

U.S. Roadway Under

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Interstate Group Works To Prevent Dangers from Underground Mines

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Exposed mine void beneath State Route 32.



Eighteen-foot trench after excavation of the overburden and mined coal seam. Note the exposed mine openings.

Sinkholes and slides from abandoned and deteriorating underground mines are little-known threats to traveler safety throughout the United States. Transportation agencies must protect roadways and other facilities near old mines, despite a lack of knowledge and experience in dealing with the problem. The potential danger and liability are significant.

Roadway Problems: Ohio

On March 5, 1995, a 12-foot section of Interstate Route 70 in Guernsey County, Ohio, suddenly collapsed when an abandoned underground mine subsided. Three cars and a truck encountered the collapsing roadway and narrowly escaped tragedy. The state closed this vital highway for four months, repairing the water-filled mine by grout injection at a cost of \$3.6 million.

This startling incident attracted nationwide attention. However, it was not the Ohio Department of Transportation's (DOT's) first encounter with mines beneath roadways. Maintenance crews periodically had filled road subsidences from mine collapses at other locations. One site was the interchange of I-70 and I-77, among the largest interchanges in the United States.

Subsequent investigations at the I-70/I-77 interchange revealed underground voids within a few feet of the pavement of one of the ramps. The grout injection repair of the mines beneath the interchange cost \$4.7 million (see sidebar, page 23).

Ohio has completed other notable mine repair projects on multilane divided highways since 1995. These have included

- ◆ The excavation and replacement of 1,700 linear feet of I-470 at a cost of \$3 million;
- ◆ The excavation of a half mile of State Route 32—the mine depth varied from 7 to 25 feet—at a cost of \$5 million¹; and
- ◆ The grouting of an unmapped clay and shale mine beneath U.S. Route 52.

¹ The Ohio DOT website offers a photographic chronicle of the repairs to State Route 32, www.dot.state.oh/mine/.

mined

Mines beneath and adjacent to roadways are a past, present, and unavoidable future problem that is becoming more prevalent as mines age. Detailed maps from the Division of Geological Survey of the Ohio Department of Natural Resources show approximately 4,200 abandoned mines in Ohio; an estimated 2,000 additional abandoned mines in the state do not have detailed maps (1).

Roadway Problems: Other States

Many other states have encountered notable problems with mines beneath roadways. However, the problems and the methods of repair often have not gained publicity. Following are a few examples.

- ◆ Missouri DOT has investigated a new route that crosses an area of old lead and zinc mines. Problems encountered include old pits, shafts, shallow prospects, subsidences, and piles of tailings (ore residues).

- ◆ Kansas DOT has repaired many roadways in southeast Kansas affected by subsidences of coal, lead, and zinc mines.

- ◆ In New York, the flooding and subsequent collapse of a salt mine destroyed a bridge on a state highway.

- ◆ Active long-wall mining of coal has caused problems in several states, such as Pennsylvania, where mining beneath I-70 in 2000 caused a pavement subsidence of as much as 4.5 feet.

Addressing the Task

Mines can endanger the traveling public by causing pavement collapses, sinkholes in roadway shoulders or side slopes, the settlement of bridges and other structures, and landslides from collapses or drainage. The I-70 site in Guernsey County, Ohio, underscored the potential for severe danger to travelers and for liability to the state.

Ohio DOT personnel recognized the need for a systematic process to address the problem. The number of mines near roadways in the state could be as high as 1,000, making timely remediation at every site impossible.

Ohio DOT therefore developed an abandoned underground mine inventory and risk assessment process to locate and evaluate the condition and safety of mine sites underlying highways. An Ohio



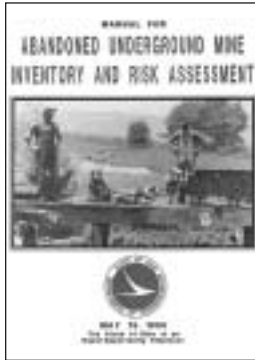
Ohio DOT employee in front of four-foot-high void discovered underneath eastbound lanes of State Route 32.

