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TRANSPORTATION RESEARCH BOARD

Updating Designs for Mechanically-Stabilized Earth Walls in AASHTO

October 8, 2020

@NASEMTRB
#TRBwebinar

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- 1.5 Professional Development Hour (PDH) – see follow-up email for instructions
- You must attend the entire webinar to be eligible to receive PDH credits
- Questions? Contact Reggie Gillum at RGillum@nas.edu

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#TRBwebinar

Learning Objectives

1. List new MSE wall design changes

2. Compare and contrast new design methods

3. Discuss how these changes impact MSE wall design

#TRBwebinar

TRB Webinar:
Updating Designs for Mechanically Stabilized Earth Walls in AASHTO

Daniel Alzamora, FHWA

October 8, 2020

Updating Designs for Mechanically Stabilized Earth Walls in AASHTO

Presentation objective:

- Provide an overview of changes related to MSE wall design in AASHTO 2020
- Describe differences in the design methods
- Describe limitations in the use of these methods (extensible reinforcements)
- Discuss design impact of these changes

Updating Designs for Mechanically Stabilized Earth Walls in AASHTO

Topic	Presenter	Duration
Introduction and Summary of Changes	Alzamora	5 min
Review of current design methods • Coherent Gravity • Simplified	Alzamora	10 min
Introduce new design methods • Limit Equilibrium • Stiffness	 Leshchinsky Allen	 20 min 20 min
Impact on Design	Alzamora	5 min
Questions	Han	25 min

Updating Designs for Mechanically Stabilized Earth Walls in AASHTO

Why add new design methods?

- The Simplified Method has not been good at predicting reinforcement loads as compared to measured loads, particularly for extensible reinforcements.
- Goal of the changes are to update and improve the requirements for internal stability design of MSE walls.

Updating Designs for Mechanically Stabilized Earth Walls in AASHTO

How did we get here?

- AASHTO T15/FHWA MSE Task Force
  - Started 2012 – one focus area was MSE internal stability
  - Composed of MSE leaders in academia, consulting, and the industry
  - Assessed best path forward (limit equilibrium, and new stiffness method)
  - Recommended research needed and eventual adoption
- AASHTO T15 and COBS
  - Beginning in 2014, continued this assessment
  - Used formal AASHTO COBS process through T15 mid-yr meetings, the annual AASHTO COBS meetings, and e-mail
  - Final decision:
    - adopt the Stiffness Method for geosynthetic walls
    - allow the continued use of the Simplified Method
    - Use limit equilibrium for situations that are beyond empirical basis for the other methods, and for compound stability
- Adopted in the AASHTO LRFD Specifications as the “Stiffness Method” in 2019 (published 3-2020)

Updating Designs for Mechanically Stabilized Earth Walls in AASHTO

Changes to MSE wall design

Change in Tmax calculation

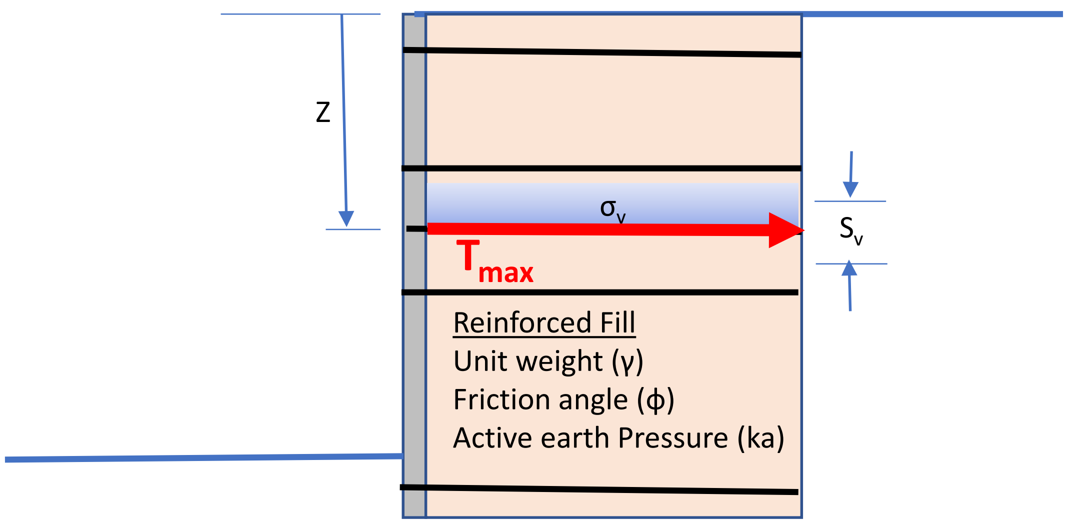
- Existing methods
  - Simplified Method
  - Coherent Gravity Method (inextensible Reinforcement)
- New methods
  - Stiffness Method
  - Limit Equilibrium
  - These methods are limited in AASHTO to extensible reinforcements only

Change in Overall Stability Calculation

- Service limit vs strength limit

Updating Designs for Mechanically Stabilized Earth Walls in AASHTO

What is Tmax?



Source: FHWA

T_{max} is the force acting on the MSE reinforcement at any given depth.

T_{max} is a function of the:

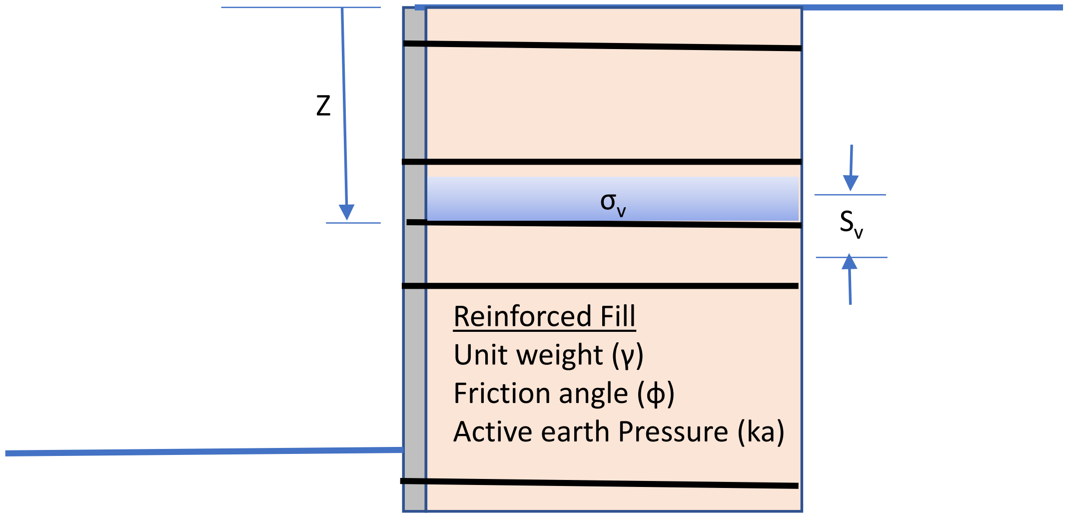
- vertical stress
- strength of the soil
- spacing of the reinforcement
- Reinforcement stiffness
- Facing

Updating Designs for Mechanically Stabilized Earth Walls in AASHTO

Simplified Method

$$\sigma_V = \gamma_r Z + \ldots\ldots$$

$$\sigma_H = K_a (K_r / K_a)\, \sigma_V$$



Source: FHWA

$$T_{MAX} = \sigma_H S_V$$

S_V is vertical reinforcement spacing, for equally spaced reinforcements

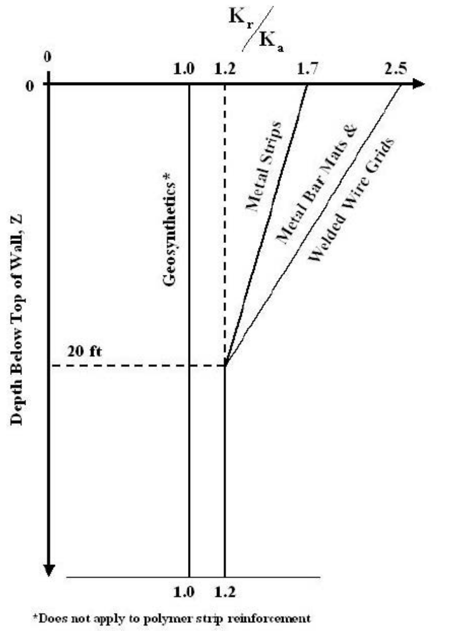


Figure 4-10. Variation of the coefficient of lateral stress ratio (K_r/K_a) with depth in a MSE wall (Elias and Christopher, 1997; AASHTO; 2002; & after AASHTO, 2007).

Source: FHWA NHI-10-024

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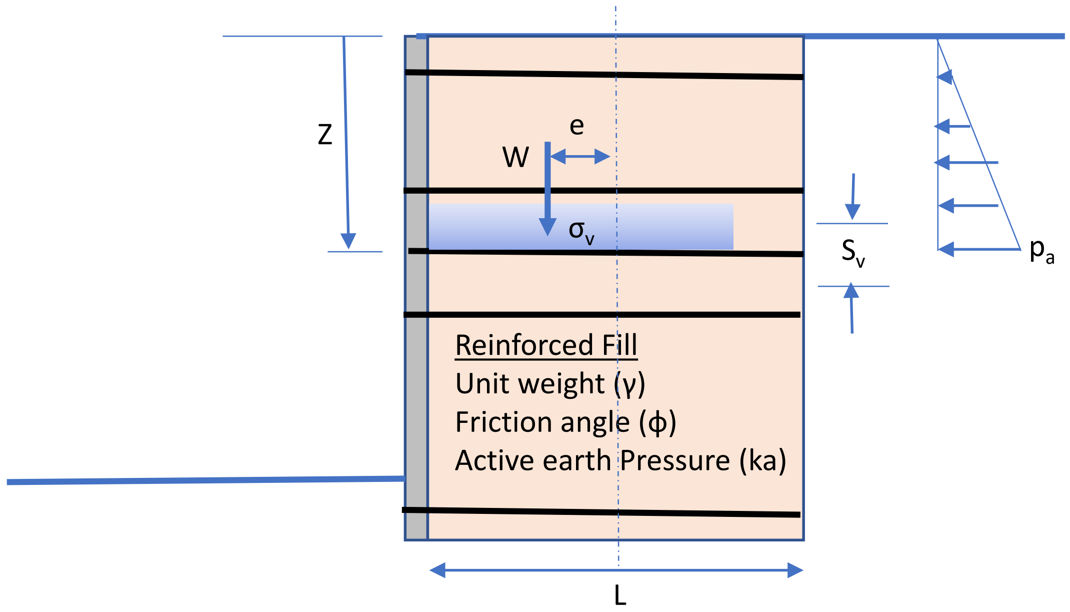
Coherent Gravity Method



Source: FHWA

$$W = \gamma_r Z$$

$$\sigma_V = W/(L-2e)$$

$$\sigma_H = K_a (Kr/Ka)\sigma_V$$

$$T_{MAX} = \sigma_H S_V$$

K_r / K_a = Lateral earth preassure based on Figure 4-10

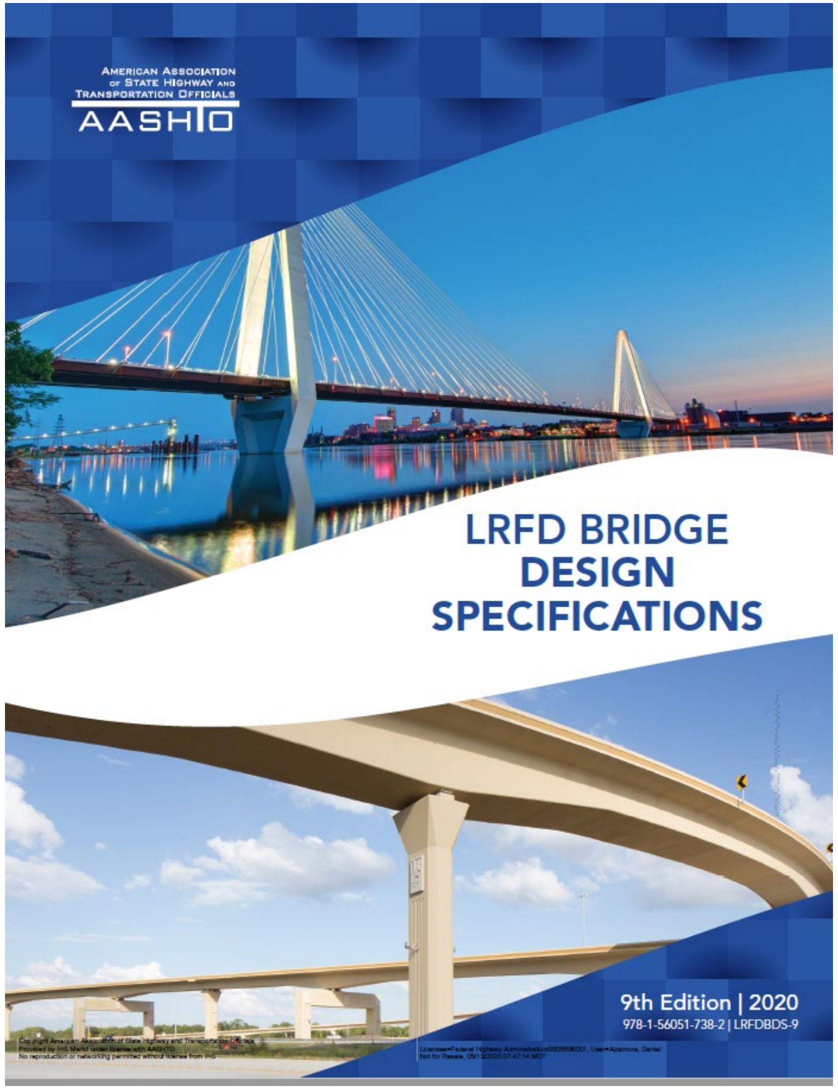
S_V is vertical reinforcement spacing, for equally spaced reinforcements

Updating Designs for Mechanically Stabilized Earth Walls in AASHTO

New Methods to calculate T_{max}

2020 AASHTO – Incorporates the use of these new design methods for extensible reinforcements.

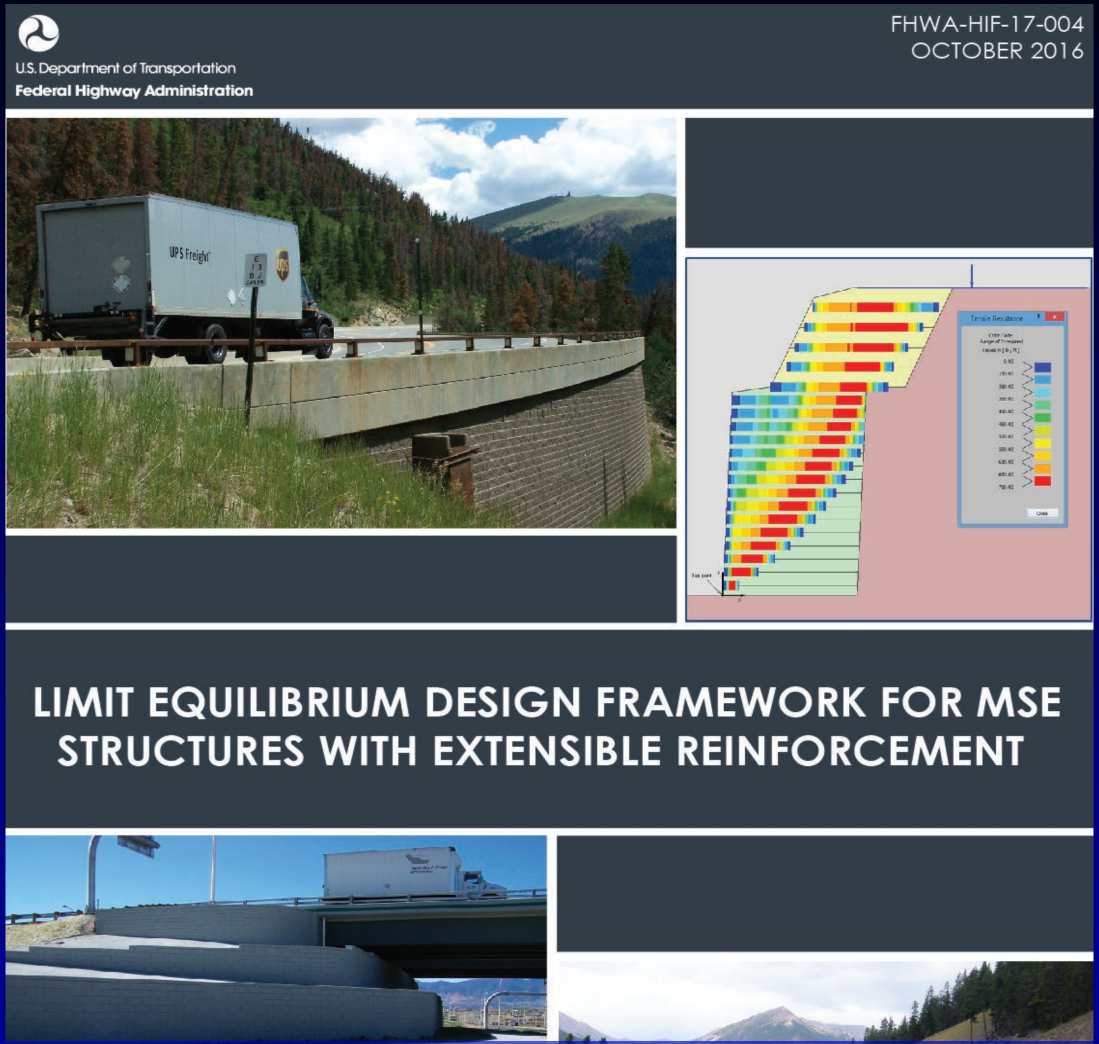
- Limit Equilibrium
- Stiffness Method



Limit Equilibrium Design: Overview and Instructive Examples

Dov Leshchinsky
Emeritus Professor, University of Delaware
Newark, Delaware
Partner, ADAMA Engineering
Clackamas, Oregon

https://www.fhwa.dot.gov/engineering/geotech/pubs/hif17004.pdf



Technical Report Documentation Page

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4. Title and Subtitle Limit Equilibrium Design Framework for MSE Structures with Extensible Reinforcement	5. Report Date October 2016 6. Performing Organization Code
7. Principal Investigator(s): See Acknowledgements for Authors and Contributors Dov Leshchinsky, Ph.D[1], Ora Leshchinsky, P.E.[1], Brian Zelenko, P.E., John Horne, Ph.D., P.E.	8. Performing Organization Report No.
9. Performing Organization Name and Address Parsons Brinckerhoff 1015 Half Street, SE, Suite 650 Washington, DC 20003 [1]ADAMA Engineering, Inc., 12042 SE Sunnyside Rd., Suite 711, Clackamas, OR 97015	10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTFH6114D00047-5010
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15. Supplementary Notes

FHWA COR – Silas Nichols, P.E.
FHWA Alt. COR – Khalid Mohamed, P.E.

16. Abstract

Current design of reinforced soil structures in the U.S. distinguishes between slopes and walls using the batter angle as a criterion. Using a unified approach in limit state design of reinforced 'walls' and 'slopes' should diminish confusion while enabling a wide and consistent usage in solving geotechnical problems such as complex geometries and soil profiles. Limit equilibrium (LE) analysis has been used successfully in the design of complex and critical (e.g., tall dams) for many decades. Limit state analysis, including LE, assumes that the *design* strength of the soil is mobilized. Presented is a LE framework, limited to extensible reinforcement, which enables the designer to find the tensile force distribution in each layer required at a limit state. This approach is restricted to Allowable Stress Design (ASD). Three example problems are presented.

17. Key Words	18. Distribution Statement
Mechanically Stabilized Earth Wall Design, MSE Wall Design, Limit Equilibrium, Geotechnical, Extensible reinforcement	No restrictions.

