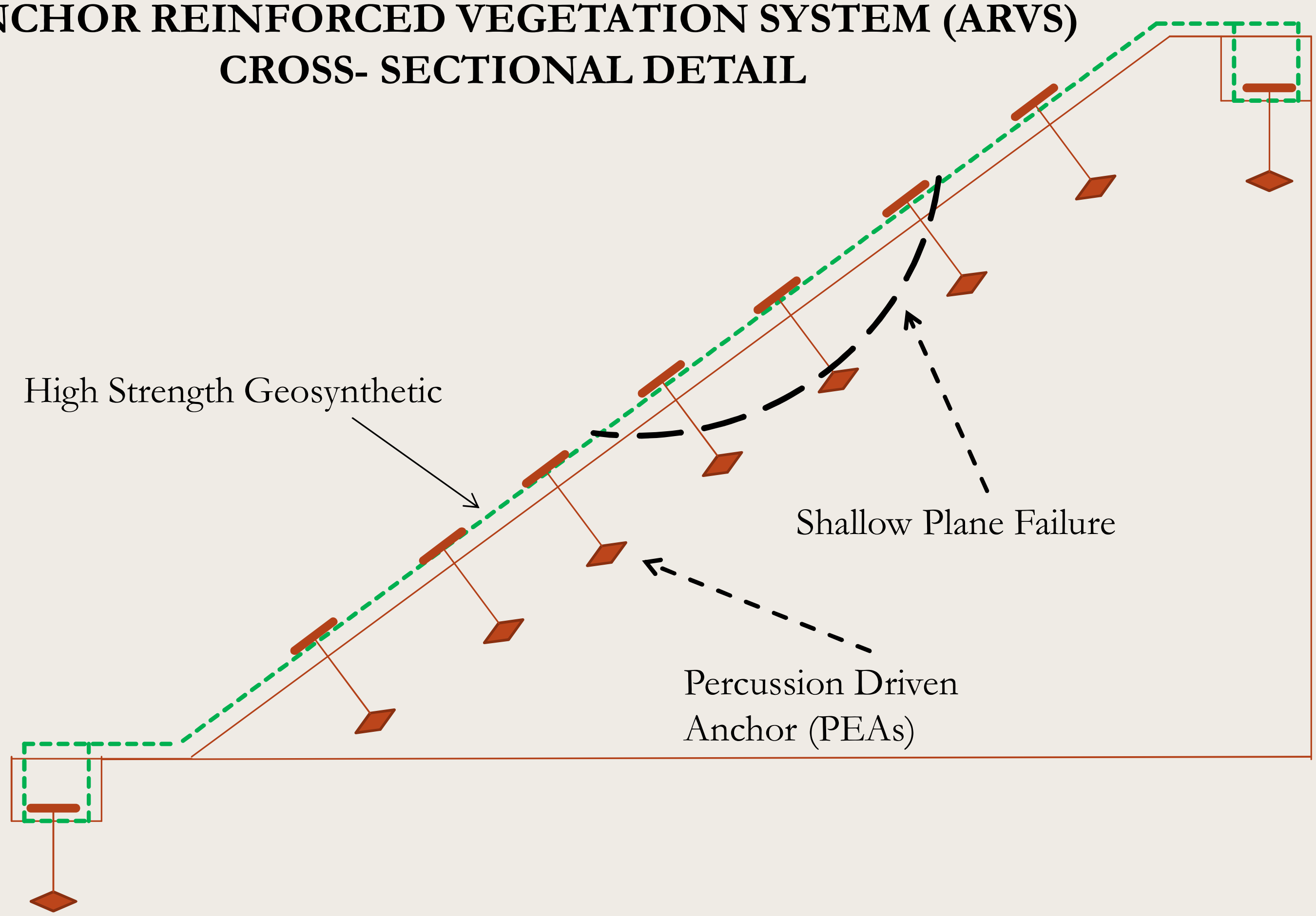

Geotechnical Design

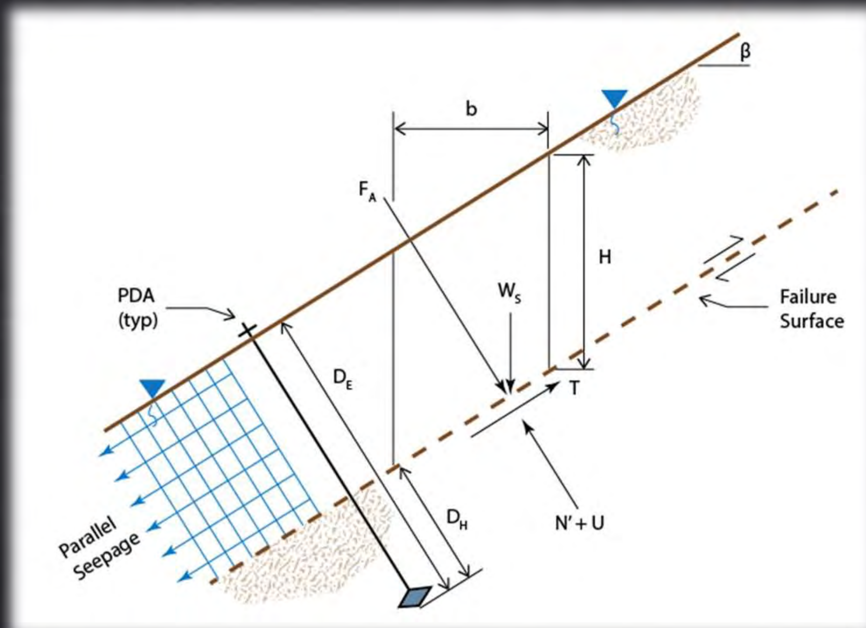
TYPICAL SHALLOW PLANE FAILURE
ANCHOR REINFORCED VEGETATION SYSTEM (ARVS)
CROSS- SECTIONAL DETAIL




Stabilized Slope

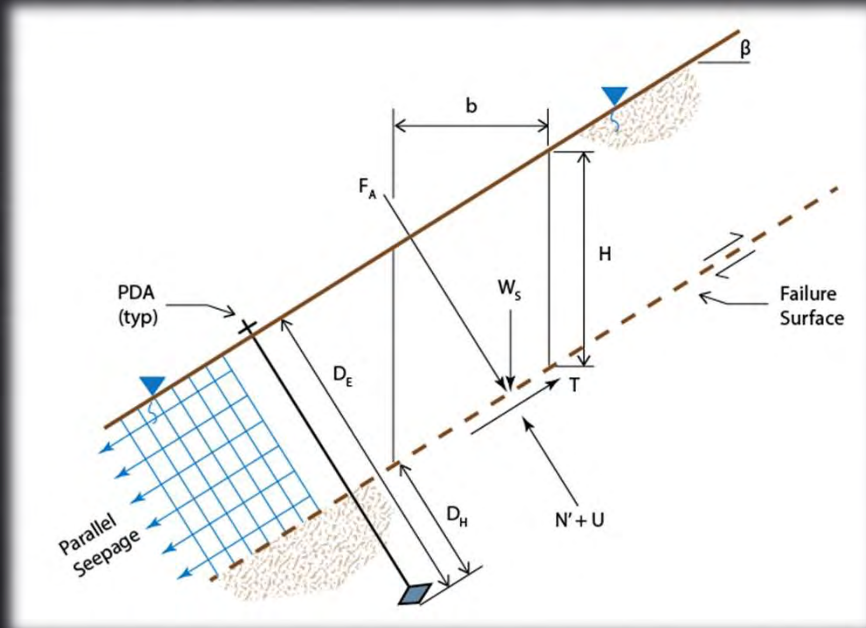
ARVS Theory and Benefits

- Interaction with vegetation for soft armor and reinforcement
- Deep-seated anchors that provide downforce to surficial soil mass, improving stability
- Immediate erosion protection
- Long-term erosion protection

