Emergency Landslide Mitigation & Restoration of US Hwy 441 - GRSM

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2016 Geohazard in Transportation Forum

Engineering America's Scenic Highways
Landslide Location

Scenic road between the towns of Gatlinburg, TN & Cherokee, NC
US Hwy 441 Landslide

- January 16, 2013
- Washed away a stretch of 250 feet.
- Triggered by heavy rainfall (9"")
Site Reconnaissance

January 16 - 21, 2013
EFLHD visited the site, completed the survey and initial geotechnical investigation.
Site Reconnaissance

Abandoned road above the failed slope
Site Reconnaissance

Snow storm following the slope failure
Contracting Methods

- **Phase I** – Emergency (letter) contract
- **Phase II** – Permanent Repair
Phase I Contract

- Emergency (Letter) Contract
- Remove debris
- Establish temporary access roads
- Place rock base
Phase II Contract

- Permanent Repair
- Fast and practical design
- Fast Construction
- Competent contractor with a proven record of success
Phase II Contract

- 2 Step Bidding Process
  - Step 1 - Request for Technical Proposals
    - Released January 28, 2013
    - 12 contractors submitted proposals
    - 5 firms found technically acceptable
Phase II Contract

- 2 Step Bidding Process
  - Step 2 – Advertisement of PS&E
    - February 7, 2013 Advertisement
    - February 15, 2013 Bids Opened
    - February 20, 2013 Project Award
Phase I – Emergency Contract

January 28, 2013

A letter contract issued to remove slide debris, construct temporary access roads and place base stone to bridge soft soils.
Phase I – Emergency Contract
Subsurface Conditions

Subsurface conditions exposed during Phase I construction

South side

West side
Subsurface Conditions

Test pits
Soil borings (24-35 ft)
Subsurface Conditions

Top Boring

Borings drilled at the top and bottom of failed slope

Bottom Boring
Subsurface Conditions

- Cobbles & boulders (fill)
- Residual soils/N = 12 to >50 bpf
- Auger refusal
Subsurface Conditions

Top Boring

- EL 3290
  - Sandy SILT-Silty SAND/N = 3 to 8 bpf
- EL 3273
- EL 3270
- Residual soils/N = 25 to >50 bpf
- Auger refusal
- EL 3266
Typical as-built plan along NFG
What triggered the failure?
What triggered the failure

- Heavy rain (9”)
- Steep slope
- Presence of springs and surfaced runoffs
- Failure of the subdrainage system
Design Analysis

- Reinforced Soil Slope (RSS)
  - Layers of geogrid and granular backfill
- Drainage System
  - Subsurface Drainage
  - Surface Runoff
RSS Advantages

- Fast-track construction
- Simple
- Offers flexible design and construction
- Cost effective
- Integrates well with the park landscape
Phase II - RSS Construction
Phase II Construction

03/10/2013

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Lessons Learned

- Work with the community and respond to their needs
- Incentives can be a powerful tool
- Use of crushed stone/select granular material (SGM)
Respond to the community needs
Incentives
Use of Crushed Stone/SGM
Highway 441 Landslide
90 DAYS – Landslide to Repair