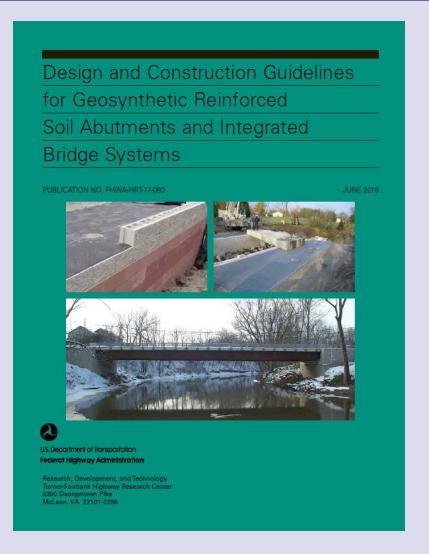
Words Matter
Consistency Matters
Engineering Matters
Mechanically Stabilized Earth (MSE) retaining wall
projects that went sideways

Stan Boyle, PhD, PE, BC.GE., M.ASCE Shannon & Wilson, Inc.

57th Annual Kansas Geotechnical Engineering
Conference

November 6, 2025

PROJECT 1 - GRS-IBS versus MSE Wall



Design and Construction of Mechanically Stabilized Earth (MSE) Walls

FHWA GEC 011









Sponsored by

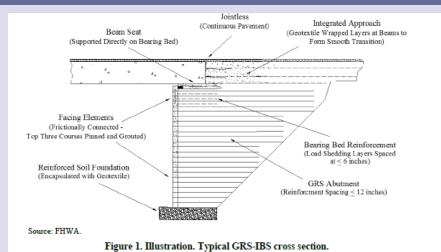
Office of Infrastructure FHWA-HIF-24-002

August 2023



GRS-IBS MSE Wall versus



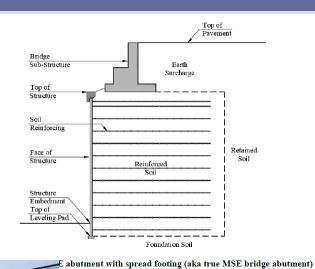




GRS-IBS—versus

MSE Wall







SHANNON & WILSON, INC

GRS – Closely Spaced Reinforcement



A. $S_V \approx 16$ inches.



B. $S_V \approx 8$ inches.



C. $S_V \approx 4$ inches.

Source of subfigure images: FHWA.

Figure 2. Photos. Composite behavior of GRS versus GMSE as shown in tests conducted at reinforcement spacings of 16, 8, and 4 inches.

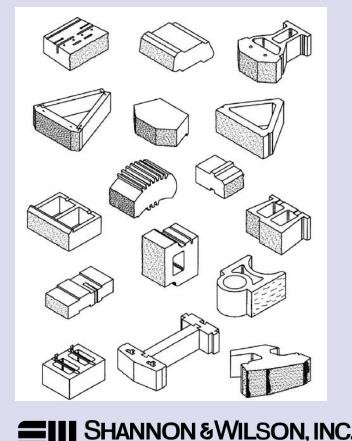


GRS-IBS MSE Wall versus

GRS Wall does not require connection to fascia.