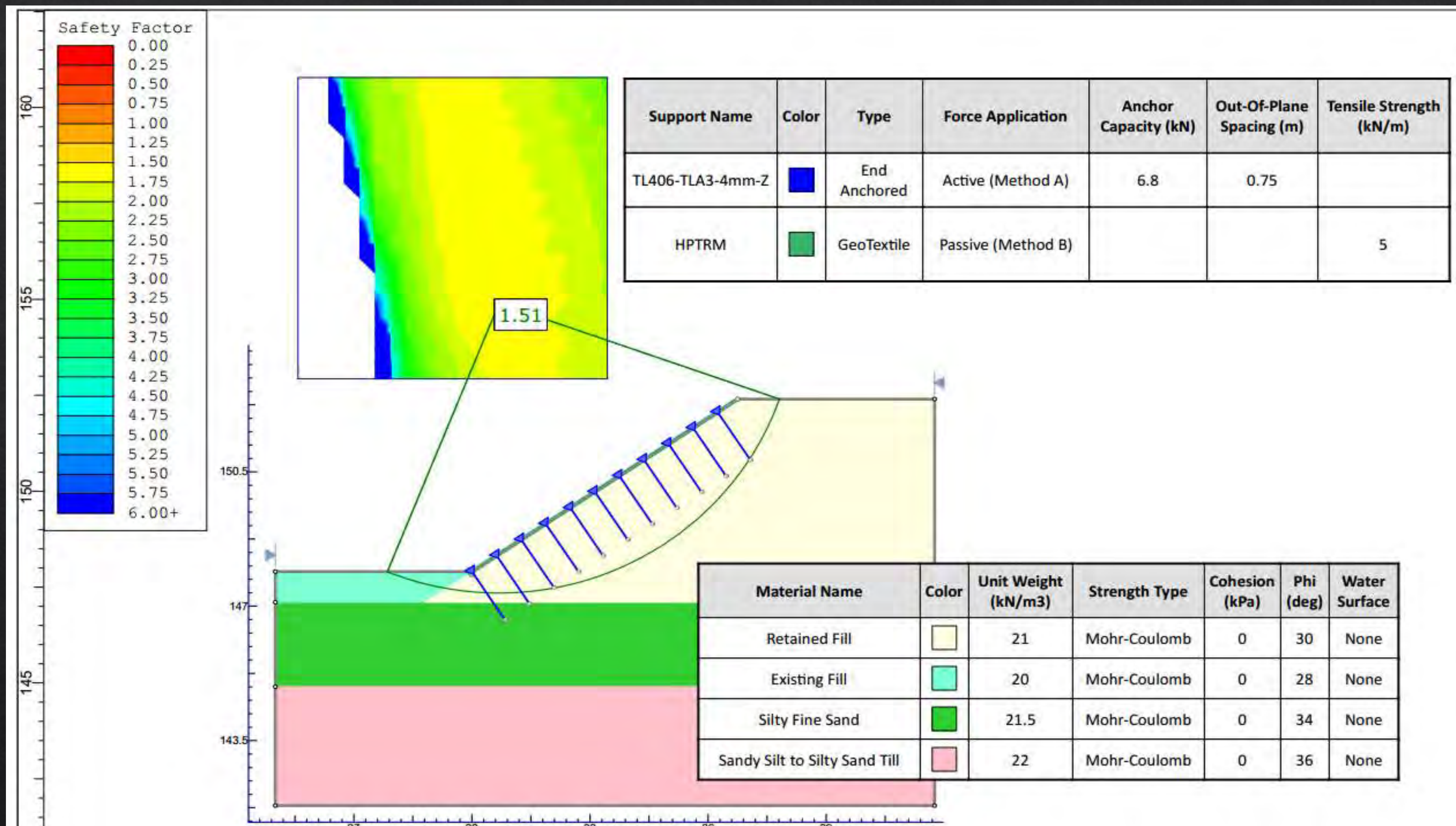


ARVS Theory and Benefits

- Sum Forces to Determine the Limit of Stability
- Total Anchor Force Distributed Overt the Unit Width
- Fabric Transfers Load to Soil Between Anchors



