found guilty of one count, and Lentz and Gepp were found guilty on three counts each of violating the RCRA. Although each faced up to 15 years in prison and $750,000 in fines, they received sentences of 1,000 hours of community service and 3 years' probation. The judge justified the relatively light sentences on the grounds of the high standing of the defendants in the community and the fact that they had already incurred enormous court costs. Because the three engineers were criminally indicted, the U.S. Army could not assist them in their legal defense. This was the first criminal conviction of federal employees under RCRA.

CASE 2

Big Dig Collapse[3]

On July 10, 2006, a husband and wife were traveling through a connector tunnel in the Big Dig tunnel system in Boston. This system carries Interstate 93 beneath downtown Boston and extends the Massachusetts Turnpike to Logan Airport. As the car passed through, at least 26 tons of concrete collapsed onto it when a suspended concrete ceiling panel fell from above. The wife was killed instantly and the husband sustained minor injuries. The Massachusetts attorney general's office issued subpoenas next day to those involved in the Big Dig project. Soon, a federal investigation ensued.

The National Transportation Safety Board (NTSB) released its findings a year after the incident. The focus of the report was the anchor epoxy used to fasten the concrete panels and hardware to the tunnel ceiling. This product was marketed and distributed by Powers Fasteners, Inc., a company that specializes in the manufacturing and marketing of anchoring and fastening materials for concrete, masonry, and steel.

Investigators found that Powers distributed two kinds of epoxy: Standard Set and Fast Set. The latter type of epoxy, the one used in the collapsed ceiling tile, was susceptible to "creep," a process by which the epoxy deforms, allowing support anchors to pull free. The investigators concluded that this process allowed a ceiling tile to give way on July 10, 2006.

According to the NTSB report, Powers knew that Fast Set epoxy was susceptible to creep and useful for short-term load bearing only. Powers did not make this distinction clear in its marketing materials—the same materials distributed to tunnel project managers and engineers. Powers, the report continued, "failed to provide the Central Artery/Tunnel project with sufficiently complete, accurate, and detailed information about the suitability of the company's Fast Set epoxy for sustaining long-term tensile-loads." The report also noted that Powers failed to identify anchor displacement discovered in 1999 in portions of the Big Dig system as related to creep due to the use of Fast Set epoxy.

On the basis of the NTSB report, Powers was issued an involuntary manslaughter indictment by the Massachusetts attorney general's office just days after the release of the report. The indictment charged that "Powers had the necessary knowledge and the opportunity to prevent the fatal ceiling collapse but failed to do so."

The NTSB also targeted several other sources for blame in the incident (although no additional indictments were made). It concluded that construction contractors Gannett Fleming, Inc. and Bechtel/Parsons Brinkerhoff failed to account for the possibility of creep under long-term load conditions. The report indicated that these parties should have required that load tests be performed on adhesives before allowing their use and that the Massachusetts Turnpike Authority should have regularly inspected the portal tunnels. It asserted that if the Authority had conducted such inspections, the creep may have been detected early enough to prevent catastrophe.

The report provided recommendations to parties interested in the Big Dig incident. To the American Society of Civil Engineers, it advised the following:

> Use the circumstances of the July 10, 2006, accident in Boston, Massachusetts, to emphasize to your members through your publications, website, and conferences, as appropriate, the need to assess the creep characteristics of adhesive anchors before those anchors are used in sustained tensile-load applications.

To what extent must engineers educate themselves on the various materials being used and processes being employed in a project in order to ensure safety? If lack of knowledge played a part in causing the collapse, how might such understanding specifically help engineers to prevent an event like this in the future? How else might engineers work to avoid a similar catastrophe?

REFERENCES

1. National Transportation Safety Board, Public Meeting of July 10, 2007, "Highway Accident Report Ceiling Collapse in the Interstate 90 Connector Tunnel, Boston, Massachusetts," July 10, 2006. This document can be accessed online at https://www.ntsb.gov/investigations/AccidentReports/Reports/HAR0702.pdf
2. The Commonwealth of Massachusetts Office of the Attorney General, "Powers Fasteners Indicted for Manslaughter in Connection with Big Dig Tunnel Ceiling Collapse." This document can be accessed online at www.mass.gov.

CASE 3

Bridges[4]

On August 1, 2007, the I-35W bridge over the Mississippi River in Minneapolis, Minnesota, collapsed during rush hour, resulting in 13 deaths and a multitude of injuries. The bridge was inspected annually dating from 1993 and every two years before that since its opening in 1967. The most recent inspection, conducted on May 2, 2007, cited only minor structural concerns related to welding details. At that time, the bridge received a rating of 4 on a scale from 0 to 9 (0 = shutdown, 9 = perfect). The rating of 4, although signifying a bridge with components in poor condition, meant that the state was allowed to operate the bridge without any load restrictions.

A bridge rated 4 or less is considered to be "structurally deficient." According to the U.S. Department of Transportation, this label means that "there are elements of the bridge that need to be monitored and/or repaired. The fact that a bridge is 'deficient' does not imply that it is likely to collapse or that it is unsafe. It means it must be monitored, inspected, and maintained." In some cases, load restrictions are placed on structurally deficient bridges.

The failure, which happened during a roadway rehabilitation construction project, was attributed to a design error in which main truss gusset plates were not sufficiently thick for the loads applied. The NTSB report of the failure identified several factors that resulted in insufficient gusset plate thicknesses.[5] The designer, Sverdrup & Parcel and Associates, Inc., failed to specify proper thicknesses and the design quality control procedures failed to detect this problem. The NTSB noted that the "generally accepted practice among federal and state transportation officials of giving inadequate attention to gusset plates during inspections … and of excluding gusset plates in load rating analyses."

The incident raised important questions about the state of U.S. bridges. In Minnesota, there are 1,907 bridges that are structurally deficient, which means they have also received a rating of 4 or lower on inspection. Bridges may also be considered "functionally obsolete," a label that the American Society of Civil Engineers (ASCE) Report Card for America's Infrastructure defines as a bridge that has "older design features and, while it is not unsafe for all vehicles, it cannot safely accommodate current traffic volumes, and vehicle sizes and weights." In 2003, 27.1 percent of bridges in the United States were deemed either structurally deficient or functionally obsolete.

The ASCE urges that "America must change its transportation behavior, increase transportation investment at all levels of government, and make use of the latest technology" to help alleviate the infrastructure problem involving the bridge system. In order for Americans to answer this charge, they must be aware of the problem. What role should engineers and engineering societies play in informing the public about