MSE Wall Design procedure requires connection





Project 1 – Texas







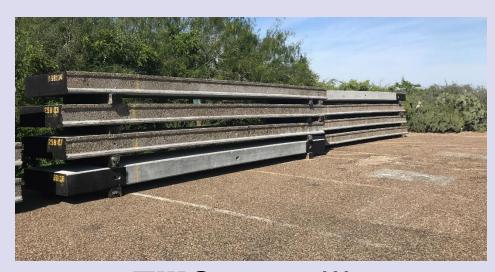


Project 1 – Texas



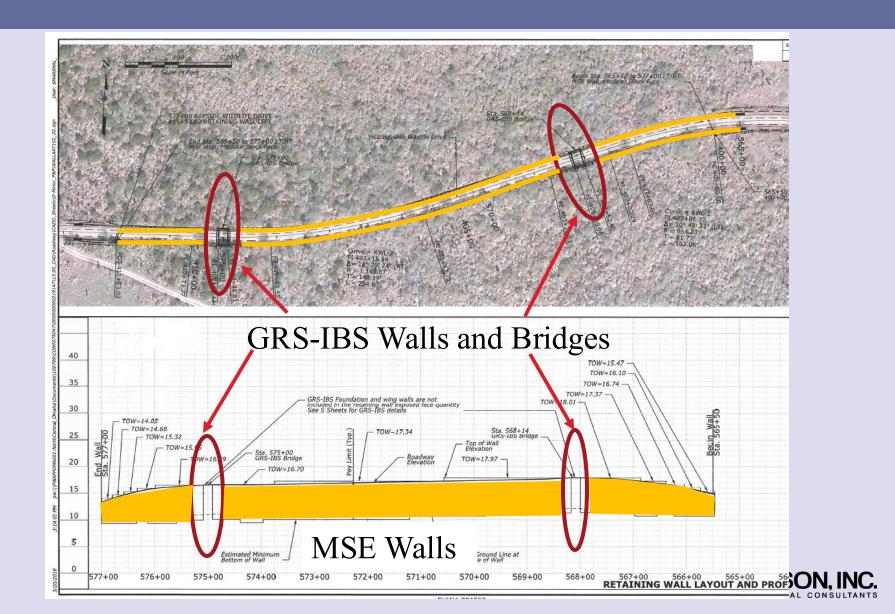




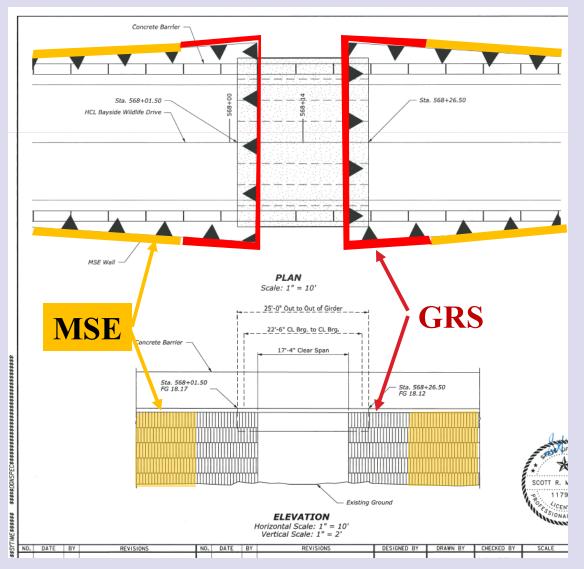




GRS-IBS versus MSE Wall



GRS-IBS versus MSE Wall



- Same maximum wall height
- Same soil
- Same reinforcement
- Same reinforcement spacing
- Same fascia
- Is there a difference?



Fascia blocks moved during compaction















Deconstruct and Re-construct Wall









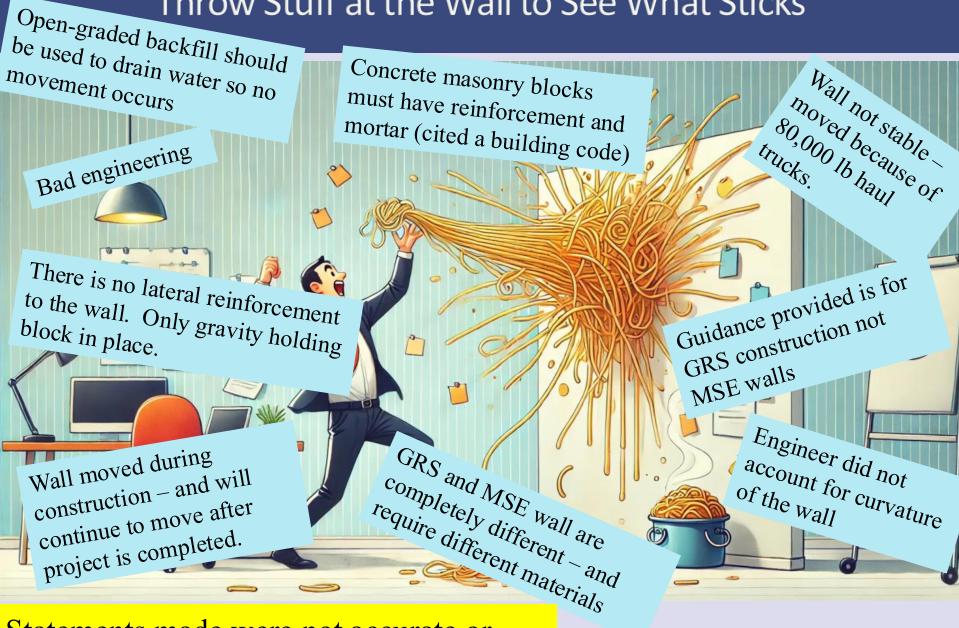




Throw Stuff at the Wall to See What Sticks



Throw Stuff at the Wall to See What Sticks



Statements made were not accurate or may not be truly relevant to the problems.



Project 1 – Take aways

- Use terminology consistent with the industry reference documents.
- Beware of standard specifications they may not be applicable to all features of all project elements.
- Late design stage changes result in insufficient time or budget to adequately incorporate changes.
- 4. No Good Deed Goes Unpunished!
- 5. Don't blindly rely on a design document some things professed in them may not be the best!
- Lots of stuff will be thrown Some WILL stick!