19. Security Classif. (of this report)	20. Security Classif. (of this	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	120	

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1. ***Provides analytical details***
2. ***Verifies using numerical and physical models***

Roadmap of Presentation

- Limit Equilibrium Analysis: Global Approach
- The Safety Map Tool
- Limit Equilibrium Analysis: Baseline Solution
- Limit Equilibrium: Design Approach
- Limit Equilibrium: Instructive Examples
- Concluding Remarks

Global Limit Equilibrium (LE)

- *Simple yet applicable to complex problems*
- *Vast experience*
- *MSE: Subset of slope stability analysis*
- *No arbitrary distinction between ‘wall’ and ‘slope’*
- *Global LE design is half-cooked➔ Strength of reinforcement is examined globally while locally required strength, including connections, is overlooked ➔ Ignores local demand by smearing (shedding) the load amongst all layers*

∴Does not deal explicitly with ‘Internal Stability’ which is concerned with local demand ➔ Provides an important, but narrow, design perspective

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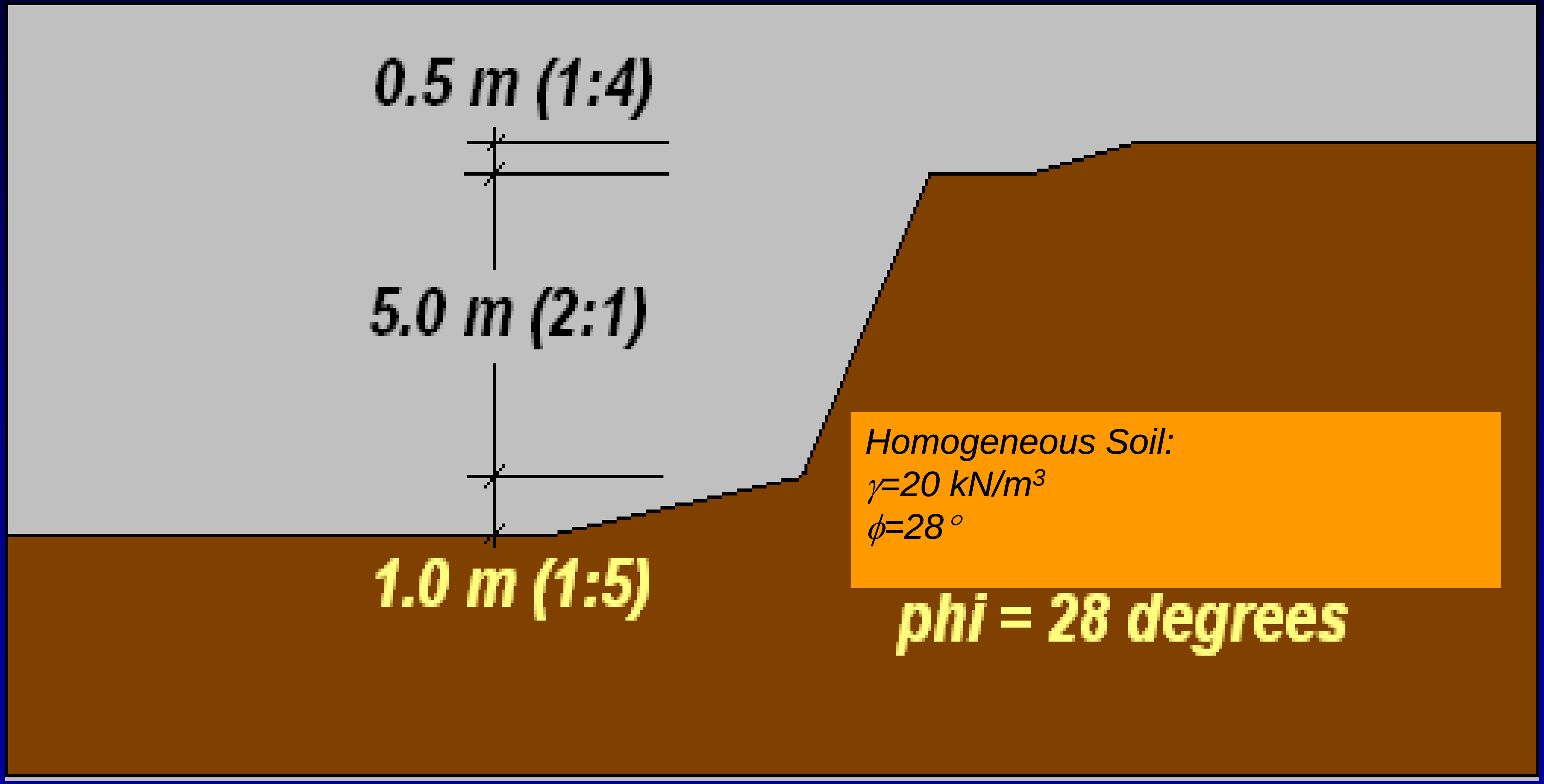
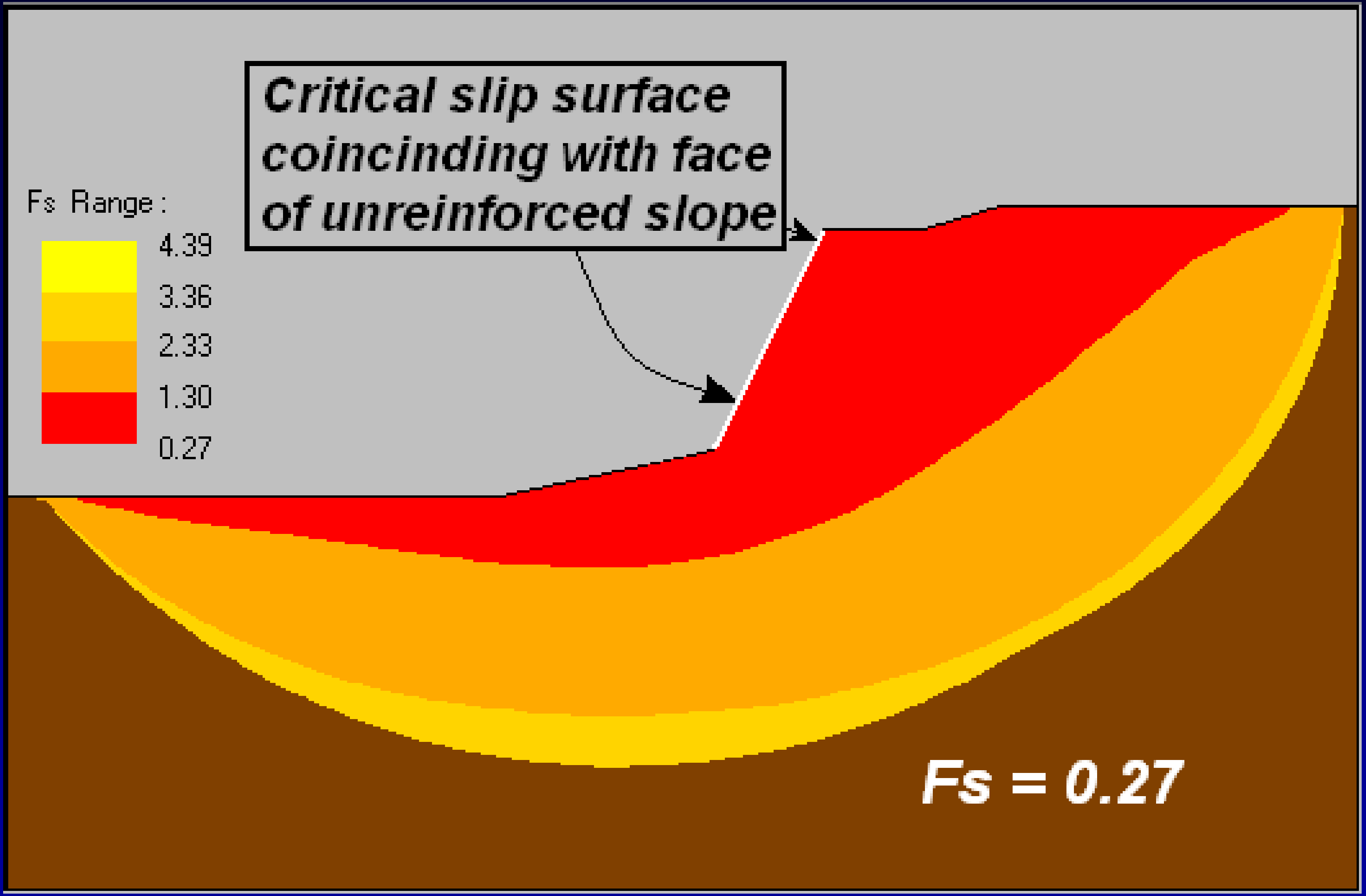
The Safety Map Tool

- Baker and Leshchinsky (2001) introduced the concept of, and coined the term, Safety Map
- Safety Map = Visual diagnostic tool for the state of stability of reinforced soil mass
- Design Objective: Select strength & layout of reinforcement to produce an efficient structure that is adequately stable

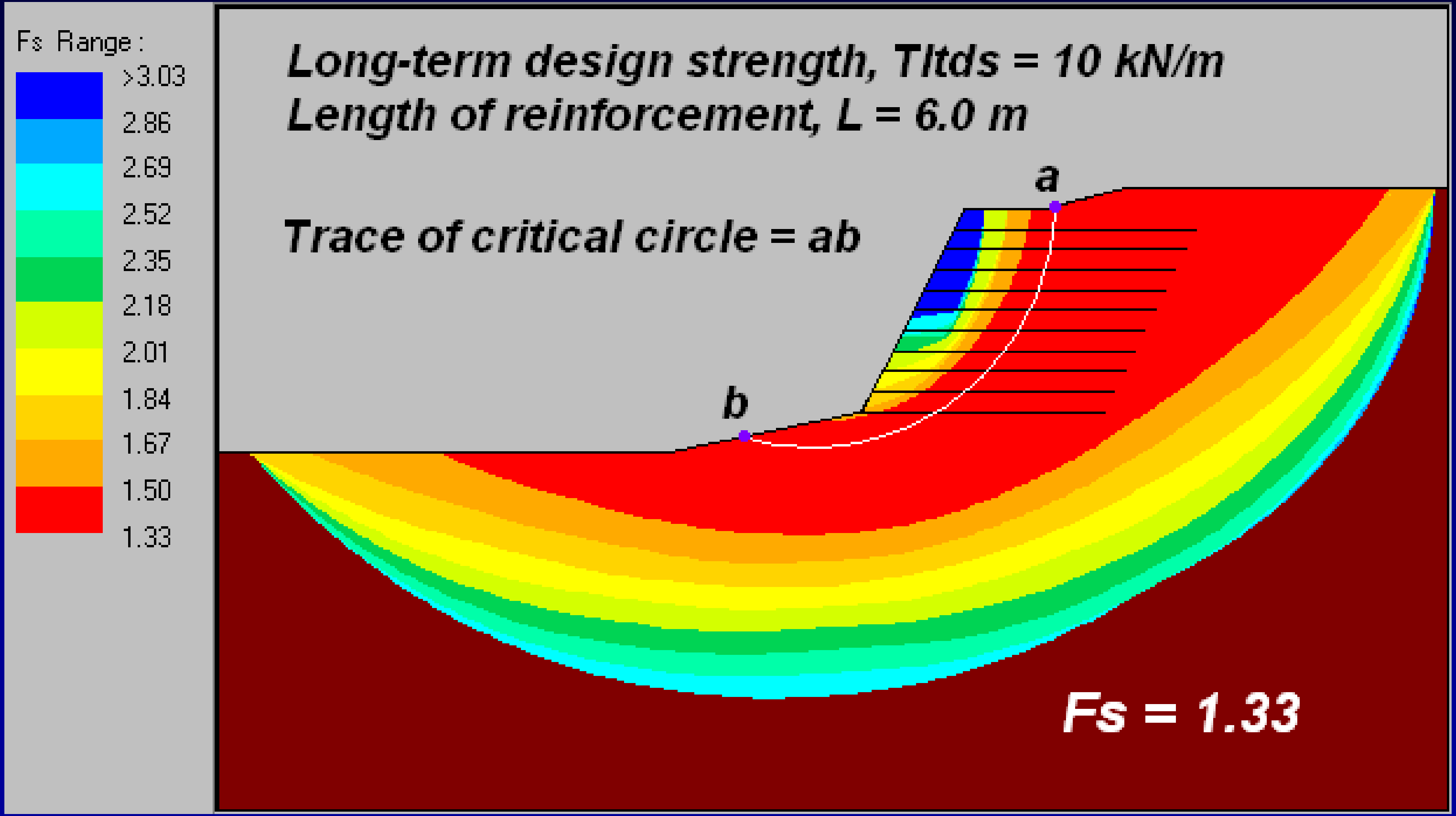
Example Problem



Unreinforced Problem (Bishop)



Adequate Reinforcement Layout using Circular Arc (Bishop)



Roadmap of Presentation

- Available Limit State Methods of Analysis
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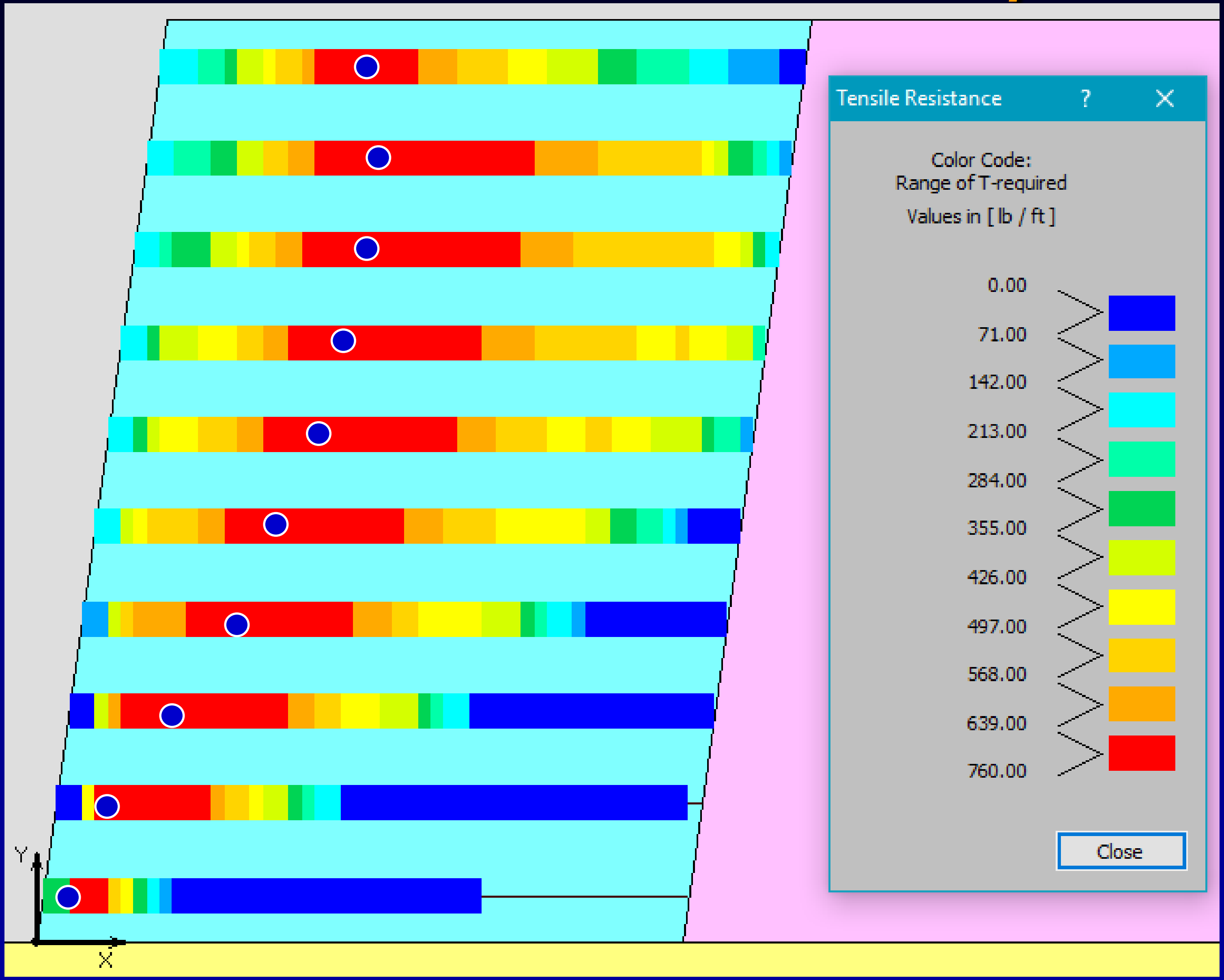
Baseline: Inverse of Safety Map…

- *Safety Map finds the spatial distribution of global safety factors, SF, in a reinforced soil mass*

- *Conversely, Internal Stability analysis in LE produces the local tensile resistance needed for Fs=SF=1.0 everywhere*

- *The Internal Stability approach produces the baseline solution: Tension Map, $T_{req}(x)$, including T_{max} and T_o for each layer → It leads to a rational and robust selection of reinforcement and facing*

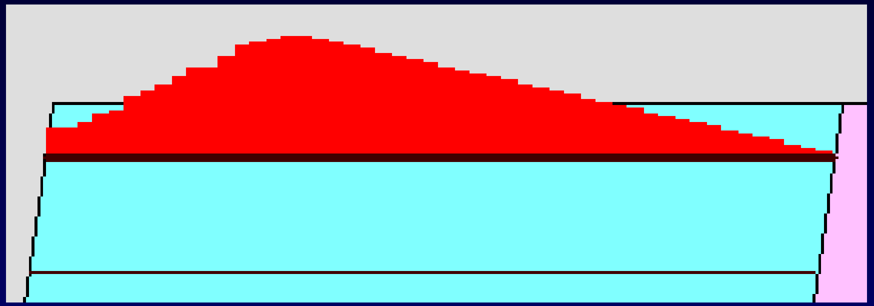
Tension Map: Visualization of $T_{req}(x)$



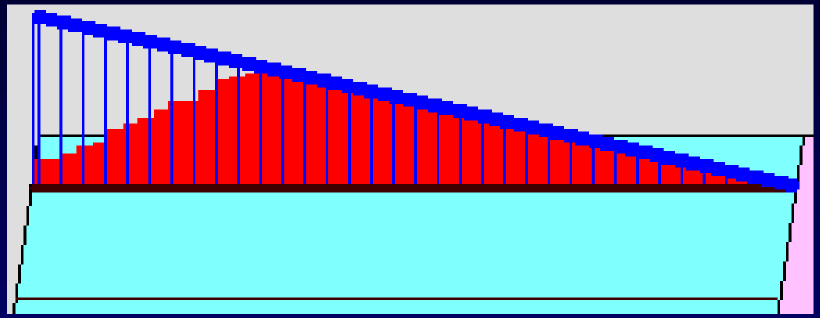
The Framework: Process in Nutshell

- Check numerous test bodies adjusting $T_{req}(x)$ for each layer so that SF=1.0 → Use a systematic top-down process
- For $T_{req}(x)$ distribution, failure along any surface is equally likely → $T_{req}(x)$ therefore is termed Baseline Solution → Tension Map
- The tension, $T_{req}(x)$, may be limited by pullout at the rear and/or front ends
- $T_{req}(x)$ is the resistance needed locally to yield a structure at a limiting equilibrium state

