TDOT

Developing and Implementing a Rockfall Management System and Mitigation Program for Tennessee

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As rock cuts along Interstates and highways age, weather, and become unstable, the risk of rockfall increases. Many rock cuts owned by transportation agencies were built before the development of design standards for rockfall catchment. Consequently, many rock cuts have inadequate or nonexistent catchment areas. A transportation agency therefore needs a systematic way to manage the hazards of rockfalls.

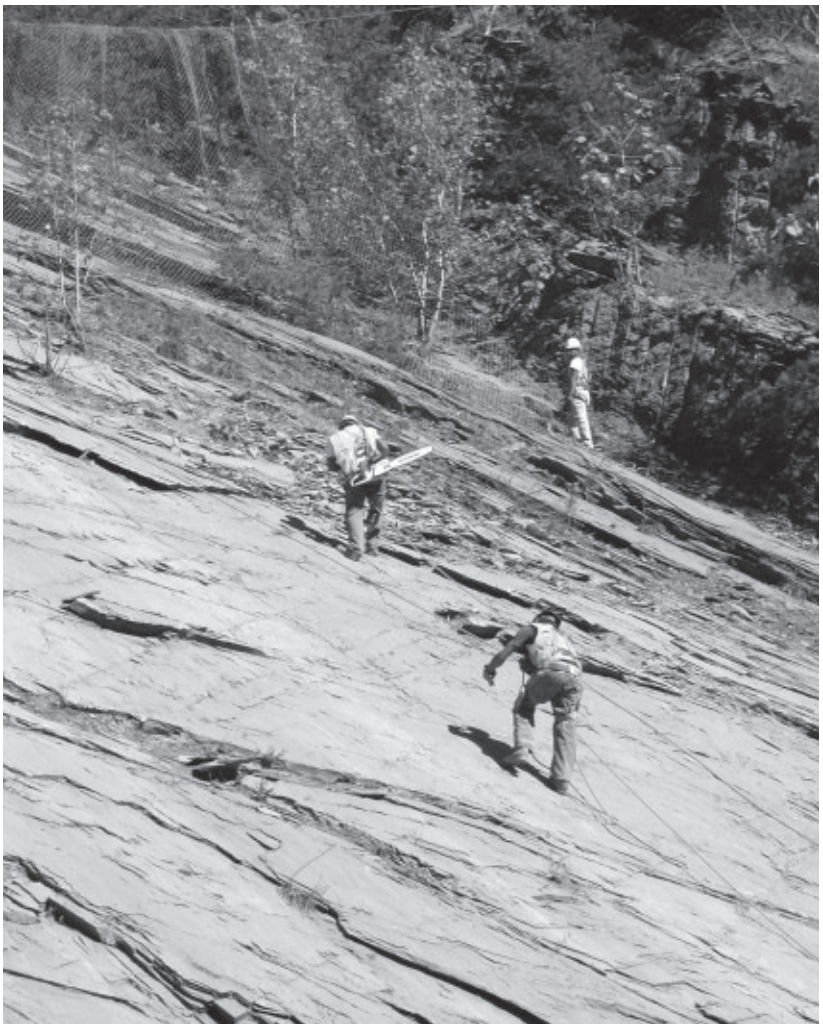

PHOTO: HARRY MOORE

Rockfall mitigation work in progress—workers assess a site in Cocke County, Tennessee, for initial vegetation removal and scaling operations. Tennessee DOT has moved from a reactive to a proactive approach to rockfall management.

Problem

Rockfall management at the Tennessee Department of Transportation (DOT) historically was reactive—that is, rockfall maintenance problems and catastrophic failures drove the remediation responses (*1*). This haphazard approach did not make the best use of resources, and no mechanism was in place to approach the problem on a statewide basis.

Rockfall sites could not be compared within or across maintenance districts, and no map showed all sites statewide. Tennessee had an unknown number of problem sites that presented an unknown level of hazard; moreover, the state had no systematic program to rate the hazards, to estimate costs, or to let mitigation projects.

Solution

Multidisciplinary Approach

Tennessee therefore initiated a research project to develop a hazard rating system for the state and to produce a statewide map of sites. A rockfall database integrated into web-based geographic information systems (GIS) was developed to display, analyze, and prioritize rockfall hazards. Researchers developed field data collection forms, both paper and electronic, which linked to the rockfall database via PDAs—that is, handheld mobile computers. Tennessee DOT developed a training program and manuals to assist geotechnical personnel in implementing the system.

Principal investigators from Tennessee DOT, the University of Tennessee, and Virginia Tech led the multidisciplinary research team, which had backgrounds in civil engineering, geological engineering,

and geology. The team developed the initial hazard rating system and database, piloted it in five counties, and then refined the rating system, field procedures, and database before mapping the rest of the state.

Photologs from the Tennessee DOT Roadway Information Management System made possible a virtual driving tour along every mile of state roadways, looking for potentially hazardous rock cuts. Potential sites were noted and verified in the field, and new sites were added during the field work (*2*).

Rating Sites

Initially, sites were rated as A, B, or C according to the Rockfall Hazard Rating System (RHRS) developed for Oregon DOT and the Federal Highway Administration (*3, 4*). At A-sites, a rockfall has a high potential for reaching the roadway and affecting traffic; B-sites have a moderate potential hazard; and C-sites have a low potential hazard.

