National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: September 9, 2004

In reply refer to: H-04-29 and -30

Honorable Mary E. Peters
Administrator
Federal Highway Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

About 7:45 a.m., on May 26, 2002, the towboat *Robert Y. Love*, pushing two empty asphalt tank barges, was traveling northbound on the McClellan-Kerr Arkansas River Navigation System (M-KARNS) near Webbers Falls, Oklahoma. As the tow approached the Interstate 40 highway bridge (I-40 bridge) at mile 360.3, it veered off course and rammed a pier 201 feet west of (outside) the navigation channel.[1] The impact collapsed a 503-foot section of the bridge, which fell into the river and onto the barges below. According to witnesses, highway traffic continued to drive into the void in the bridge created by the collapsed spans. When traffic stopped, eight passenger vehicles and three truck tractor-semitrailer combinations had fallen into the river or onto the collapsed portions of the bridge. The accident resulted in 14 fatalities and 5 injuries and caused an estimated $30.1 million in damage to the bridge, including the operation of detours, and $276,000 in damage to the barges.

The National Transportation Safety Board determined that the probable cause of the *Robert Y. Love's* allision with the Interstate 40 highway bridge and its subsequent collapse was the captain's loss of consciousness, possibly as the result of an unforeseeable abnormal heart rhythm. Contributing to the loss of life was the inability of motorists to detect the collapsed bridge in time to stop their vehicles.

One safety issue explored by this investigation was bridge protection, specifically the vulnerability of existing bridges to vessel impacts and other extreme events. Although the I-40 bridge had pier protection cells *inside* the navigation channel, this accident occurred outside the navigation channel. Another such accident involved the Queen Isabella Causeway,[2] when the *Brown Water V* and its tow struck an unprotected pier 175 feet west of the navigation channel.

[1] For more information, read National Transportation Safety Board, *U.S. Towboat* Robert Y. Love *Allision With Interstate 40 Highway Bridge Near Webbers Falls, Oklahoma, May 26, 2002,* Highway Accident Report NTSB/HAR-04/05 (Washington, DC: NTSB, 2004).

[2] NTSB docket number HWY-01-I-H036.

Four additional accidents[3] investigated by the Safety Board involved vessels that rammed approach piers outside the navigation channel, and another accident involved an allision with a railroad bridge far from the navigation channel.[4] Such occurrences demonstrate that most bridges over navigable water can be struck either within or outside the regular navigation channel by barge tows and individual commercial vessels, thus increasing the complexity of bridge protection.

Protecting all substructure components of all bridges from vessel impacts would be an enormous task. The vulnerability of a given bridge to vessel impacts depends on the bridge design, location, current conditions, water depth at the bridge support(s), and the width and vertical clearance of the span(s). The I-40 bridge had 12 piers in the water, and the draft of the empty barges in this accident was 1 foot, making most of the piers accessible and therefore vulnerable to vessel impacts. According to the Oklahoma Department of Transportation (ODOT), in today's dollars, providing protection cells costs about $300,000 per pier in labor and materials. ODOT also noted that installing protection cells at all piers of the I-40 bridge would cost approximately $6.8 million. The I-40 bridge is just one of Oklahoma's 11 highway crossings on the M-KARNS; 6 of these 11 crossings have parallel bridges, for a total of 17 bridges with 74 piers in the water. To place a protection cell on both the upstream and downstream sides of the piers and one in between each parallel bridge on the M-KARNS alone would require 128 protection cells at a cost of $39.7 million.[5]

The M-KARNS is just one waterway in one State. Nationwide, U.S. Coast Guard records show more than 18,000 highway and railroad bridges spanning about 26,000 miles of commercially navigable waterways. The National Bridge Inventory lists 2,844 highway bridges requiring a bridge permit. Many of these bridges have multiple piers that are vulnerable to vessel impact. The Safety Board concluded that because of the cost, replacing or constructing pier protection for each existing bridge pier vulnerable to vessel impact nationwide may not be reasonable.

Bridge engineers have a tool to effectively assess a given bridge's risk (and acceptable risk) for vessel impact. The American Association of State Highway and Transportation Officials's (AASHTO's) Vessel Collision Guide Specifications[6] provide guidelines for determining a bridge's risk to impact by assessing vessel and vehicle traffic characteristics and

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[3] (a) National Transportation Safety Board, SS African Neptune*: Collision With the Sidney Lanier Bridge at Brunswick, Georgia, on November 7, 1972, With Loss of Life*, Marine Accident Report USCG/NTSB/MAR-74/04 (Washington, DC: NTSB, 1974); (b) National Transportation Safety Board, *Ramming of the Benjamin Harrison Bridge by the* SS Floridian *Near Hopewell, Virginia, February 24, 1977*, Marine Accident Report NTSB/MAR-78/01 (Washington, DC: NTSB, 1978); (c) National Transportation Safety Board, *Ramming of the Sunshine Skyway Bridge by the Liberian Bulk Carrier* Summit Venture*, Tampa Bay, Florida, May 9, 1980,* Marine Accident Report NTSB/MAR-81/03 (Washington, DC: NTSB, 1981); and (d) National Transportation Safety Board, *U.S. Towboat* Chris *Collision With the Judge William Seeber Bridge New Orleans, Louisiana, May 28, 1993,* Highway-Marine Accident Report NTSB/HAR-94/03 (Washington, DC: NTSB, 1994).