Project 2 – MSE Wall versus RSS



Volume 1: MSE

U. S. Department of Transportation Federal Highway Administration Publication No. FHWA-NHI-10-024 FHWA GEC 011 – Volume I November 2009

NHI Courses No. 132042 and 132043

Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume I

Developed following:

AASHTO LRFD Bridge Design
Specifications, 4th Edition, 2007,
with 2008 and 2009 Interims.

AASHTO LRFD Bridge Construction Specifications, 2nd Edition, 2004, with 2006, 2007, 2008, and 2009 Interims.











MSE: Wall face 0° to 20° from vertical

RSS: Slope face more than 20° from vertical



Volume 2: RSS

U. S. Department of Transportation Federal Highway Administration Publication No. FHWA-NHI-10-025 FHWA GEC 011 – Volume II November 2009

NHI Courses No. 132042 and 132043

Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume II

Developed following:

AASHTO LRFD Bridge Design
Specifications, 4th Edition, 2007,
with 2008 and 2009 Interims.

and

AASHTO LRFD Bridge Construction Specifications, 2nd Edition, 2004, with 2006, 2007, 2008, and 2009 Interims.





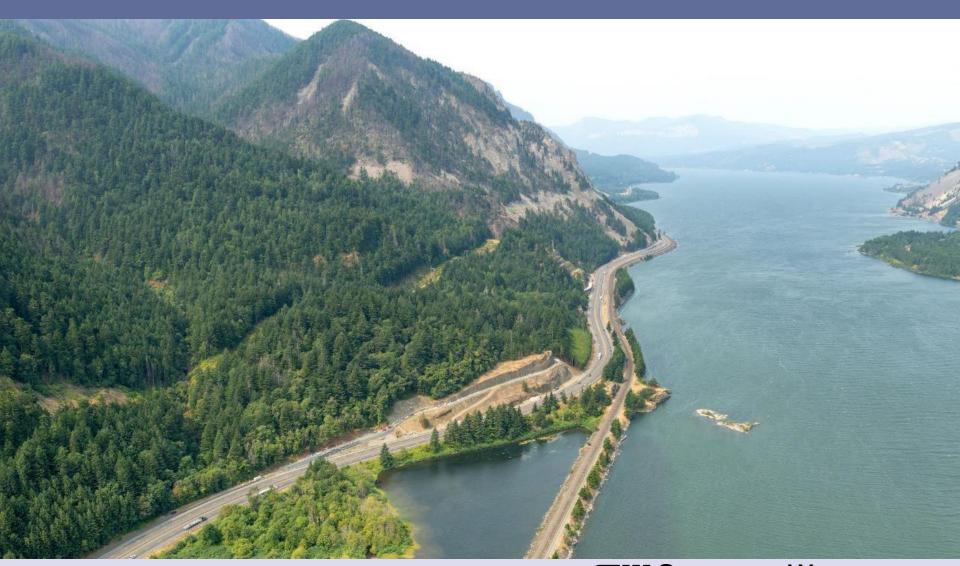








Project 2 – Oregon





Project 2 – Oregon

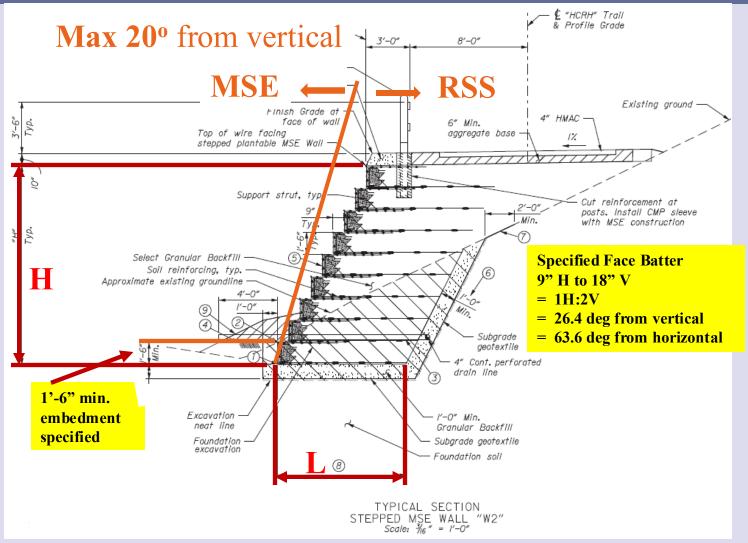






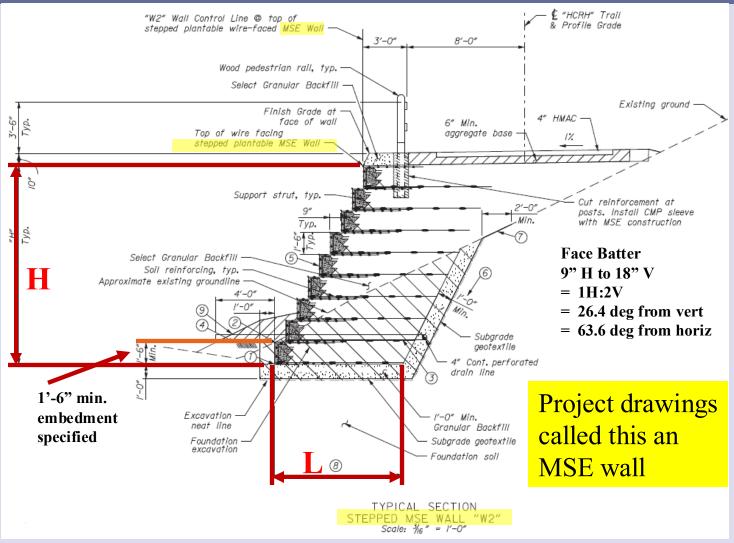


Wall Detail from Project Drawings



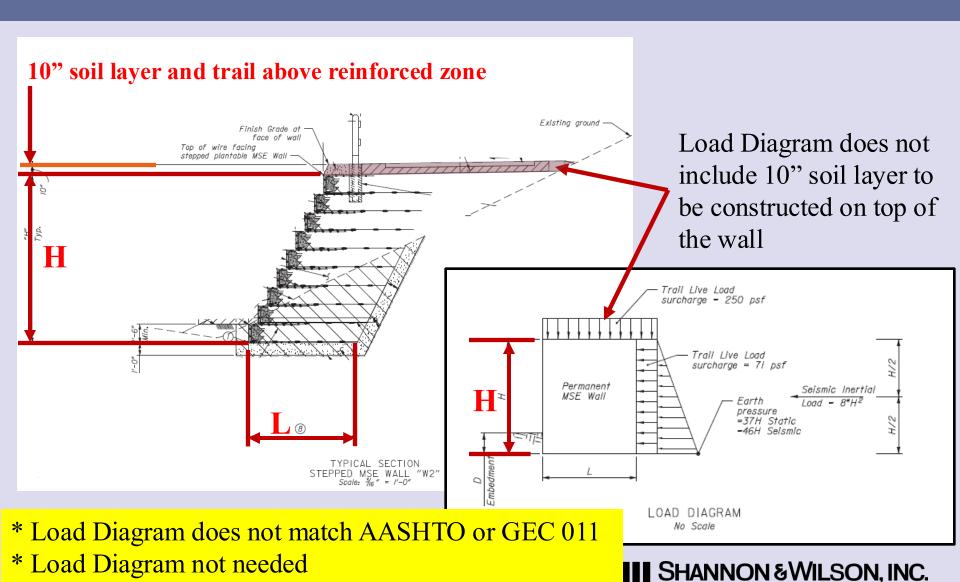


Wall Detail from Project Drawings

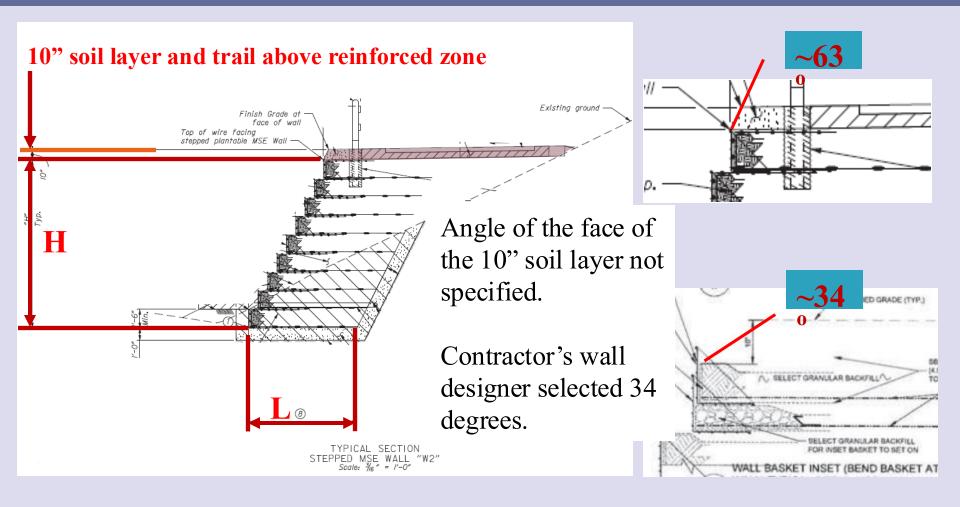




Details from Project Drawings



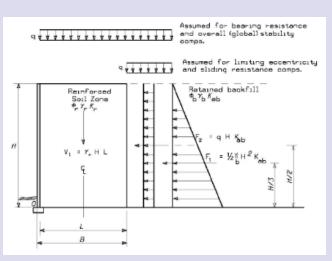
Unspecified Slope Angle above the Reinforced Zone



