The Great Impact of Geotechnical Features on System Performance

Scott A. Anderson, Ph.D., P.E.
Benjamin S. Rivers, P.E.
FHWA Resource Center – Geotechnical Technical Services Team
Keywords

- Transportation Asset Management (TAM)
- Geotechnical Assets/Geotechnical Features
- System Performance
- Performance Management
What is “performance”? 

- Many definitions concurrently
- Our ultimate objective(s)
- Something that can be measured
- Something that can be managed

“The Nation’s highway system provides safe, reliable, effective and sustainable mobility for all users.”
What is a geotechnical feature?

- A geotechnical asset: slopes, walls, and embankments are examples
- Geohazards – such as karst, liquifiable soils, abandoned under ground mines, etc.
- Soil & bedrock foundation materials
- Appurtenances – drainage systems, rock bolts and ground anchors, rockfall mitigation systems, etc.
Recent U.S. Examples

Geotechnical Features Impacting System Performance

Source: NCDOT
Embarkment on I-75 in TN

- March 8, 2011
- Both SB lanes closed 5 days
- Built in 1970s
- 150 ft high embankment
- CMP culvert
  - Deterioration
  - Separation
  - Saturation
  - Weakening
  - Failure
Embankment on I-75 in TN

- ER contract executed Mid-April
- Key-trench, Berm
- Replace with durable rock fill
- Soil-nail upper slope

Source: TDOT
Embankment on I-75 in TN

• Impacts
  - ADT 28000 affected for estimated 5.5 months
  - SB lanes closed 5 days after initial failure
  - 20-30 mile detour routes
  - SB lanes closed and one NB lane closed 14 days after localized failure during construction
  - 3 lanes open along NB footprint during most of repair
    • Back-ups in excess of 20 miles during holidays and peak travel times
  - Repair Cost estimated at $9.2M to $12.6M
Rockslide on I-40 in NC

- October 2009
- 53-mile section closed for 6 months
- ADT 24000
- 55K CY rock removed
- 540 anchors installed
- $13.7M

Source: NCDOT
Rockslide on I-40 in NC

- January 2010 – 2nd Failure
- 5 additional high-risk sites identified and mitigated
- 3 lanes restricted traffic for 3-mile section of additional 6-months.
- Total Repair Costs for all: $19.2M

Source: NCDOT

US-64 in TN, November 2009, $3M
Blue Ridge Parkway information is available at (828) 298-0398.

Plan ahead before driving by visiting the NCDOT Traveler Information Management System Web site at www.ncdot.gov/traffictravel/ or calling 511, the state’s free travel information line, for current travel conditions.
Rockslide on I-40 in NC

- 130-mile detour
- Frequent Back-ups in excess of 7-miles common in Asheville, NC

Table 1: Total Transportation Costs of I-40 and US-64 Rock Slides

<table>
<thead>
<tr>
<th></th>
<th>I-40 Rockslide</th>
<th>US-64 Rockslide</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Operating Costs</td>
<td>$56.9</td>
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<td>$64.1</td>
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<tr>
<td>Diversion Travel Time</td>
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<td>$10.7</td>
<td>$75.9</td>
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<td>Emissions Costs</td>
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<td>$5.0</td>
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<td>Congestion Travel Time</td>
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<td>Pavement Maintenance</td>
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<td>TOTAL</td>
<td>$174.9</td>
<td>$22.1</td>
<td>$197.0</td>
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</table>

From HDR Report
Rockfall on I-70 in CO

- March 2010
- Repeat from Nov. 2004
- 4 days full closure
- 200 mile detour
- 2 months partial closure
- $1.6 m repair

Culvert failure on same corridor
- June 2003
- Similar closures
- $4.2 m repair
Takeaways from U.S. Examples

• Geotechnical features do impact system performance
  ▪ Direct repair costs
  ▪ Indirect costs to mobility, wear/tear of other routes, vehicle operations, quality of life and economies.

• Geotechnical features and their impacts can be managed
Transportation Asset Management (TAM)

• Performance-based
• Pavement and bridge management has seen early attention
• Incorporates risk assessments
• References:
  - NCHRP Report 632: An Asset-Management Framework for the Interstate Highway System
  - NCHRP Report 677: Development of Levels of Service for the Interstate Highway System
• MAP-21
Establishes system performance requirements

State Highway Agencies to develop asset management plan toward achieving national highway performance goals

- Risk-based plan to improve and preserve assets and performance of the system
- Must include pavement and bridges
- Encourages inclusion of all assets within the corridor right-of-way
Performance Goals

- **Safety** – reduce fatalities and injuries;
- **Infrastructure Condition** – maintain the highway infrastructure asset system in a state of good repair;
- **Congestion Reduction** – reduce congestion on NHS;
- **System Reliability** – improve efficiency;
- **Freight Movement and Economic Vitality** – improve the freight network, strengthen ability of rural communities to access national and international trademarks, support regional economic development.
Risk Statement:

- If established indicators, measures and state-developed asset management plans do not collectively consider the impacts of all manageable features having significant influence on the effective performance of the highway system and its corridors, then established standards and targets might well be met while the impacts due to other significant features and their associated costs may be left ineffectively managed, resulting in inadequate performance to the system and its components.
For a system to perform well, its corridors must perform well and deliver mobility, capacity, efficiency, reliability and safety.

One broken link can change all of that.
• Corridors are the primary assets of a transportation agency. A transportation system will have multiple corridors.

• Geotechnical features such as embankments, slopes and retaining walls have a large influence on the performance of corridors.

• Performance (corridor or system) is the attribute agencies will be measuring and managing – and care most about.
Corridors in Wyoming

The State Significant Corridor System

URS, WYDOT, 2010
## Assets by Class

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>Pavement</th>
<th>Bridge</th>
<th>Walls</th>
<th>Culverts</th>
<th>Slopes</th>
<th>Embankments</th>
<th>Drainage</th>
<th>Signage</th>
<th>SUM (units)</th>
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(a) Inventory, with total for each Asset Class shown.

### Condition (performance) rating or level of service (LOS), with average shown for each Asset Class.

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<tr>
<th>Asset Class</th>
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(b) Condition (performance) rating or level of service (LOS), with average shown for each Asset Class.
## Assets Prioritized by Corridor

<table>
<thead>
<tr>
<th>Corridors (by performance priority)</th>
<th>Pavement</th>
<th>Bridge</th>
<th>Walls</th>
<th>Culverts</th>
<th>Slopes</th>
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Inventory evaluated as a list of corridors prioritized for system performance.
Corridor Management Concept - Summary

• Optimizes system performance

• Relieves burden of populating entire inventories
Challenges

• Incorporate geotechnical features within State Asset Management Plan
• Establish expectations for geotechnical features
  ▪ Implement methods for measuring and testing performance
  ▪ Establish targets for performance
    (e.g. frequency of rockfall from a rock-cut, long-term settlement of bridge approach, movement of anchored wall, corrosion of steel MSE reinforcement or rock-bolt)
• Predicting change in performance as $f(t)$ and identifying investment value as $f(t)$. 
Conclusions

• Corridor concept – rational means to phase geotechnical features into system performance in an affordable and meaningful way

• Melding of a) inventory and condition rating, b) risk assessment, c) performance monitoring and performance management is the future
Questions?