[4] National Transportation Safety Board, *Derailment of AMTRAK Train No. 2 on the CSXT Big Bayou Canot Bridge Near Mobile, Alabama, September 22, 1993*, Railroad-Marine Accident Report NTSB/RAR-94/01 (Washington, DC: NTSB, 1994).

[5] ODOT estimates include $38.4 million for materials and labor and an additional $1.3 million in mobilization costs.

[6] American Association of State Highway and Transportation Officials, *Guide Specification and Commentary for Vessel Collision Design of Highway Bridges* (Washington, DC: AASHTO, 1991).

the ability of the bridge to withstand the impact. These guidelines have been incorporated in the load and resistance factor design (LRFD) bridge standards, which, after 2007, will become the mandatory standards for all new Federal-aid bridge construction. Florida, with many bridges over water, is already using the LRFD standards for new bridge design.

Louisiana, after the 1993 Judge William Seeber Bridge accident,[7] embarked on a program using the AASHTO Vessel Collision Guide Specifications to evaluate existing bridges over navigable water. After the I-40 bridge accident, ODOT hired a consultant to evaluate bridges at 12 river crossings using the AASHTO Vessel Collision Guide Specifications. Although these standards can and are being used to evaluate the vulnerability of *existing* bridges to vessel impacts and vehicle collisions, they are not mandatory. The Safety Board concluded that to adequately protect the motoring public, bridge owners should be required to evaluate an existing bridge's vulnerability to vessel impact.

The Federal Highway Administration (FHWA) sufficiency rating system is a method of measuring one bridge's needs against another when qualifying for limited Federal-aid funds. Currently, the FHWA's sufficiency rating system does not include the relative risk of a bridge to extreme events such as occurred in this accident. Risk assessment tools available to bridge engineers for designing *new* bridges and evaluating *existing* bridges include scour assessment methods, the debris loading specification, seismic risk methodology, and the Vessel Collision Guide Specifications. Once the relative risks of extreme events, such as vessel or vehicle impacts, flooding (including scour and debris loading), seismic events, and terrorist attacks, are established using these tools, this information can be included in a bridge's sufficiency rating and used to prioritize bridges for rehabilitation or replacement, balancing the different needs of State bridge programs while not ignoring conditions that can lead to catastrophic events. The Safety Board concluded that including the relative risk of extreme events in bridge sufficiency ratings and in priority for rehabilitation and replacement would help provide a more accurate assessment of a bridge's risk to collapse and loss of life.

Bridge protection is a multitiered process. In addition to providing physical protection against vessel impacts (pier strengthening and pier protection) and to instituting measures to prevent allisions from occurring (installing aids to navigation and improving operator decision-making), methods that mitigate the loss of life following a vessel impact, such as motorist warning systems, may be necessary.

In this accident, 11 vehicles either fell with the collapsed sections of the bridge or drove off the bridge and into the void. The surviving drivers indicated that they could not see the void in the bridge in time to avoid driving into it. The Safety Board examined the available sight distance for both passenger cars and tractor-semitrailers on the eastbound and westbound approaches to the void in the bridge. The sight distances ranged from 150 to 350 feet; the minimum total stopping distance[8] at 70 mph (the posted speed limit at the accident site) for passenger cars was 622 feet and for tractor-semitrailers was 726 feet. The minimum total stopping distance for a tractor-semitrailer traveling at 57 mph (self-reported by one driver) was 514 feet. These total stopping distances are greater than the maximum estimated distance of 350

[7] NTSB/HAR-94/03.

[8] Includes perception/reaction and braking distances.

feet for the first point of possible perception, indicating that some drivers involved in this accident did not have sufficient time to stop their vehicles after detecting the collapsed sections of the bridge. In light of the statements of surviving drivers, estimates of the point of first possible perception, and calculations of total stopping distance, the Safety Board concluded that the drivers in this accident did not have adequate time to detect, identify, and respond to the hazard posed by the collapsed sections of the bridge.