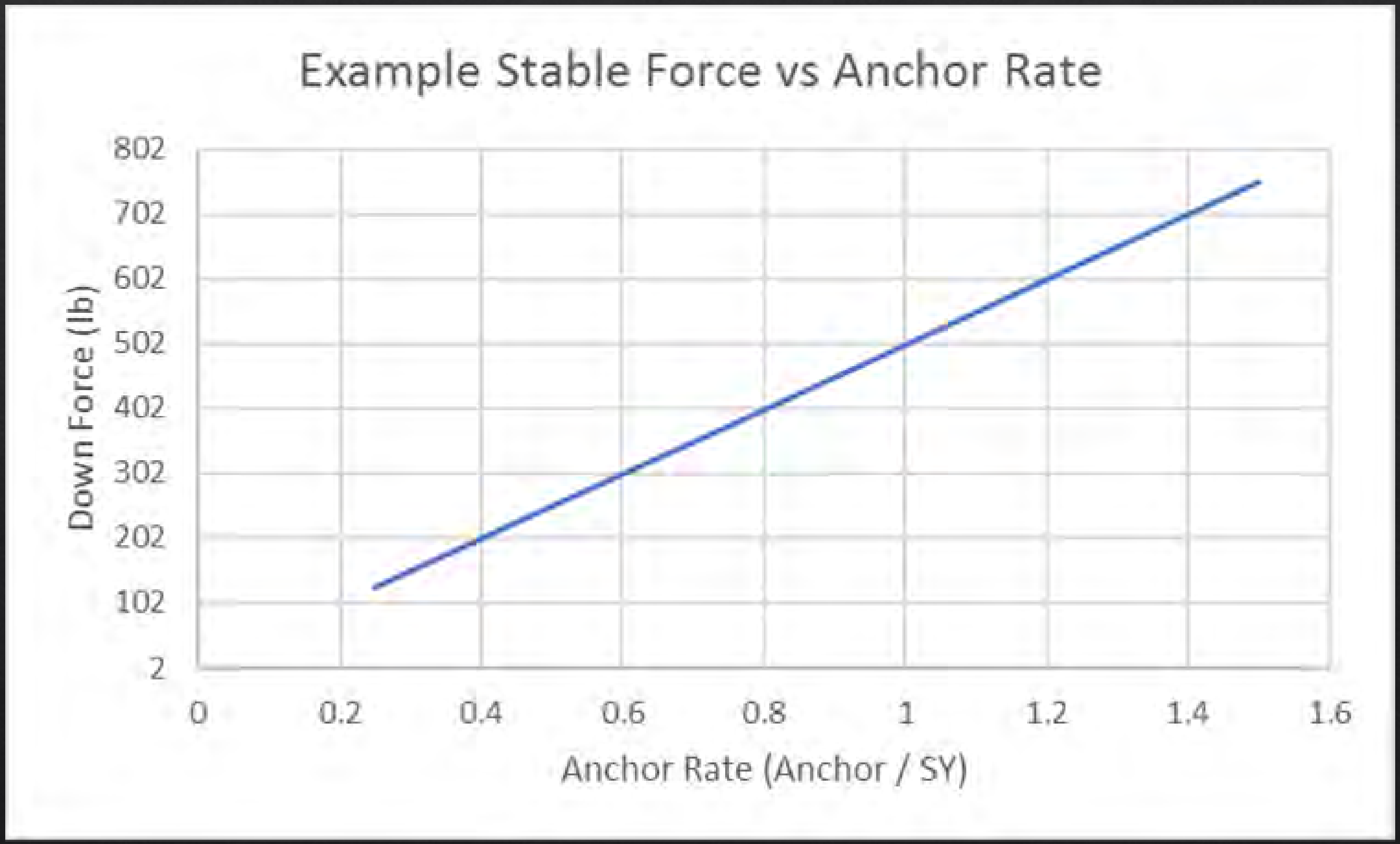
Limit Equilibrium Analysis



Support Name	Color	Type	Force Application	Anchor Capacity (kN)	Out-Of-Plane Spacing (m)	Tensile Strength (kN/m)
TL406-TLA3-4mm-Z		End Anchored	Active (Method A)	6.8	0.75	
HPTRM		GeoTextile	Passive (Method B)			5

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface
Retained Fill		21	Mohr-Coulomb	0	30	None
Existing Fill		20	Mohr-Coulomb	0	28	None
Silty Fine Sand		21.5	Mohr-Coulomb	0	34	None
Sandy Silt to Silty Sand Till		22	Mohr-Coulomb	0	36	None

Design Example



Anchor Reaction and Deformation

- Definition of performance
  - As the soil mass is displaced, the system deforms
  - Fabric strength and elongation effects deformation with respect to loading
  - Testing conducted to determine deflection at anchor working load
  - Upgraded fabric strength and elongation properties reduces deformation at load, thus allowing greater distance between anchors

ARVS Theory and Benefits

Other Methods

- HEC – 18
  - Determination of Pier and Abutment Scour
  - Hydraulics and Scour Prediction
- HEC – 23
  - Scour Countermeasures
  - Riprap, Concrete Armor Units, Concrete
- Coastal / Levee
  - Non - Equilibrium States and Site Specific Design

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- www.kahoot.it

Case Study 1

- Project Basics
  - Road Cut Slope
  - 2:1 Slope, 10′ High
  - Clay Soil, Georgia
  - R = 400, LS = 2.5, K =0.25
  - Remote Road, but Mitigation Required
  - Roadway Drainage / Rainfall From Slope
  - Roadside/Slope Toe Ditch – 1.5 psf

- Option A
  - HECP on Slope
- Option B
  - HECP on Slope and Degradable RECP in Channel
- Option C
  - Degradable RECP on Slope, Permanent RECP in Channel
- Option D
  - HECP on Slope, ARVS in Channel

