PURDUE UNIVERSITY

Agricultural and Biological Engineering

CAPSTONE/SENIOR DESIGN EXPERIENCE 2020

Monon High Bridge Trail: Slope Stabilization

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1. Problem Statement

The current instability of the slope along the Monon Trail poses a risk to human safety and threatens the existence of the trail. There is an urgent need to prevent further expansion of the gully and stabilize the bank if the trail is to remain open to the public.

2. Background

The Monon High Bridge Trail (Delphi, Indiana) follows an old railroad line as it runs along the banks of a local creek (Deer Creek). A portion of the bank has recently collapsed and is cutting into the trail (FIg. 2).

Figure 1 Photos from the site taken at the Monon Trail

Figure 2 Aerial map of site location along Deer Creek

The depression that was formed is 60 feet tall from trail to streambed over a horizontal distance of 120 feet. The collapsed portion measures 30 feet at the trail in width and widens at the toe (FIg. 3).

The bank became unstable due to a combination of geotechnical and hydrologic problems, namely a non-cohesive soil profile and excess water buildup within the slope base. Both issues were addressed by integrating a variety of solutions into the design.

3. Impact and Sustainability

- Preserves trail for use by nearby communities
- Designed for long-term soil stabilization
- Blends in well with natural landscape
- Uses multiple approaches to address drainage, soil stabilization, erosion control, and stream undercutting

4. Criteria and Constraints

- Reasonable cost below the given budget of $400,000
- Successful bank stabilization
- Sustainable design
- Aesthetically appealing
- Restoration of public safety
- Low negative ecological impact
- Feasible construction accessibility
- Feasible maintenance requirements

5. Alternative Solutions

Trail Erosion
- **Trail Rerouting**
- Bridge/Boardwalk

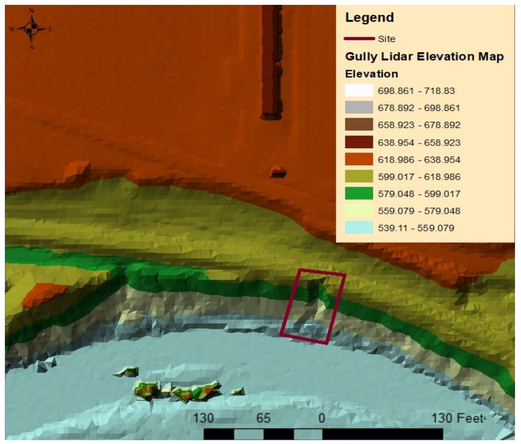
Energy Dissipation
- **Riprap**
- J-Hook

Bank Stabilization
- **Log Crib Wall**
- **Gabion Basket**

Drainage
- **Trench Drain**
- **Tile Drain**

Erosion Control
- **Jute Netting**
- Geocells

6. Site Analysis



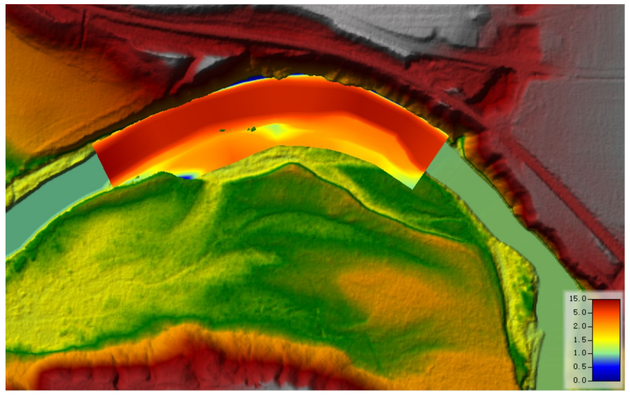


Figure 3 (left) LIDAR Elevation Map, 2018
Figure 4 (right) HEC-RAS model of site

7. Final Design

New Trail Path
- Trail is rerouted 37.5 ft and 5 ft down from current centerline
  - INDOT #8 Class A gravel
  - 10 ft wide and 130 ft long
- Benefits
  - Accommodates slope stabilization method and city's future trail expansion
  - Increases pedestrian safety