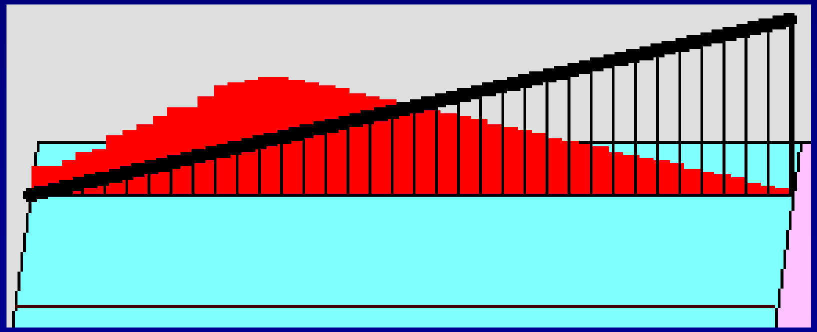
Details: Baseline & Pullout



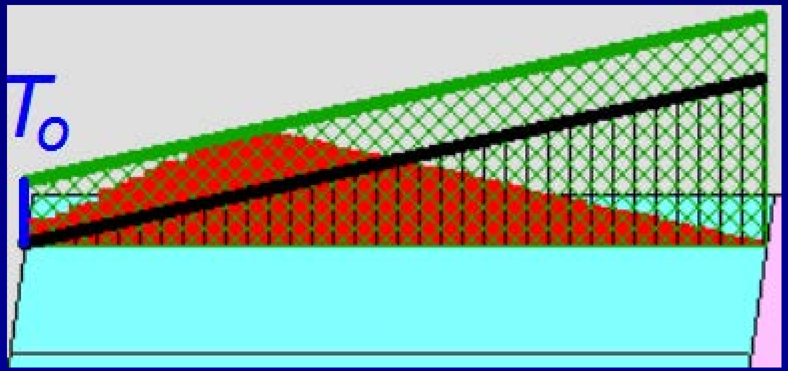
1. $T_{req}(x)$



2. Rear pullout constraint



3. Front pullout… oops



4. Adjust front pullout

➔ Upwards shift is T_o

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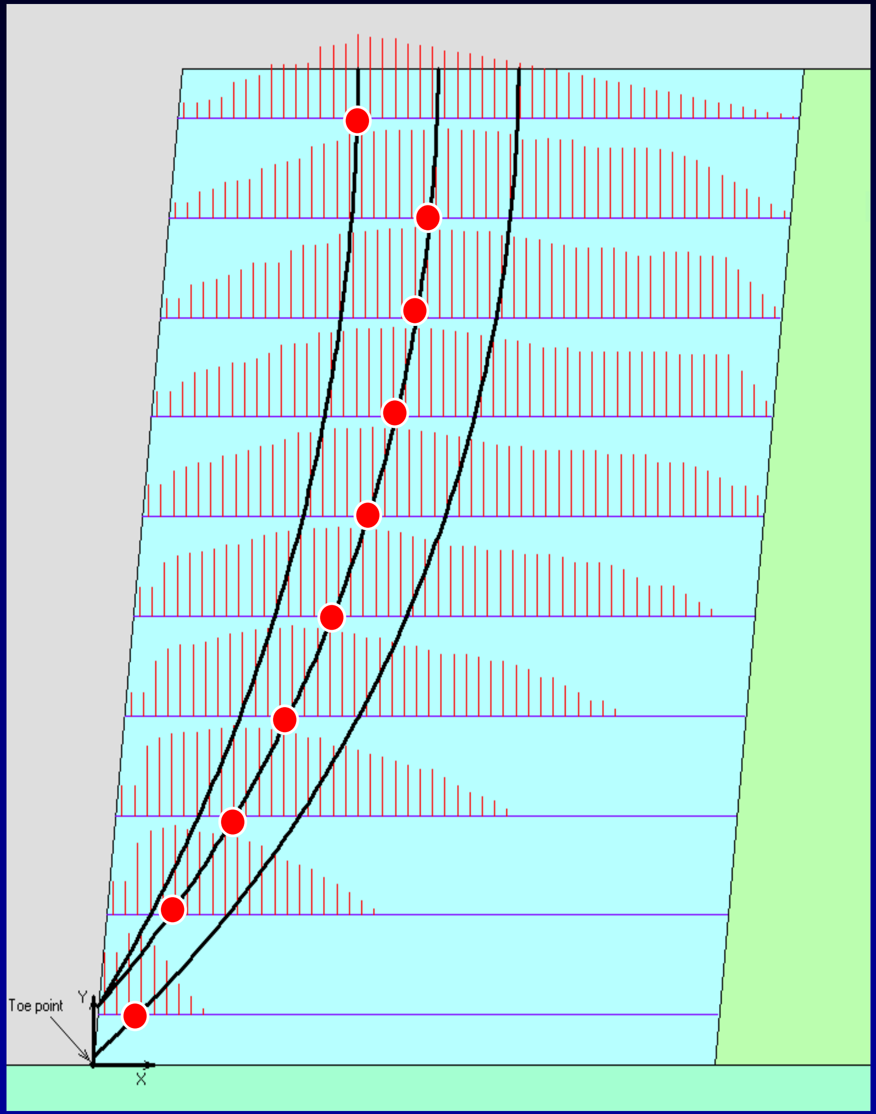
Advancement of Current Design

- Apply the LE design approach in two stages: Internal Stability and Global Stability
- Stage I: Internal stability - Find $T_{req}(x)$ in all reinforcements - Baseline Solution
- Consider geometry, loading conditions, reinforcement layout, pullout resistance, batter, water, seismicity, etc.
- Stage II: Global stability – consistent with current design → Standard slope stability → Not discussed here

Conduct Global Stability → Why use then Internal Stability?

- *Reinforcement resistance in Global Stability is evenly divided amongst all layers* → *Results in T_{max} that is smaller than in Internal Stability* → *Global ignores local demand through 'smearing'*

- *Global Stability tells us nothing about connection load, T_o*



Global Stability: Locus of T_{max} is NOT on a singular surface.

Stage I: *Internal Stability*

- *Find $T_{req}(x)$ including T_{max} & T_o (connection)*
- *Determine max(T_{max}) to select geosynthetic*
- *LTDS=$F_{s\text{-}strength}\times$max($T_{max\text{-}i}$) where $F_{s\text{-}strength}$=1.5*
- *T_{ult}=LTDS$\times RF_{cr} \times RFd \times RFid$*
- *Stage I is a rational and robust alternative to existing approaches → Consistent with principles of LE and is <u>not</u> arbitrary → Ensures no overstressing*

Roadmap of Presentation

- *Available Limit State Methods of Analysis*
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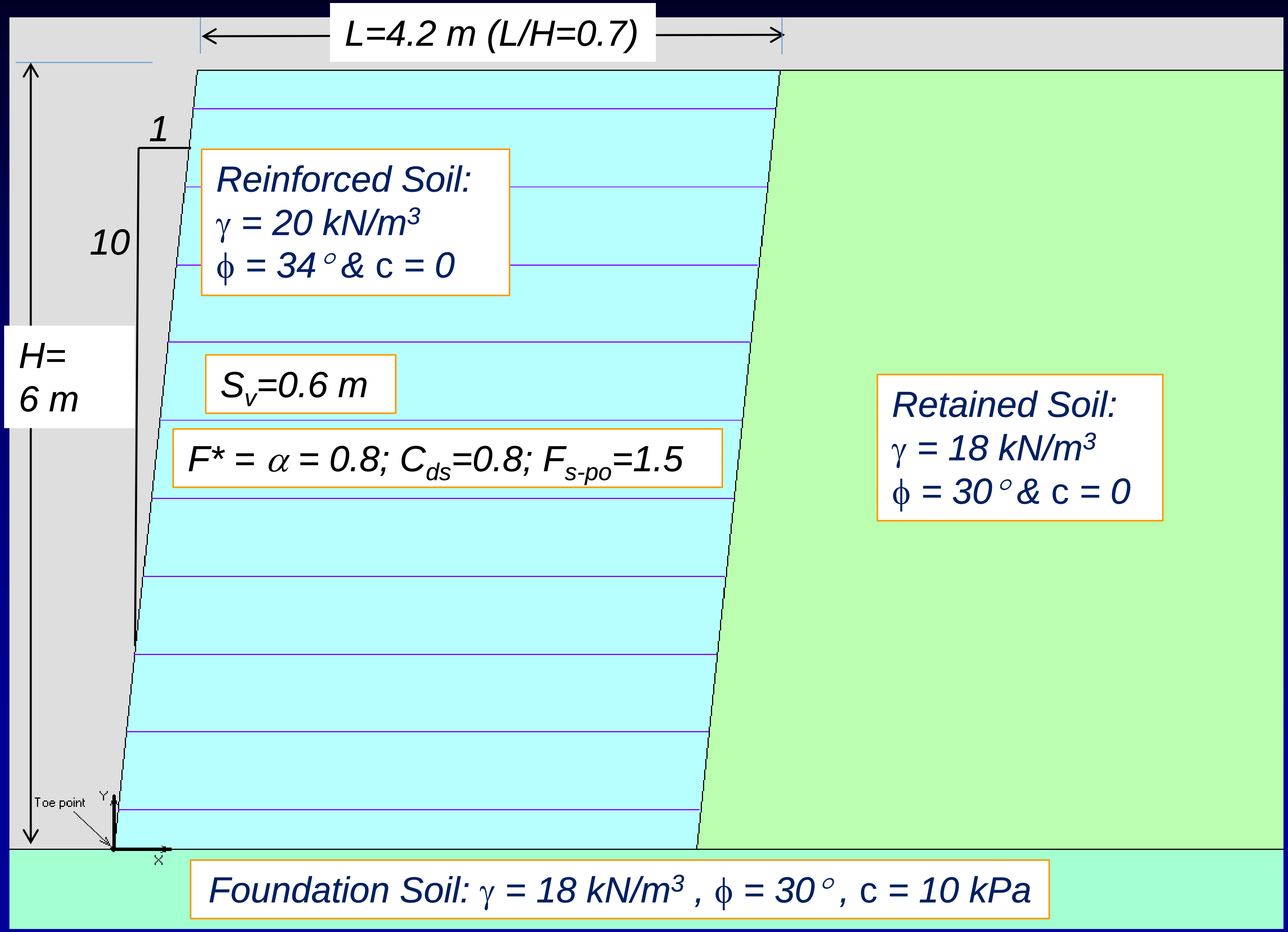
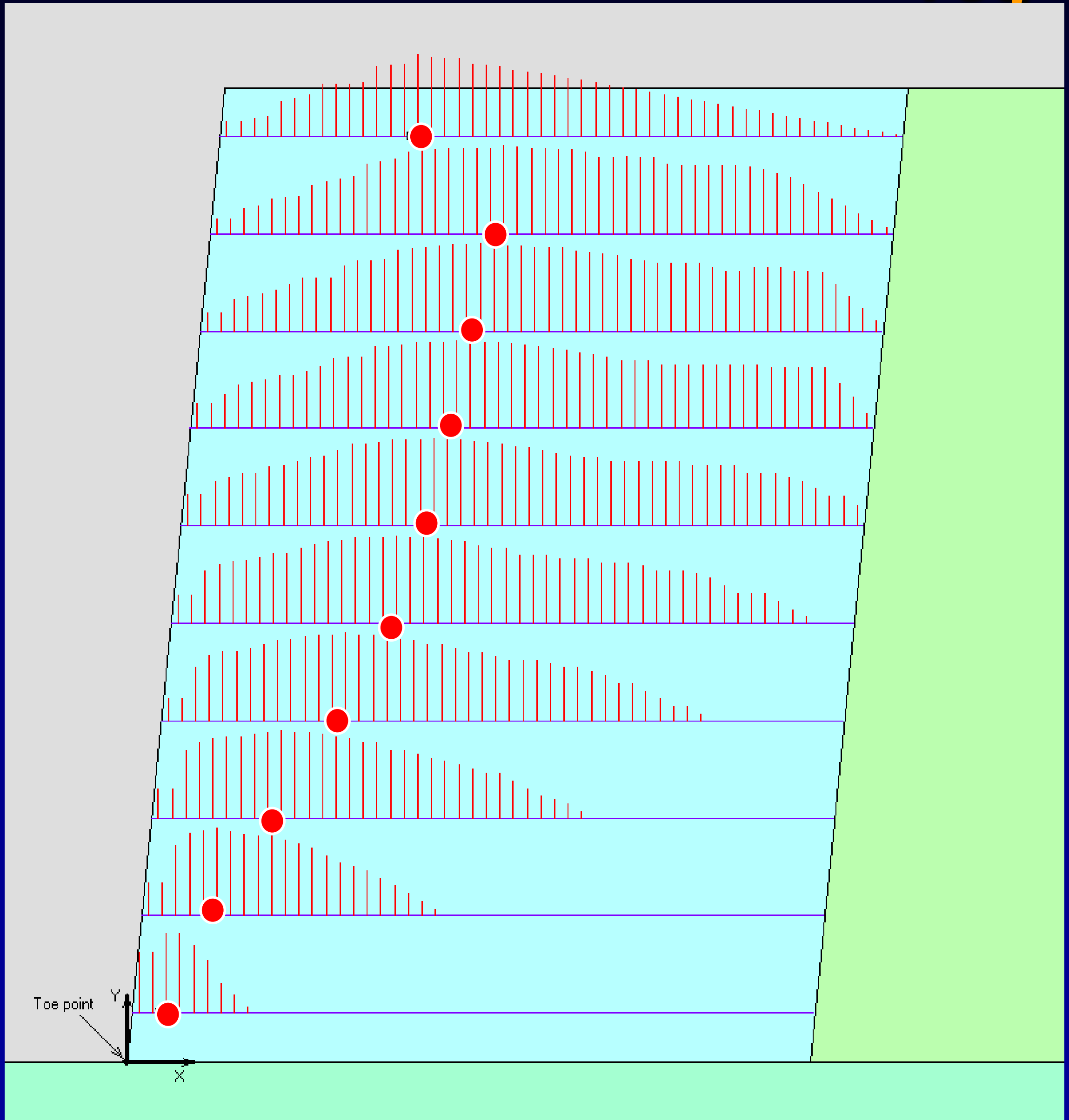
- *Limit Equilibrium: Design Approach*
- ***Limit Equilibrium: Instructive Examples***
- *Concluding Remarks*

Benchmark Problem

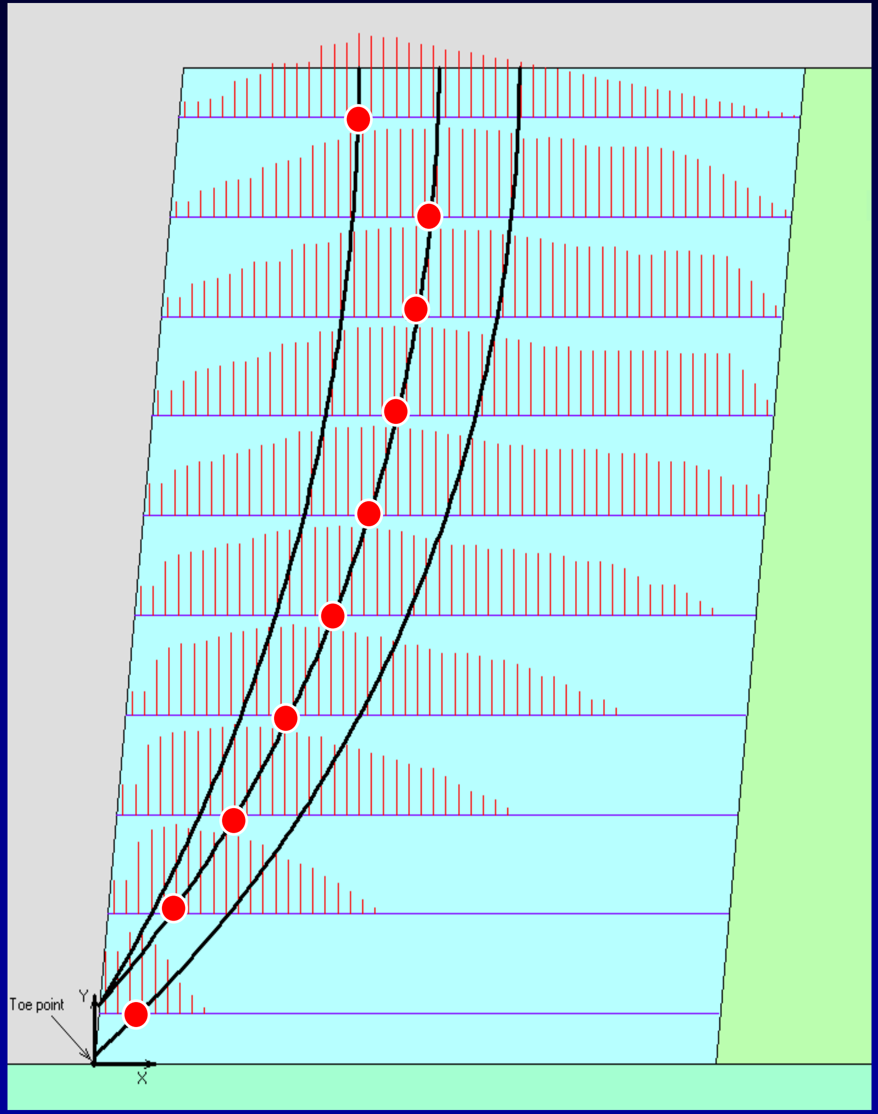


Computed Distribution of $T_{req}(x)$

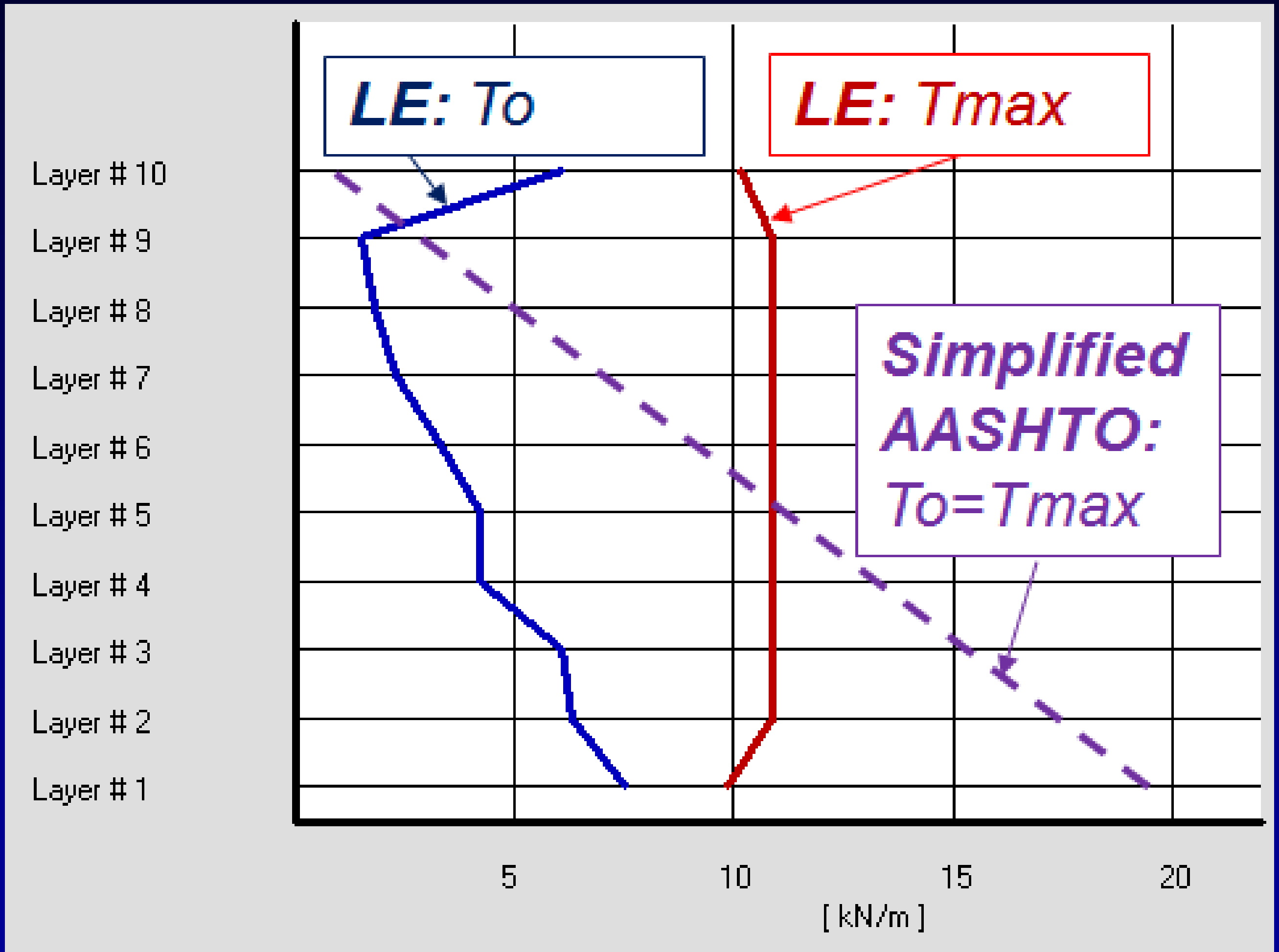


Computing T_{max} in Internal Stability: Critical Circles

1. Hypothesis in AASHTO: locus of T_{max} is defined by a singular slip surface. Is it?
2. Well-defined active and resistant zones. Is it?



