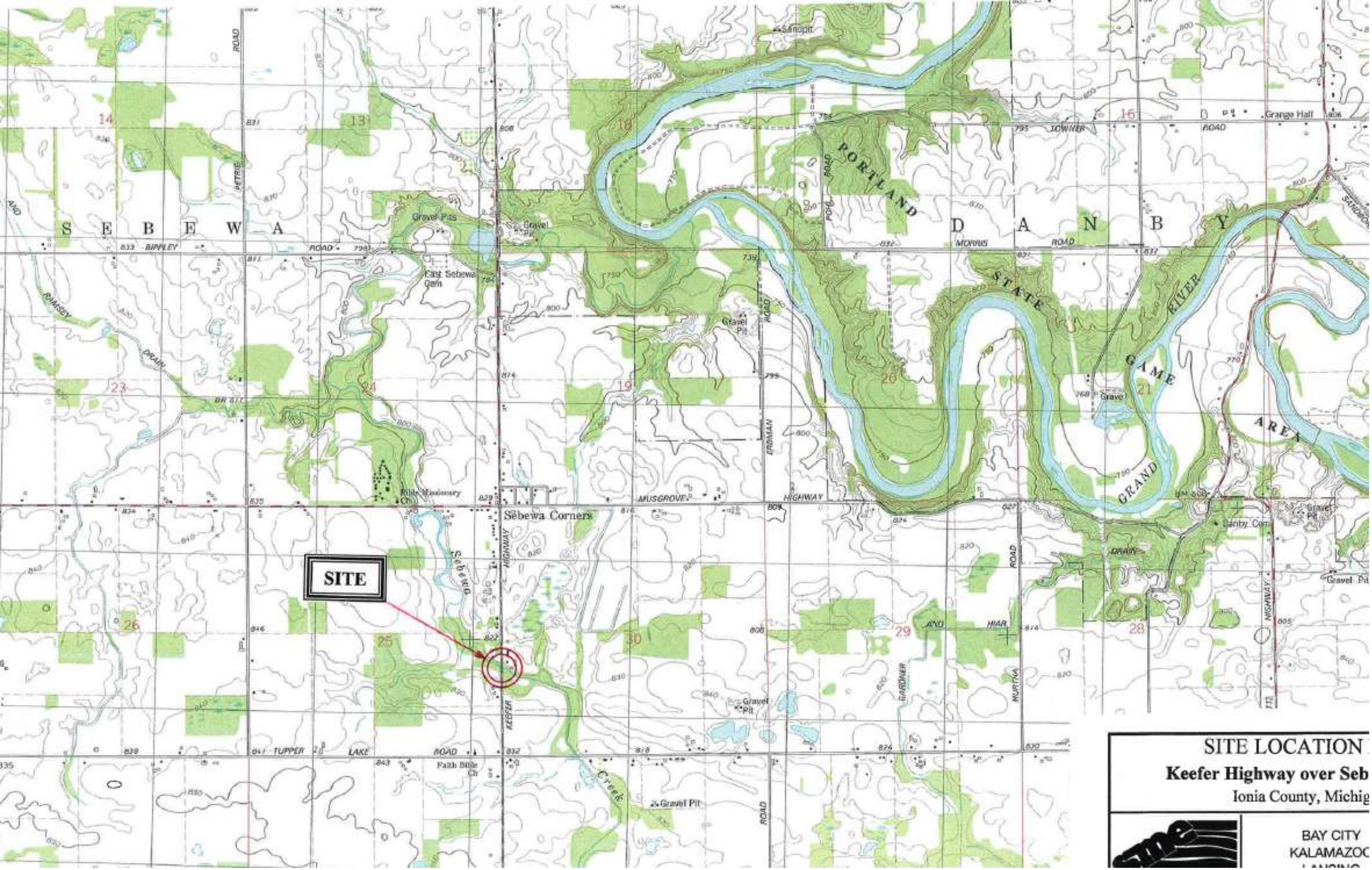
Christopher R. Byrum, Ph.D., P.E.
SME, Inc.

