

TRD

Research Development and Technology

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Development of a Highway Rock Cut Rating System For Missouri Highways

Missouri Rock Fall Hazard Rating System (MORFH RS) is a new scheme for rating of rock fall hazards along the roads of the Missouri State Highway System. Existing rock fall hazard rating systems used in other States focus on the risk of failure and ignore the consequence of failure, or they lump the ratings for risk and consequence together. In MORFH RS, risk and consequence factors are given equal weight and isolated from each other. The ratings for the categories that relate to risk or consequence are easy to determine and are more objective. The risk – consequence rating system can be used by the Missouri Department of Transportation (MoDOT) and others to cost effectively determine the need and priority of remediation, and help facilitate the design of maintenance on rock cuts in order to provide for the safety and convenience of the motoring public by reducing the risk and consequence of rock fall to life and property.

MORFH RS utilizes two phases:

1. Identification of the most potentially problematic rock cuts, by using mobile digital video logging, and making measurements on the images.
2. Characterization and prioritization for remediation for the potentially problematic rock cuts identified, using video image measurements and on-site assessments.



Figure 1: Missouri rock cuts with contrasting degrees of hazard (Left: Highway 63, Right: Highway 65)

Digital Video Logging

A simple, inexpensive digital video logging system (Figure 2) is used as a screening tool to identify problematic highway rock cuts. Alternatively the MoDOT ARAN system can be used to acquire digital images. A specific subset or the entire network of Missouri highways can be video logged. Trained geologists or geotechnical engineers can review the video footage at a computer workstation in their office to identify problematic cuts and then decide which sites warrant more detailed investigation.



Figure 2: DV camcorder for video logging.

Measurements on Scaled Video

The same images that are used for video logging can also be used to measure some of the parameters required for the rating system (Figure 3). Typical measurements include slope heights, lengths, and angles; ditch widths, depths, and volumes; mass volumes; and other linear measures.

Although not as accurate as manual measurements in the field, the measurements are sufficiently accurate to provide input data for a rock hazard rating system. Accuracy of the RockSee computer program was verified by calculating and comparing measurements from video images to manual measurements of road widths, ditch widths and depths, and slope heights and angles obtained using tape measures, measuring rods, and a range-finding clinometer. Errors on average were found to be less than 10%.



Figure 3: RockSee computer program to measure various parameters needed for the rating system.

Risk Consequence System

In phase 2, four types of parameters are evaluated:

1. Parameters such as slope height, slope angle, ditch width, ditch depth, shoulder width, block size, ditch capacity, and expected rock fall quantity can often be measured on computer scaled video images in the office.
2. Parameters which are descriptive, such as weathering, face irregularities, face looseness, strength of rock face, water on the face, and design sight distance will require field evaluation.
3. Non-slope parameters such as average daily traffic, number of lanes, and average vehicle risk are obtained from the video images, MoDOT records, calculated or otherwise determined for each section of road.
4. Conditional parameters such as adversely oriented discontinuities, karst features, ditch capacity exceedence, and the effect of bad benches will require field evaluation

The following is a list of all the parameters:

1. Slope Height (SH)
2. Slope Angle (SA)
3. Ditch Width (DW)
4. Ditch Shape (DS)
5. Ditch Volume (DV)
6. Expected Rock Fall Quantities (ERFQ)
7. Shoulder Width (SW)
8. Number Of Lanes (NOL)
9. Average Daily Traffic (ADT)
10. Average Vehicle Risk. (AVR) (Using rock cut length, number of cars per day, posted speed limit, and number of lanes)
11. Block Size (BS)
12. Adverse Discontinuities (AD)
13. Ditch Capacity (ERFQ/DV)
14. Rock Fall Instability (RFI)
15. Weathering Factor (WF)
16. Strength of the Rock Face (SORF)
17. Face Irregularity (FI)
18. Face Looseness (FL)
19. Water On Face (WOF)
20. Decision Sight Distance (DSD)
21. Karst Effect (KE)
22. Bench Factor (BF)
23. Slope Factor (SF)

Of these parameters, 9 can be measured on the video images, 7 must be rated in the field, 3 are constants or internally calculated, and 4 are conditional parameters, used only under certain circumstances.

The parameters are organized into a risk and a consequence rating on a scale of 1-100. Risk and consequence ratings are plotted against each other (Figure 4), and from this the relative priority of remediation can be determined (Figure 5).

