

Case Studies on Rockfall Mitigation & Rock Slope Stabilization in CA, TN, & VA



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Eastman Lake, CA

USACE

Cut Slope created in 70's

90' tall, 850' long section with continuous failures





- CR 29 in Eastman Lake Park
- Closely to moderately fractured with joint spacing between 3 to 10 feet.
- Heavy rains caused portions of the slope to fail in 1996-1997
- Winter of 2010-2011 large blocks (30'x20') had fallen on the road.
- Rock dowels vs. spin-lock
- 10'/14' to 20'/24'
- 42kips to 59.3 kips

Double twist wire mesh cable system





Access!









Army Corp predicted 316 bolts (4,108 LF) for the lower slope and 108 bolts (1,260 LF) for the mid slope.



USACE reports no further dilation or failure of the rock slope since completion in 2011.





WE ULTRA ROOM

297027

CF-60-C3

Brokebush
Thank You!

2874A1



Grundy County, TN Emergency Repair



Sandstone underlain by a very soft, decomposed shale containing clay seams and coal layers











Blount County, TN - SR-73 Emergency Slide Repair (TDOT)





Narrow Roadway:

All work completed from
the inboard lane of SR-73

Working Bench:

- Drilled from below with bench up to 10-ft.
- Max Reach: 35-ft
- Increased Drill Rate





Crane Basket:

Used to drill all anchors at heights > 35-ft



Safety:

- Rock Fence in place to protect traffic lane



Hybrid Barrier:

- Catch additional debris that may fall from flatter slope above

Tecco® Mesh:

- 5'H x 5'V Pattern
- 5-25' Embedment Lengths





Height Increase:

- Increased 20' in some areas after scaling
- Called Frank Amend - Geobruigg Rush Shipped 10,000 SF of Tecco® Mesh to keep the project on schedule



Shotcrete:

- Area with highly weathered rock
- Erosion concerns







Carroll County, VA - SR-765 Emergency Rock Slide Repair (VDOT)





- Drilled into the boulders and injected an Expansive Demolition Agent



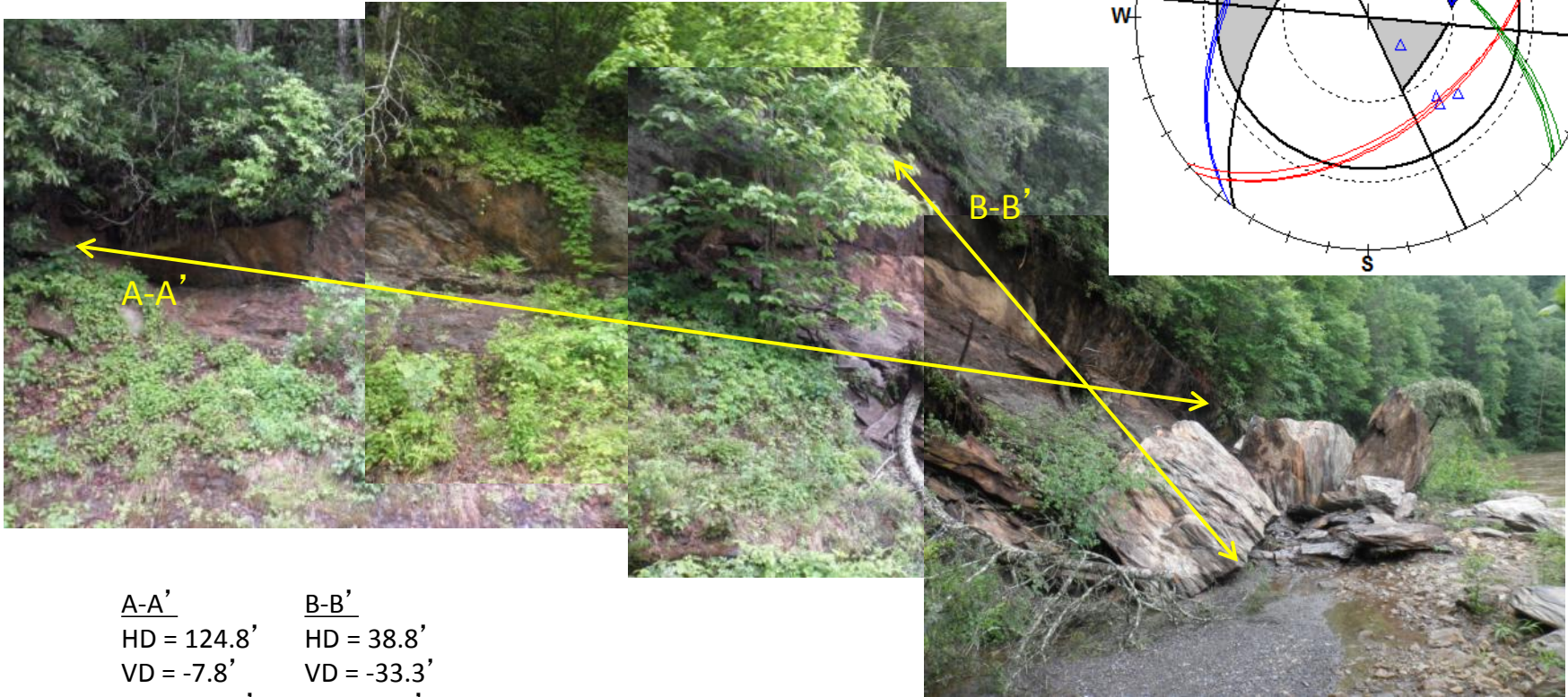
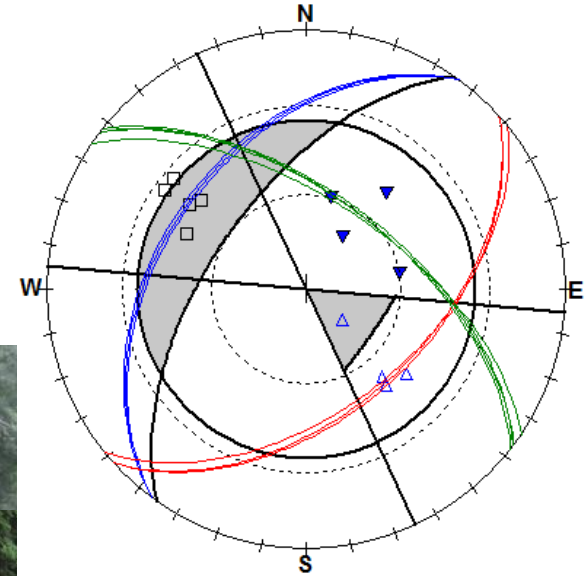
- Left overnight the expansive agent breaks the block into manageable pieces
- VDOT was able to haul off the broken boulders