T_{max} and T_o Distribution

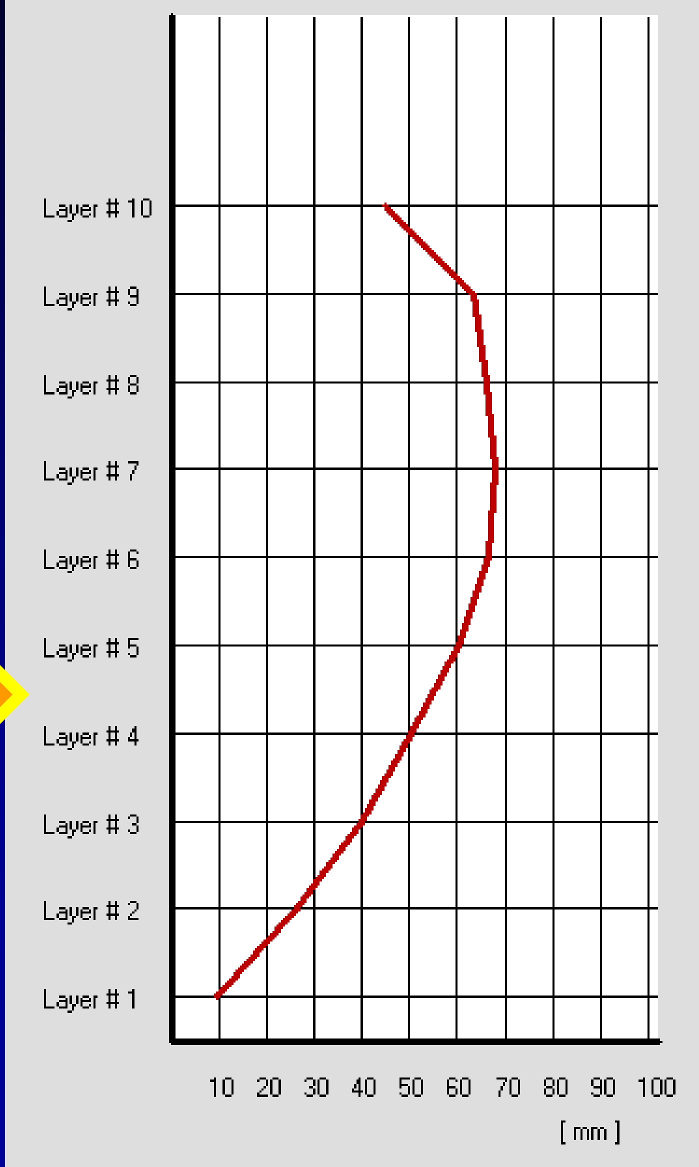


max(T_{max}): LE ➔ 10.9 kN/m AASHTO ➔19.3 kN/m

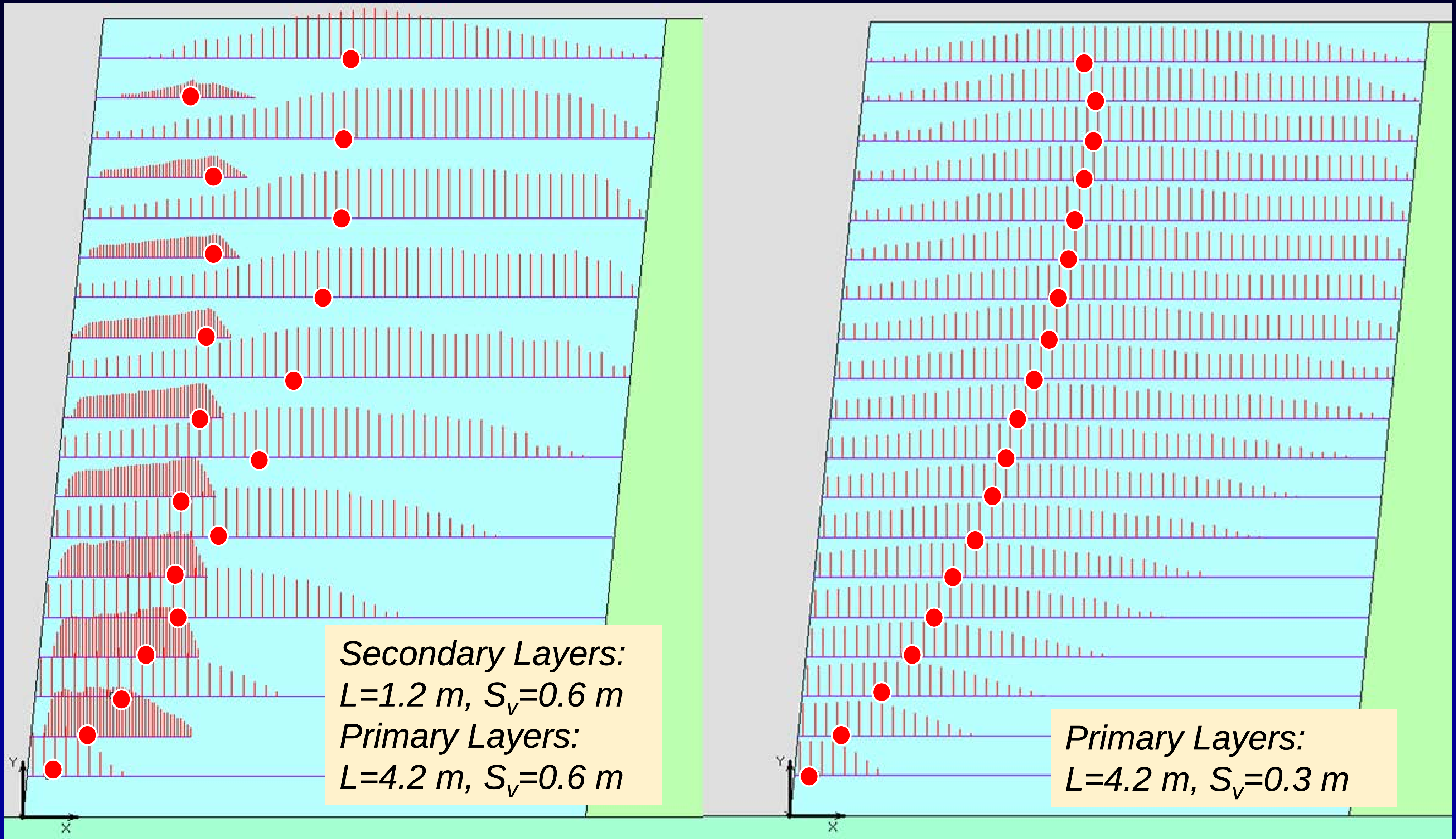
Horizontal Displacement Distribution: Serviceability

Knowledge of $T_{req}(x)$ for Fs=1.0 → Estimation of the lateral displacement at a limit state

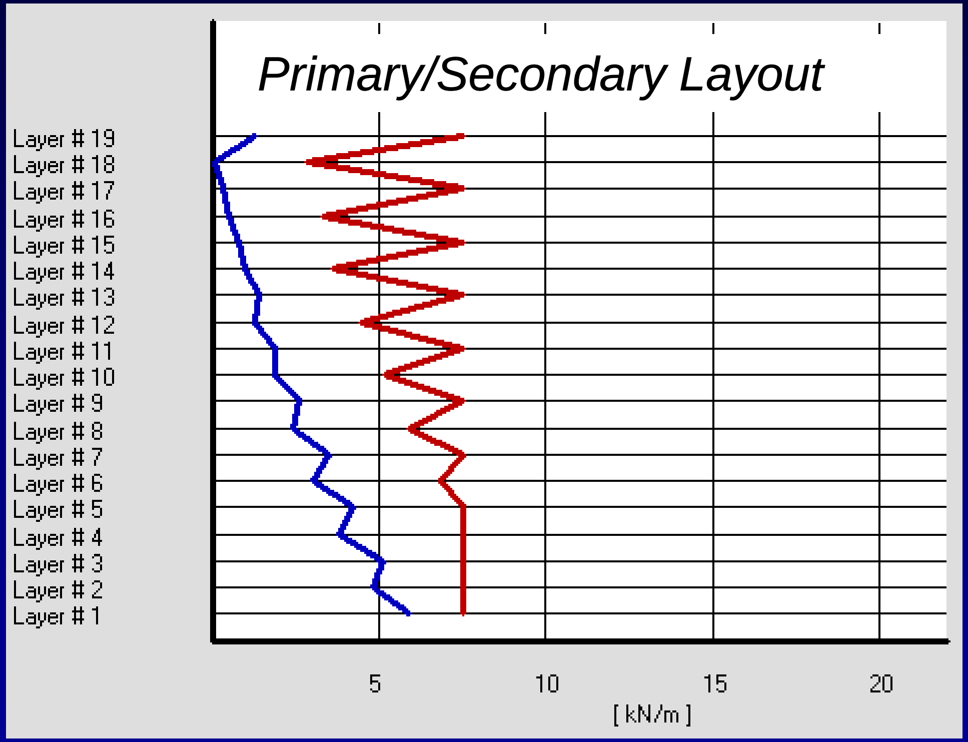
e.g., for J=500 kN/m

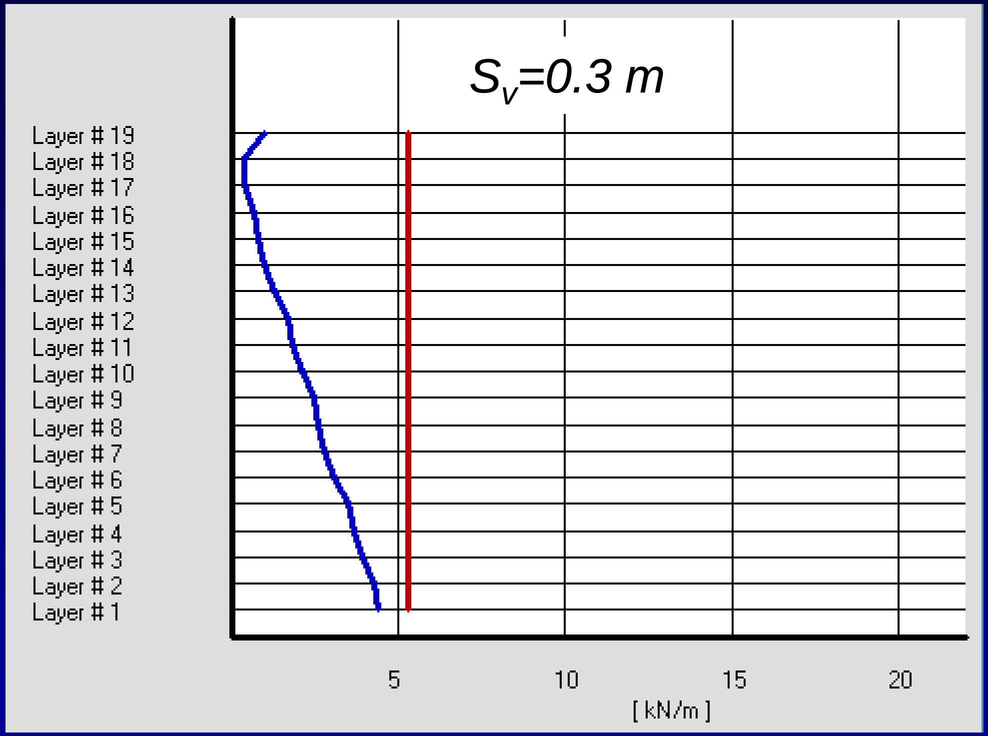


Effects of Secondary Layers



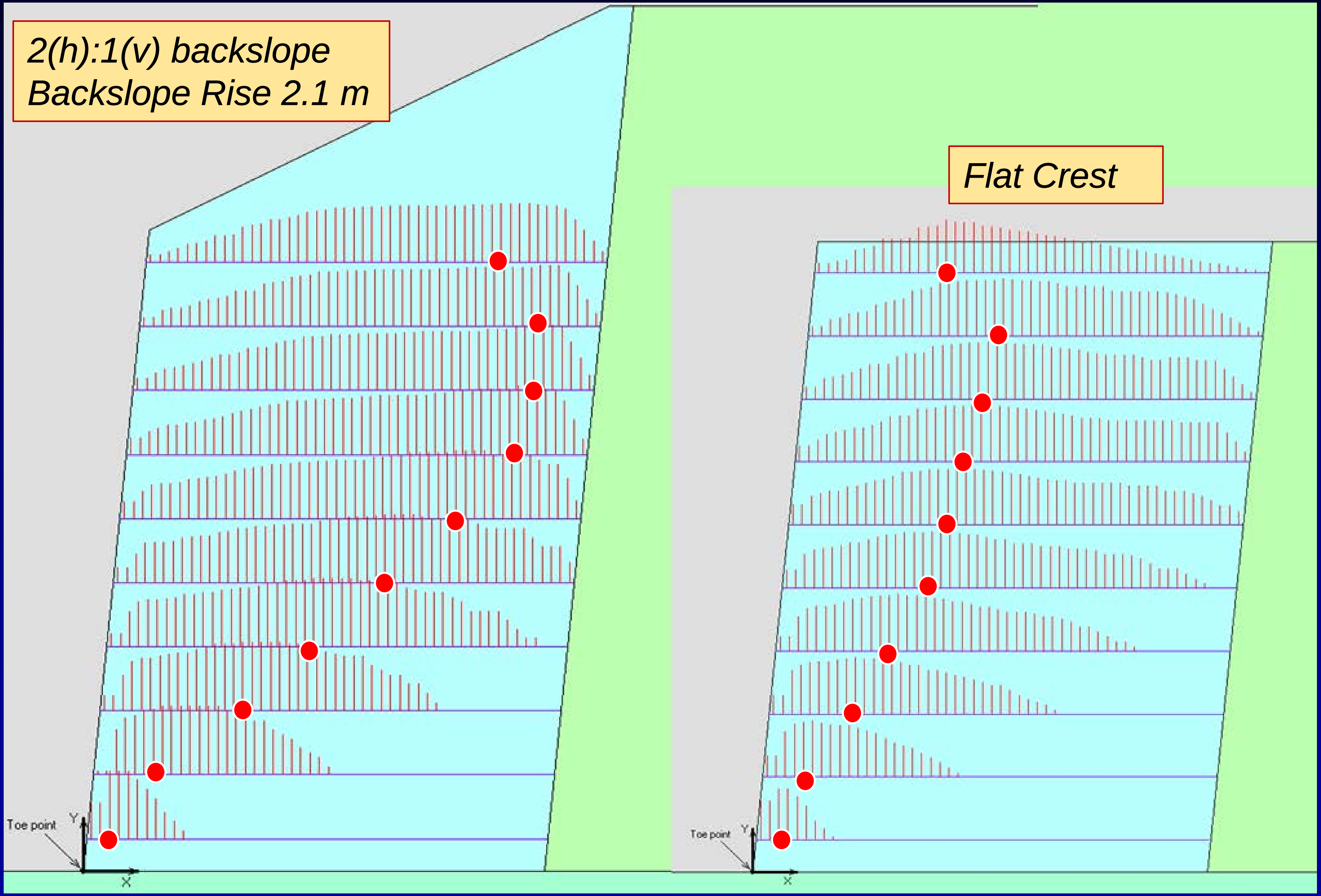
T_{max} and T_o: Secondary versus Close Spacing





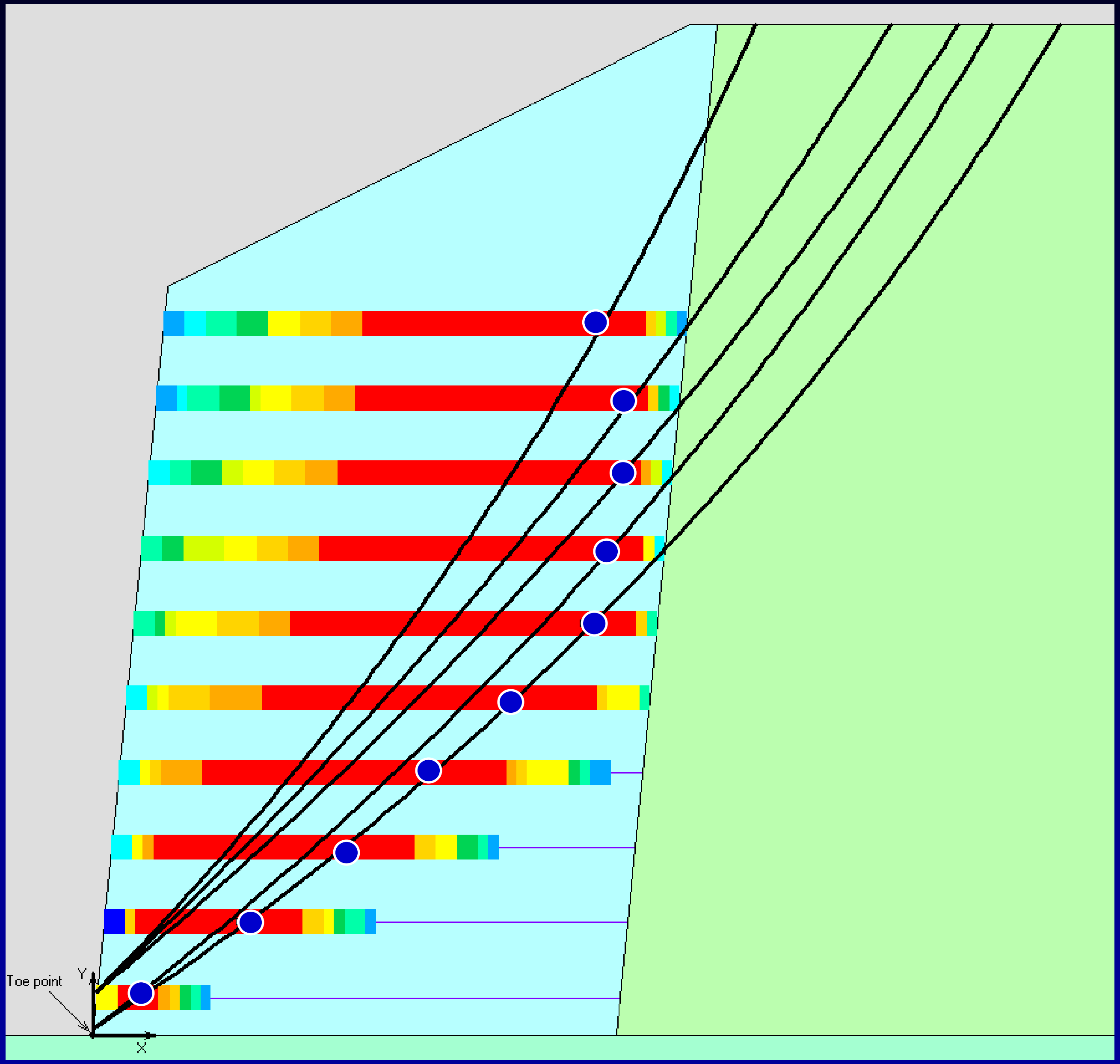
Depending on relative length of secondary reinforcement, it may decrease T_{max}. Generally it has significant effects on T_o.