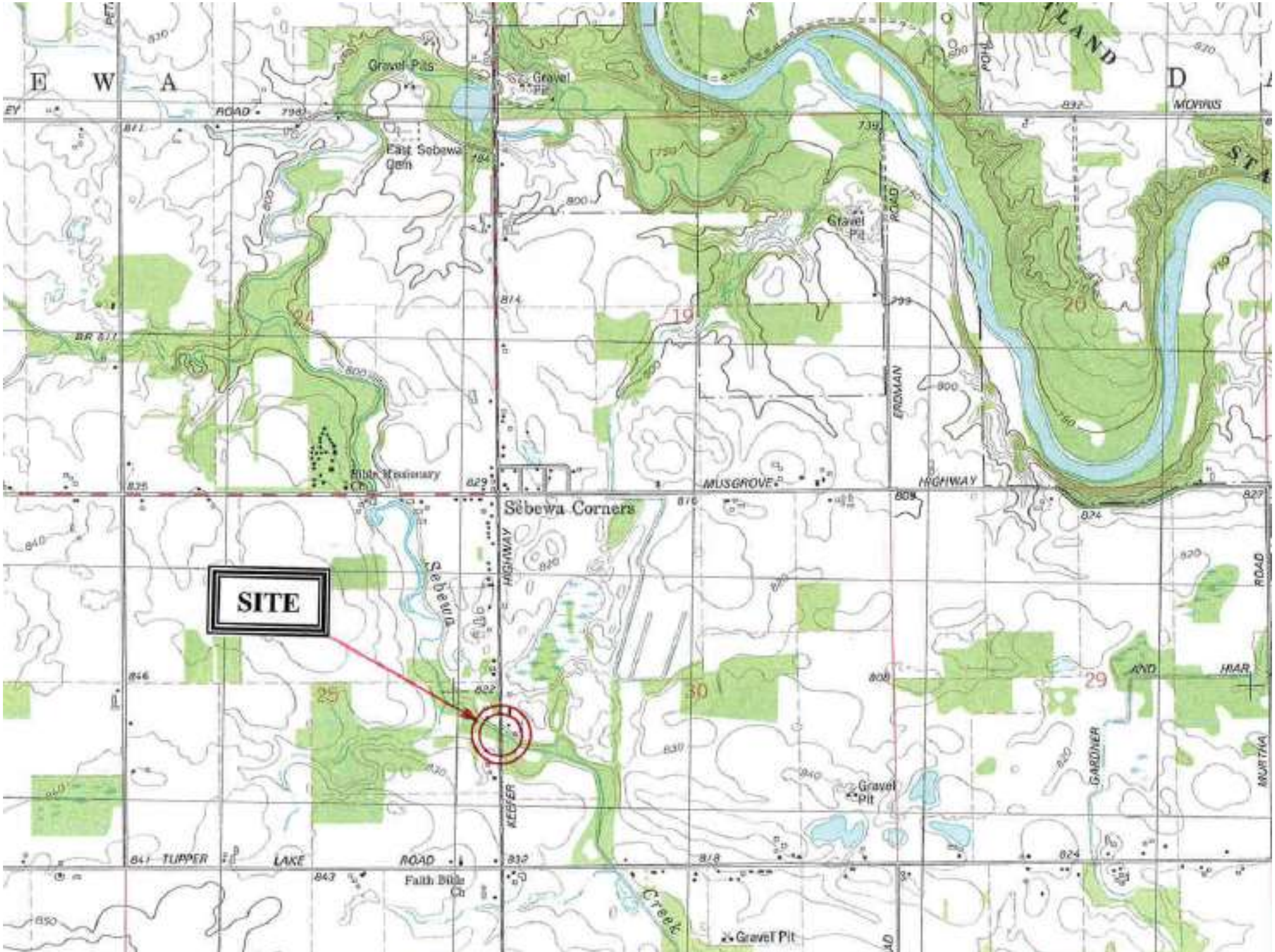


BRIDGE SITE

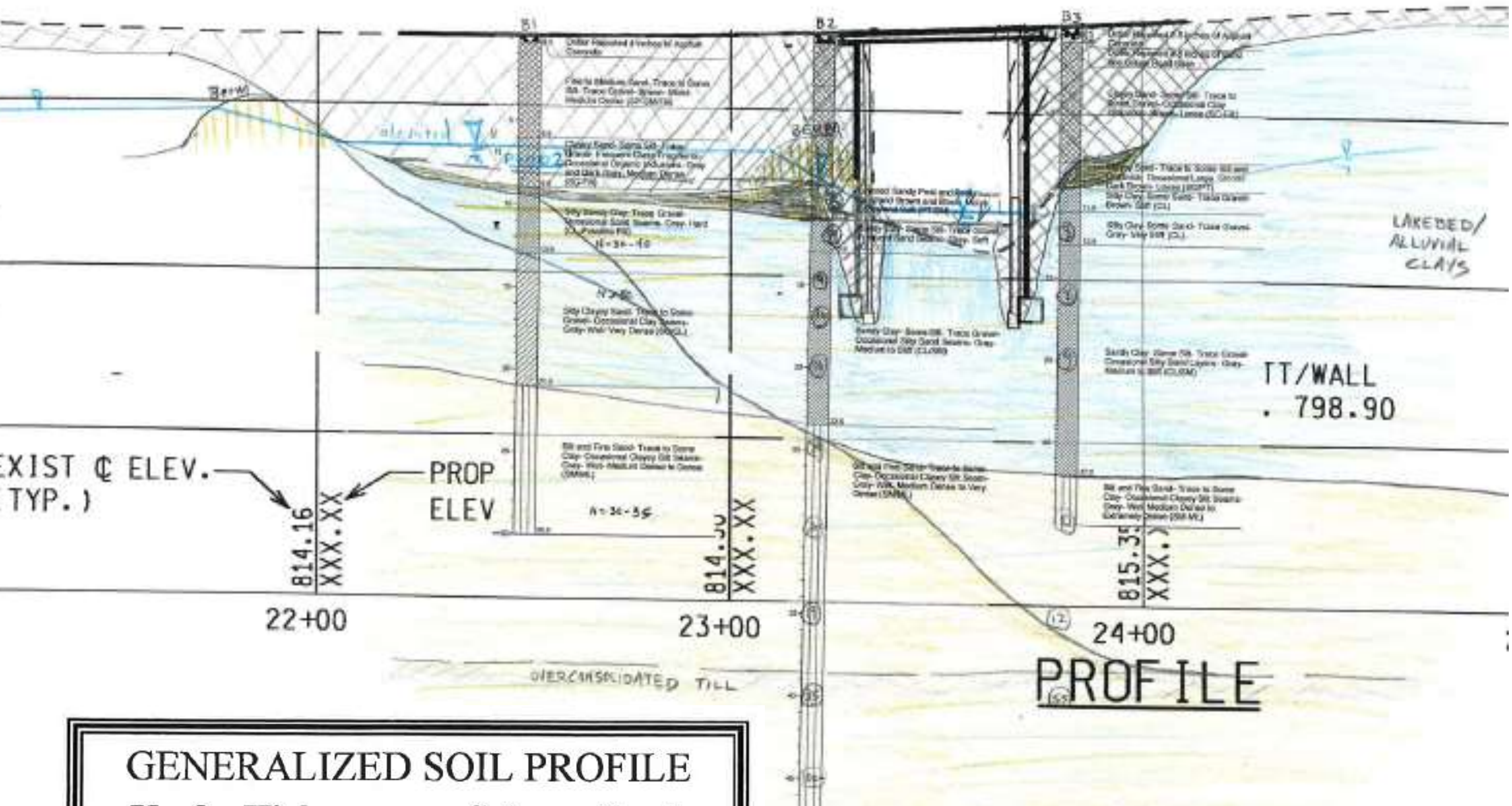
On a Recessional Moraine

Cooks Corners
Belding
Orleans
Smyrna
Hubbardston
Matherton
Maple Rapids
Eureka
Henderson
Carland
Pewamo
Fowler
St Johns
Shepardsville
Ovid
Burton
Owosso
Ionia
Lyons
South Ionia
Saranac
Westphalia
Bennington
Shiawassee
Portland
Laingsburg
Pittsburg
Elmdale
Morrison Lake
Clarksville
DeWitt
Bath
Morrice
Perry
Wacousta
Eagle
Park Lake
Shaftsburg
Lake Odessa
Jordan Lake
Freeport
Woodbury
Sunfield
Mulliken
Grand Ledge
Delta Mills
Bretton Woods
Tower Gardens
LANSING
East Lansing
Carlton Center
Woodland
Hoytville
Little Venice
Okemos
Coats Grove
Needmore
Williamston
Webberville
Hastings
Gresham
West Windsor
Holt
Vermontville
Potterville
Dimondale
Chester
Nashville
Maple Grove
Kalamo
Charlotte
North Aurelius
Mason
Dansville
Petrieville
Aurelius
Eden
Millville
Cloverdale
Dowling
Lacey
Vickery Landing
Eaton Rapids
Bunker Hill
Assyria
Olivet Station
Brookfield
Onondaga
Leslie
Stockbridge
Hickory Corners
Olivet
Charlesworth
Fitchburg
Bellevue
CLINTON
EATON
SHIAWA
Grand
River
TRUNK
CENTRAL
MERIDIAN
MICHIGAN


SITE
SITE LOCATION
Keefer Highway over Seb
Ionia County, Michig
BAY CITY
KALAMAZOO
S E B E W A
D A N B Y
PORTLAND STATE GAME AREA
GRAND RIVER
Sebewa Corners
East Sebewa Cem
Gravel Pits
Gravel Pit
Bible Missionary Ch
Faith Bible Ch
Danby Cem
Grange Hall
Sandpit
Sebewa Creek
BIPPLEY ROAD
MORRIS ROAD
MUSGROVE HIGHWAY
TUPPER LAKE ROAD
KEEFER HIGHWAY
ERDMAN ROAD
GARDNER
MURTHA ROAD
PETRIE ROAD
POHL ROAD
IONIA ROAD
RAMSEY DRAIN
HIAR


SITE
Sebewa Corners
East Sebewa Glen
Gravel Pits
Gravel Pit
Bible Missionary Ch
Faith Bible Ch
MUSGROVE HIGHWAY
TUPPER LAKE ROAD
KEEFER HIGHWAY
ERDMAN ROAD
GARDNER
MURTHA ROAD
MORRIS
Sebewa Creek
E W A
D


BERM
B3
B2
B1
BERM
LOWER POND
BERM/DAM
UPPER POND
© 2013 Google



GENERALIZED SOIL PROFILE

Keefer Highway over Sebewa Creek

Sebewa Twp., Ionia County, Michigan

SME Project No. 67283

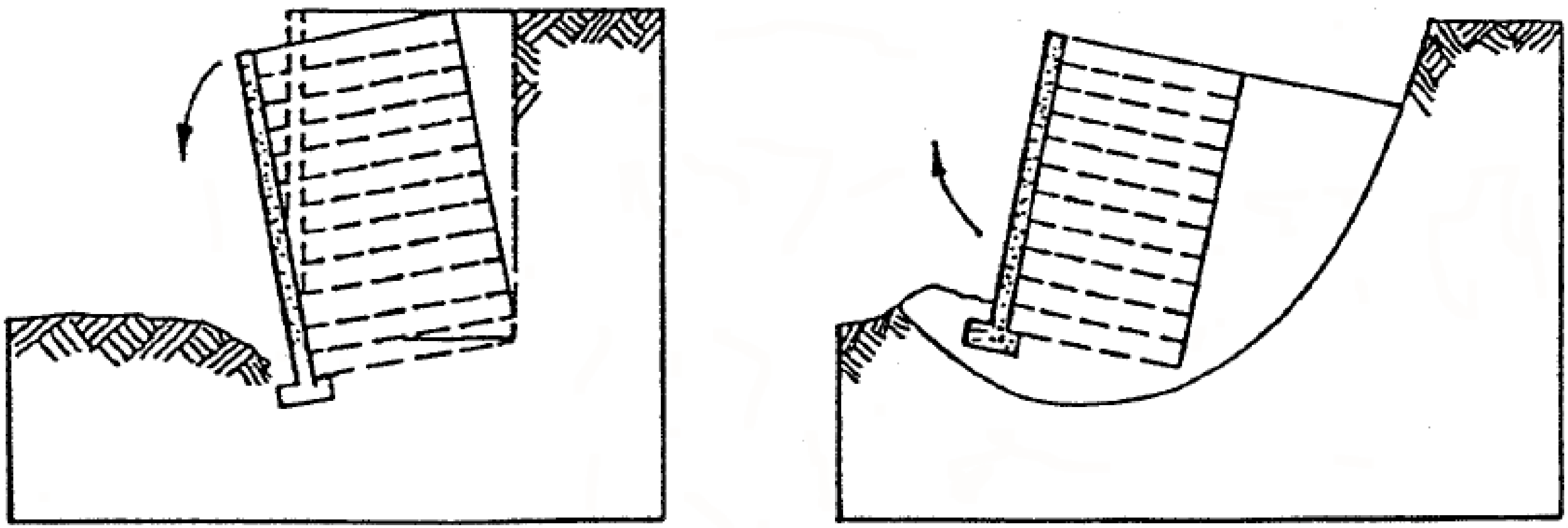
DRY DENSITY (pcf) -- ■ 90 100 110 120	MOISTURE & ATTERBERG LIMITS (%) PL —MC◆— LL 10 20 30 40

▽ HAND PENETROMETER
⊠ TORVANE SHEAR
○ UNCONFINED COMPRESSION
⊡ VANE SHEAR (PEAK)
✕ VANE SHEAR (REMOLD)
⊕ TRIAXIAL (UU)
SHEAR STRENGTH (K

LATITUDE: 42.790098 N
LONGITUDE: -84.955858 W
NORTHING: 470699.5 FT
EASTING: 12965217.7 FT
SURFACE ELEVATION: 814.2 FT

DEPTH (FEET)	PROFILE DESCRIPTION	ELEVATION
0.5	Driller Reported 6 inches of Asphalt Concrete	813.7
3.0	Fine to Coarse Sand- Trace to Some Gravel- Trace Silt- Brown- Moist- Dense (SP/Fill)	811.2
4.5	Fine to Coarse Sand- Some Silt and Gravel- Gray- Moist- Medium Dense (SM/Fill)	809.7
6.0	Silty Clay- Some Sand- Trace Gravel- Brown- Stiff (CL-Fill)	808.2
8.5	Clayey Sand- Some Silt- Trace to Some Gravel- Brown- Moist- Loose (SC-CL-Fill)	805.7
11.0	Layered Sandy Peat and Peaty Sand- Gray and Brown and Black- Moist- Loose and Soft (PT/SM)	803.2
14.0	Sandy Clay- Some Silt- Trace Gravel- Frequent Sand Seams- Gray- Soft (CL)	800.2
	Sandy Clay- Some Silt- Trace Gravel- Occasional Clayey Sand Seams & Layers- Gray- Medium to Stiff (CL/SC)	