All A- and B-sites were located. All A-sites were further analyzed with the Tennessee RHRS, which produces a detailed hazard rating. The Tennessee RHRS includes identification of the rockfall failure modes expected at a site, such as planar, wedge, topple, differential weathering, or raveling. The Tennessee RHRS also requires such data as cut height and length, average daily traffic, roadway width, decision sight distance, rockfall history, ditch effectiveness, presence of water, geologic failure mode, and the extent of the potential failure area, expressed as a percentage of the slope surface area.

All of this information determines the Tennessee RHRS score, which has a maximum of 800 points. Sites with a score above 350 are classified as priority. Of the 1,950 sites statewide, almost half—963 sites—were classified as A and received a Tennessee RHRS analysis (Figure 1, below). Thirty-six of the A-sites were rated high priority, with scores of 500 or more.

After the initial research was complete, Tennessee DOT added a Rockfall Closure Impact (RCI) rating and initial cost assessments for the sites. The RCI rates a site according to average daily traffic, potential disruption to traffic, roadway blockage time, length of the detour around the blockage, and facility degradation.

Applications

In 2008, Tennessee DOT used the rockfall hazard inventory, database, GIS map, photographs, and other data to launch a rockfall mitigation program. The following sites with high scores on the Tennessee RHRS, high RCI scores, and high assessments of mitigation costs were let in three contracts:

- The first contract, for $780,000, was to mitigate 0.3 mile of highway in Campbell County, where a rockfall recently had occurred on I-75. Mitigation measures involved the installation of a rockfall fence at the base of the slope on the edge of the paved shoulder.
- The second contract, for $1.2 million, was to mitigate 0.5 mile of I-40 in Cocke County near the North Carolina border. Mitigation measures involved the installation of a rockfall fence, draped wire mesh, and a hybrid wire mesh system to reduce significantly the risk of a rockfall impacting traffic.
- The third contract, for $537,000, was to mitigate 0.65 mile of I-440 in Nashville in Davidson County. Mitigation measures involved scaling and trimming the slope to remove loose, overhanging, and unstable rock; cleaning and regrading the catchment ditch; and installing a rockfall fence as needed.

Benefits

The three-year research effort cost $1 million in addition to the routine work related to rockfalls. Although it is too early yet to quantify the financial benefits of the research, recovering the investment and savings is a realistic expectation, based on past experience of road closures, property damage, fatalities, and inconvenience to motorists.

The Rockfall Management System has allowed Tennessee DOT to approach rockfall issues as a statewide problem and to apply resources in a ratio-

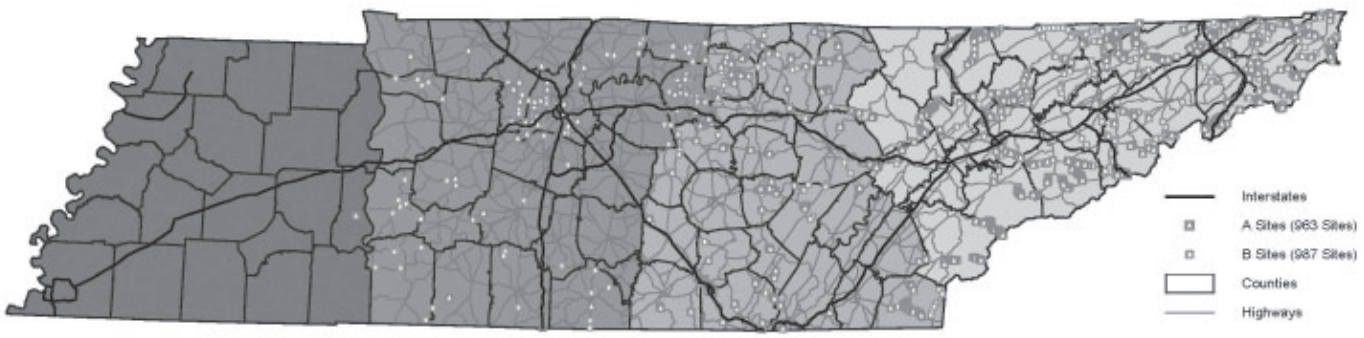

FIGURE 1 Rockfall sites in Tennessee: state routes, U.S. highways, and Interstates.

nal way. Personnel can compare the hazard ratings of sites, the costs of mitigation, and the potential effects on the traveling public. Tennessee DOT has expanded the results from the research to incorporate preliminary cost estimates and RCI scores; along with the Tennessee RHRS scores, these constitute the selection criteria for prioritizing mitigation projects.

With the interactive maps, Tennessee DOT personnel can display site data according to a variety of criteria and can add or modify sites as conditions change. The database information about rockfall sites is updated periodically and as needed. The database gives Tennessee DOT staff instant access to all data, photographs, Tennessee RHRS scores, and related reports before mobilizing to a rockfall site.

The GIS maps clearly identify areas within corridors that have a high concentration of rockfall sites. This information is valuable in the cost–benefit analyses for roadway widening, improvements, or relocations.

Tennessee DOT plans to expand the database and web-based GIS to other geohazards such as sinkholes, landslides, and settlement areas, and to store the electronic data and the interactive map in a central location. The statewide map and system developed under this research project have allowed Tennessee DOT to implement a new management program and to improve tools, enhancing staff efficiency and ensuring safer roadways for motorists.

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PHOTO: HARRY MOORE

Scaling and vegetation removal in progress at the Cocke County rockfall site.

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Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (202-334-2952; gjayaprakash@nas.edu).