National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 24, 1990

In reply refer to: H-90-56 through -60

Honorable Thomas D. Larson
Administrator
Federal Highway Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

About 8:15 p.m. central standard time, April 1, 1989, an 85.5-foot section of the 4,201-foot-long northbound U.S. Route 51 bridge over the Hatchie River fell about 20 feet into the 24-foot-deep rain-swollen river after two pile-supported column bents supporting three bridge spans collapsed. Witness reports and physical evidence indicate that the southern column bent (70) and the two spans that it supported fell quickly, causing four passenger cars and one tractor-semitrailer to plunge into the river. The adjacent column bent (71) and the span that it was supporting then collapsed on top of the vehicles. The river had apparently been at flood stage since November 1988. All eight vehicle occupants died as a result of the collapse.[1]

Based on the physical evidence, witness statements, bridge inspection reports, and research data, the Safety Board found that the following sequence of events occurred, resulting in the collapse of the northbound U.S. 51 Bridge spans. Following the construction of the northbound bridge, the Hatchie River conformed to a pattern of natural channel migration, moving northward at a average rate of 0.8 feet per year until 1974. In 1974, the Tennessee Department of Transportation (TDOT) constructed a 999-foot-long southbound bridge 58 feet west of and parallel to the northbound bridge. The constriction of the Hatchie River flood plain caused by the construction of the southbound bridge embankments reduced the available area (4,201 feet to 1,000 feet) through which flood waters passed downstream at the bridge site. In response to this flood plain constriction, the Hatchie River underwent a series of changes in an attempt to reach a hydrologic balance with the reduced flood plain opening. One of those changes was an increase in the northward migration of the main channel. By 1979, the north bank of the main channel was about 20 feet north of pier 7 (when the bridge was constructed,

[1] For more detailed information, read Highway Accident Report--"Collapse of Hatchie River Bridge, Covington, Tennessee on April 1, 1990." (NTSB/HAR-90/01).

the north bank was south of pier 7). The main channel continued to move northward at an accelerated rate until 1981. At that time, the channel began to reach a balance with the flood plain constriction, and between 1981 and 1989, the rate of channel migration slowed. By 1985, the north bank of the main channel had moved north of column bent 7C, and the streambed at the column bent was about 4 feet beneath the bottom of the footing. By 1989, the streambed was 5.9 feet or more below the bottom of the footing. Additionally, the duration and severity of the 1988/89 flood season probably caused from 3 to 4 feet of local scour at column bent 70.

As a result of the combined effects of channel migration and local scour, the friction piles supporting column bent 70 became exposed to water as much as 10 feet deep, and these piles were no longer capable of supporting the bridge loads. Therefore, about 7:15 p.m. on April 1, 1989, as vehicles passed over spans 77 and 78, the piles supporting column bent 70 began to embed, and the column bent began to lean northward. As a result, the 78-ton spans began to shift, placing additional vertical and lateral forces on column bent 70 as they slid away from pier 7 and column bent 71. About 8:00 p.m., as additional vehicles passed over the spans, the piles continued to embed or buckle, creating the 2- to 3-foot depression in the bridge deck described by witnesses. Shortly afterward, the column bent fell northward, and spans 77 and 78 fell into the river.

At the time of the collapse, the northbound U.S. 51 bridge had not received a diver inspection because it was submerged less than 10 feet during the late summer months; however, TDOT did not inspect the bridge during the period when the river level was lowest. During the 1987 inspection, the measured water level was 13 feet at pier 7. As a result, the Safety Board concludes that the 1987 TDOT inspection of the northbound bridge did not occur when conditions were optimum for inspectors to examine the substructure bridge elements. In April 1990, TDOT revised its diver inspection criteria to include all bridges that had substructure members submerged more than 3.5 feet during low water. The Safety Board recognizes that this new criteria will increase the number of bridges that receive a diver underwater inspection; however, it is the Safety Board's opinion that it may not be possible to schedule each bridge for inspection during lowest water level periods. Therefore, the Safety Board believes that TDOT should expand its inspection criteria to require that submerged bridge elements that cannot be fully examined by bridge inspectors during scheduled inspections receive follow-up or diver inspections.

Further, as a result of the collapse of the New York Thruway Bridge near Amsterdam, New York, in 1987,[2] the FHWA revised the National Bridge Inspection Standards (NBIS) to include a requirement that the inspection frequency and procedure be described for those bridges with underwater members that cannot be visually evaluated during periods of low flow or examined by feel for condition and integrity due to excessive water depth or

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[2]For more information, see Highway Accident Report "Collapse of the New York Thruway (I-90) Bridge Over the Schoharie Creek Near Amsterdam, New York, April 5, 1987." (NTSB/HAR-88/02).

turbidity. The Safety Board believes that the FHWA should further expand the NBIS to require follow-up or diver inspections of those members that are not examined visually or by feel during scheduled bridge inspections due to excessive water depth or turbidity.