Effects of Backslope

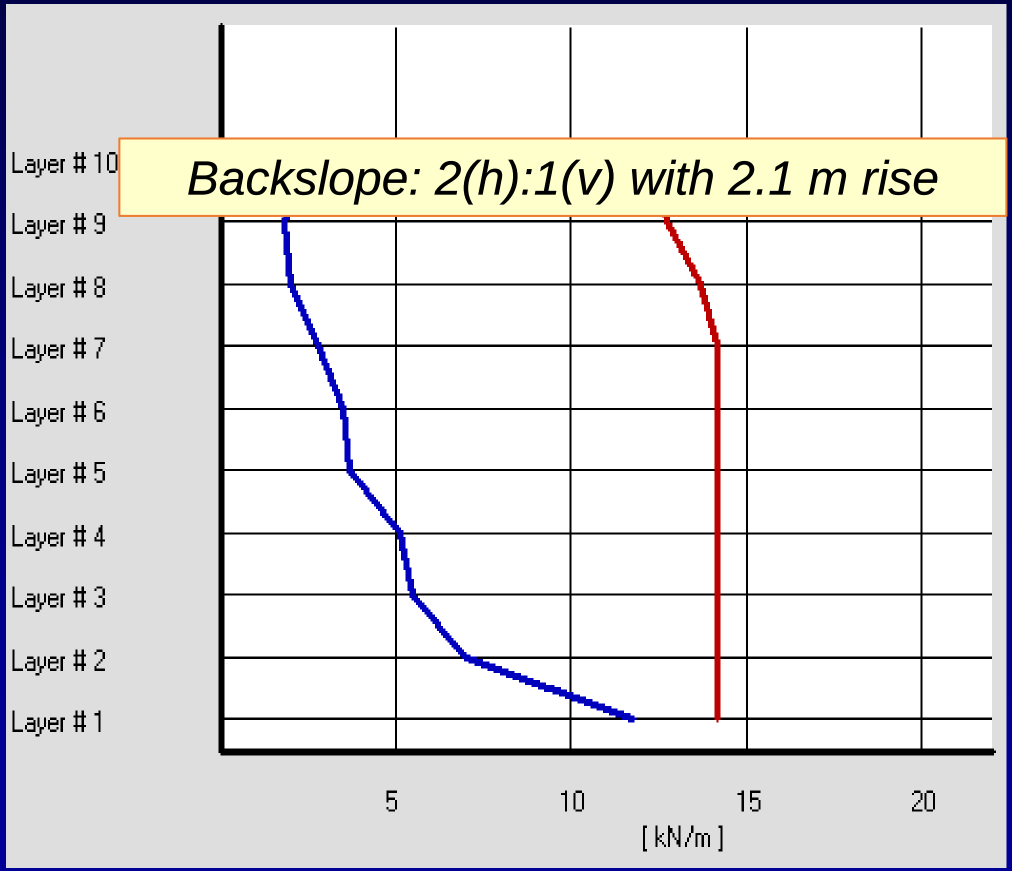


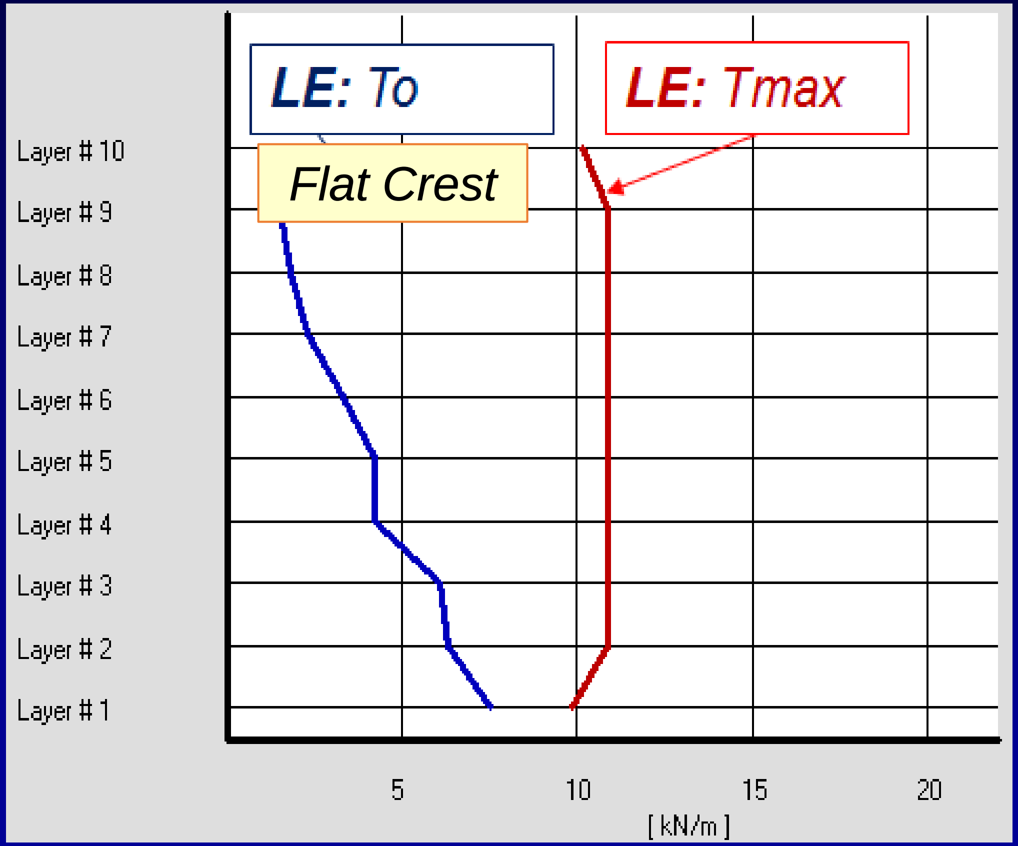
Computing T_{max} in Internal Stability: Critical Circles

Note:
Global Stability → Top 4 layers are not needed for stability.
Baseline Solution, Stage I → Identifies the need for these layers!

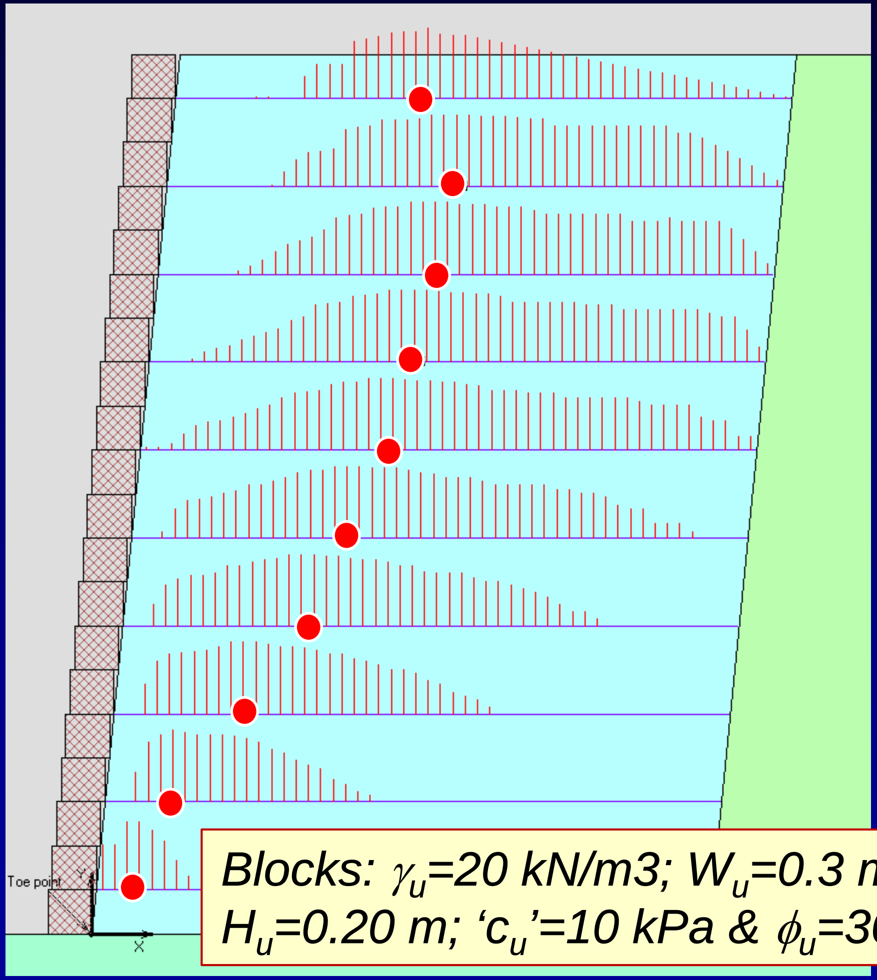


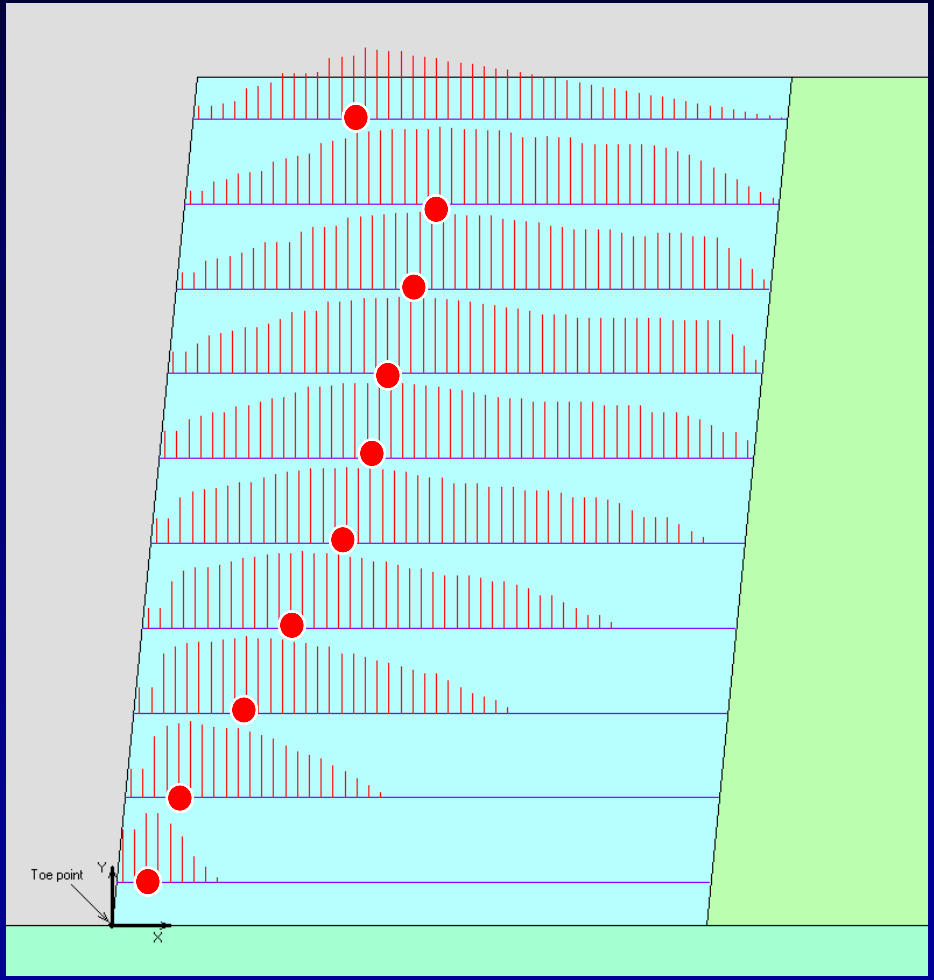
Effects of Backslope: T_{max} and T_o





Effects of Facing: Small Blocks

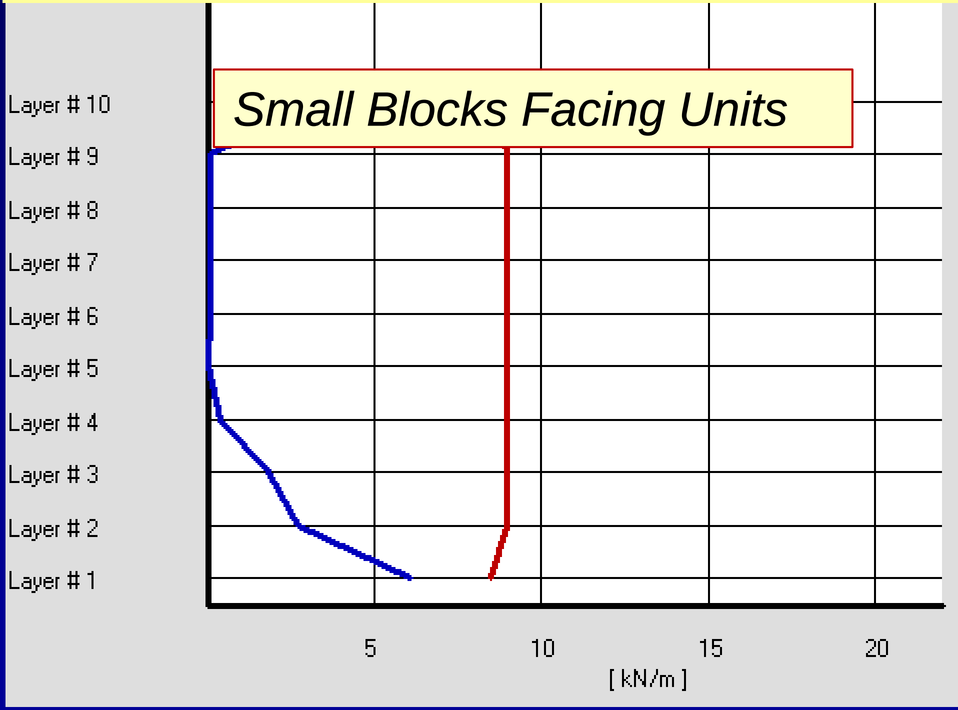


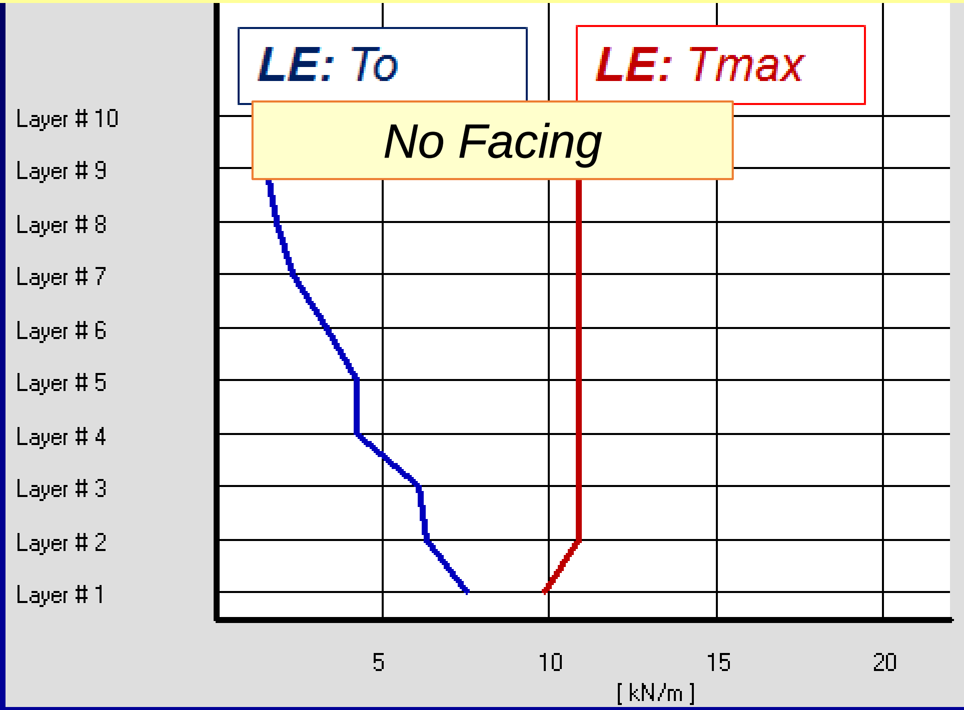


Blocks: γ_u=20 kN/m3; W_u=0.3 m; H_u=0.20 m; 'c_u'=10 kPa & ϕ_u=30^o

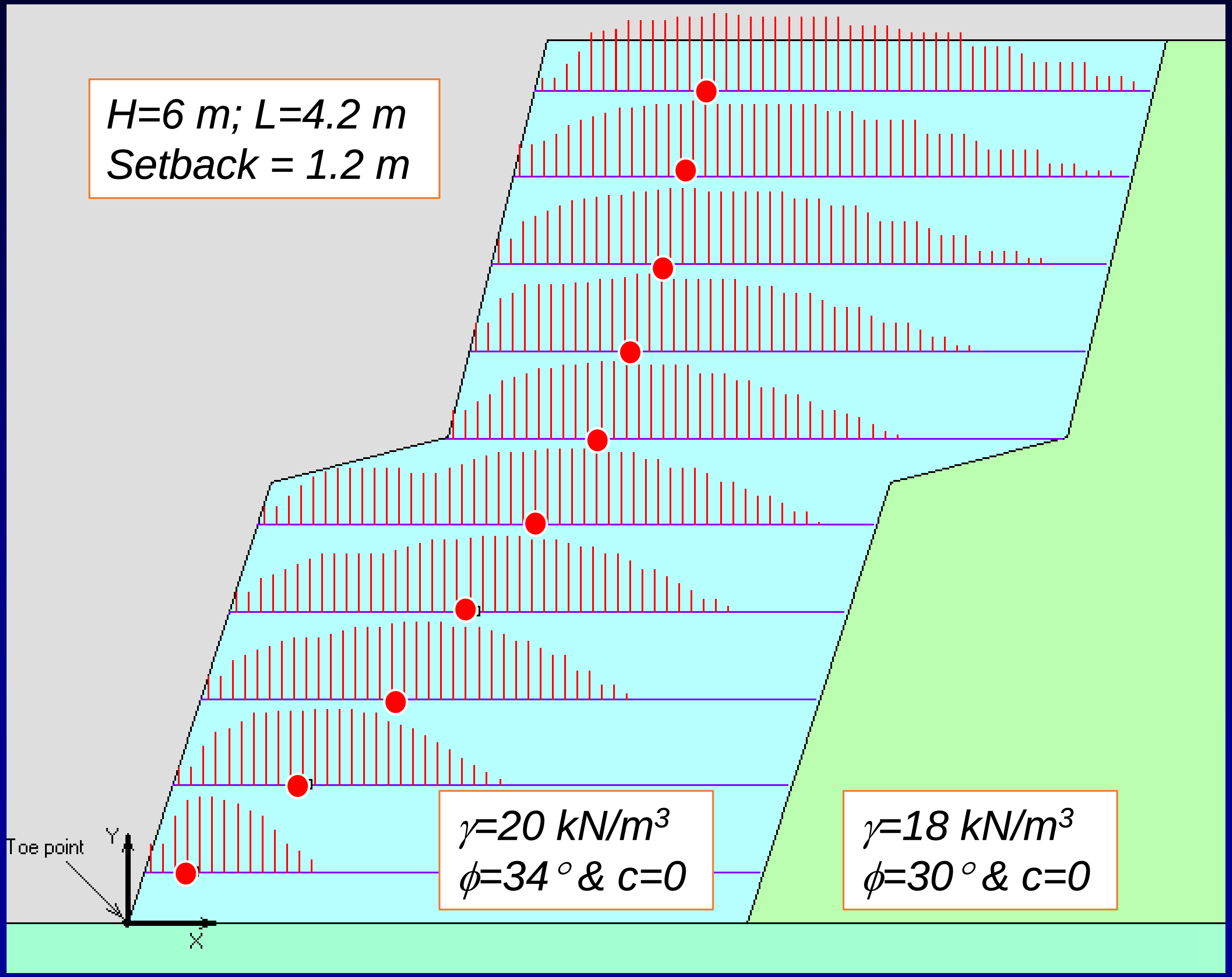
Effects of Small Blocks Facing: T_{max} and T_o

Large blocks or high interblock and toe resistance may reduce significantly the need for reinforcement (length and strength)

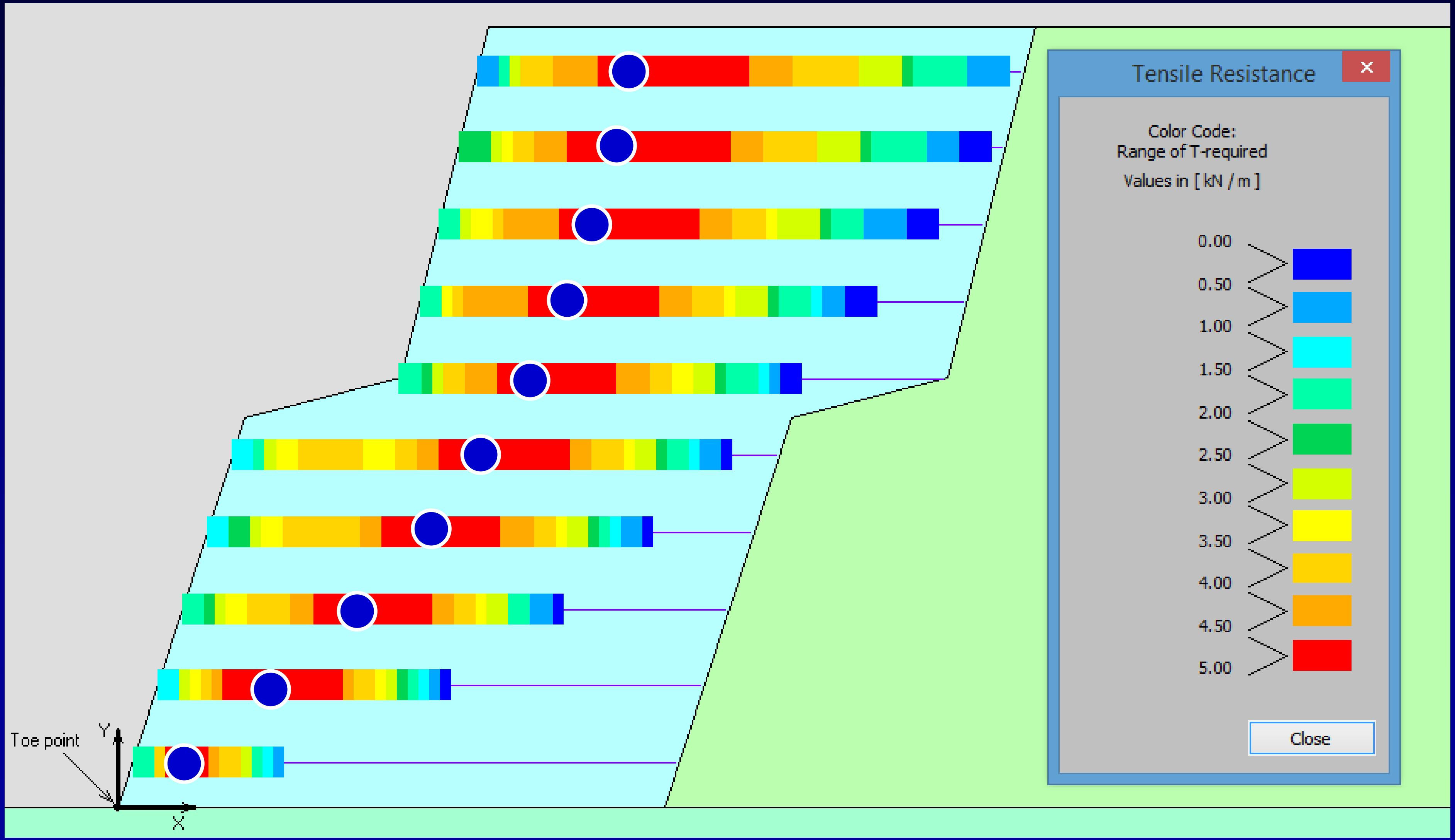




3(v):1(h) Two-Tier Wall



Tension Map: 2-Tier Wall



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Concluding Remarks

- Baseline Solution: Fs=1.0 on soil strength is used to determine LTDS, consistent with Internal Stability principles → LRFD can be used, same as in AASHTO
- AASHTO has approved the LE approach as presented in FHWA-HIF-17-004
- T_{max} and T_o: Global stability ignores possible local overstressing while the Baseline Solution considers local demand rationally
- Global LE: Applicable to external stability -- sliding, eccentricity, and bearing load


THANK YOU!