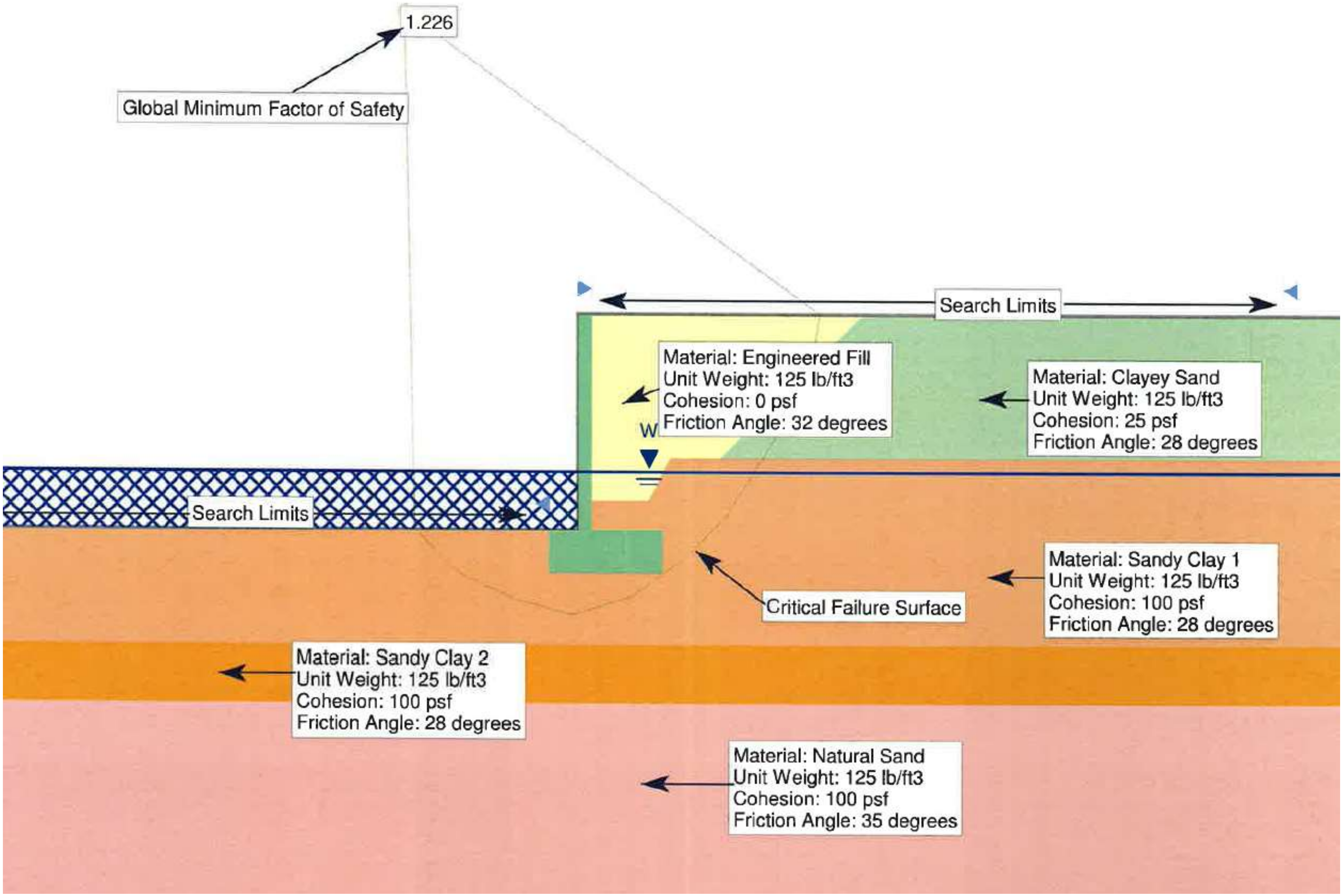
SAMPLE TYPE/NO. INTERVAL	BLOWS PER SIX INCHES	N-VALUE -- ○	MOISTURE (%)	SHEAR STRENGTH
SS1	17 18 27	45		
SS2	12 10 7	17	16	▽
SS3	2 2 3	5	16	⊠ 0.2
SS4	3 3 3	6	25	⊠ 0.2
SS5	4 5 4	9	12	⊠ 0.4
SS6	4 4 5	9	10	⊠ 0.4
SS7	4 5 5	10	10	▽
SS8	6 6 10	16	10	▽

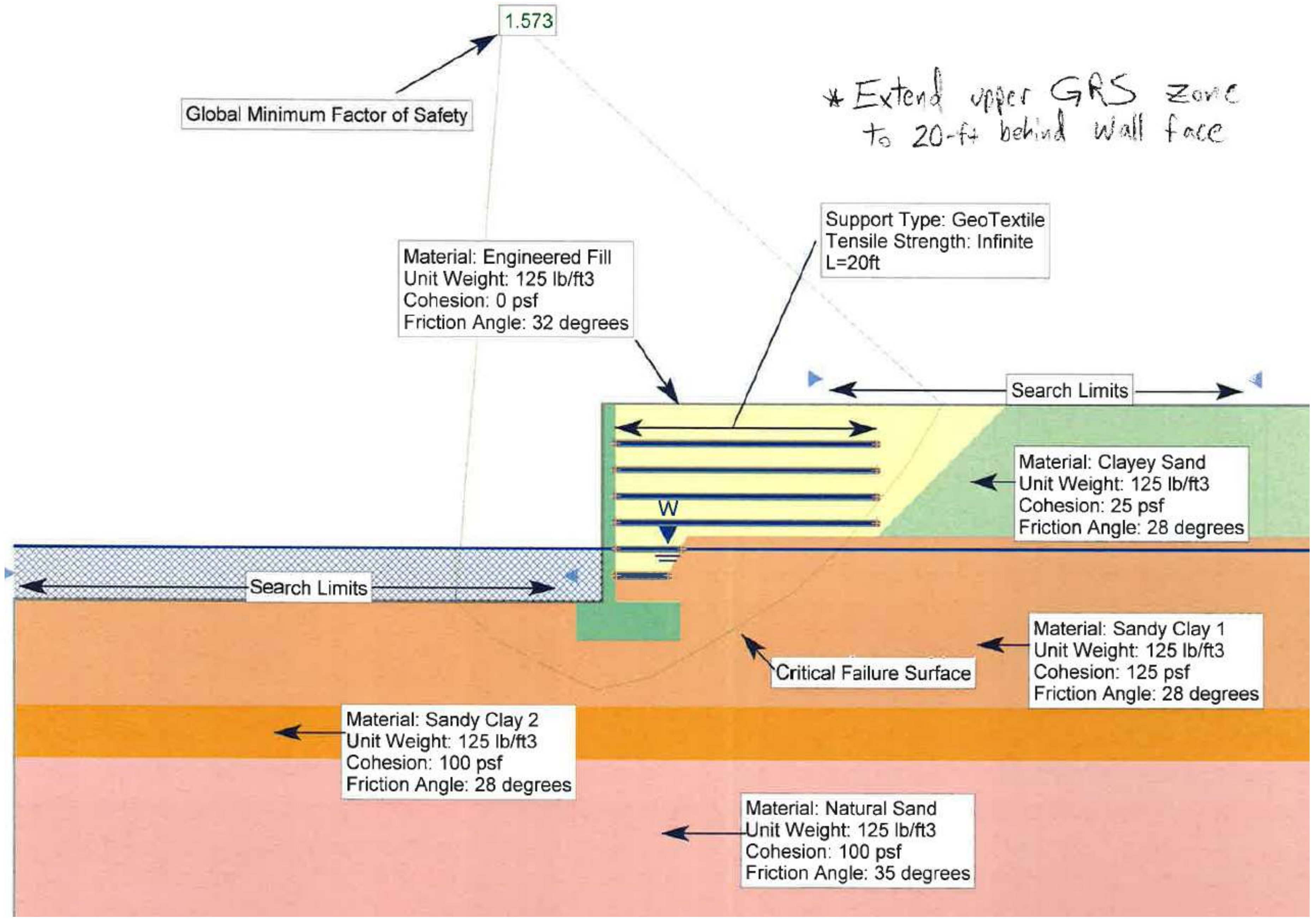


(c) Bearing capacity

(d) Deep seated stability (Rotational)

Figure 21. Potential external failure mechanisms for a MSE wall.


1.226
Global Minimum Factor of Safety
Search Limits
Material: Engineered Fill
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Material: Clayey Sand
Unit Weight: 125 lb/ft3
Cohesion: 25 psf
Friction Angle: 28 degrees
W
Search Limits
Material: Sandy Clay 1
Unit Weight: 125 lb/ft3
Cohesion: 100 psf
Friction Angle: 28 degrees
Critical Failure Surface
Material: Sandy Clay 2
Unit Weight: 125 lb/ft3
Cohesion: 100 psf
Friction Angle: 28 degrees
Material: Natural Sand
Unit Weight: 125 lb/ft3
Cohesion: 100 psf
Friction Angle: 35 degrees


1.573
Global Minimum Factor of Safety
* Extend upper GRS zone to 20-ft behind wall face
Support Type: GeoTextile
Tensile Strength: Infinite
L=20ft
Material: Engineered Fill
Unit Weight: 125 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Search Limits
Material: Clayey Sand
Unit Weight: 125 lb/ft3
Cohesion: 25 psf
Friction Angle: 28 degrees
W
Search Limits
Material: Sandy Clay 1
Unit Weight: 125 lb/ft3
Cohesion: 125 psf
Friction Angle: 28 degrees
Critical Failure Surface
Material: Sandy Clay 2
Unit Weight: 125 lb/ft3
Cohesion: 100 psf
Friction Angle: 28 degrees
Material: Natural Sand
Unit Weight: 125 lb/ft3
Cohesion: 100 psf
Friction Angle: 35 degrees

Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide

PUBLICATION NO. FHWA-HRT-11-026

JUNE 2012

U.S. Department of Transportation
Federal Highway Administration

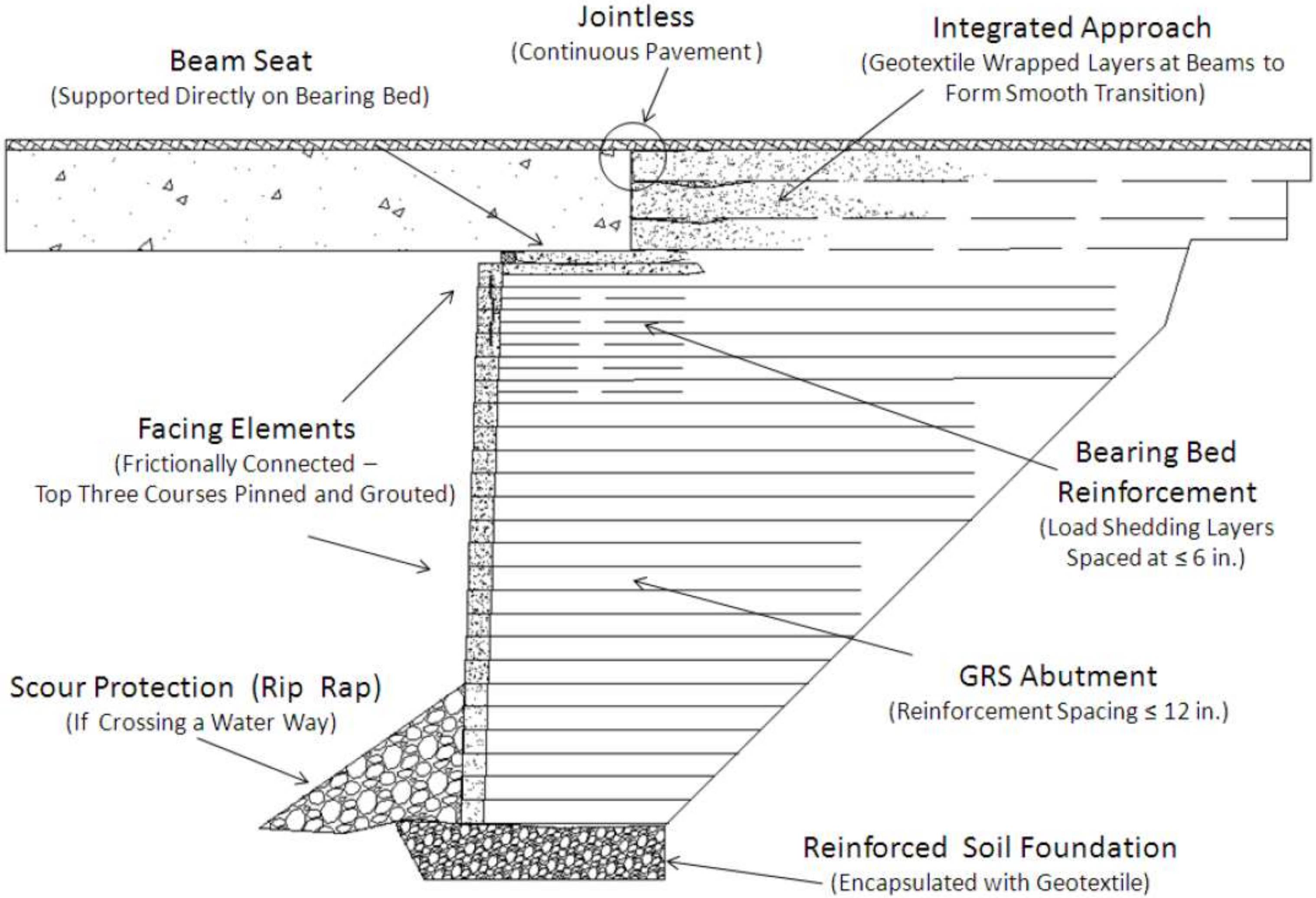


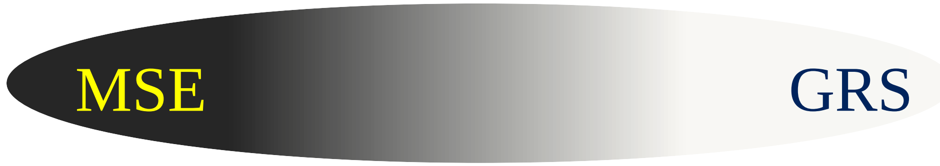
Figure 1. Illustration. Typical GRS-IBS cross section.

Geosynthetic Reinforced Soil Performance Testing—Axial Load Deformation Relationships

PUBLICATION NO. FHWA-HRT-13-066

AUGUST 2013

GRS - Composite Behavior



S_v = 32”   28”   24”   20”   16”   12”   8”   4”

S_v = 16”

S_v = 8”

S_v = 4”

Image source: FHWA

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


0.5 ksf
(25 kPa)


3.1 ksf
(148 kPa)


4.1 ksf
(196 kPa)

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)

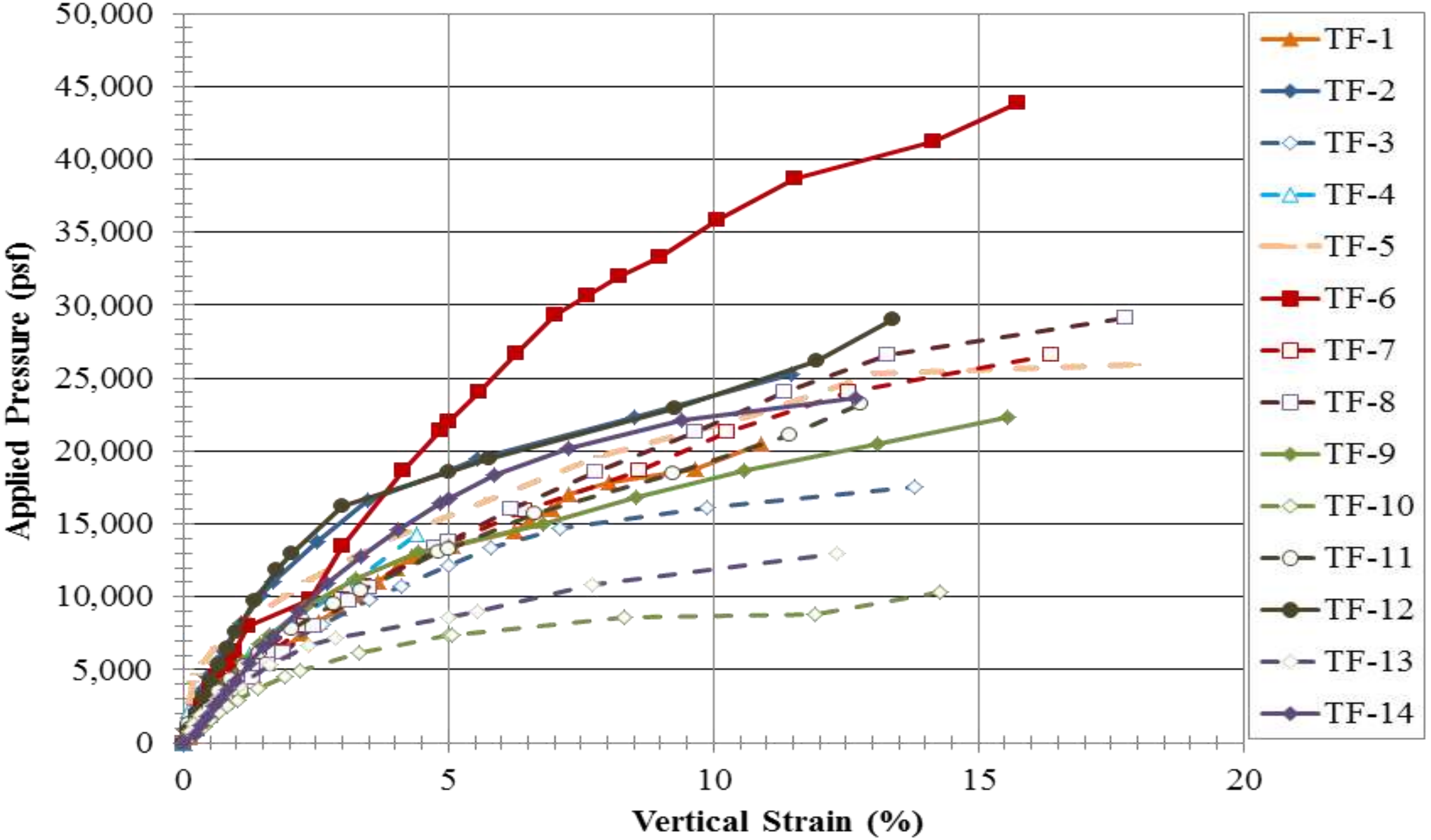

13.9 ksf
(666 kPa)

15.3 ksf
(733 kPa)