Refilling Mines Beneath an Interchange

Not long after the 1995 roadway collapse in Guernsey County, Ohio DOT maintenance personnel at the I-70/I-77 Interchange notified state engineers of an ongoing need to fill subsidences adjacent to the roadways and in infield areas. Mine maps from the Ohio Department of Natural Resources Division of Geological Survey showed abandoned mines beneath most of the interchange. However, diaries and other records of the original construction provided limited information about encounters with abandoned mines or about the treatment of mine voids.

Investigative borings approximately every 50 feet along all mainline and ramp lanes of the interchange revealed unmapped mine voids, deteriorating mine roof rock, and progressive overburden failure. Ohio DOT closed one ramp immediately to allow emergency grouting of a void.

Engineers prepared plans for grouting all mine voids beneath the interchange. The repair work proceeded by drilling bore holes 25 feet apart and injecting a grout mixture of portland cement, fly ash, and sand to fill the mine voids. The remedial work affected 5.7 lane-miles of the interchange.



Ohio DOT manual on abandoned mines.

DOT technical manual documents the process (2); the manual is also published by FHWA (3).

Canvassing for Information

During the repair of the I-70 site and the development of the *Abandoned Underground Mine Inventory and Risk Assessment Manual*, Ohio DOT contacted other state DOTs as well as state and federal agencies to determine methods and actions in use to locate, investigate, rate, remediate, and monitor roadways above abandoned mines.

The responses made it evident that the knowledge and experience gained by state DOTs was not widely shared. Other state DOTs were wrestling with the same issues and problems; each state had made successful and unsuccessful attempts, trying various methods and procedures, often repeating unknowingly what others already had tested. The state personnel dealing with mine issues also were encumbered with other responsibilities and pressing issues and consequently could expend only limited effort on mine-related issues.

Clearly, the problems of mines beneath roadways is widespread. The Office of Surface Mining Reclamation and Enforcement of the U.S. Department of the Interior maintains a repository of mine maps—mostly of coal mines—for 45 states (4). However, states that do not have maps in the repository also have reported subsidences.

Many transportation agencies must assess or address a potentially large number of sites with mines beneath roadways, but are hindered by a lack of information, knowledge, experience, resources, and time. This situation has hampered progress in adopting and developing systematic methods to locate, monitor, and address the problem sites.

Call to Cooperation

Ohio DOT convened a workshop in 1997 for state DOTs and state and federal agencies to share knowledge and experiences with mines. FHWA provided funding for the workshop, attended by representatives of nine states and one turnpike authority: Illinois, Kansas, Kentucky, Maryland, Missouri, New York, North Dakota, Ohio, and Pennsylvania and the Pennsylvania Turnpike.

In addition, seven state and federal agencies participated: the U.S. Department of Interior, Office of Surface Mining; the U.S. Geological Survey; FHWA; the Ohio Department of Natural Resources; the Ohio Mine Subsidence Inventory Underwriting Association; the Ohio Environmental Protection Agency; and the Ohio Department of Development.

Discussions focused primarily on procedures to inventory and assess sites, but also covered other aspects of dealing with mines beneath roadways,

such as locating mine voids, monitoring conditions, and performing remediation. The workshop produced a lively exchange of information, benefiting all participants, who agreed to continue cooperation and sharing information.

Grouping Up

The Interstate Technical Group on Abandoned Underground Mines, established soon after the workshop, consists of technically oriented personnel responsible for the remediation of underground mines beneath highways. Membership includes representatives of Arizona, FHWA, the Federal Railroad Administration, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Michigan, Missouri, New York, North Dakota, Ohio, Ontario (Canada), Pennsylvania, the Pennsylvania Turnpike, and West Virginia.

The goals of the group are to

- ◆ Generate and disseminate information, and
- ◆ Obtain outside funding or share the costs of research or other mutually beneficial efforts.

The expected benefits from achieving these goals are

- ◆ Increased efficiency and effectiveness of each state's operations, and
- ◆ Enhanced safety for the traveling public.

Stimulating Communication

Group members have cultivated contacts from the original and subsequent workshops, generating and disseminating information. FHWA hosts an interactive website, www.fhwa-ohio.org/mine.html, featuring member contact information, a discussion board for group communication, summaries of past workshops, information about upcoming workshops, the Ohio DOT mine manual, and links to related websites. The website soon will add other features, such as information about ongoing and completed research and projects.