Internal Stability of MSE Walls: The Stiffness Method

Tony Allen
WSDOT
TRB Webinar

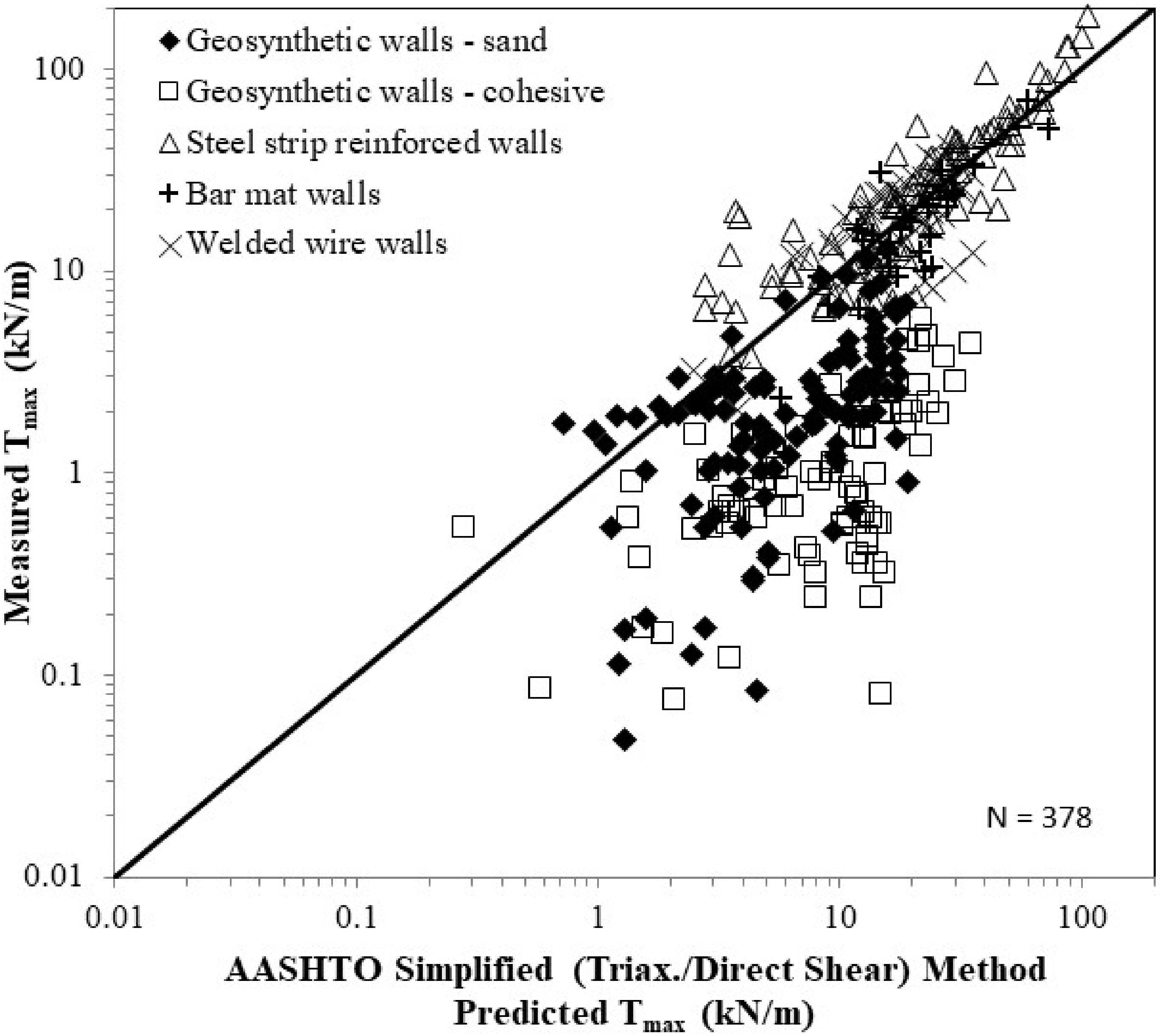
Historical Background - Research

- Available methods obviously conservative
- Analysis of many instrumented case histories 1990's through 2010's
  - 85 full scale field walls (449 T_{max} measurements), half of which were steel reinforced MSE walls
  - 16 full scale lab test walls at RMC (665 T_{max} measurements), 2 of which were steel reinforced MSE walls, taken to near failure
  - Numerical (FLAC) modeling
- New T_{max} prediction method (K-Stiffness) in 2003
- Reformulated in 2015 - Simplified Stiffness Method

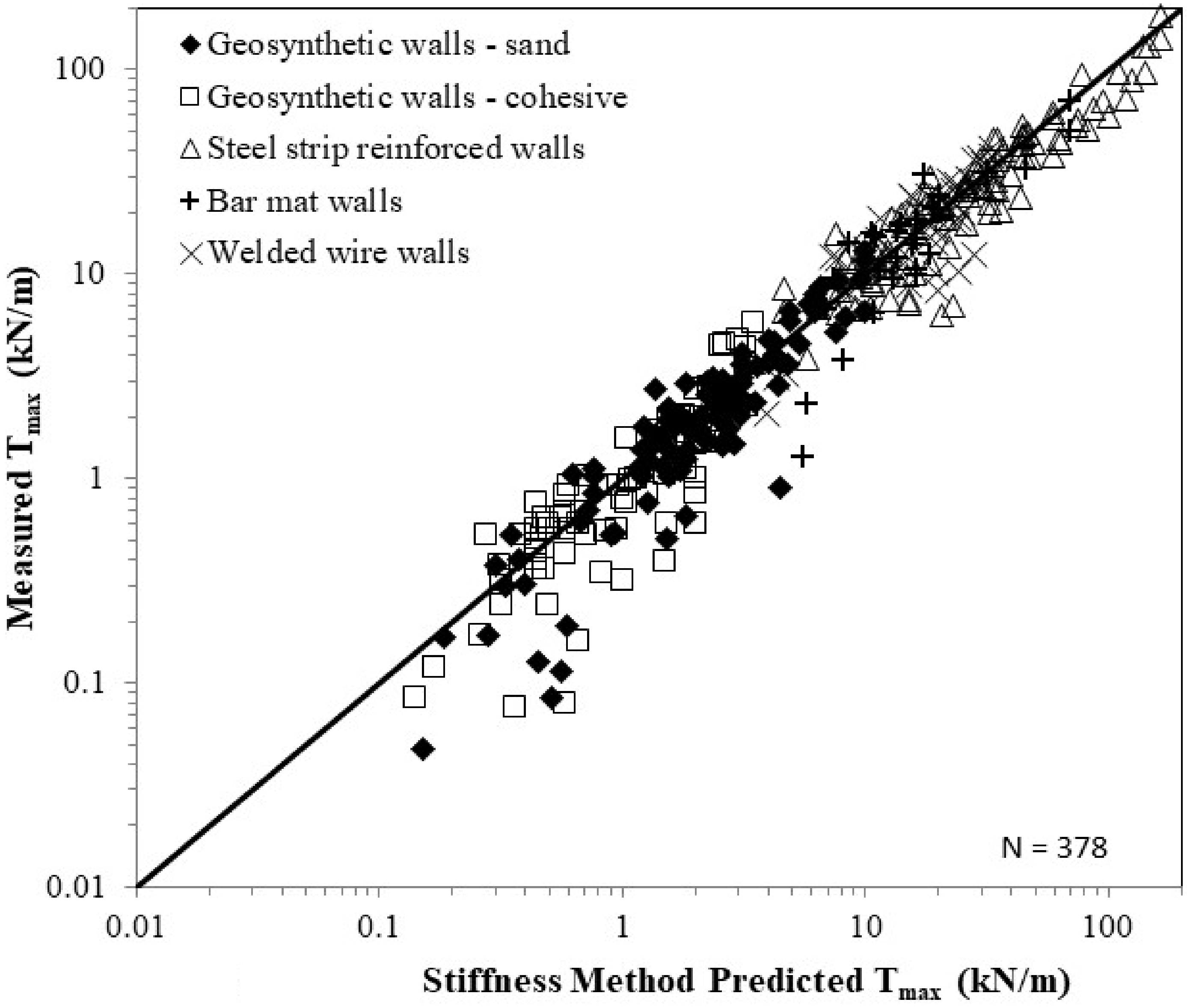
Advancements and /or Advantages of Stiffness Method over Prior Ones

- Addresses key parameters known to affect reinforcement loads
- More accurate T_{max} prediction
- Can address a wider range of soils
- Handles facing batter more accurately
- Seamless across all soil reinforcement types (including steel)
- Can address service limit to assess and design for reinforcement strain
- LRFD calibrated

Simplified Method T_{max} Prediction



Stiffness Method T_{max} Prediction



EQUATION EQUIVALENCY

Simplified Method

$$T_{max} = S_v \sigma_v K = S_v \left[\gamma_r\, z + \gamma_f\, S \right] K_a (K_r/K_a)$$

$$T_{max} = S_v \left[\gamma_r H D_{tmax} + \gamma_f (H_{ref}/H)\, S \right] K_{avh}\, \Phi_{fb}\, \Phi_g\, \Phi_{fs}\, \Phi_{local} \Phi_c$$

Stiffness Method

Same equation for geosynthetic <u>and</u> steel reinforcement MSE wall types

EQUATION EQUIVALENCY

Simplified Method

$$T_{max} = S_v \sigma_v K = S_v \left[\gamma_r\, z + \gamma_f\, S \right] K_a \, (K_r / K_a)$$

$$T_{max} = S_v \left[\gamma_r H D_{tmax} + \cancel{\gamma_f} (\cancel{H_{ref}} / \cancel{H}) \cancel{S} \right] K_{avh} \, \cancel{\Phi_{fb}} \, \Phi_g \, \cancel{\Phi_{fs}} \, \cancel{\Phi_{local}} \, \cancel{\Phi_c}$$

Stiffness Method

PRACTICAL APPLICATION OF STIFFNESS METHOD

Current Simplified Method → $T_{max} = S_v(\gamma_r\, z)\, K_a(K_r/K_a)$

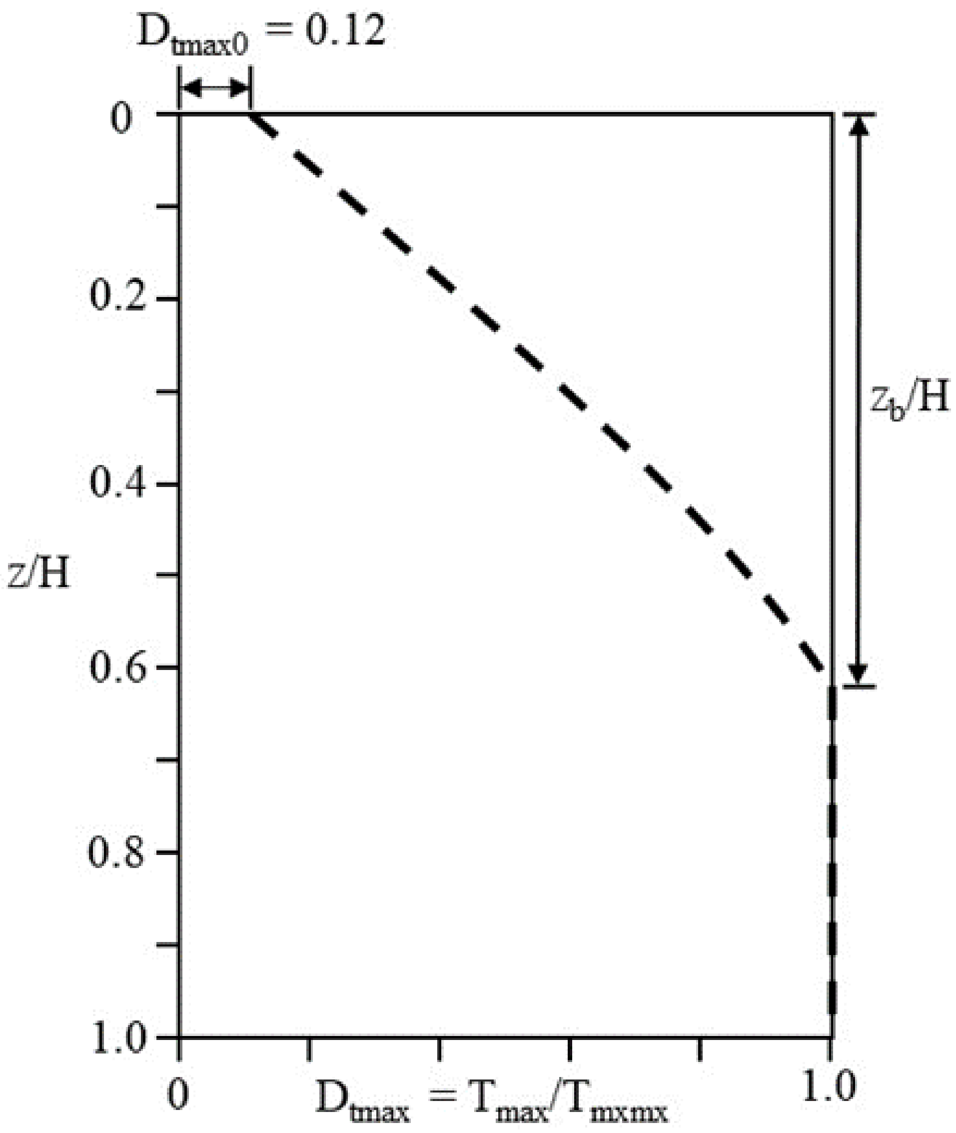
Stiffness Method ⟶ $T_{max} = S_v\,(\gamma_r H D_{tmax})\, K_a\, \Phi_g$

$$\Phi_g = 0.16\,(S_{global}/P_a)^{0.26}$$

$S_{global} = \Sigma J/H$
= global reinforcement stiffness
J = reinforcement stiffness
H = height of wall
P_a = atmospheric pressure

Only new input needed is 1,000 hr, 2% secant reinforcement stiffness - can be obtained from published AASHTO NTPEP reports (and Allen and Bathurst 2019)

T_{max} Distribution



For $z < z_b$:

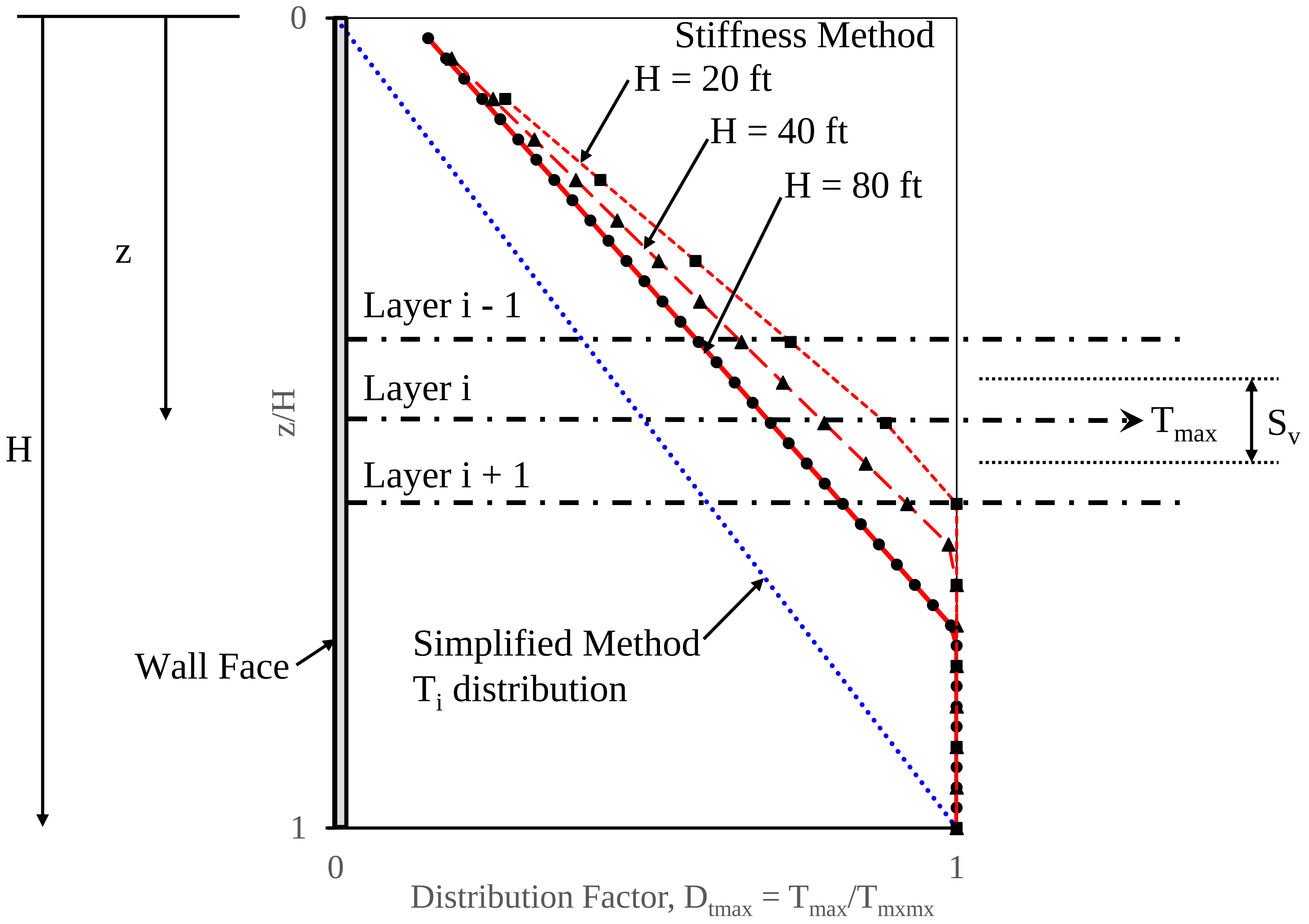
$$D_{t\max} = D_{t\max 0} + \left(\frac{z}{z_b}\right)\left(1 - D_{t\max 0}\right)$$