An effective motorist warning system, mounted on or near the bridge and capable of alerting motorists to the bridge failure or directing vehicles to stop, might have prevented some of the vehicles, the majority of which were traveling westbound, from driving off the I-40 bridge. Because westbound vehicles, traveling at 57 to 75 mph, could have traversed the 1,500 feet from the east end of the bridge to the void in 13 to 18 seconds, it can be argued that had warning signs been activated within a few seconds, several of the westbound vehicles probably would have had time to react to the warning signs and stop before driving off the bridge.

A participant in a fishing tournament nearby, who fired a flare pistol to warn the driver of a westbound tractor-trailer truck of the hazard, said that he saw at least one vehicle fall with the bridge and that he then accelerated his boat toward the bridge and reached the area in about 20 seconds. He also stated that he saw two more vehicles drive off the bridge before he called 911; after the call, he saw five more vehicles drive off the bridge before shooting the flare. It is difficult to estimate exactly how much time elapsed between the collapse and the time the truckdriver saw the flare, stopped, and blocked the westbound approach with his truck. Further, only by coincidence did this recreational boater witness the accident and have the presence of mind to fire a warning flare. The first emergency responder arrived in 8 minutes, so, certainly, in the absence of a fishing tournament or other witnesses to the bridge collapse, an effective warning system would have stopped additional vehicles from driving off the bridge. The Safety Board therefore concluded that the quick-acting fisherman who fired the warning flare to alert motorists on the bridge probably prevented further loss of life. The Safety Board further concluded that an effective motorist warning system on the I-40 bridge might have mitigated the loss of life in this accident.

The Texas Department of Transportation installed such a motorist warning system after the 2001 Queen Isabella Causeway accident,[9] in which 10 vehicles either collapsed with the bridge or drove off the void, resulting in eight fatalities. This early warning collapse detection system, which became operational in March 2004, consists of fiber-optic cable, which, if severed, activates flashing lights to warn motorists of danger ahead. Although protecting all bridges against all events is not possible, in the case of long bridges with many vulnerable piers, such as the Queen Isabella Causeway, or bridges with curvature that results in sight distance limitations, such as the I-40 bridge, it is critical to protect the motoring public by installing automatic bridge failure detection and warning devices.

The Safety Board has addressed the installation of bridge motorist warning systems in previous accident investigations involving the Lake Pontchartrain Causeway, Sunshine Skyway

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[9] NTSB docket number HWY-01-I-H036.

Bridge, and Sidney Lanier Bridge.[10] The Board is aware of at least one discontinuity warning system that has been installed since these accidents, the one on the Sunshine Skyway Bridge in Florida, which the Florida Department of Transportation has characterized as being unreliable. The Safety Board understands that the FHWA is working to improve the reliability of such systems, specifically the ability of long-term monitoring instrumentation to withstand the conditions typically found on bridges, through its March 2004 Structural Health Monitoring initiative and through continuing Intelligent Transportation Systems programs. The development of reliable long-term sensing technology is critical in protecting the motoring public, and the Safety Board encourages your agency to continue its efforts to provide reliable motorist warning systems. Furthermore, once a reliable long-term detection system has been developed, the Safety Board believes that the FHWA should encourage the States to deploy this technology in comprehensive motorist warning systems; such systems could also be used on bridges vulnerable to collapse from other circumstances such as scour, seismic events, and terrorist attack.

The National Transportation Safety Board therefore recommends that the Federal Highway Administration:

> Revise your sufficiency rating system, which prioritizes bridges for rehabilitation and replacement, to include the probability of extreme events, such as vessel impact. (H-04-29)
>
> Develop an effective motorist warning system to stop motor vehicle traffic in the event of a partial or total bridge collapse. (H-04-30)

In addition, because neither the Vessel Collision Guide Specifications nor the 1983 FHWA technical advisory,[11] provide guidance on the use of motorist warning systems, the Safety Board is also recommending that once an effective motorist warning system has been developed, that the American Association of State Highway and Transportation Officials provide guidance to the States on its use. The Safety Board also issued a safety recommendation to the U.S. Coast Guard.

Please refer to Safety Recommendations H-04-29 and -30 in your reply. If you need additional information, you may call (202) 314-6177.

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[10] (a) National Transportation Safety Board, safety recommendation letter to the Greater New Orleans Expressway Commission, January 8, 1975, notation 1423; (b) NTSB/MAR-81/03; and (c) USCG/NTSB/MAR-74/04.

[11] Federal Highway Administration, “Pier Protection and Warning Systems for Bridges Subject to Ship Collisions,” Technical Advisory T5140.19 (Washington, DC: FHWA, 1983).

Chairman ENGLEMAN CONNERS, Vice Chairman ROSENKER, and Members CARMODY, HEALING, and HERSMAN concurred in these recommendations.

Original Signed

By: Ellen Engleman Conners
Chairman