National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 24, 1990

In reply refer to: H-90-61 through -63

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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

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

channel was about 20 feet north of pier 7 (when the bridge was constructed 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 70, 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.

When TDOT performed its hydraulic analysis for the construction of the southbound bridge, it considered the environmental backwater effects on the surrounding flood plain and the local scour effects on the proposed bridge as a result of the flood plain constriction caused by the construction of the bridge embankments. The analysis assumed a maximum 5 fps flow velocity to determine a maximum vertical scour depth of 19 feet in the main channel. The southbound bridge was then subsequently designed to accommodate this scour. However, the hydraulic analysis for this bridge did not address the migration of the river channel. The potential lateral changes in a channel from man-induced alterations of river reaches, such as the 1974 flood plain constriction of the Hatchie River, were generally not considered during bridge design in the 1970's. Research concerning the importance of lateral migration effects and bank adjustments of channels in response to man-induced river alterations did not emerge until the early 1980's. Further, during the construction of the southbound bridge, the north bank of the river was located just south of column bent 70 of the northbound bridge. Therefore, if the bridge designers had applied the information contained in the hydraulic analysis to the condition of the northbound bridge, it is unlikely that they would have concluded that column bent 70 was potentially threatened with undermining as a result of the flood plain constriction. Although constriction of the flood plain occurred only during floods, the length and duration of the annually recurring Hatchie River flood season made the constriction effect a frequent and sustained occurrence.

The 1973 AASHO Standard Specifications for Highway Bridges indicated that bridge designers should consider "natural stream meanders" when selecting bridge locations. While it is understandable that the TDOT designers would not have considered the lateral migration effects caused by the constriction of the flood plain, they did not compare the historical river data collected by the U.S. Army Corps of Engineers at the bridge site. Had the designers compared these data with the northbound bridge design plans, they would have discovered that the north bank of the main channel had moved northward more than 40 feet toward column bent 70. Although in 1974, column bent 70 was not yet undermined, the designers did not recognize an established pattern of channel migration and the potential for undermining of column bent 70. Therefore, the Safety Board concludes that enough information and guidance was available for the designers of the southbound bridge to have discovered the natural channel meander of the Hatchie River and to have anticipated that further migration would undermine column bent 70 of the northbound bridge.

The current AASHTO bridge design specifications regarding bridge waterways are similar to the 1973 AASHO design specifications used during the design of the southbound bridge. The hydraulic studies section of the 1989 specifications discusses the collection and evaluation of hydrologic and hydraulic information to determine the design details for a new bridge. However, the standards do not provide instructions for designers to evaluate the detrimental effects to existing bridges caused by the construction of a new bridge in the same reach of the stream. The collapse of the northbound U.S. 51 Bridge highlights how man-induced alterations in streams, such as the construction of the southbound bridge embankments, can dramatically affect existing structures. Therefore, the Safety Board believes that hydraulic and hydrologic bridge design evaluations should include an examination of geomorphic changes in the river reach caused by the construction of a new bridge and the effects of those changes on existing structures.

Prior to the 1987 TDOT bridge inspection, the TDOT regional inspection office developed inspection sheets for each bridge member based on the bridge design plans. These sheets identified the bridge member configuration; however, they did not indicate dimensions. The sheets were subsequently used by the inspection team in lieu of the bridge design plans during the on-site inspection. The regional inspection engineer testified that these sheets replaced the need for on-site design plans and that, as a result, inspection teams rarely possessed design plans when inspecting a bridge. During the 1987 inspection of the northbound U.S. 51 Bridge, the inspector measured the column bent 70 footing by feeling along its side with a rod and determined that the footing was 5 feet deep. Utilizing this 5-foot measurement, the inspector calculated that about 1 foot of the piles supporting the column bent were exposed to water. However, the bridge design plans and the examination of the bridge wreckage by divers revealed that the column bent 70 footing depth was only 3 feet. Therefore, the piles supporting column bent 70 were actually exposed about 3 feet in 1987. Although the length of exposed piles was not accurately represented on the inspection report, the

undermining of the column bent 70 footing was identified, and the inspectors indicated that the column bent should be protected from scour. Further, when the regional inspection engineer reviewed the 1987 inspection report, he apparently did not compare the report with the bridge design plans; had he made this comparison, the conflicting footing measurement may have been discovered.