The United States Geological Survey indicated that unaltered streams in west Tennessee are often naturally meandering. Further, the 1983 American Association of State Highway and Transportation Officials (AASHTO) Manual for Maintenance Inspection of Bridges indicates that channel profile records should be maintained for bridges over water to determine significant changes concerning the tendency toward "scour, channel shifting, degradation, or aggradation." Although information was only emerging in the mid 1980's concerning the lateral movement of stream channels in response to man-induced channel alterations, the effects of natural stream meanders were known. Therefore, the Safety Board concludes that enough guidance and information were available in 1987 for TDOT to have recognized the need to develop and study a channel profile record for the Hatchie River at the site of the U.S. 51 Bridges. Had TDOT established a channel profile record, the evaluator for the 1987 inspection report may have recognized the lateral channel movement occurring at the bridge site and the potential for further undermining of column bent 70. Further, since most streams naturally change configuration and flow pattern with time, the Safety Board believes that the FHWA should require States to develop and maintain channel profile records for bridges over water and to evaluate those channel profile records to determine the effects of channel changes on bridges.

Further, TDOT evaluators failed to recognize the importance of the exposure of the friction piles supporting column bent 70 that was noted in the 1987 inspection report. Friction piles are dependent on the surrounding soil for their load bearing capacity, and any exposure of those piles diminishes their ability to carry the bridge loads. Although the evaluators may not have been aware of the potential magnitude of scour, they should have identified a potentially hazardous situation based on the exposed friction piles. The exposure of the friction piles may have required immediate repairs of column bent 70, more frequent inspections, or underwater inspections of the bridge to monitor the condition of the piles. Therefore, the Safety Board concludes that TDOT evaluators failed to identify the potential hazard to the column bent 70 piles, even though the information to make this determination was included in the 1987 bridge inspection report.

Currently, the NBIS establishes qualification requirements for the individual in charge of the State bridge inspection organization and the inspection team leaders; however, the NBIS has no qualification requirements for bridge inspection report evaluators. In 1987, the TDOT bridge inspection report evaluator failed to identify the fundamental importance of the exposure of the column bent 70 friction piles. Even though the individual in charge of the State bridge inspection organization is required to be qualified, the Safety Board believes that it is unreasonable to expect this individual to personally monitor the evaluation of each bridge inspection report. Therefore, the Safety Board believes that the FHWA should establish qualification requirements for personnel who evaluate bridge inspection reports.

Identifying and evaluating critical bridge features that could independently cause the sudden collapse of a bridge component should be paramount in any review of inspection material. This need is especially important for structurally nonredundant bridges, where the failure of a critical feature could cause not only the collapse of a bridge component, but a rapid, catastrophic collapse. On July 19, 1984, the Safety Board issued Safety Recommendation H-84-50 to the Federal Highway Administration. This safety recommendation was one of 15 addressed to the FHWA as a result of the Safety Board's investigation of the collapse of a section of the Interstate Route 95 highway bridge over the Mianus River near Greenwich, Connecticut, on June 28, 1983.[3] Safety Recommendation H-84-50 asked the FHWA to:

> Require each State to develop an individualized inspection procedure for each bridge under State inspection jurisdiction that has critical elements whose failure will almost certainly result in a catastrophic failure of the bridge.

The FHWA responded to this safety recommendation on November 9, 1984, by transmitting a copy of an FHWA memorandum from the FHWA Associate Administrator for Engineering and Operations to all Regional Federal Highway Administrators. The subject of the July 16, 1984, memorandum was cited as being "Inspection and Maintenance of Major or Unusual Bridges." The memorandum contained the following directive to the Regional Federal Highway Administrators:

> Each Regional Administrator, through FHWA and State highway agency channels, is directed to take appropriate measures, including contract modification if necessary, to assure that all ongoing design contracts for these types of bridges require explicit in-service inspection and maintenance guidance for bridge owners. Provision should, of course, be made for developing such guidance as part of any new design efforts for these same categories of bridges.
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> To provide bridge safety inspectors with additional guidance concerning the inspection and evaluation of fracture critical details of bridges, the FHWA is developing a manual on "Inspection of Fracture Critical Bridge Members" and a companion training course. The manual and course should be available in 1985. For your information, we are attaching a copy of the "Statement of Work" for the contract being awarded for this work.

Based on these efforts by the FHWA, Safety Recommendation H-84-50 was classified as "Closed--Acceptable Action" on June 10, 1985.

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[3]For more information, see Highway Accident Report "Collapse of a Suspended Span of Interstate Route 95 Highway Bridge Over the Mianus River, Greenwich, Connecticut, June 28, 1983." (NTSB/HAR-84/03).

