

INVESTIGATIONS

Collapse Report Stirs Debate on Epoxies

Answers to Central Artery/Tunnel epoxy controversy slowly unfold as firms speak out

The National Transportation Safety Board's hearing into the deadly 2006 ceiling collapse in a Boston Interstate 90 tunnel portal appears to be the catalyst for a flurry of related action. A state criminal investigation into the accident may be crystallizing and officials of some firms involved in the tunnel's construc-

tion are trying to clarify the results of the July 10 hearing. NTSB concluded that fast-set epoxy usage on the tunnel ceiling anchors led to the fatal collapse that killed a 38-year-old local woman.

Officials close to the Central Artery/Tunnel project confirm a published report that project consultant Bechtel/Parsons Brinckerhoff is being pressured to make a substantial financial settlement in exchange for immunity before the state attorney general releases findings in a criminal investigation into the accident. Those findings were scheduled for release this month.

On July 10, 2006, 20 ceiling anchors pulled out from the tunnel, causing 10 precast concrete panels and hardware, weighing 52,000 lb, to fall (ENR 7/24/06 p. 10). Powers Fasteners Inc., Brewster, N.Y., supplied the two-component epoxy and threaded bolts as part of an engineered product that supported the panels.

A Powers spokesperson says the firm was asked on June 3, 1999, by distributor Newman, Renner, Colony (NRC), Canton, Mass., to supply a special order of

Power-Fast standard-set epoxy for the I-90 portal ceiling-panel anchors. The order was for 120 units, costing \$1,287.60, which was sufficient to anchor about 2,500 threaded stainless-steel bolts, each eight inches long. A unit consists of a hardener and resin attached to a single nozzle. The shipment required making up a special label, NRC 1000 Gold, and took eight weeks to fill, arriving in early August. At the same time, NRC was supplying at least 1,000 units of Power-Fast fast-set epoxy, also under the NRC 1000 Gold label, to tunnel contractor Modern Continental Construction Co. Inc. for use on wall panels and tiles.

"What we know is that Modern began to use epoxy for ceiling bolts in late July, which suggests that they did not wait for the standard-set," says Karen Schwartzman, Powers spokesperson. "All along Powers believed that standard-set epoxy was used in the ceiling."

Bolts began to slip out as early as October 1999, when Powers was asked by project officials to send engineers to determine the problem. Powers wanted

to conduct destructive ultimate-load tests since standard-set epoxy passed previous creep tests, and its officials wanted to see if there were installation issues, like voids.