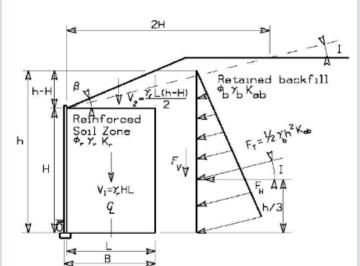


GEC 011 MSE Wall – Earth Load above Wall

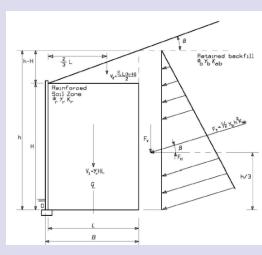




Horizontal Top Surface



Break in slope at horizontal distance less than 2H

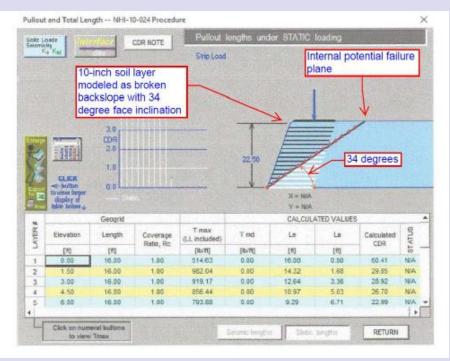


Continuous or infinite backslope

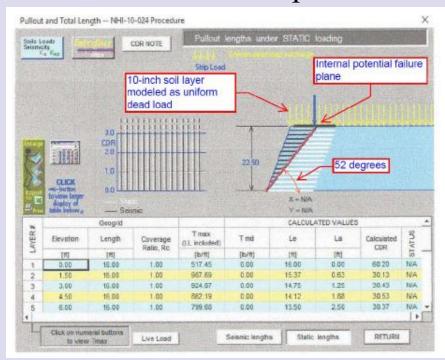


GEC 011 MSE Wall – MSEW Results

Broken backslope output



Equivalent horizontal dead load output

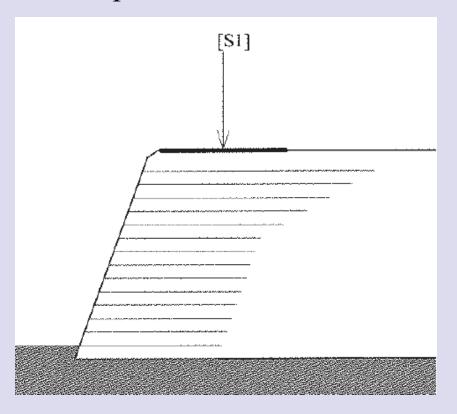


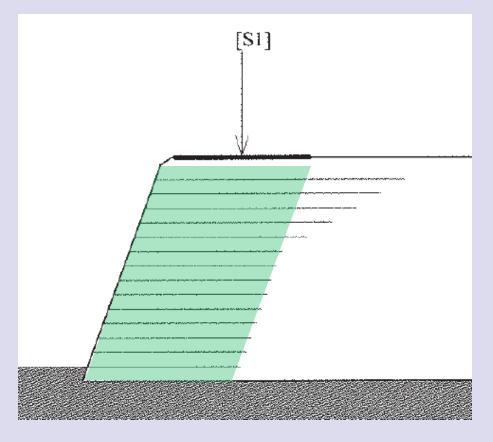




Engineer Increased Reinforcement Lengths

Longer reinforcement for design resulted in lots more excavation and imported backfill than for L = 0.7H.



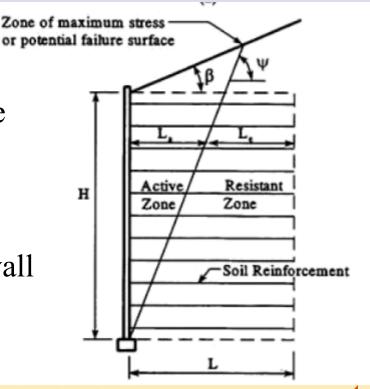




GEC 011 – Battered Face, Broken Backslope

Engineer used 20° face batter instead of RSS 26.4°

20° is limit for MSE wall



For vertical face $\psi = 45 + \frac{\phi}{2}$

For walls with a face batter angle (0) 10° or more from the vertical,

$$\tan(\psi-\theta) = \frac{-\tan(\phi-\beta) + \sqrt{\tan(\phi-\beta)[\tan(\phi-\beta) + \cot(\phi+\theta-90)][1+\tan(\delta+90-\theta)\cot(\phi+\theta-90)]}}{1+\tan(\delta+90-\theta)[\tan(\phi-\beta) + \cot(\phi+\theta-90)]}$$
 with $\delta = \beta$