For $z \geq z_b$:

$D_{tmax} = 1.0$

$$z_b = C_h\left(H\right)^{1.2}$$

C_h = 0.32 when H is in ft
C_h = 0.40 when H is in meters

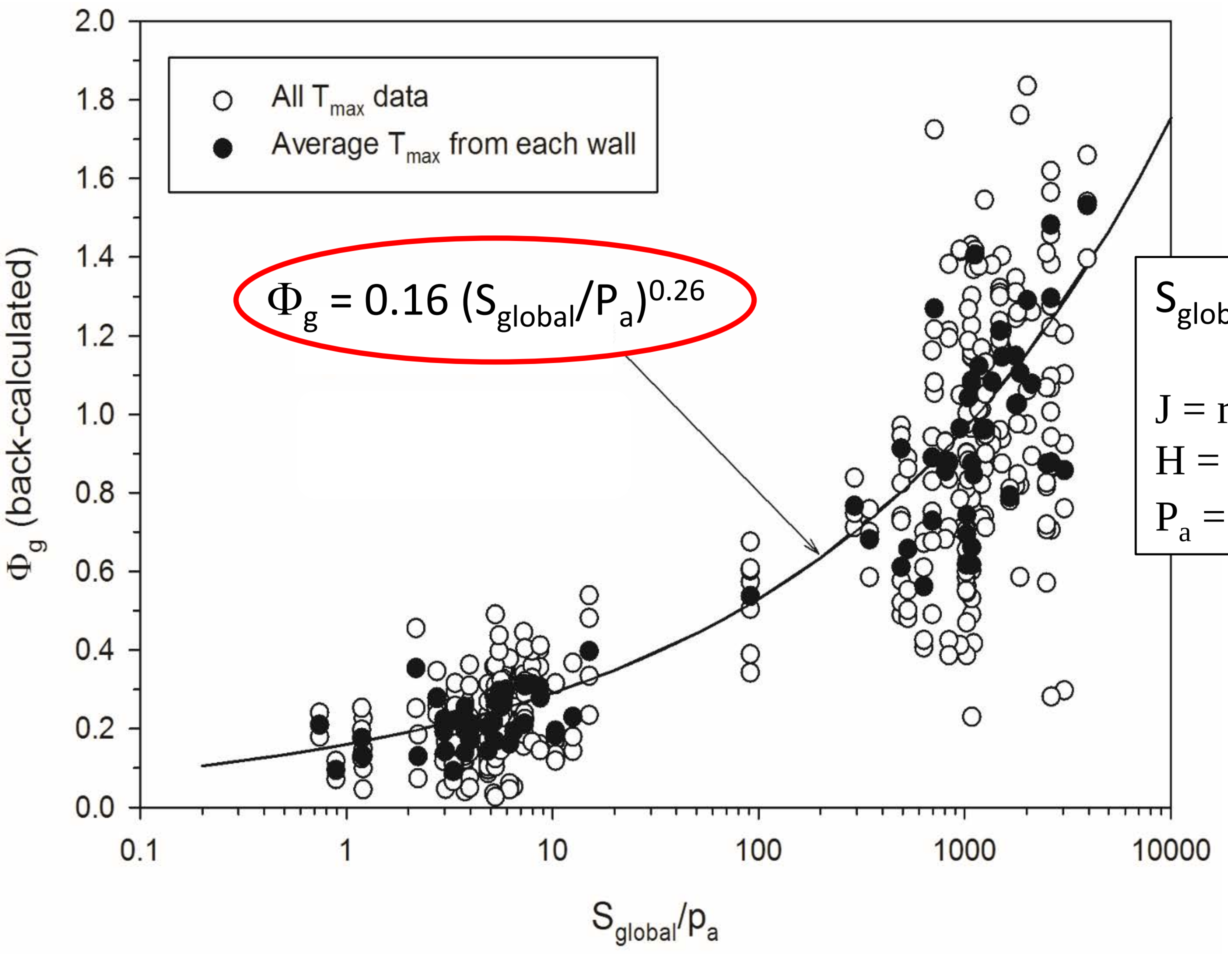


0
1
0
1
z/H
Distribution Factor, $D_{tmax} = T_{max}/T_{mxmx}$
Stiffness Method
H = 20 ft
H = 40 ft
H = 80 ft
Layer i - 1
Layer i
Layer i + 1
T_{max}
S_v
z
H
Wall Face
Simplified Method
T_i distribution

Back-calculation of Global Stiffness Factor Φ_g

$$T_{max} = S_v\,(\gamma_r H D_{tmax} + \gamma_f (H_{ref}/H)\,S)\,K_{avh}\,\Phi_{fb}\,\Phi_g\,\Phi_{fs}\,\Phi_{local}\Phi_c$$

$$\Phi_g = T_{max}\,(\text{measured}) / [\,S_v\,(\gamma_r H D_{tmax} + \gamma_f (H_{ref}/H)\,S)\,K_{avh}\,\Phi_{fb}\,\Phi_{fs}\,\Phi_{local}\Phi_c\,]$$



$S_{global} = \Sigma J/H$

$= $ global reinforcement stiffness

J = reinforcement stiffness

H = height of wall

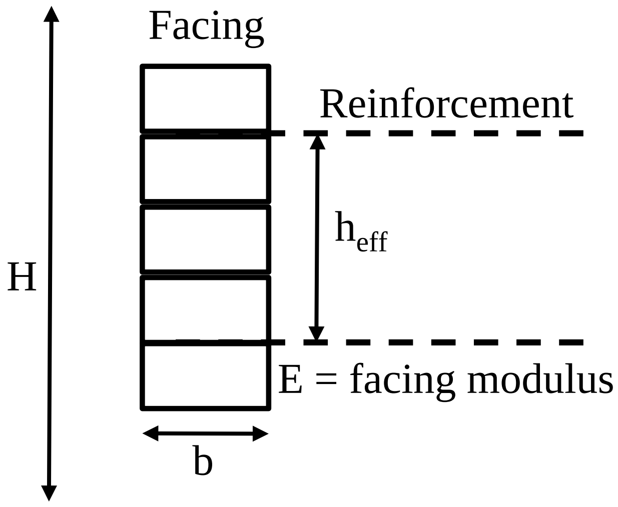
P_a = atmospheric pressure

EQUATION EQUIVALENCY

$$T_{max} = S_v \sigma_v K = S_v(\gamma_r z + \gamma_f S)\, K_a (K_r/K_a)$$

Facing stiffness factor

$$T_{max} = S_v\, (\gamma_r H D_{tmax} + \gamma_f (H_{ref}/H)\, S)\, K_{avh}\, \Phi_{fb}\, \Phi_g\, \Phi_{fs}\, \Phi_{local}\, \Phi_c$$



$$\Phi_{fs} = \eta((S_{global}/p_a)F_f)^{\kappa}$$

$$F_f = \frac{1.5H^3 p_a}{Eb^3 (h_{eff} / H)}$$

EQUATION EQUIVALENCY

$$T_{max} = S_v \sigma_v K = S_v(\gamma_r\, z + \gamma_f\, S)\, K_a (K_r/K_a)$$

Facing batter factor

$$T_{max} = S_v\, (\gamma_r H D_{tmax} + \gamma_f (H_{ref}/H)\, S)\, K_{avh}\, \Phi_{fb}\, \Phi_g\, \Phi_{fs}\, \Phi_{local} \Phi_c$$

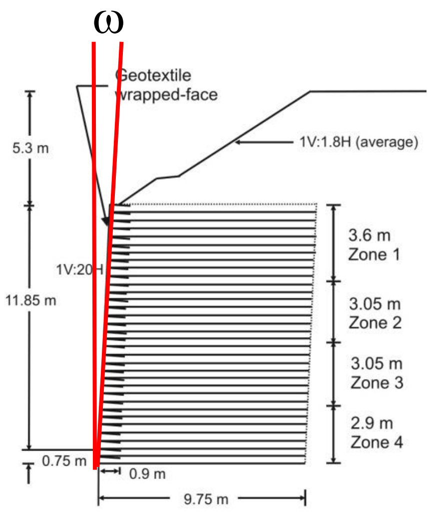
Corrects for the influence of wall facing batter.

If ω = 0 (vertical wall) then Φ_{fb} = 1

If ω > 0 (battered wall) then Φ_{fb} < 1

$$\Phi_{fb} = \left(\frac{K_{abh}}{K_{avh}}\right)^d$$

and d = 0.4

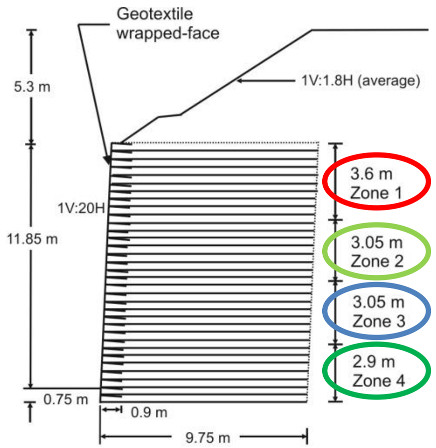


EQUATION EQUIVALENCY

$$T_{max} = S_v \sigma_v K = S_v(\gamma_r\, z + \gamma_f\, S)\, K_a (K_r/K_a)$$

Local reinforcement stiffness factor

$$T_{max} = S_v\,(\gamma_r H D_{tmax} + \gamma_f (H_{ref}/H)\, S)\, K_{avh}\, \Phi_{fb}\, \Phi_g\, \Phi_{fs}\, \Phi_{local}\, \Phi_c$$



$$S_{local} = \left(\frac{J}{S_v}\right)$$

$$S_{localave} = \Sigma \left(\frac{J}{S_v}\right) / n$$

$$\Phi_{local} = \left(\frac{S_{local}}{S_{localave}}\right)^a$$

a = 0.5 for geosynthetics
a = 0 for steel

Note: this factor is usually required for very tall walls.

n = total number of layers

Application of the Stiffness Method to MSE Wall Design

- Limit states to be considered
  - Soil “failure” (Service Limit)
  - Reinforcement rupture (Strength Limit)
  - Connection failure (Strength Limit)
  - Pullout (Strength Limit)
- Amount of reinforcement needed
  - Soil failure limit – usually controls
  - Connection failure – controls only if connection is very inefficient
  - Pullout – may control for polymer straps

Load and Resistance Factors for Stiffness Method

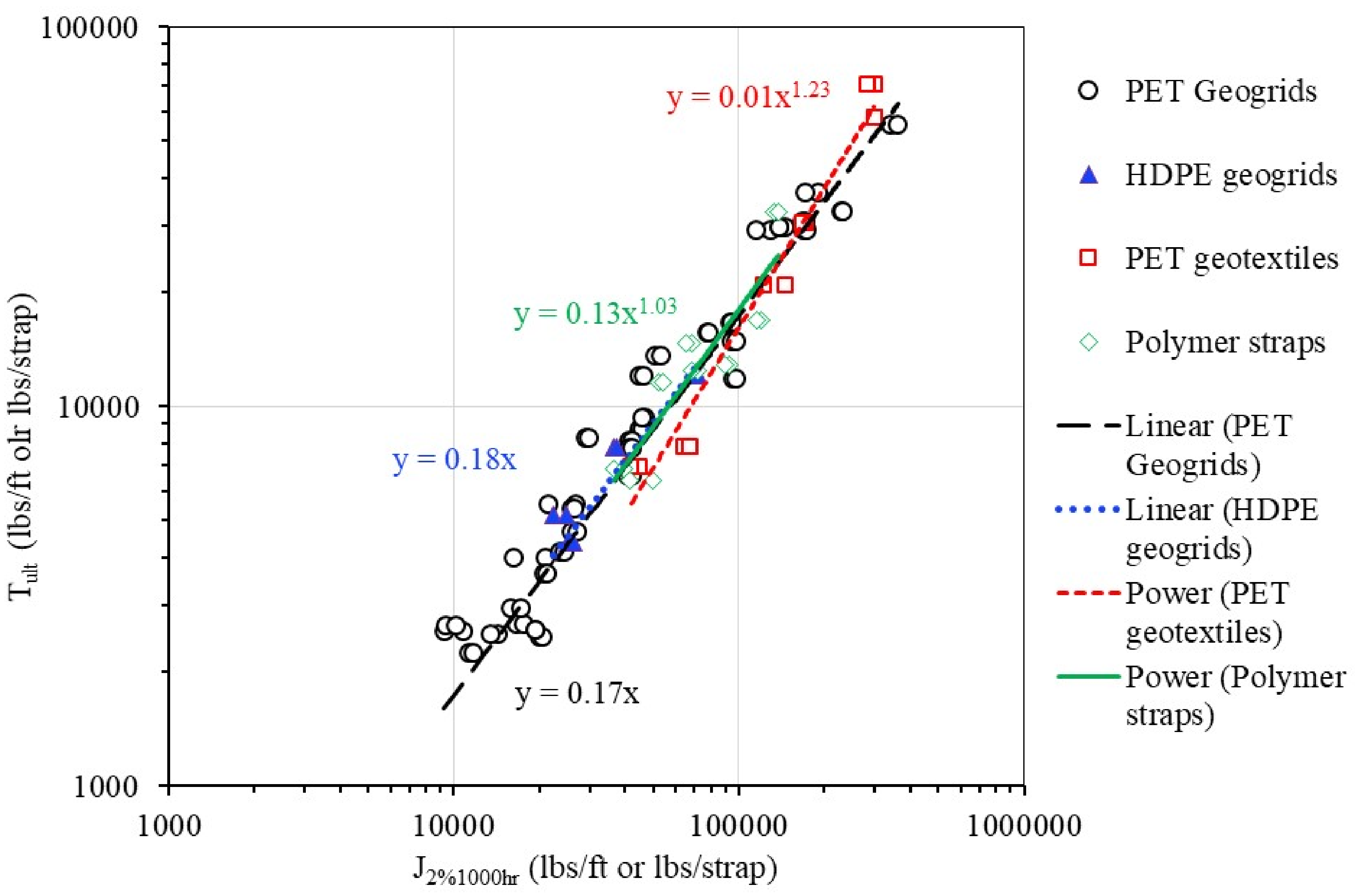
	Limit State	(T_{max}) Load Factor γ_{EV}, γ_{con} and γ_{sf}	Resistance Factor φ_{rr} , φ_{cr} and φ_{sf}
Geosynthetic	Reinforcement and connection failure – geogrids and geotextiles	1.35	0.80
	Reinforcement and connection failure – polymer straps	1.35	0.55
	Soil failure	1.2	1.0
	Pullout (default model in AASHTO)	1.35	0.70

Stiffness Method Soil Failure Limit State:

- Working stress conditions may not apply if there is a contiguous failure surface through the reinforced soil zone.
- As specified in AASHTO (2020), keep factored peak reinforcement strains in wall < 2% for stiff faced walls, and <2.5% for flexible faced walls, to maintain (soil) working stress conditions.
- These target maximum strains are 0.5% strain more conservative than recommended in the Allen and Bathurst (2018) ASCE paper.

$$\varepsilon_{rein} = \frac{\gamma_{p-EVsf} T_{max}}{\phi_{sf} J_i} \leq \varepsilon_{mxmx}$$

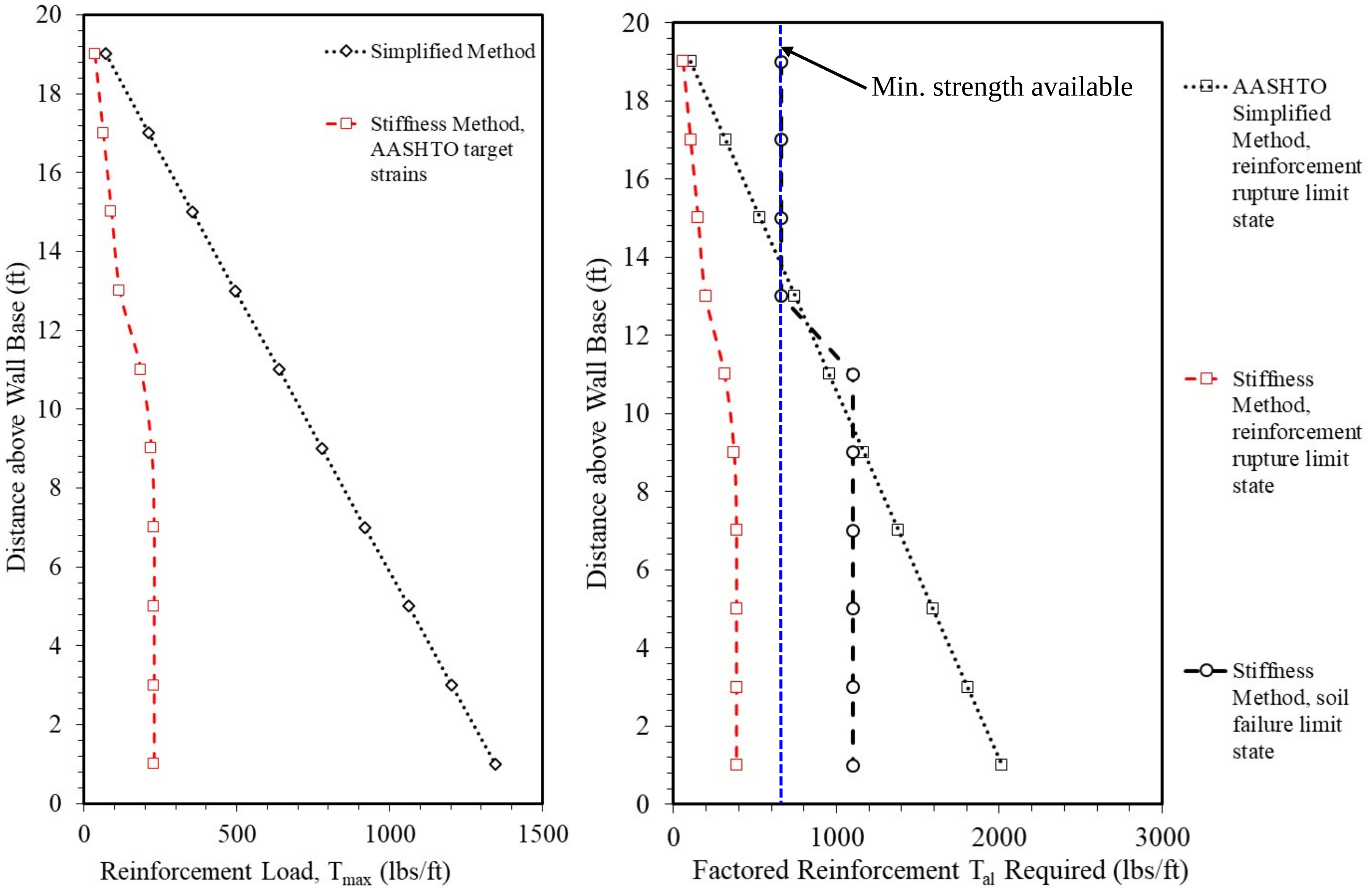
Relating Creep Stiffness to Tensile Strength



Design Approach

- Soil failure limit state usually controls design (start with this)
  - Determine reinforcement stiffness needed for each layer to meet maximum allowed reinforcement strain
  - If Φ_{fs} = 1.0, use strain limit for flexible walls even for stiff faced wall systems (i.e., per AASHTO, 2.5%)
  - Estimate reinforcement ultimate strength needed to obtain required stiffness
- Then check reinforcement rupture, connection rupture, and pullout using stiffness needed for soil failure limit to calculate T_{max}

PET geogrid, AASHTO design, $T_{ultconn} = 1.0T_{ult}$



Range of Applicability for the Stiffness Method

Height Range: 15 to 35 ft for modular block facing, 13 to 41 ft wrapped facing
Average Soil Surcharge: 0 to 8 ft
Facing batter from vertical: 0 to 27^o
Triaxial or direct shear ϕ: 24 to 47^o
Cohesion: 0 to 350 psf
Fines content: 0 to 91%
Vertical spacing of reinforcement (S_v): 0.8 ft to over 3 ft
R_c: 0.18 to 1.0
S_{global} for geosynthetics = 2,500 to 192,000 psf

If have typical conditions for which compound stability could control, must check results with limit equilibrium analysis (e.g., steep toe slope, continuous sloping soil surcharge above wall, foundation on top of wall, weak or compressible foundation soil).