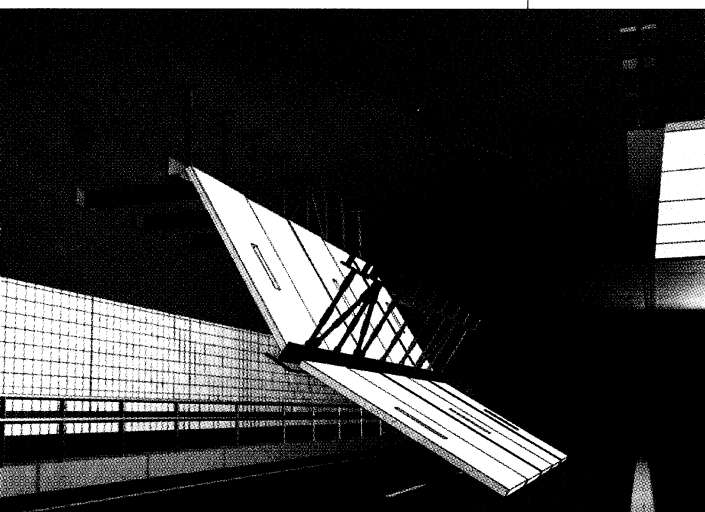
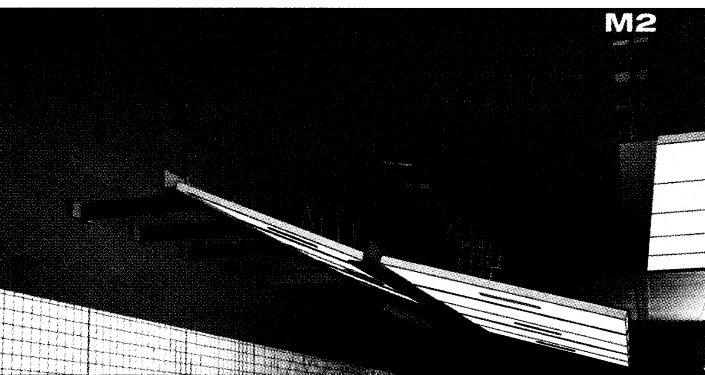
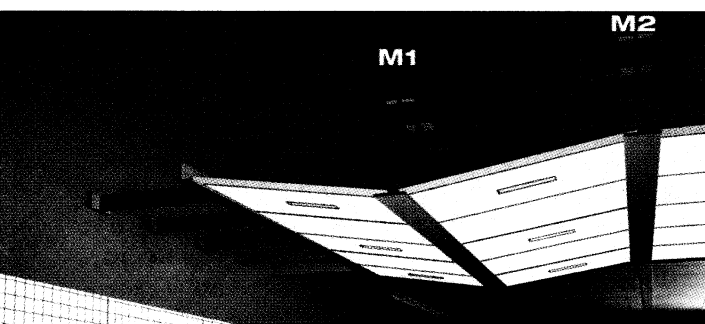
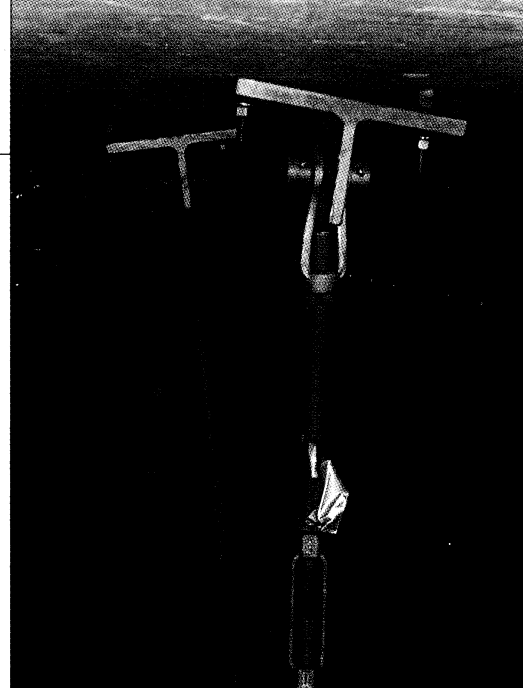
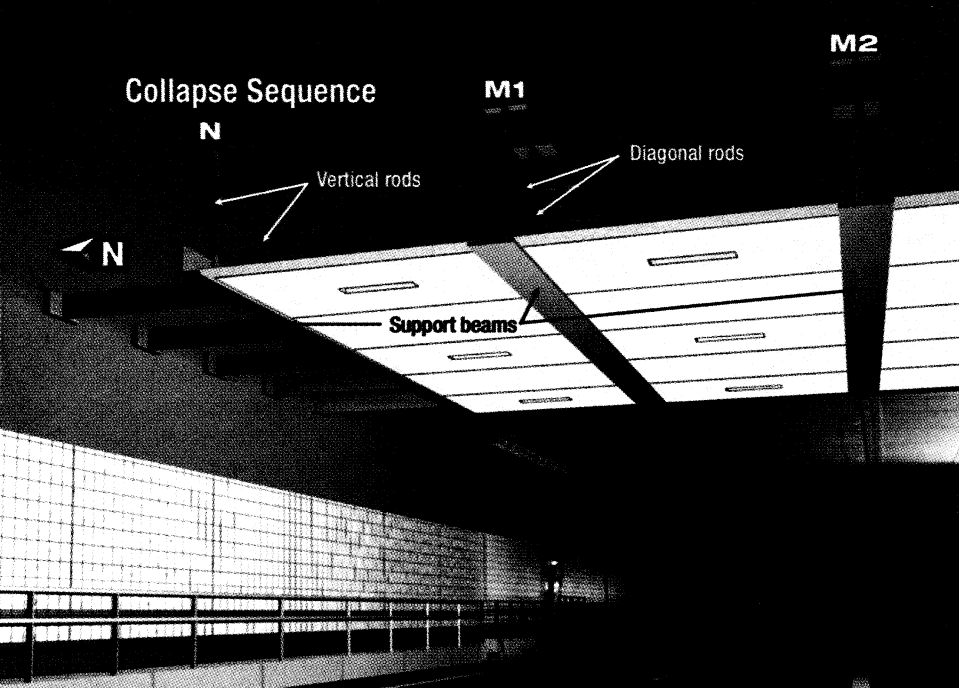
"We were not allowed to conduct pull tests," Schwartzman says. "What was allowed were torque tests. We found that all bolts were overtightened to 120 lb when specs called for 90 lb, which confirmed an installation problem."