Risk	Value	Rating	Consequences	Value	Rating	
Rock Cut Height	30	6	Ditch Width	9	4.8	
Slope Angle	65	7	Ditch Volume	12	72	
Rockfall Instability	4	12	Slope Angle	65	25	
Weathering	3	18	Shoulder Width	9	3	
Rock Strength	0	12	Lanes Number	1	12	
Face Irregularities	4	12	Average Daily Traffic	5500	33	
Face Looseness	4	12	Rockfall Quantity	10	3	
Block Size	5	0	Average Vehicle Risk	60	968	8.4
Water on Face	2	6	Design Sight Dist.	0	0	
	Joint	Sinkh.	Block Size	5	12	
Adjust. Factor	0	0	Adjust. Factor	1	0	
Total		71	Total		46.8	

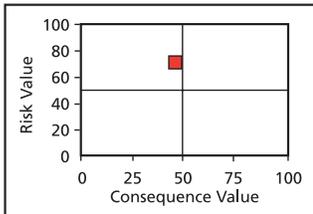


Figure 4: Risk-consequence assessment.

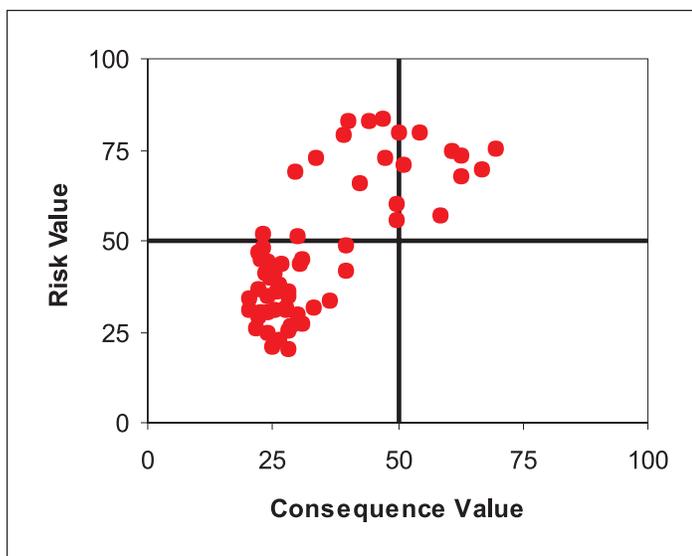
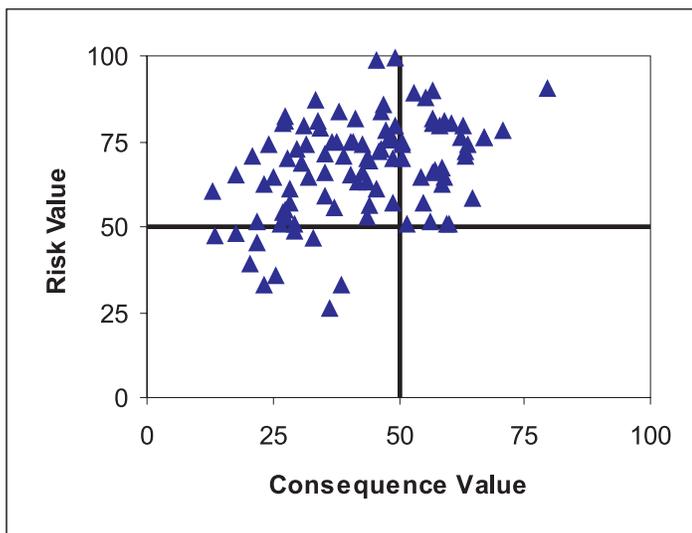


Figure 5: Ratings for sections of Highway 63 north of Rolla (top) and Highway 65 north of Branson (bottom).

Field Testing

MORFH RS has been tested on sections of Missouri Highways 63, 44, 65, 54, and other highways in Missouri. About 300 rock cuts were evaluated and used to prepare and modify the system. Parameter selection was done by careful consideration of a variety of parameters. Sensitivity analysis of the system was done by quantifying potential errors in the video measurements and by a rating comparison by MoDOT and University of Missouri-Rolla (UMR) personnel on rock cuts along Highway 63.

Conclusions:

MORFH RS has been developed, finalized and demonstrated to be capable of rating the risk and consequences of rock cuts failures as well as prioritizing rock cuts for remediation. Mobile video logging and use of the video images to obtain accurate measurements promises tremendous time and cost savings for the rating process.

Recommendations

1. The development and population of a MoDOT compatible GIS database with 100 detailed rock cut evaluations per month, starting with interstate routes, U.S highways, state highways, and other roads in that order.
2. The prioritization of evaluated rock cuts, and implementation of a remediation schedule.

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