In previous bridge collapse investigations, the Safety Board has noted that inspectors did not have adequate design or as-built plans when inspecting bridges. As a result, serious deficiencies that contributed to the collapses were overlooked. The investigation of the New York Thruway Bridge collapse[2] revealed that because the inspectors did not have design plans, they assumed that the bridge was supported by piles when the bridge was actually supported by spread footings. Further, the investigation of the S.R. 675 Pocomoke City Bridge collapse[3] revealed that because the inspectors did not have design or as-built plans, they were unable to determine the original diameters of the substructure piles and, therefore, did not recognize that the piles had been reduced in cross section by as much as 35 percent.

The Safety Board concludes that if bridge design or as-built plans had been available to the TDOT inspector in 1987, he may have discovered that his measurement of the column bent 70 footing was contrary to the designed footing depth. At a minimum, this may have generated more scrutiny of the exposed timber piles by the inspectors and the regional inspection engineer. Therefore, the Safety Board believes that it is essential for inspectors to have available bridge design or as-built plans during on-site bridge inspections.

The last TDOT load rating of the northbound U.S. 51 Bridge indicated that the bridge was capable of supporting an H-15 truck and therefore, according to TDOT policy, did not require load posting. However, the load rating calculations did not consider the substructure bridge elements or the actual physical condition of the substructure, nor were they required to do so. Although the load carrying capacity of column bent 70 was not determined, it is apparent that the exposure of the friction piles supporting the column bent significantly reduced their ability to support heavy loads. As illustrated by this collapse, the Safety Board believes that the bridge substructure can become a weak member of the bridge and, therefore, should be considered in load rating procedures.

The Safety Board previously addressed the issues of load rating in its 1989 report on the collapse of the S.R. 675 bridge over the Pocomoke River.

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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).

[3]For more information, see Highway Accident Report--"Collapse of the S.R. 675 Bridge Spans over the Pocomoke River near Pocomoke City, Maryland, August 17, 1988." (NTSB/HAR-89-04).

As a result of the investigation, the Safety Board issued Recommendation H-89-72 to the American Association of State Highway and Transportation Officials:

> Modify Section 4.5 "Rating of Bridges, Evaluations" to require the evaluation of substructural bridge members during load rating calculations. (H-89-72)

This safety recommendation was issued on January 9, 1990, and is currently classified as "Open--Awaiting Response."

Further, the AASHTO Manual for Maintenance Inspection of Bridges states that: "A concrete bridge need not be posted for restricted loading when it has been carrying normal traffic for an appreciable length of time and shows no distress." Although the northbound U.S. 51 bridge did not require load posting, if it had, the bridge may have been exempt from posting because of this clause. The bridge had carried normal traffic for over 55 years and at the time of the last inspection, did not show any severe distress due to traffic loading. Although, AASHTO recommends that these concrete bridges receive more frequent inspections, the Safety Board believes that all bridges should be load rated and then appropriately posted. Simply because a bridge has not yet shown any distress from traffic does not indicate that it can safely support frequent heavy truck loads.

Therefore, the National Transportation Safety Board recommends that the American Association of State Highway and Transportation Officials:

> Modify Section 1.3.2, "Hydraulic Studies" of the Standard Specifications for Highway Bridges to include evaluations of geomorphic changes in streams caused by the construction of a new bridge and the effects of those changes on existing structures. (Class II, Priority Action) (H-90-61)

> Modify section 2.3, "Frequency and Level of Inspection" of the Manual for Maintenance Inspection of Bridges to include a requirement that bridge inspectors be provided with available bridge design or as-built plans during on-site bridge inspections. (Class II, Priority Action) (H-90-62)

> Modify section 4.6, "Rating of Bridges, Limiting Vehicle Weights" of the Manual for Maintenance Inspection of Bridges to delete the section which exempts certain concrete bridges from load posting. (Class II, Priority Action) (H-90-63)

Further, as a result of its investigation of this accident, the National Transportation Safety Board reiterates Safety Recommendation H-89-72 to the American Association of State Highway and Transportation Officials:

> Modify Section 4.5 "Rating of Bridges, Evaluations" of the Manual for Maintenance Inspection of Bridges to require the evaluation of substructural bridge members during load rating calculations. (H-89-72)

Also, as a result of its investigation, the Safety Board issued Safety Recommendations H-90-56 through -60 to the Federal Highway Administration, H-90-64 through -72 to the Tennessee Department of Transportation, and H-90-73 to the State of Tennessee.

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

By: James L. Kolstad
Chairman