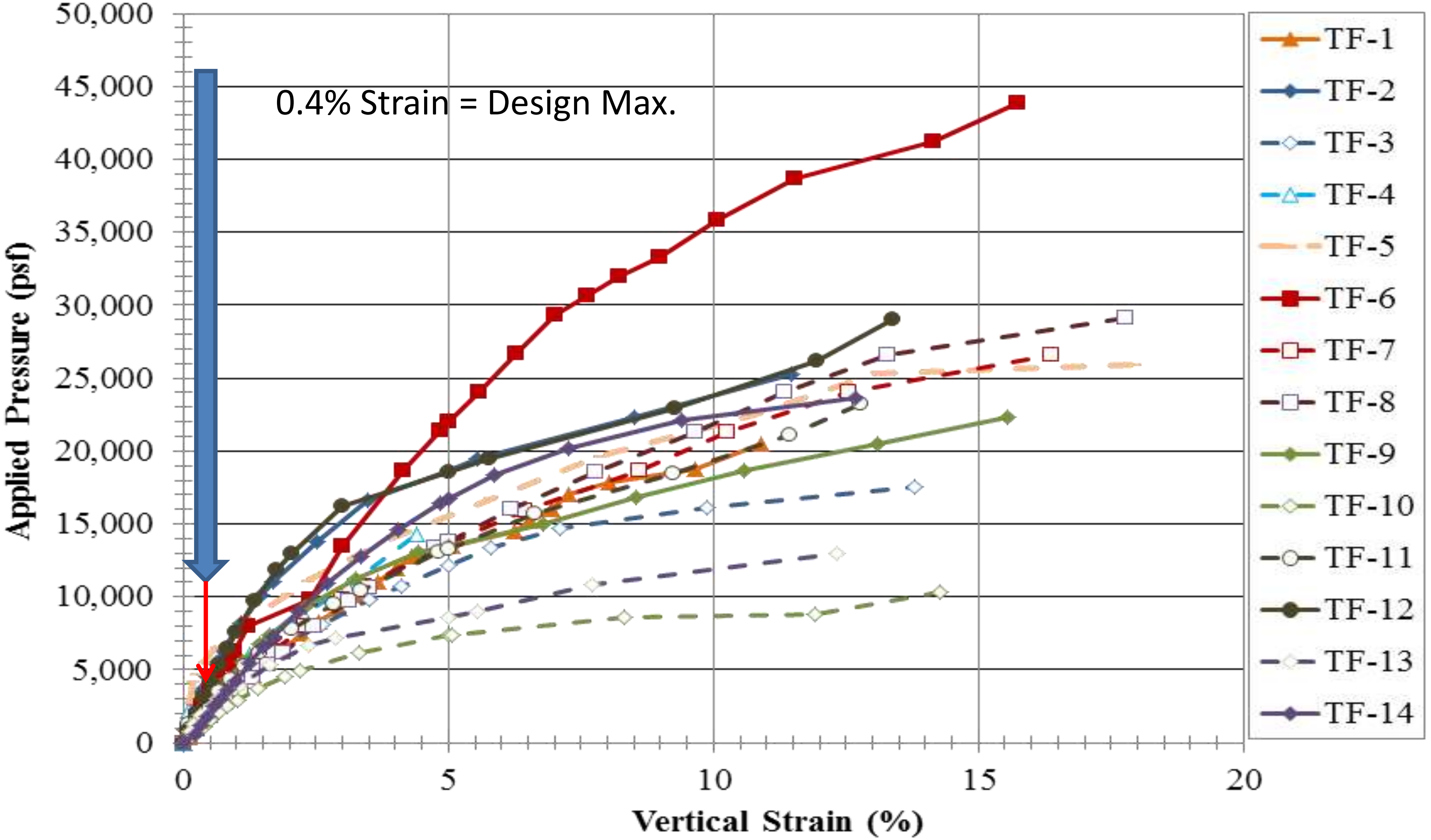
16.7 ksf
(800 kPa)

18.1 ksf
(867 kPa)

Load-Deformation Results



Load-Deformation Results



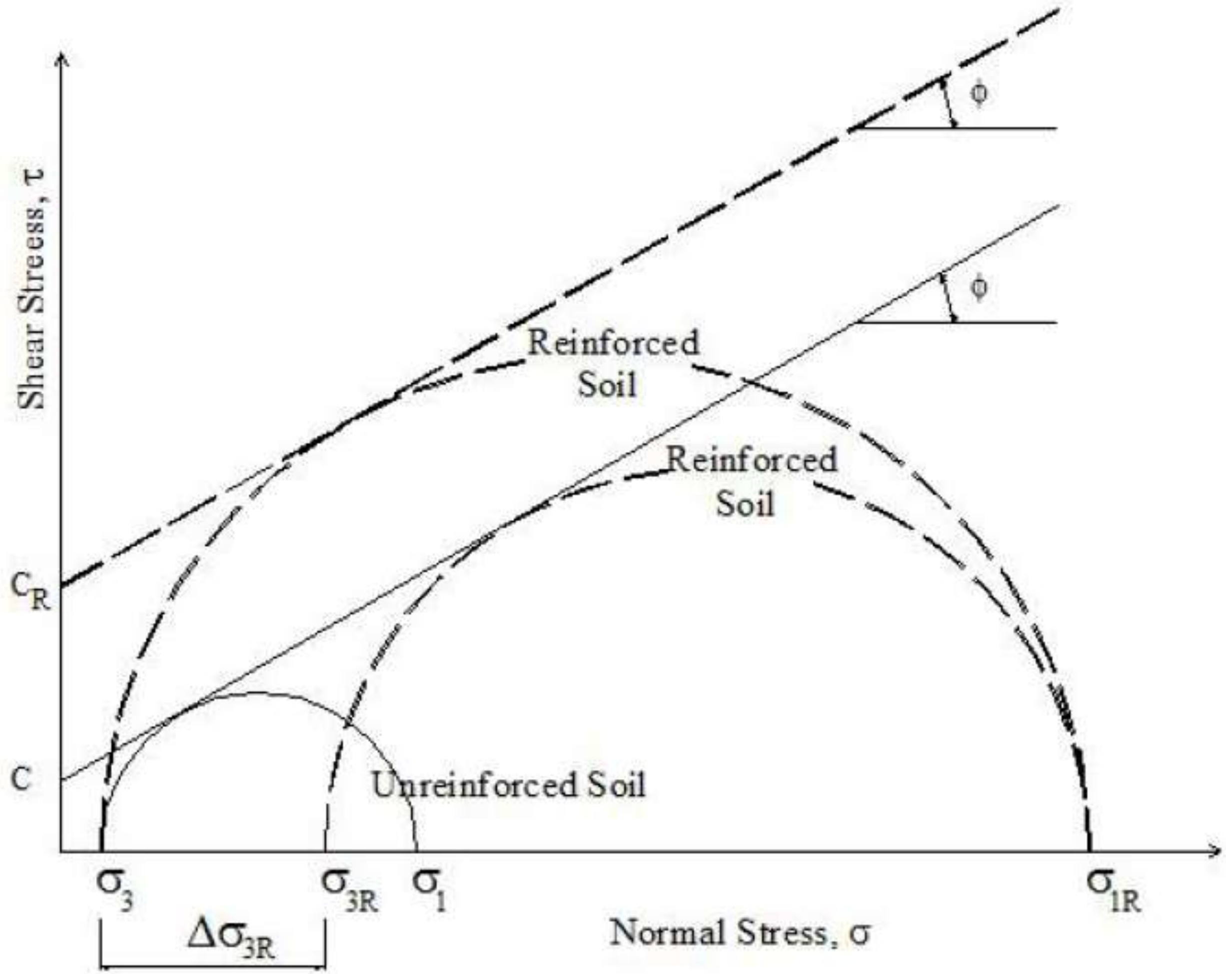


Figure 222. Illustration. Concept of apparent confining pressure and apparent cohesion of a GRS composite.