3 Repair Options

1. Retaining Wall Buttress
2. Post-Tensioned Rock Bolts
3. Ignore / Clear Rock from Roadway



Joint Set I – Blue
 Joint Set II – Red
 Joint Set III - Green



A-A'

HD = 124.8'

VD = -7.8'

SD = 125.1'

INC = -3.6°

AZ = 228.7°

B-B'

HD = 38.8'

VD = -33.3'

SD = 51.1'

INC = -40.7°

AZ = 279.0°

Site Survey:

- Skip Watts –Radford University
- Brendan Fisher – Fisher & Strickler Rock Engineering



<u>C-C'</u>	<u>D-D'</u>
HD = 6.8'	HD = 3.4'
VD = -16.2'	VD = -10.4'
SD = 17.5'	SD = 10.9'
INC = -67.8°	INC = -71.6°
AZ = 220.8°	AZ = 207.9°

Site Survey:

- Joint between unstable and stable material - 40 deg
- Upslope Distance – 50 feet



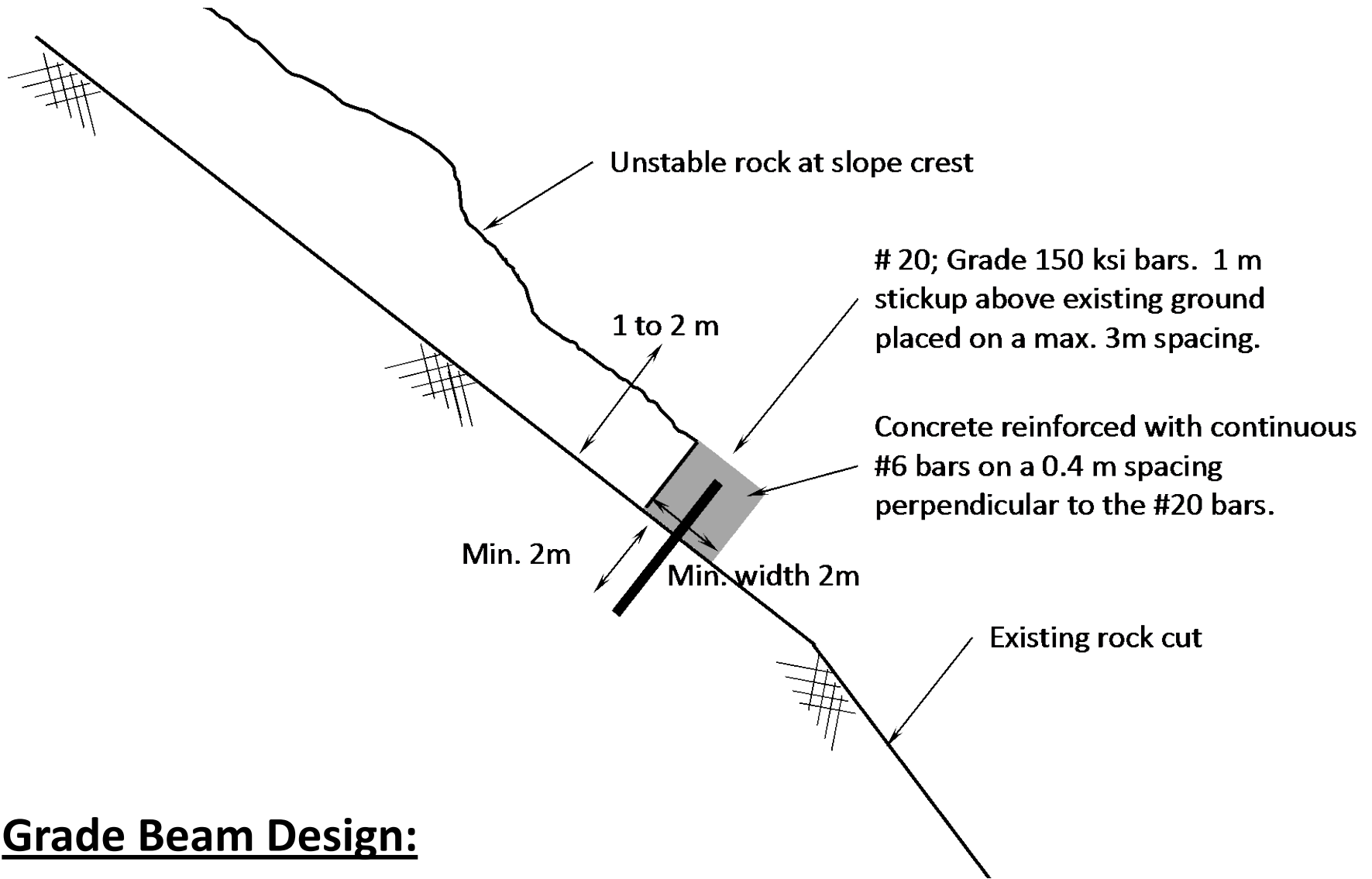
E-E'
 HD = 99'
 VD = -15'
 SD = 100'
 INC = -8.5°
 AZ = 227.4°

F-F'
 HD = 7.8'
 VD = -4.6'
 SD = 9.1'
 INC = -29.9°
 AZ = 97.6°

G-G'
 HD = 1.4'
 VD = -5.7'
 SD = 5.9'
 INC = -76.2°
 AZ = 128.7°

H-H'
 HD = 22.4'
 VD = -19.6'
 SD = 29.8'
 INC = -41.2°
 AZ = 319.5°

I-I'
 HD = 31'
 VD = -30'
 SD = 43'
 INC = -44.4°
 AZ = 264.3°



Grade Beam Design:

- Skip Watts –Radford University
- Used in Washington State

Grade Beam Design Allowed Our Crews to Work Safely Under Stabilized Material

Grade Beam Example: Washington State



Figure D-13

Grade beam design by Wyllie & Norrish for a WSDOT project



Grade Beam Example:
Washington State

Figure D-15

Grade beam design by Wyllie & Norrish for a WSDOT project



Construction:

- 150 L.F. of Repair
- 8' anchors w/ 5' drilled into stable material
- 4-ft Tall on Ends – 7-ft Tall in the Center



Shotcrete:

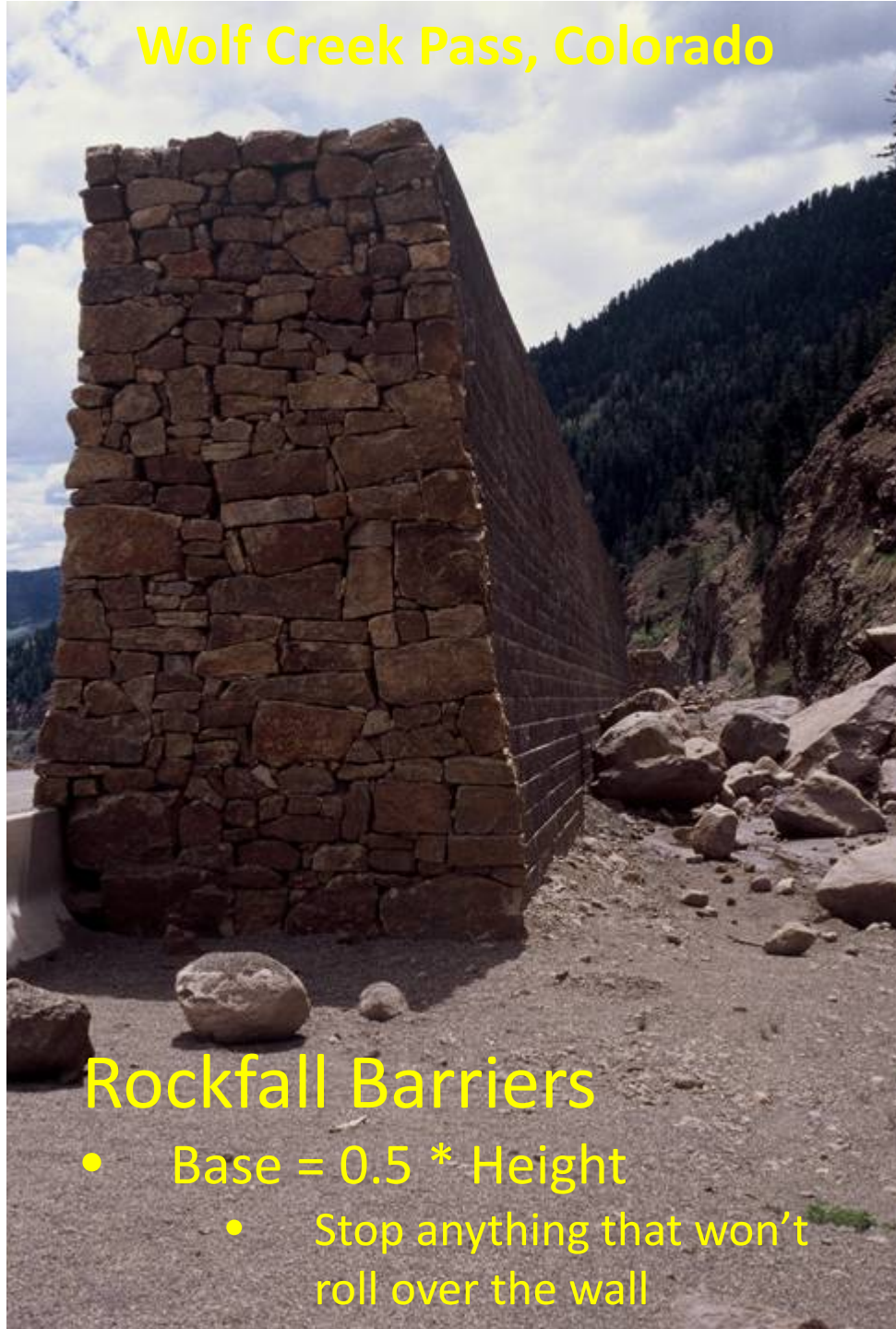
- Placed in 12-inch lifts
- Reinforced with Rebar and WWM







Wolf Creek Pass, Colorado



Rockfall Barriers

- Base = $0.5 * \text{Height}$
 - Stop anything that won't roll over the wall




- 5+ Million Foot-pound Impact
- 12' Diameter
- Fell from 75-100' upslope



Damage to Blocks, Structure Intact. Note that back portion of block remains adhered to backfill, preventing material loss

Wire Basket Faced GRS/GCS Rockfall Barrier





Tremendous Impact
Energy with No
Front Facing
Deformation

10+ Million Foot
Pound Impact



Structure impacted
by this rock falling
over 100 ft





Minimal Damage to
Upper Rows



- Back in Service After Minor Repairs
- Note: Color Difference – original block manufacturer went out of business