In further efforts on the issue of individualized bridge inspection procedures, the FHWA issued Transmittal 427 to Volume 6, Chapter 7, Section 2, Subsection 1, of the Federal-Aid Highway Program Manual. This material was issued as part of the 1989 revision to the NBIS and indicated that the individual in charge of the organizational unit that has been delegated the responsibilities for bridge inspection, reporting, and inventory shall determine and designate on the individual inspection and inventory records and maintain a master list of:

> Those bridges which contain fracture critical members, the location and description of such members on the bridge and the inspection frequency and procedures for inspection... Those bridges which contain unique or special features requiring additional attention during inspection to ensure the safety of such bridges and the inspection frequency and procedure for inspection of each such feature...

However, these efforts by the FHWA have been limited to the inspection of those bridge members that may be fracture critical or unusual. As a result of the Safety Board's investigation of the collapse of the northbound U.S. 51 Bridge, it is apparent that properly inspecting fracture critical bridge members is not enough to ensure the safety of a bridge. The proper evaluation of the data gathered during bridge inspections is also essential; without this evaluation, repairs in response to information obtained during the inspections may not occur. The 1987 inspection report of the northbound U.S 51 Bridge adequately identified a condition that eventually led to the sudden collapse of the bridge; however, because the inspection report evaluator failed to recognize the critical nature of this condition, repairs were never made. Further, the Safety Board does not believe that the inspection report evaluator alone should be responsible for the identification of critical bridge features that could independently cause the sudden collapse of a bridge component. Therefore, the Safety Board believes that the FHWA should require States to develop a crucial element checklist for each bridge based on the bridge design and as-built plans or available bridge data. The list should identify bridge elements or conditions that when damaged, exposed, corroded, or deformed would independently cause a sudden unexpected collapse of a section of the bridge. This list should then become part of each bridge inspection report. Further, when an inspector discovers the deterioration of a bridge element contained in the crucial element checklist, the States should be required to immediately close the bridge or perform needed repairs.

During the months preceding the collapse, a variety of overweight trucks (more than 80,000 pounds but less than 150,000 pounds) were permitted to travel across the northbound U.S. 51 Bridge. Permit applications for vehicles weighing less than 150,000 pounds are not reviewed by the TDOT Bridge Inspection and Repair Office when these vehicles cross bridges that are not load posted. Further, load posting is only required when the maximum legal load under State law (80,000 pounds in Tennessee) exceeds the bridge

operating rating.[4] The northbound U.S. 51 Bridge was subjected to an average of 76 trucks per month that exceeded the legal load limit. Although there are no indications that successive overweight vehicle loads contributed to the collapse, the Safety Board concludes that the frequency with which these vehicles traveled across the bridge was potentially harmful to the structure. Therefore, the Safety Board believes that States should establish review procedures for overweight vehicles to evaluate the effects of frequent overweight loads on unposted bridges. Further, based on this evaluation, the States should then limit the number and size of overweight vehicles permitted to cross those bridges that may be damaged because of frequent exposure to heavy loads.

Therefore, the National Transportation Safety Board recommends that the Federal Highway Administration:

Modify the National Bridge Inspection Standards to require follow-up or diver inspections of those bridges with underwater members that cannot be examined visually or by feel during scheduled bridge inspections because of excessive water depth or turbidity. (Class II, Priority Action) (H-90-56)

Require States to develop and maintain channel profile records for bridges over water and to evaluate the channel profile records to determine the effects of channel changes on bridges. (Class II, Priority Action) (H-90-57)

Modify the National Bridge Inspection Standards to require qualifications for personnel who evaluate bridge inspection reports. (Class II, Priority Action) (H-90-58)

Require States to develop a crucial element checklist for each bridge based on the bridge design and as-built plans or available bridge data. The list should identify bridge elements or conditions that when damaged, exposed, corroded, or deformed would independently cause a sudden unexpected collapse of a section of the bridge. This list should then become part of each bridge inspection report. Further, require the States to immediately close the bridge or perform needed repairs when an inspector discovers the deterioration of a bridge element contained in the crucial element checklist. (Class II, Priority Action) (H-90-59)

Require that States review overweight vehicle traffic to evaluate the effects of frequent overweight loads on unposted bridges. Require that, based on these evaluations, the States limit the number or size of overweight vehicles permitted to cross those bridges that may be damaged because of frequent exposure to heavy loads. (Class II, Priority Action) (H-90-60)

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[4] The absolute maximum permissible load to which the structure may be subjected.

Also, as a result of its investigation, the Safety Board issued Safety Recommendations H-90-61 through -63 to the American Association of State Highway and Transportation Officials, H-90-64 through -72 to the Tennessee Department of Transportation, and H-90-73 to the State of Tennessee. The Safety Board also reiterated Safety Recommendation H-89-71 to the American Association of State Highway and Transportation Officials.

KOLSTAD, Chairman, COUGHLIN, Acting Vice Chairman, and BURNETT and LAUBER, Members, concurred in these recommendations.

By: James L. Kolstad
Chairman