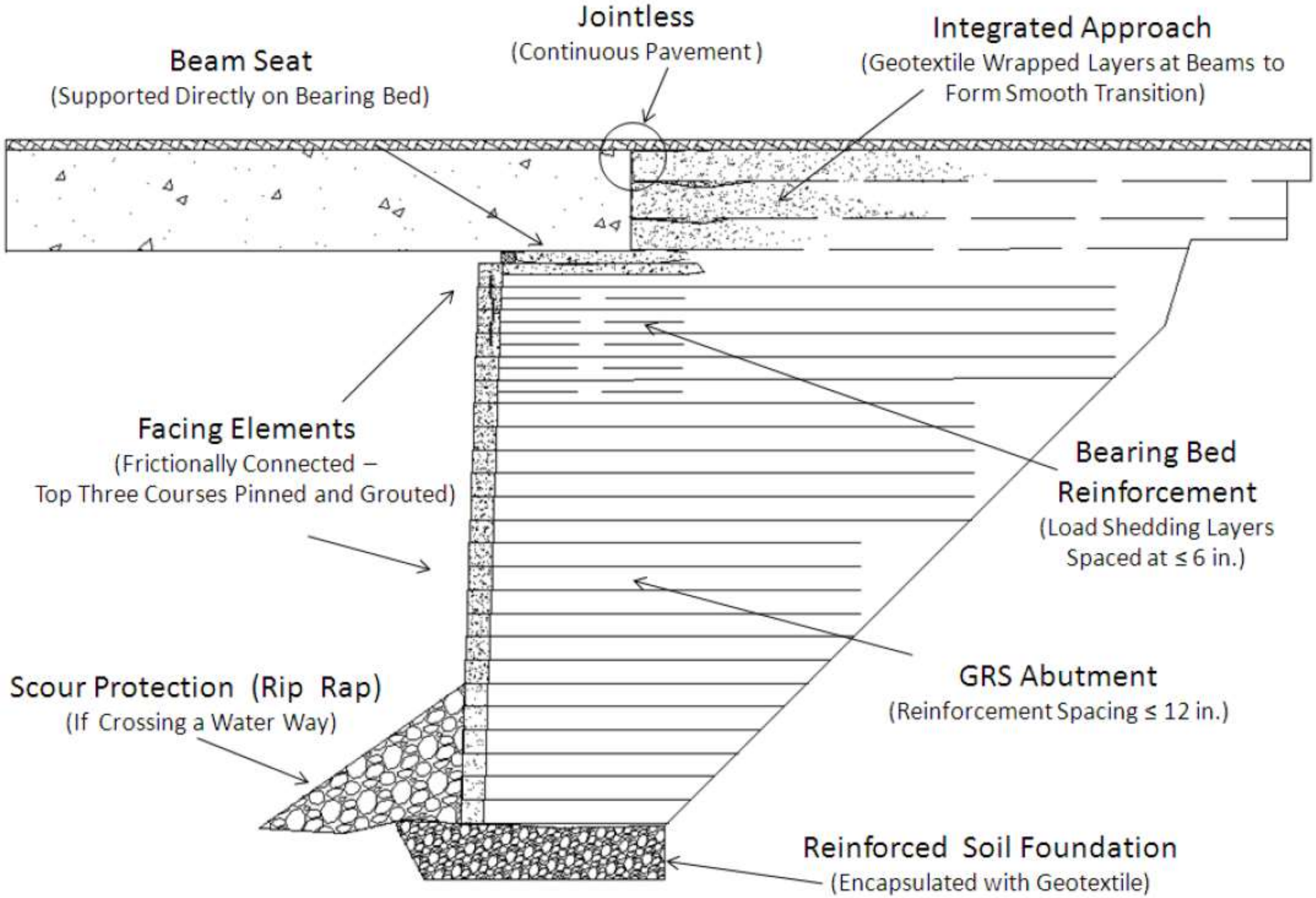


Figure 1. Illustration. Typical GRS-IBS cross section.

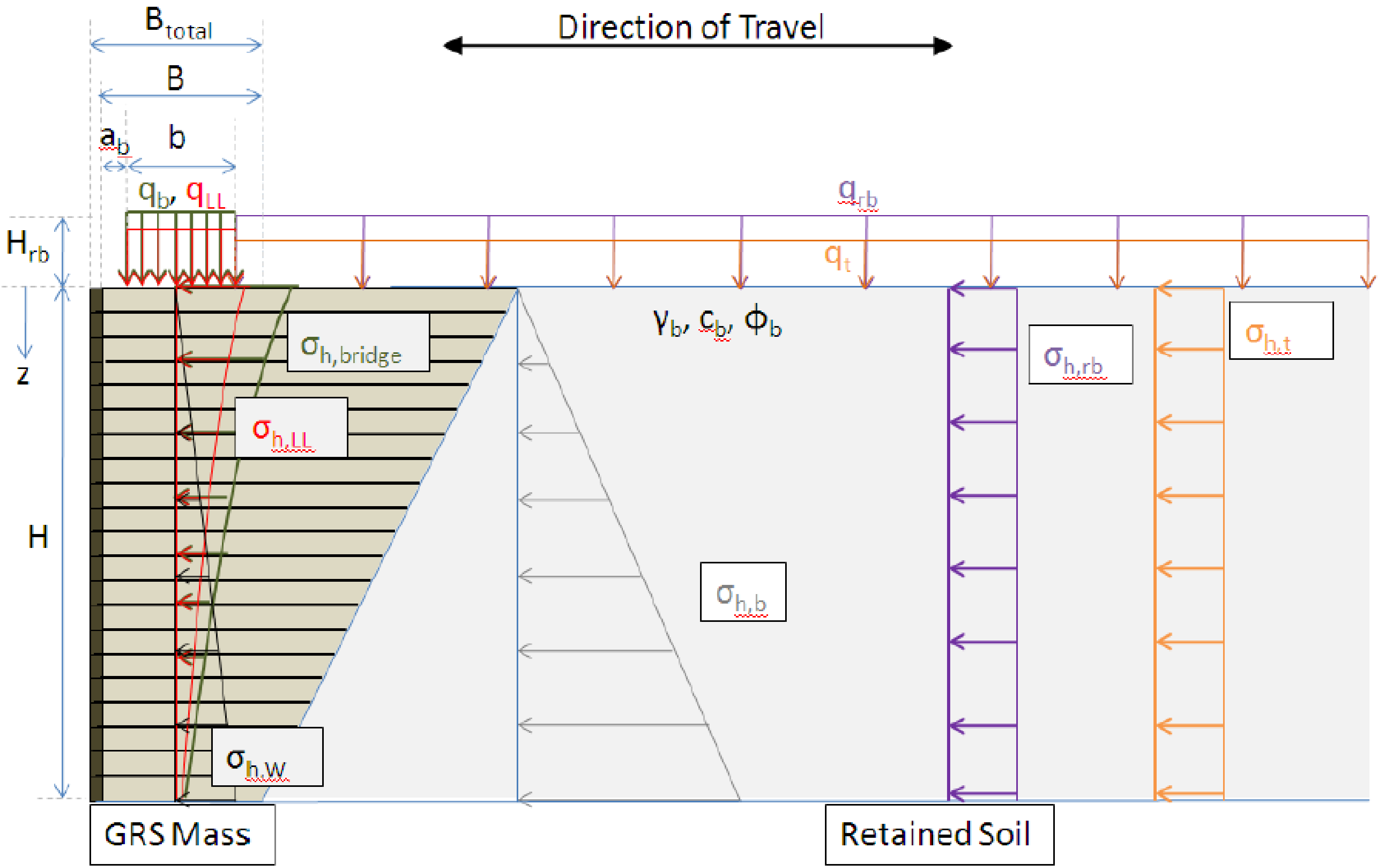


Figure 14. Illustration. Vertical and lateral pressures on a GRS abutment.

DESIGN SPREADSHEET (LRFD) FOR GRS ABUTMENTS

Data Entry: Enter in shaded areas from the top down, until all warnings are gone to complete a design

1.) Bridge Geometry/Site Data

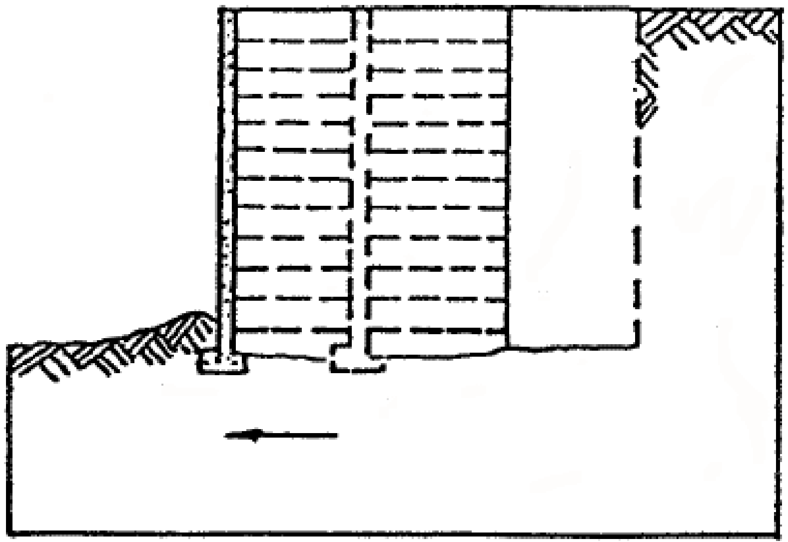
PROJECT NAME: *Keefer Road Over Sebewa Creek Abutment B*

Pavement Elev. at Beam Seat =	815.31	feet	*this is the bridge abutment reference point elevation, or use a simplified assumed elevation.
Top GRS Reinf. Layer Elev. =	812.33	feet	*this is the highest GRS Block Reinforcement elevation, just below the beam seat.
max. RSF Bottom Elev. =	801.10	feet	* bottom of Reinforced Soil Foundation (RSF). Typically below the design scour elevation.
100-yr Water Elev. =	807.94	feet	*this is used for sliding analyses for bouyant weight effects.
Normal/Low Water Elev. =	803.30	feet	*this is used to calculate the Meyerhoff Bearing Pressure for the GRS Wall design.
L_{span} =	48.00	feet	* the approximate bridge span length.
RSF Thickness, D_{RSF} =	2.67	feet	* this is the RSF thickness, if already known. If not known, start with 2.667 feet.
	Thickness OK		-- use 8 inch thick wrapped layers

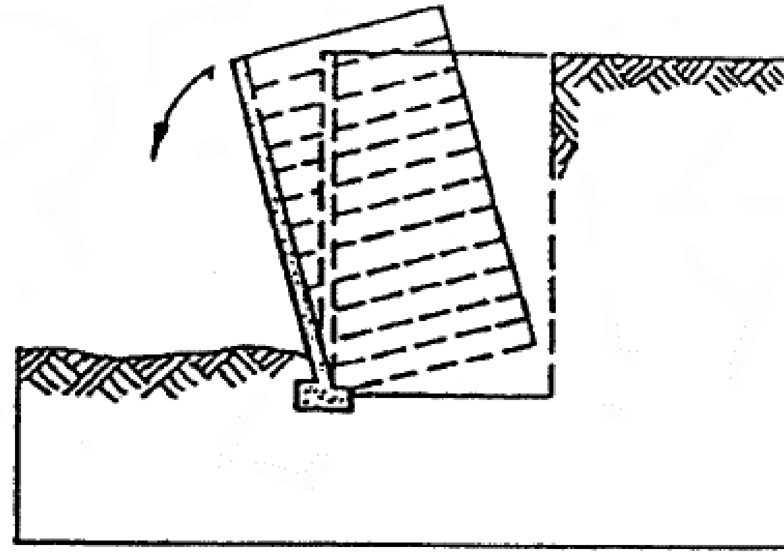
MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
GEOSYNTHETIC REINFORCED SOIL ABUTMENT

a. Description. The work consists of furnishing and installing a Geosynthetic Reinforced Soil Abutment in accordance with the contract, the FHWA Geosynthetic Reinforced Soil-Integrated Bridge System Interim Implementation Guide, dated June, 2012 (Publication No. FHWA-HRT-11-026), the standard specifications, and as directed by the Engineer.