NTSB, however, determined "improper or deficient anchor-installation procedures or practices alone would not account for all the anchor failures that were observed before and after the accident" (ENR 7/16 p. 13). The question remains, who knew what about creep and when, and what did they do with the information?

Powers has used a red label for its fast-set product and a blue label for its standard-set epoxy since introducing the line over 15 years ago, according to Schwartzman. While the colors may have differentiated cure rates, they may not have clearly delineated usage since both products are marketed as Power-Fast.

Also, a pull test by itself would not detect creep, only installation problems. A creep test subjects an anchor to 80 days of long-term loading to check for movement. According to NTSB, such tests were conducted on the Powers line in 1995 by an independent laboratory retained by the firm. The fast-set failed, which should have precluded its use in load situations. Information on the stan-

GRAPHICS AND PHOTO COURTESY OF NTSB



▲ **Weak Point.** Failure of the central M1 support structure due to anchor creep released 10 precast panels and hardware totaling 52,000 lb.

dard-set, which passed, was provided to the International Conference of Building Officials (ICBO), says Schwartzman.

NTSB criticized Powers for not identifying the October 1999 failure as creep and for inadequate and misleading information. Schwartzman notes that subsequent to the torque tests Powers sent Modern and designer Gannett Fleming, Harrisburg, Pa., a draft ICBO report ER-4514, reissued Oct. 1, 1999, on standard- and fast-set epoxy and Chem-Stud Adhesive Anchor Systems, which lays out the limitations of adhesive anchors.

"The report was accepted by both firms and made a part of the specification for the ceiling system in January 2000, even though they knew they had a problem," says

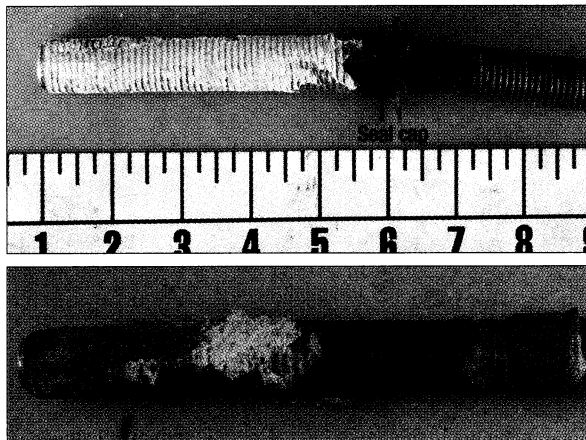
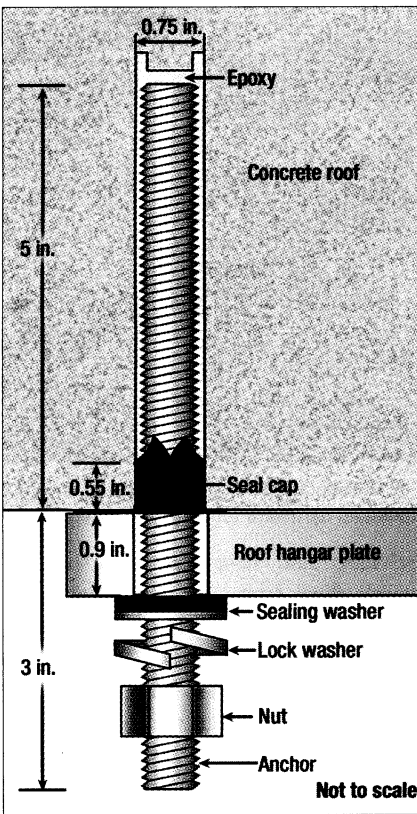
Schwartzman. "Essentially, they specified standard-set epoxy without checking to make sure that was what was installed in the ceiling. It has been intimated that Powers had not warned parties of the limitations of fast-set, but the report specifically addressed the issue in the very first finding: fast-set is inappropriate to use in long-term load situations."