<u>This method does not work well for MSE walls supporting bridge footings, as the soil failure limit state design becomes overly conservative.</u>

Important References

Allen, T.M., and Bathurst, R.J., 2015, “Improved Simplified Method for Prediction of Loads in Reinforced Soil Walls,” *ASCE Journal of Geotechnical and Geo-environmental Engineering*, DOI: http://dx.doi.org/10.1061/(ASCE)GT.1943-5606.0001355, 14 pp., plus Supplemental Data.

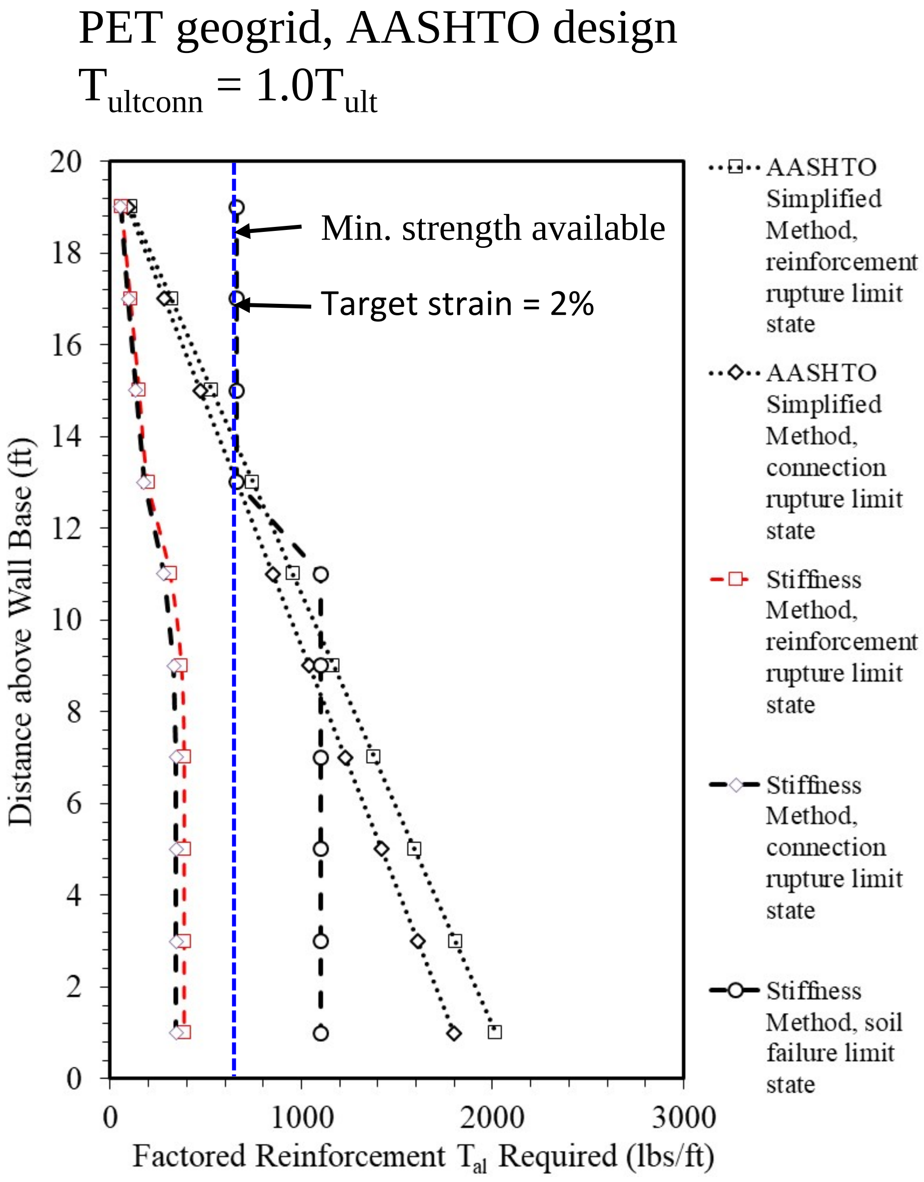
Allen, T.M., and Bathurst, R.J., 2018, “Application of the Simplified Stiffness Method to Design of Reinforced Soil Walls,” ASCE Journal of Geotechnical and Geo-environmental Engineering, DOI: http://dx.doi.org/ 10.1061/(ASCE)GT.1943-5606.0001874, 13 pp., plus Supplemental Data.

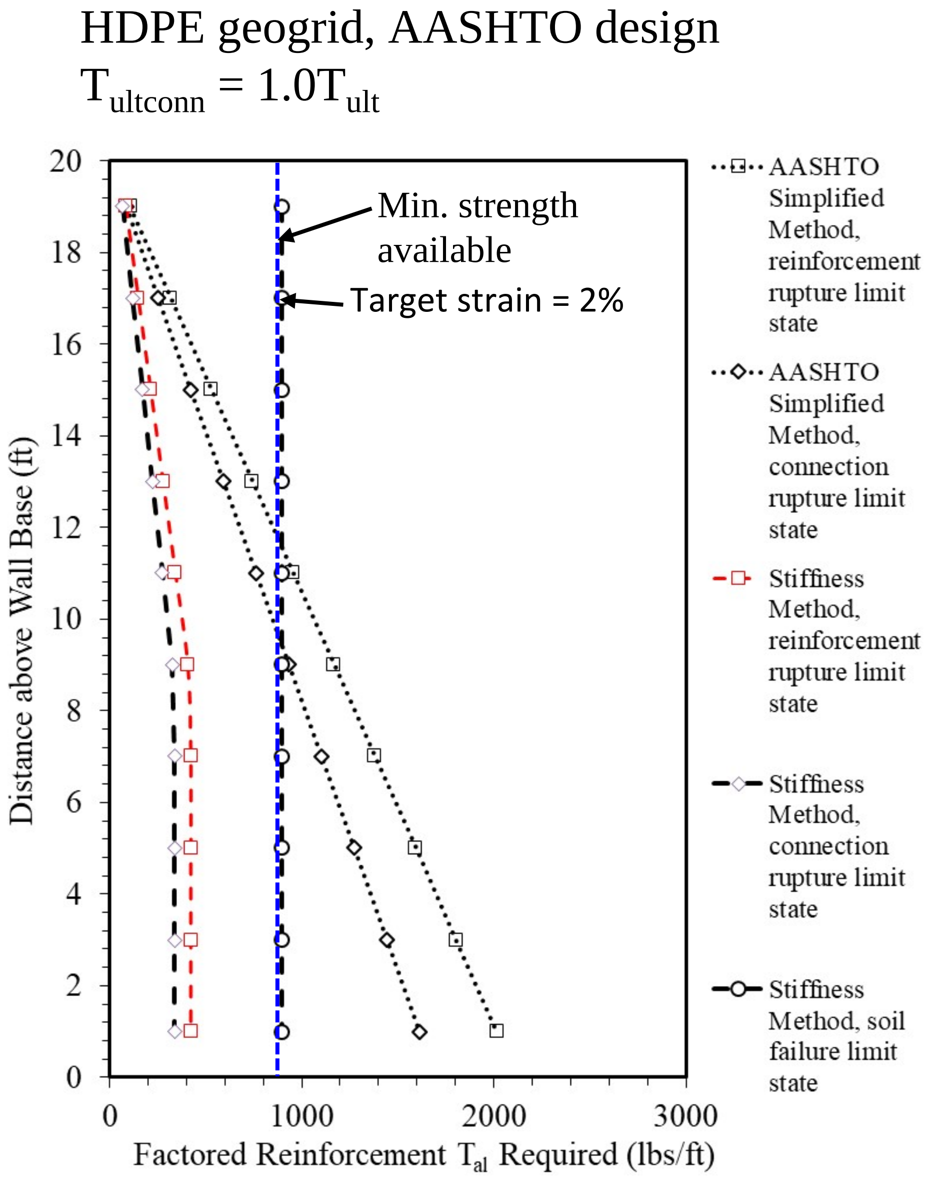
Bathurst, R.J., Allen, T.M., Lin, P., and Bozorgzadeh, N., 2019, “LRFD Calibration of Internal Limit States for Geogrid Walls,” *ASCE Journal of Geotechnical and Geo-environmental Engineering*, DOI: http://dx.doi.org/10.1061/(ASCE)GT.1943-5606.0002124, 13 pp., plus Supplemental Data.

Allen, T.M., and Bathurst, R.J., 2019, “Geosynthetic Reinforcement Stiffness Characterization for MSE Wall Design,” Geosynthetics International, Vol. 26, No. 6, https://doi.org/10.1680/jgein.19.00041, pp. 592-610, plus Supplemental Material.

Design Impact Summary for Stiffness Method Relative to Previous Design Practice (i.e., Simplified Method)

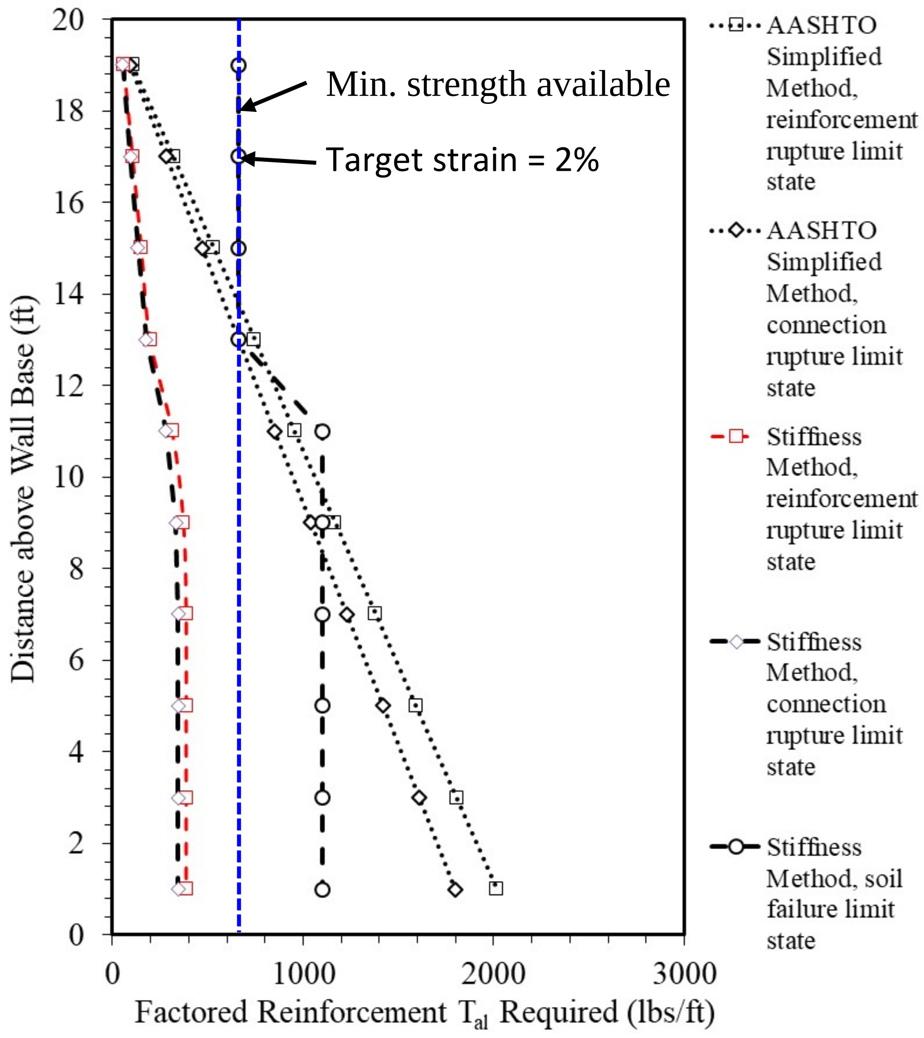
Design Required for 20 ft High Modular Block Faced Wall



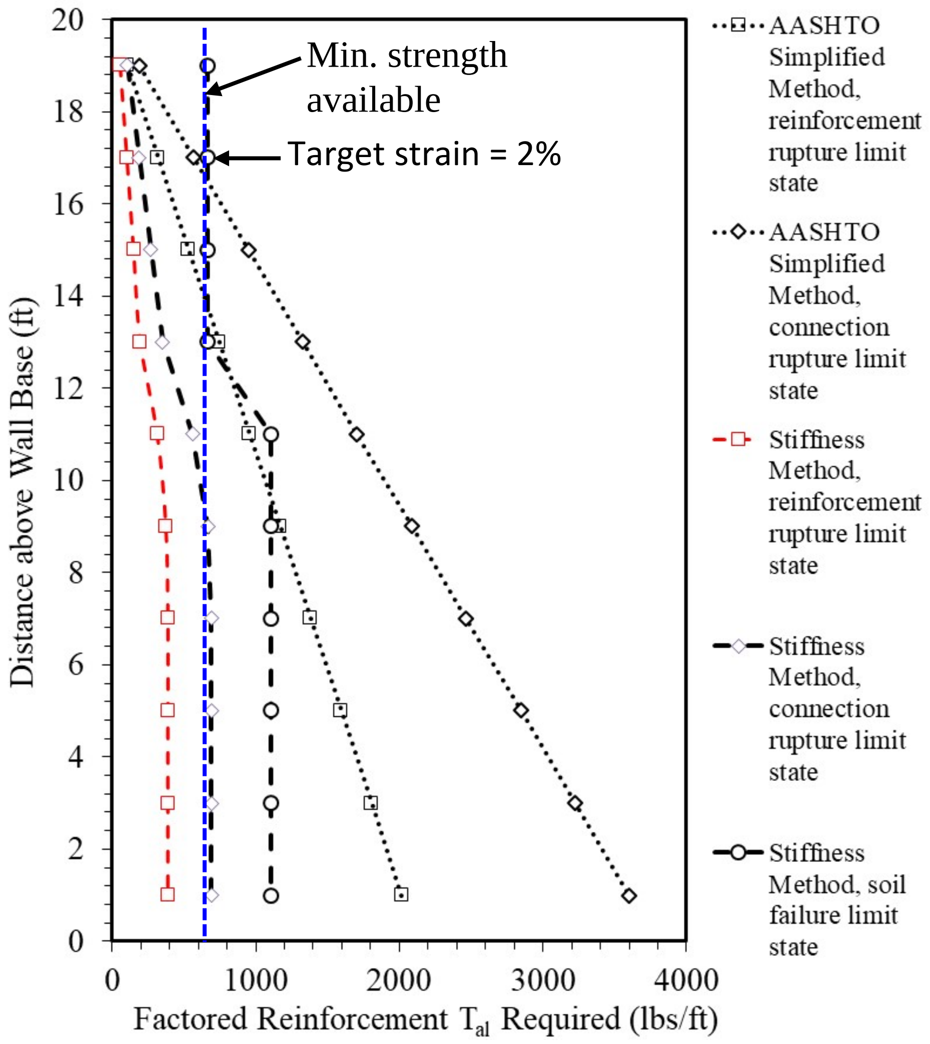


Design Required for 20 ft High Modular Block Faced Wall

PET geogrid, AASHTO design
$T_{ultconn} = 1.0T_{ult}$



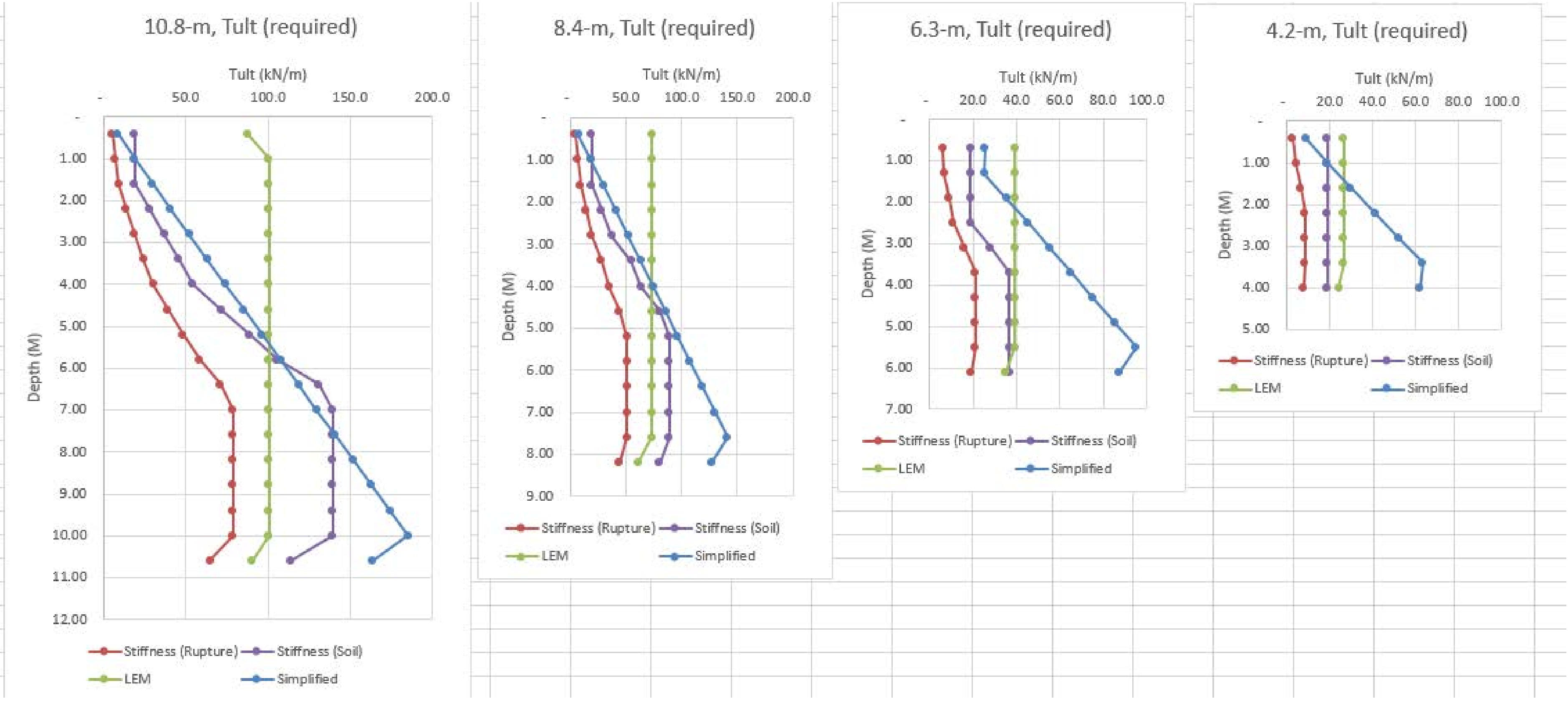
PET geogrid, AASHTO design
$T_{ultconn} = 0.5T_{ult}$



Impact on Design – Extensible reinforcements

Updating Designs for Mechanically Stabilized Earth Walls in AASHTO

Illustration of some of the design differences for specific parameters.



Source: FHWA

Updating Designs for Mechanically Stabilized Earth Walls in AASHTO

Impact on Design – Extensible reinforcements

1. More accurate model to represent loading of reinforcement
2. Generally require less reinforcement for walls under 25-ft
3. Little change for walls over 25-ft
4. New methods allow us to take into account
   - Facing contribution
   - Variable lengths of reinforcements

QUESTIONS?

Today's Panelists

#TRBWebinar

Moderator: Jie Han,
University of Kansas

ADAMA ENGINEERING

UNIVERSITY OF DELAWARE

Dov Leshchinsky

Daniel Alzamora

U.S. Department of Transportation
Federal Highway Administration

Tony Allen

Washington State Department of Transportation

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