Erosion Control
- Slope-stabilizing native grasses (bluestem, switchgrass) and ferns planted on slopes (Fig. 5)
- 4,860 ft^2 of jute netting installed for erosion control along slopes
- Benefits
  - Fast-growing plants stabilize disturbed soil
  - Netting will biodegrade

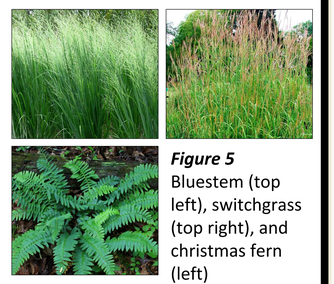


Figure 5 Bluestem (top left), switchgrass (top right), and christmas fern (left)

Drainage
- Surface MIFAB T-300 Trench Drain installed along new trail (Fig. 6)
- Subsurface tile drains placed behind walls
- Benefits
  - Avoids backfilling with water
  - Prevents flooding along trail

Figure 6 Selected Trench Drain to place along trail

Energy Dissipation
- HEC-RAS stream dynamics (FIg. 4)
  - Max velocity: 5.76 ft/s
- Revetment Riprap
- Benefits
  - Easy construction
  - Viable cost: $35-$50 yd^3
  - Fewer permitting requirements

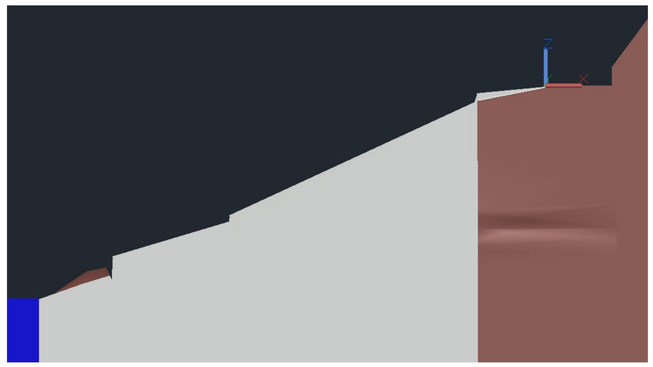


Figure 7 CAD Model of Crib Wall and Gabion Basket design
Wall Dimensions (from high elevation to low):
Log wall - 5x3x36 ft Gabion wall middle - 4x2x36 ft Base Gabion - 6x3x36 ft

Slope Stabilization
- Crib walls designed to meet safety factors in different categories:
  - Foundation bearing failure, sliding, rotation
- Global analysis finds critical slip surface, local analysis determines size and locations of walls
- Final wall properties (Fig. 7):
  - 2 Gabion Baskets → Near base
  - 1 Log Crib → Near trail
- Benefits
  - Retains soil mass and prevents further collapse
  - Multiple small walls advantageous due to earth pressure theories
  - Gabions allow easy installation while crib gives aesthetic appeal

8. Schematic

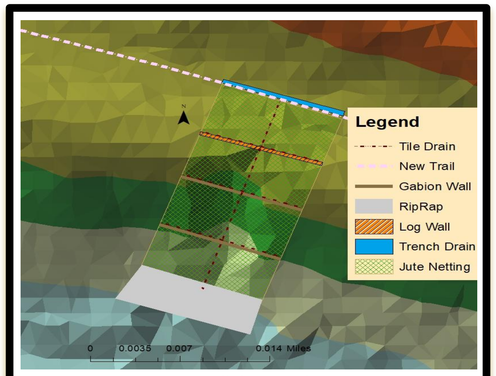


Figure 8 Overall design schematic

9. Permits

- Section 404 Regional General Permit
- Section 401 Water Quality Certification
- Certificate of Approval:
  - Construction in a Floodway
  - Navigable Waters
- Local Floodplain Ordinance

10. Budget Analysis

- Excavation Costs…….…. $5188
- Trench Drain Costs…… $2980
- Tile Drain Costs……$403
- Gabion Wall Costs…….. $1858
- Log Wall Costs……..$880
- Riprap Costs……..…..$6000
- Vegetation Costs…..……$185
- Jute Netting Costs……... $4450
- Clearing Costs……$19450
- Trail Rerouting Costs…… $1700

TOTAL: $43,076

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