Outline

- Project Background
- Subsurface Conditions and Evaluation
- Design Options Considered
- Construction
- Performance
- Lessons Learned
- Questions
Project Background

Location:
- Salisbury, Maryland

Owner:
- MDSHA
  - District 1

Designer:
- Schnabel Engineering
- Sabra-Wang and Associates
Project Background (cont’d)

Slope failures on 3 ramps at US 50 and Naylor Mill Rd:

- About 410 feet of failed area
Ramp Embankment Slopes:
- Constructed in 2000
- 2H:1V
- 30 to 35 feet tall at tallest point

Failures occurred during and after construction
Site Reconnaissance and Subsurface Study

- The ramps are open sections – no curb or gutters
- Failed areas are 2 to 3 feet deep
- Failures not necessarily where you would expect it to occur.
What is Causing Instability?

- **Hand Augers**
  - Up to 10” to 18” of topsoil at failed areas
    - Topsoil very soft and saturated

- Medium dense to dense Clayey Sand (SC) embankment fill
What is Causing Instability?

- Surface water flowing down the slope face is the triggering mechanism for the slope erosion.
- Saturates the thick, soft topsoil layer and causes it to slouch down the slope.
- Surface runoff then erodes the exposed granular embankment material.
Several options considered, but the two that made the most sense were:

- Install riprap for slope repair and protection
  - Owner is comfortable with this method.
- Re-grade and install cellular confinement slope protection
  - Owner does not have experience with this, but is open to using it
  - Cost competitive
  - Creates a “natural” looking slope
Design

- Cellular Confinement selected for Slope Stabilization
  - Simple to design
    - Supplier can help with design
  - Stakes at 3 cells spacing
  - 4” thick cellular confinement
Bidding

- Develop “perfect” set of Plans and Specs
- Develop Engineers Estimate:
  - $401,758

Four bids submitted:
- $391,495
- $399,931
- $406,294
- $416,473

Bids within 4% of our estimate!

- Celebrate!
Bidding

- Engineers Estimate for cellular confinement:
  - $141,361 ($7 per SF)

- Bid price for cellular confinement:
  - $71,692 ($3.55 per SF)
  - $84,819 ($4.20 per SF)
  - $66,644 ($3.30 per SF)
  - $61,191 ($3.03 per SF)

- We were off by as much as a factor of 3 on some bid items!
Design

After contract award, another 150 feet of slope failed!

- Redline revision to plans
- $110,784 Change Order from contractor to perform the additional work
How are slopes repaired?

- Bench Slopes
  - Remove loose soils
  - Place and compact new fills
Construction

- Install Cellular Confinement
Construction

- Install Stakes
Construction

- Place topsoil
Construction

- Seed and place erosion control matting

- Completed in 19 work days!
- Final Cost: $357,279
  - Contract came in about $34k under original bid price!
Performance
Two Years Later

- Slope is vegetated and looking good!
Performance
Two Years Later

- Weeds on the slope – but still looking good!
• However…
  • Topsoil thickness is still up to 18 inches in some areas!
  • Some localized areas are very soft and some of the topsoil started to slouch down the slope
  • Potential for more topsoil to slouch down slope again

- But the risk of failures within the embankment fill is reduced.
Lessons Learned

- Construct slope properly the first time!
  - Overbuild slope to get compaction near edges. Then cut back.
  - Keep topsoil thickness to 6 inches or less

- For Repairs: Insist that contractor bench the slope and place and compact the fill properly

- When done correctly, very little maintenance is required

- Costs about the same as rip-rap and is better looking than rip-rap slopes

- The designer should be involved during construction

- Keep topsoil thickness to 6 inches or less!
Questions?

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Thank You

Have a safe trip!