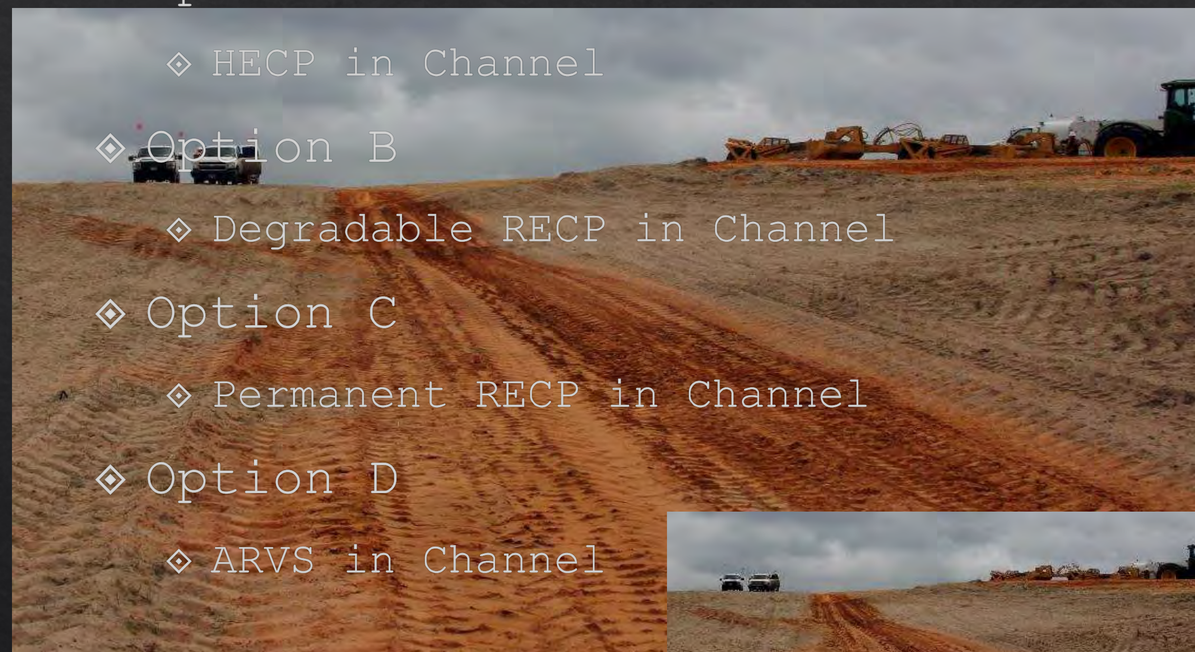
Case Study 1 – Option B

- Revegetation Potential – High
- Risk Profile – Low, Especially with Vegetation Establishment Likely Strong and Low Erodibility Soil
- Slope Yield Estimate ~ 250 T/AC/Yr ≈ C Factor Test, HECP Reduces Sediment Yield Approximately 99% in this Case
- Channel Shear Estimated at 1.5 psf, Good Stand of Vegetation Suitable for this Requirement, Especially in Low-Risk Scenario
- Option C – Upgrade for Greater Conservatism

Case Study 2

- Project Basics
  - Steep Drainage Channel on Reclamation Project
  - Very Fine Sand (almost dust)
  - Storm Drainage Yields 4.5 psf
  - Reduction of Sediment Yield Required for Permit/Closure
  - Solution Must Be Permanent without Rock, Sod and Irrigated

- Option A
  - HECP in Channel
- Option B
  - Degradable RECP in Channel
- Option C
  - Permanent RECP in Channel
- Option D
  - ARVS in Channel



Case Study 2 – Option C

- Revegetation Potential – High
- Regulation Requires Performance
- Soil Erodibility – High
- Hydraulic Forces – Higher than Natural Vegetation Can Withstand
- Permanent Installation
- Permanent RECP Required

Case Study 2 – Option C

Case Study 3

- Project Basics
  - Steep Slope in Residential Neighborhood
  - Drainage from Residential Lots and Rainfall
  - Located in South Carolina – Vegetation Establishment Prospect High

Case Study 3 – Option D

- Site Originally Utilized Degradable RECP
- Heavy Saturation Caused Mass Wasting
- Consequences of Failure High, Homeowner Involvement
- Likely Foot Traffic and Wildlife Traffic
- Ideal Solution Would Route Drainage Off the Slope and Utilizes ARVS for Geotechnical Reinforcement

Closing Thoughts

- Know What Problem Needs to be Solved
- Let that Knowledge Drive the Development of a Risk Envelope
- Consider Multiple Solutions in a Multi-Faceted Approach
- Use Relevant Design Methods to Ensure Appropriate Factor of Safety
- Let the Wide Spectrum of Tools Work for You, Knowing Each Tool is more a Specialist than a Generalist

Conclusion & Questions