Most significant are the website's interactive pages. State members regularly will update information about research and projects completed and under way, assuring that the information is accurate and up-to-date. The data will include the type of work, the location, the date completed, the degree of success, and the availability of a report.

Members use the discussion board to post questions and obtain responses from other members. In this way, group members can draw immediately on the knowledge and experience of others, at the same time assembling on the website a searchable library of practical information accessible to members and the public.

Workshop Agendas

Missouri DOT hosted the Technical Group's second workshop in St. Louis in August 1998, focusing on geophysical methods of investigation and monitoring, but also including discussions of other issues. Representatives from six states—Iowa, Illinois, Kansas, Missouri, Ohio, and Pennsylvania—one state agency, one federal agency, and seven private-sector firms participated. The Technical Group decided to convene a workshop every two years.

In April 2000 Kansas DOT hosted the third workshop in Kansas City, with representatives of nine member states as well as federal and state agencies, private consulting firms, industry, and academia. After presentations by the participating transportation authorities, the workshop examined the roadway applications of geophysical techniques such as ground-penetrating radar, seismic reflection, borehole tomography, time domain reflectometry, surface wave inversion and attenuation, and microseismic monitoring.

Each presentation offered case studies demonstrating the application of geophysical techniques to roadways over abandoned mines. The workshop also included a field trip to an abandoned underground limestone mine being converted to commercial use and for housing a local college library.

Discussions at the Kansas workshop noted that other modes of transportation—specifically railroads—also face hazards with abandoned mines. In addition, other mine-related agencies and firms are dealing with many of the same issues and using many of the same methods for monitoring, investigation, and remediation. The group therefore has invited the involvement of representatives of other transportation modes and mine-related groups.

The group has investigated affiliation with other organizations, but has decided to remain independent. Illinois and Iowa will host the next workshop in 2002 (for information, see sidebar at right).

Shared Research

The group has not yet shared actively in the cost of research. However the sharing of information has prevented states from employing unsuccessful or untried methods, modifying unsuccessful methods, or applying successful methods in untried conditions.

Group members generally choose research topics that suit their needs or interests and then share the results with other states. Pooling funds for a common research project remains a possibility. The group has not yet identified sources of outside funding for research.

Symposium Connects with Technical Group

Two TRB standing committees, on Engineering Geology and on Exploration and Classification of Earth Materials, held a symposium on Abandoned Underground Mines, May 15, 2001, in Cumberland, Maryland, before the 52nd Highway Geology Symposium hosted by the Maryland State Highway Administration. More than 80 people attended the TRB session.

Presentations described transportation projects in abandoned underground mine areas in the states of Missouri, Pennsylvania, and Kansas, and in Ontario, Canada. In addition, participants heard a review of the objectives and contents of the *Manual for Abandoned Underground Mine Inventory and Risk Assessment*, developed by Ohio DOT with input from other state DOTs and federal agencies.

Thomas Lefchik of FHWA presented information on the Interstate Technical Group on Abandoned Mines. The Technical Group will hold its 4th workshop, May 1-3, 2002, in Davenport, Iowa. For information about the Technical Group and the 2002 workshop, contact Lefchik (telephone 614-280-6845, e-mail Thomas.Lefchik@fhwa.dot.gov).

Solid Base

The Interstate Technical Group on Abandoned Underground Mines is making progress on its original goals of generating and disseminating information and of seeking outside funding and sharing in the costs of research and of other efforts of mutual interest. The group members are realizing the benefits of increased efficiency and effectiveness in operations and of enhanced safety for the traveling public. Membership has grown to 18 and remains open to interested agencies.

References

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3. *Manual for Abandoned Underground Mine Inventory and Risk Assessment*. Publication No. FHWA-IF-99-0007. Federal Highway Administration, Office of Infrastructure, U.S. Department of Transportation, May 1999.
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Websites

Interstate Technical Group on Abandoned Underground Mines www.fhwa-ohio.org/mine.html
Journal of Ohio SR 32 repairs after mine subsidence www.dot.state.oh.us/mine