The report also notes that special inspections are required. The same report, reissued Feb. 1, 2000, deals only with Chem-Stud. A subsequent report, ESR-1531, reissued Dec. 1, 2006, evaluates Power-Fast. While it requires special inspections, it does not specifically limit fast-set to short-term loads.

When the NRC order was placed, Powers also initiated action to have its standard-set epoxy and the NRC 1000 Gold label placed on the Massachusetts Highway Dept. qualified construction materials list. The state approved the Powers line without differentiating the products. It also approved the NRC 1000 Gold line. Both products are still on the list. The state relies on independent testing data and assumes field personnel read product literature and understand application use.

NRC, now Newman Associates, did not return calls from ENR. An independent salesman working exclusively for Powers plead the Fifth Amendment 27 times when questioned about the issue by NTSB investigators in March 2007.

Robert J. Dietz, president of Gannett



▲ **Tough Job.** Eight-inch threaded bolts were pull-tested but investigation showed that 19 of 20 failure-area anchors had voids. Top photo depicts good installation; bottom shows voids in red.

Fleming, defends his firm's work against NTSB criticism that Gannett Fleming did not specify anchors with sufficient creep resistance and for approving the anchors without identifying which epoxy formula was being used.

"This was a performance specification for an adhesive anchorage system, and NTSB concluded that our design and load calculations were appropriate," Dietz says. After looking at the accident photos where it appeared the anchors came out cleanly, "we reverified our computations, so our initial reaction was that it was an installation or materials problem as opposed to a loading condition."

Gannett was not directly involved in the October 1999 investigation. "Because adhesive formulations are proprietary, the choice of the epoxy was the responsibility of the contractor and its chosen supplier," Dietz

says. "The contractor selected Power-Fast and included information from the supplier as well as calculations by a licensed engineer indicating that their proposed standard-set epoxy was suitable for long-term loads."

NTSB noted that Modern Continental, which is now defunct, "was not aware, when its employees installed the adhesive anchors in the D Street portal, that the epoxy being used was susceptible to creep and was therefore unsuitable for this application." Modern hired a firm to conduct proof tests on all anchors within days of installation and the anchors passed, but kept slipping under sustained load.

Aware of creep problems, state officials, B/PB and Modern still did not institute an inspection program, which

anchors installed using fast-set epoxy "would be predicted to fail decades before nearing this service life" and that standard-set epoxy would also fail prior to the expected service life. One model predicted that fast-set would fail within seven years, almost exactly what happened. The report also notes "the behaviors observed certainly indicate a need for rigorous and frequent inspection of adhesive anchors already in use and similarly loaded elsewhere." It suggests that the continued use of adhesive anchors subject to sustained tension loads should be very limited, if not eliminated, for life-safety applications.

As a result, NTSB has banned epoxy use in sustained overhead-load conditions, at least until testing standards and safety protocols have been developed.

Based on a limited survey of nine tunnel authorities, four tunnels, three in Massachusetts and one in New York City, use epoxy anchors in overhead load conditions, according to NTSB. "We hope the industry looks at our recommendations and that good changes, like a better understanding of epoxy and a national tunnel inspection program, follow," says Mark Bagnard, NTSB I-90 lead investigator. ■

By William J. Angelo



▲ **Fatal Landing.** A 38-year-old Boston woman died in ceiling collapse.

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