 θ = wall batter angle

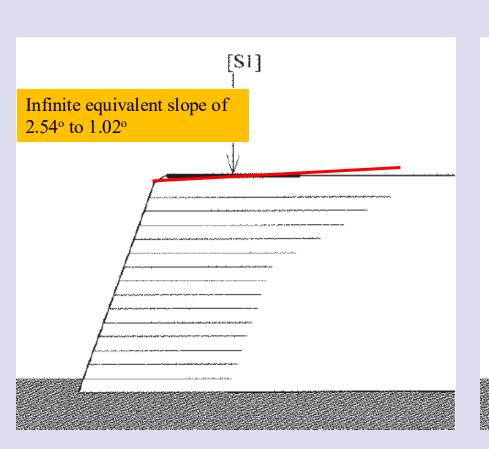


For wall with a broken backslope, use $\delta = \beta_{cs}$

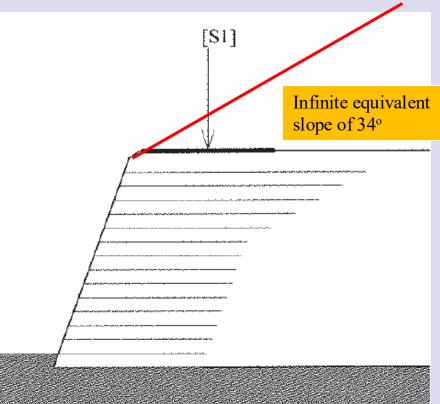


MSEW program was modeling a 34° Infinite Slope

Broken back equivalent angle, β_{cs} , that should have been used for the calculations



... Actual angle used for the calculations





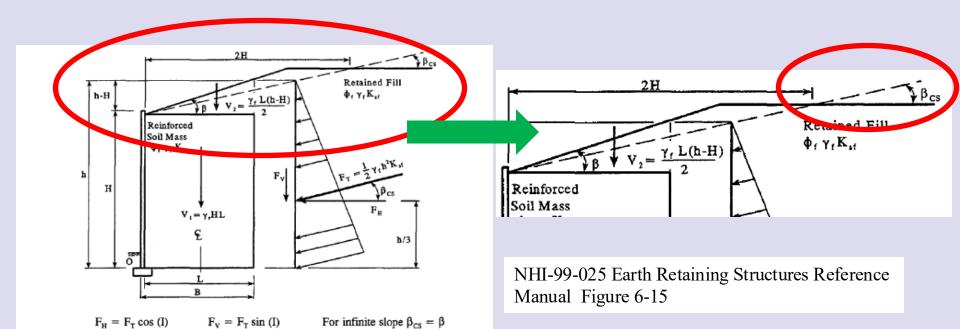
GEC 011 – Battered Face, Broken Backslope

1. β_{cs} not defined in GEC 011 or AASHTO

Compute K_{sf} for Retained Fill Using $\delta = \beta = \beta_{cs}$ (see Figure 2-2); For Limiting Eccentricity

Calculation, see Figure 6-18

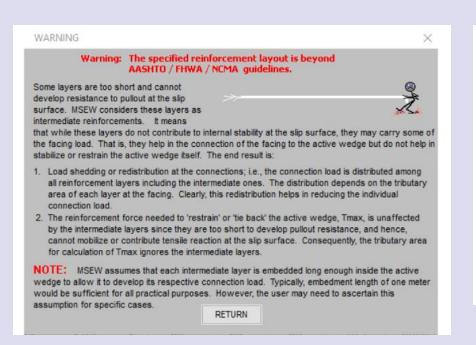
2. MSEW program used infinite backslope not broken backslope.



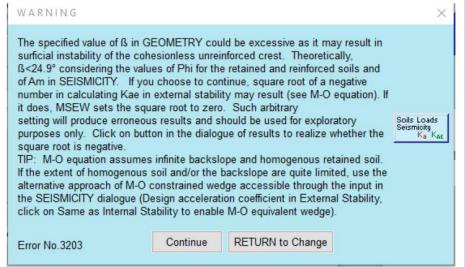


Wall Engineer Ignored Warning Messages

MSEW Warning message – Reinforcement too short



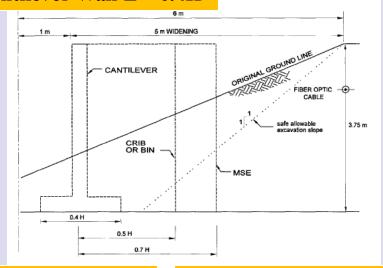
MSEW Warning message – slope face angle greater than 24.9° could create issues with M-O analyses





