

# The Great Impact of Geotechnical Features on System Performance



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# 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.”**





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# 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

# Embankment 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 – 2<sup>nd</sup> 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



US-64 in TN, November 2009, \$3M



# TENNESSEE

Plan ahead before driving by visiting the NCDOT Traveler Information Management System Web site at [www.ncdot.gov/traffictravel/](http://www.ncdot.gov/traffictravel/) or calling 511, the state's free travel information line, for current travel conditions.



Source: NCDOT

Map not drawn to scale.

**Legend**

- Official Alternate Route for I-40, 53 miles longer than I-40
- I-40 Closed
- Local Traffic Only

10.26.2009

# 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

	I-40 Rockslide	US-64 Rockslide	TOTAL
Vehicle Operating Costs	\$56.9	\$7.2	\$64.1
Diversion Travel Time Costs	\$65.2	\$10.7	\$75.9
Emissions Costs	\$4.5	\$0.5	\$5.0
Congestion Travel Time Costs	\$43.8	\$3.5	\$47.2
Pavement Maintenance Costs	\$4.6	\$0.3	\$4.9
<b>TOTAL</b>	<b>\$174.9</b>	<b>\$22.1</b>	<b>\$197.0</b>

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**



# MAP-21 – Transportation Bill

## July 2012

- **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 markets, 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**

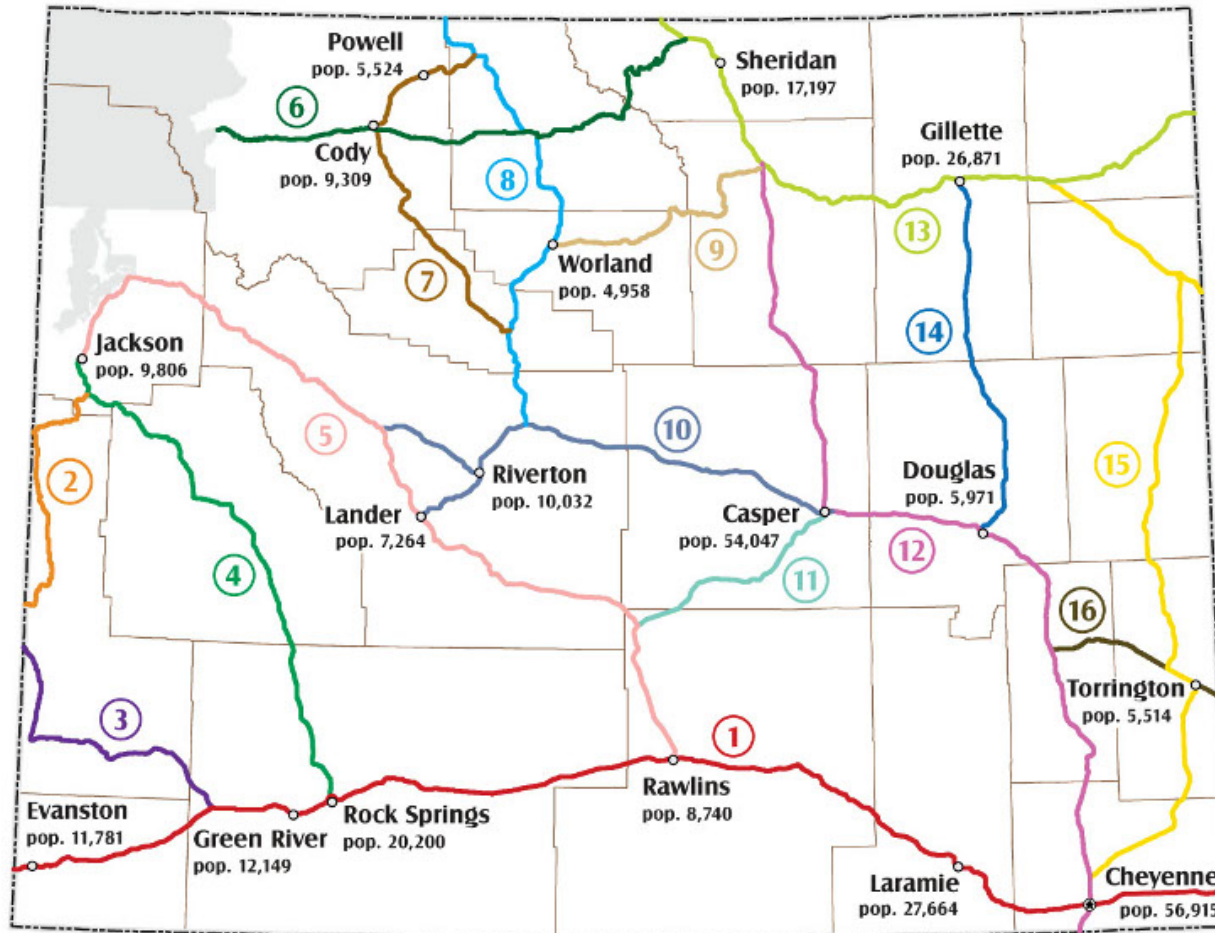


# Thesis

- 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

		Asset Class								
		Pavement	Bridge	Walls	Culverts	Slopes	Embankments	Drainage	Signage	
Highways	1	150	30	4	36	10	42	16	989	
	2	324	26	12	88	18	94	24	768	
	3	86	21	6	27	12	33	18	956	
	4	241	50	13	56	19	62	25	378	
	5	367	75	29	81	35	87	41	324	
	6	179	12	22	18	28	24	34	165	
SUM (units)		1347	214	86	306	122	342	158	3580	

(a) Inventory, with total for each Asset Class shown.

		Asset Class								
		Pavement	Bridge	Walls	Culverts	Slopes	Embankments	Drainage	Signage	
Highways	1	4	7	4	4	8	6	6	5	
	2	7	4	7	5	6	4	5	8	
	3	5	7	4	6	7	5	4	8	
	4	4	6	5	4	5	7	7	7	
	5	8	4	7	5	8	4	5	4	
	6	6	4	5	7	4	7	4	6	
AVG.		5.7	5.3	5.3	5.2	6.3	5.5	5.2	6.3	

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



# Assets Prioritized by Corridor

		Feature Type								
		<i>Pavement</i>	<i>Bridge</i>	<i>Walls</i>	<i>Culverts</i>	<i>Slopes</i>	<i>Embankments</i>	<i>Drainage</i>	<i>Signage</i>	
Corridors (by performance priority)	1	6	5	4	8	6	2	7	4	
	2	5	8	3	6	3	7	2	7	
	3	7	8	6	7	5	5	7	6	
	4	7	3	3	5	7	3	6	3	
	...	...	...	...	...	...	...	...	...	
	99	4	6	7	4	2	6	4	3	
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  $f(\text{time})$  and identifying investment value as  $f(\text{time})$ .**

# 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?



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