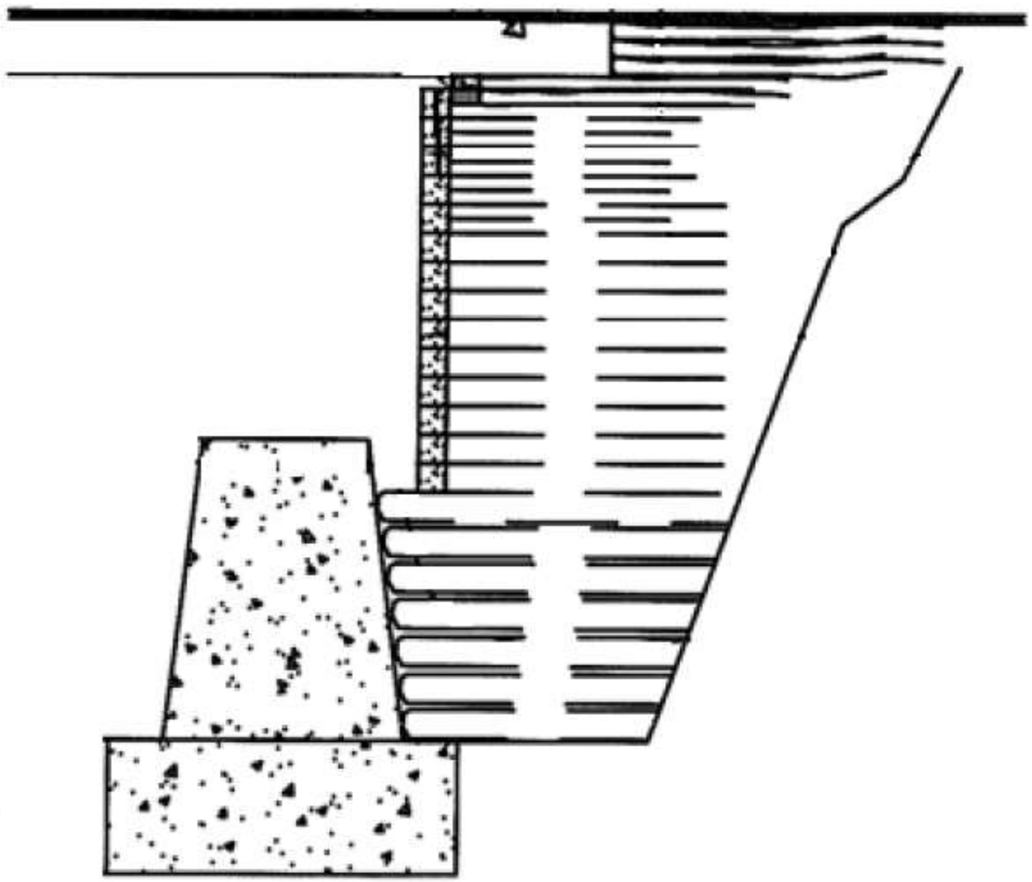
(a) Sliding



(b) Overturning (eccentricity)

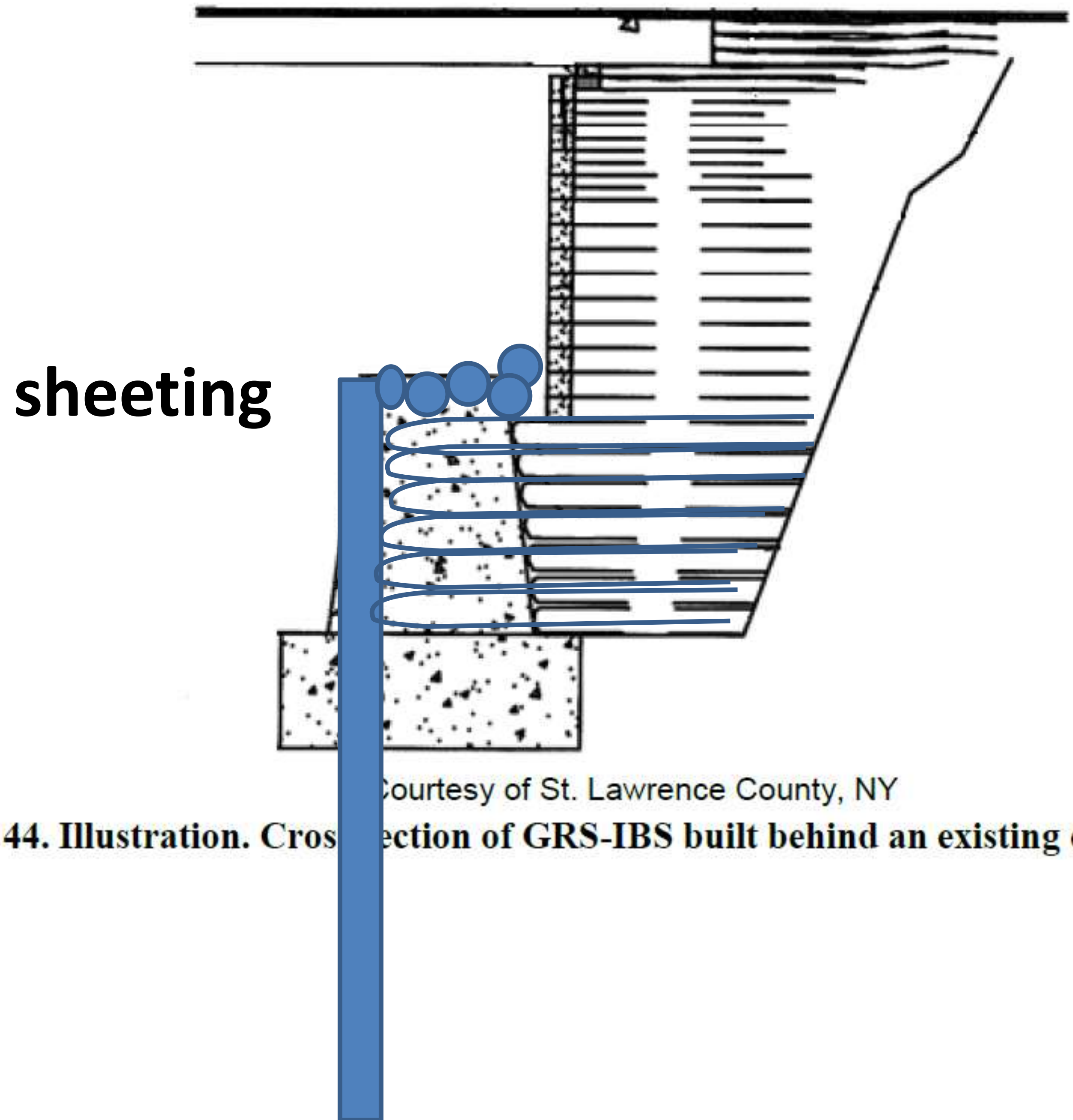
Courtesy of St. Lawrence County, NY

Figure 43. Photo. GRS-IBS built behind an existing concrete abutment.