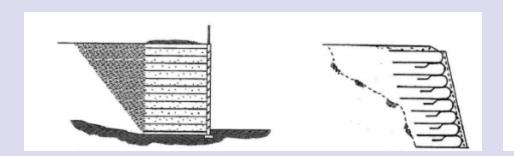
Wall Engineer Ignored RED Flags

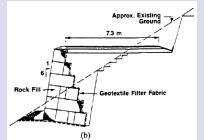
Concrete Cantilever Wall L = 0.4H

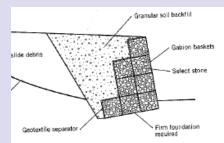


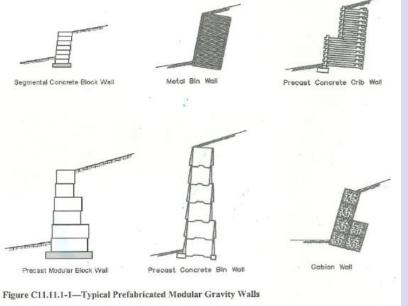
Crib or Bin Wall L = 0.5H

MSE Wall L = 0.7H



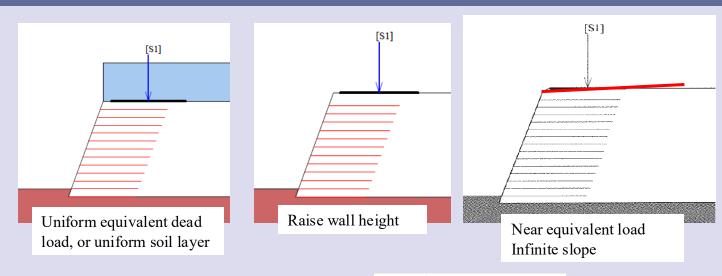


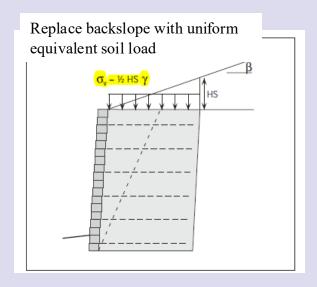


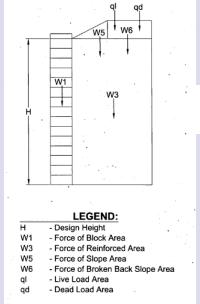




Options Available to Model 10" Layer



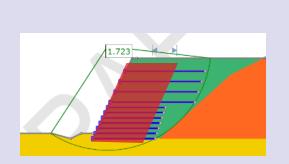


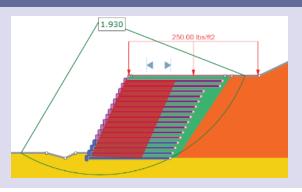


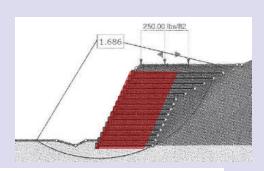
Individual load components



Sr. and Jr. Engineer Inexperienced







Alternative Designs Wall Engineer submitted. Colored overlay is 0.7H dimension. Factors of safety all MUCH greater than minimum required (1.3 static) **WARNING SIGN!**

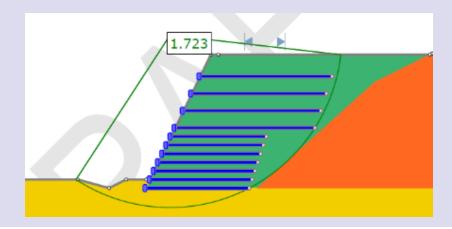
Table 4-1. Typical MSE Wall Load Combinations and Load Factors

(arter rable 5.4.1-1, AASTITO (2007)).				
Load	EH		Use One of These at a Time	
Combination Limit State	ES EV	LS	EQ	CT
STRENGTH I	γp	1.75	-	_
EXTREME EVENT I	$\gamma_{\rm p}$	γEQ	1.00	_
EXTREME EVENT II	γ _p	0.50	-	1.00
SERVICE I	1.00	1.00	-	-
Notes				

Notes:

 γ_p = load factor for permanent loading. May subscript as $\gamma_{P.EV}$, $\gamma_{P.EH}$, etc. γ_{EQ} = load factor for live load applied simultaneously with seismic loads

Live load should Be included. Use 50% live load for seismic.

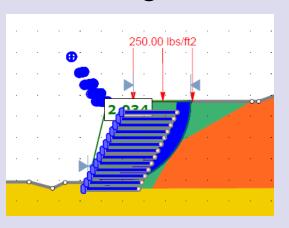


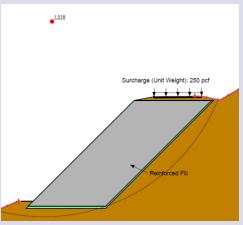
Early design had reinforcement spacing greater than 18 inches. But contract required 18 inches vertical spacing.

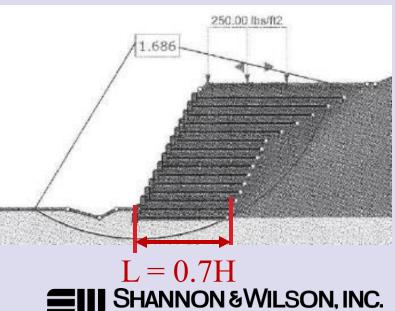


Owner Clarification – Could design as either MSE wall or RSS

- Engineer claimed they conducted an RSS design
- 2. No calculations produced
- Engineer concluded longer reinforcement for RSS than for MSE Wall **RED FLAG!**
- Engineer did calculations incorrectly (if they did them)

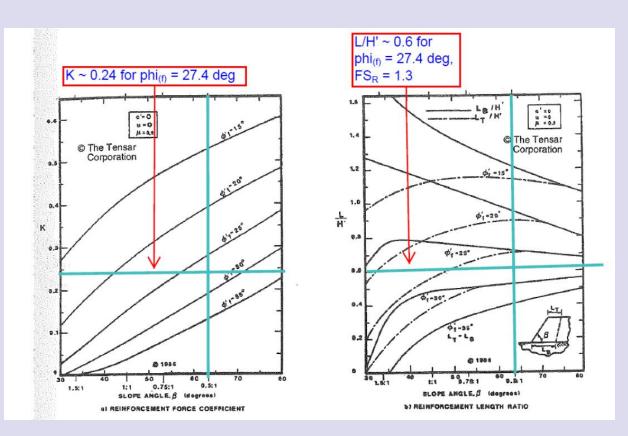


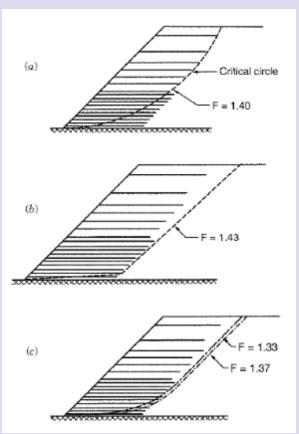






RSS Procedures well established





GEC 011

Duncan & Wright 2005



Throw Stuff at the Wall to See What Sticks



Statements made were not accurate or may not be truly relevant to the problems.



Project 2 – Take aways

- 1. Use terminology consistent with the industry reference documents.
- 2. Beware of standard specifications they may not be applicable to all features of all project elements.
- 3. Late design stage changes result in insufficient time or budget to adequately incorporate the changes.
- 4. Don't blindly use a computer program.
- 5. Don't blindly rely on a design document including AASHTO or FHWA manuals some things may be wrong!

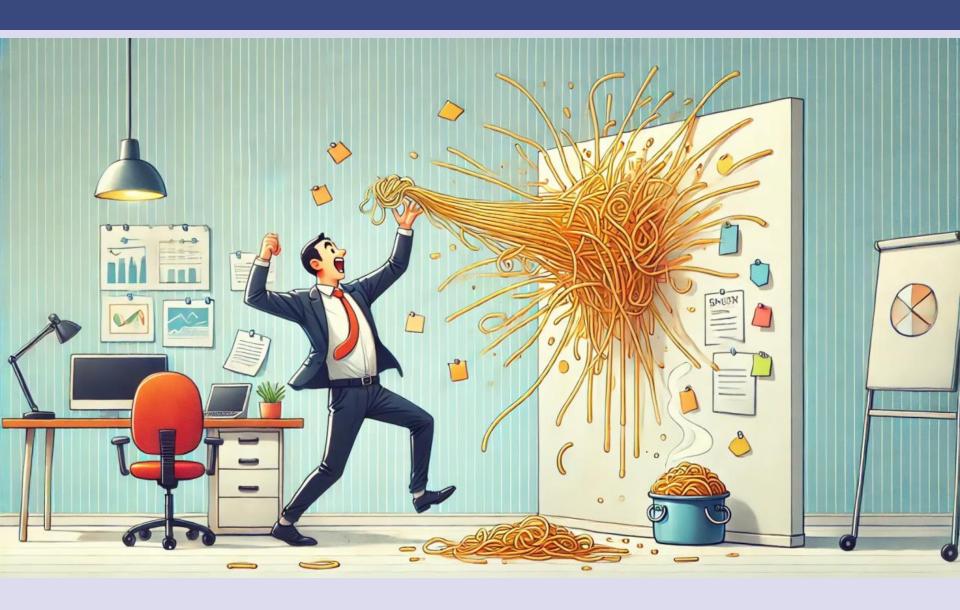


Project 2 – Take aways

- 6. Make sure calculation packages are produced and checked
- 7. Maintain good project records
- 8. Experience matters!
- 9. The right experience matters!!
- 10. "Older" does not equal "Experienced"
- 11. If something doesn't feel right Get assistance
- 12. Mistakes cost money



Lots of stuff will be thrown – SOME WILL STICK



Thank you



Stan Boyle
Shannon & Wilson, Inc.
stan.boyle@shanwil.com