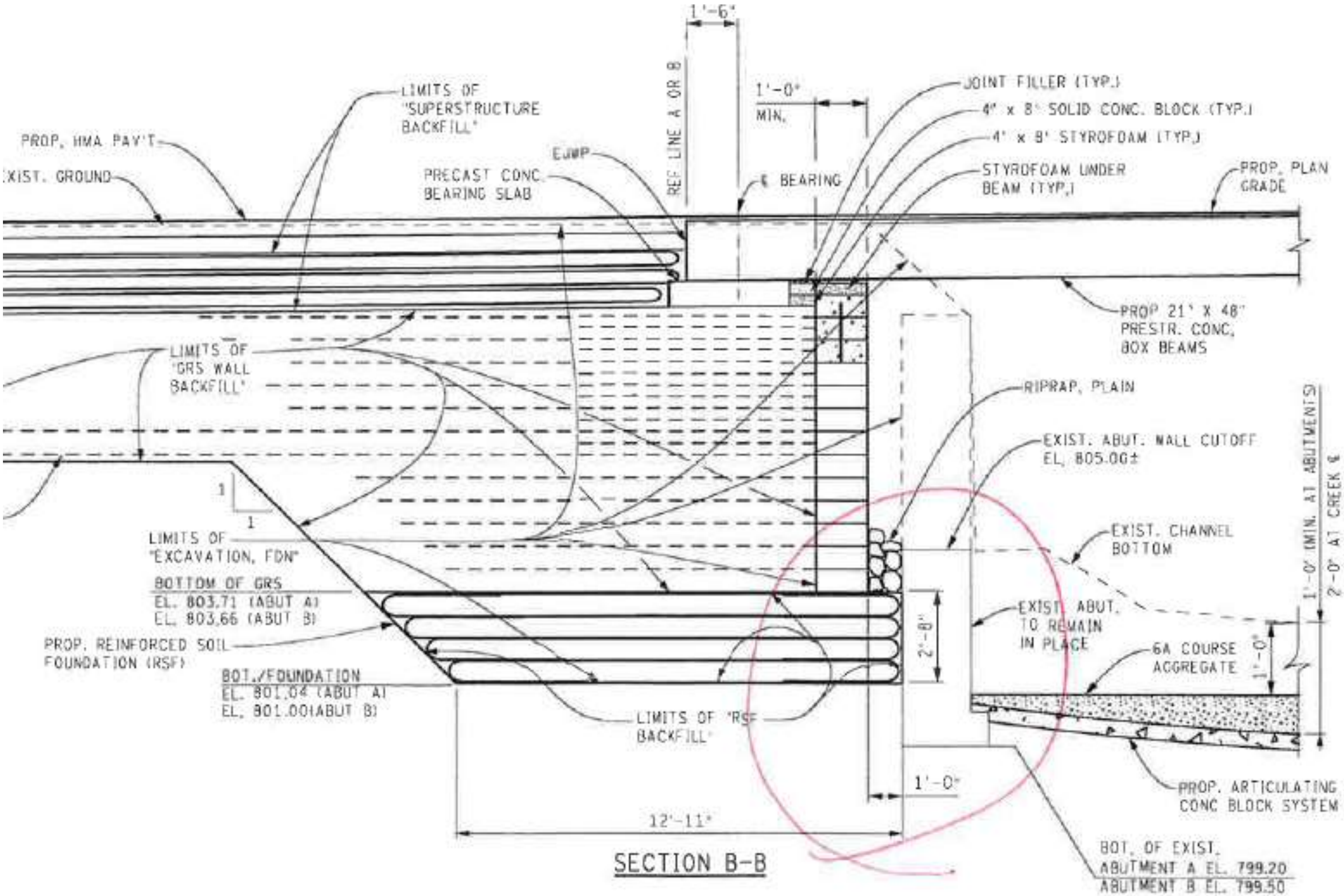
Courtesy of St. Lawrence County, NY

Figure 44. Illustration. Cross section of GRS-IBS built behind an existing concrete abutment.

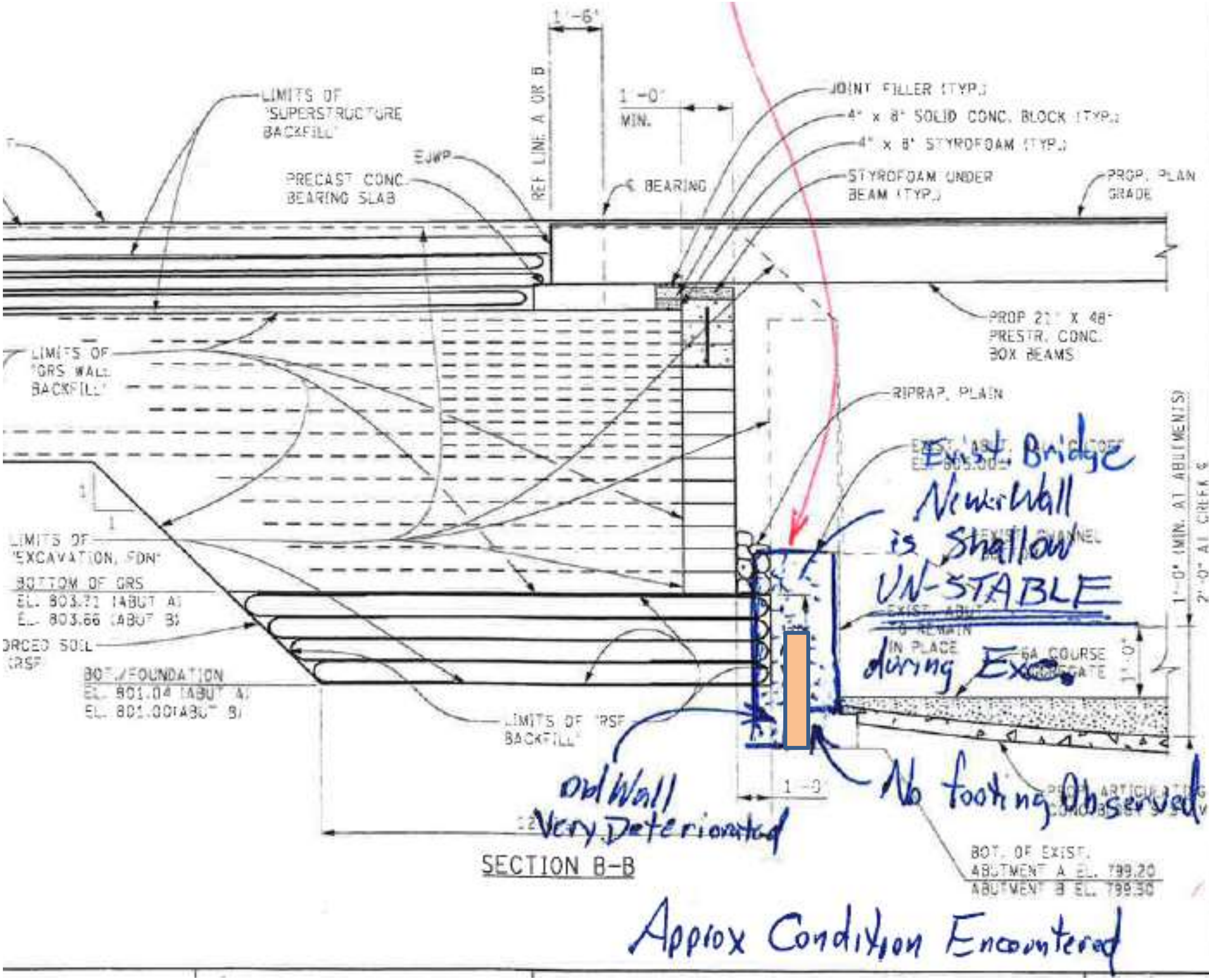


Courtesy of St. Lawrence County, NY

Figure 44. Illustration. Cross section of GRS-IBS built behind an existing concrete abutment.


1'-6"
REF LINE A OR B
1'-0" MIN.
LIMITS OF "SUPERSTRUCTURE BACKFILL"
PROP. HMA PAV'T
EXIST. GROUND
EJMP
PRECAST CONC. BEARING SLAB
℄ BEARING
JOINT FILLER (TYP.)
4" x 8" SOLID CONC. BLOCK (TYP.)
4" x 8" STYROFOAM (TYP.)
STYROFOAM UNDER BEAM (TYP.)
PROP. PLAN GRADE
PROP 21" X 48" PRESTR. CONC. BOX BEAMS
LIMITS OF "GRS WALL BACKFILL"
RIPRAP, PLAIN
EXIST. ABUT. WALL CUTOFF EL. 805.00±
1'-0" (MIN. AT ABUTMENTS)
2'-0" AT CREEK ℄
EXIST. CHANNEL BOTTOM
LIMITS OF "EXCAVATION, FDN"
BOTTOM OF GRS EL. 803.71 (ABUT A) EL. 803.66 (ABUT B)
PROP. REINFORCED SOIL FOUNDATION (RSF)
BOT./FOUNDATION EL. 801.04 (ABUT A) EL. 801.00(ABUT B)
2'-8"
EXIST. ABUT. TO REMAIN IN PLACE
6A COURSE AGGREGATE
1'-0"
LIMITS OF "RSF BACKFILL"
1'-0"
12'-11"
PROP. ARTICULATING CONC BLOCK SYSTEM
BOT. OF EXIST. ABUTMENT A EL. 799.20 ABUTMENT B EL. 799.50

SECTION B-B



1'-6"
REF LINE A OR B
1'-0" MIN.
LIMITS OF "SUPERSTRUCTURE BACKFILL"
EJWP
PRECAST CONC. BEARING SLAB
℄ BEARING
JOINT FILLER (TYP.)
4" x 8" SOLID CONC. BLOCK (TYP.)
4" x 8" STYROFOAM (TYP.)
STYROFOAM UNDER BEAM (TYP.)
PROP. PLAN GRADE
PROP. 21" X 48" PRESTR. CONC. BOX BEAMS
LIMITS OF "GRS WALL BACKFILL"
RIPRAP, PLAIN
LIMITS OF "EXCAVATION, FDN"
BOTTOM OF GRS EL. 803.71 (ABUT A) EL. 803.66 (ABUT B)
REINFORCED SOIL (RSF)
BOT./FOUNDATION EL. 801.04 (ABUT A) EL. 801.00(ABUT B)
LIMITS OF "RSF BACKFILL"
EXIST. CHANNEL
EXIST. ABUT. TO REMAIN IN PLACE
6A COURSE AGGREGATE
1'-0" (MIN. AT ABUTMENTS)
2'-0" AT CREEK ℄
1'-0"
BOT. OF EXIST. ABUTMENT A EL. 799.20 ABUTMENT B EL. 799.30
SECTION B-B
Exist. Bridge
Newer Wall is Shallow
UN-STABLE during Exc.
Old Wall Very Deteriorated
No footing Observed
Approx Condition Encountered


KOMATSU
WACKER NEUSON


DIESEL
OFF ROAD
1993

TenCate Mirafi®
HP570/15/300
NTPEP
SY1
91.44
4.57
418.06
187.21
023142527
Length (FT)
Width (Inches)
Area (Sq Yards)
Gross LBS
Date
300.00
180.00
500.00
412.75
20140220


CAT
WACKER
NEUSON


G-17
WACKER
NEUSON
G25
20 KW


KOMATSU


GIVE 'EM A
BRAKE
SAFETY
PASS
WITH
CARE
READINGROCK
BUILDING MATERIALS & SERVICES


KOMATSU


MANITOWOC
KOMATSU
WACKER NEUSON


WACKER
NEUSON


CAT
TOPCON


CAT


Beam Seat
Set back
$b \geq 2.5$ ft for $L_{span} \geq 25$ ft
$a_b \geq 8$ in.
$b \geq 2.0$ ft for $L_{span} < 25$ ft


MANITOWOC
WEST SERIES
222 EX

Questions/Comments

Geotechnical Considerations and GRS Abutments:

Christopher R. Byrum, Ph.D., P.E.

SME, Inc.

Plymouth, MI Office