National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 24, 1990

In reply refer to: H-90-64 through -72

Mr. Jimmy M. Evans
Commissioner
State of Tennessee
Department of Transportation
Jas. K. Polk Building
Nashville, Tennessee 37219

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

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[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.

The 1979, 1985, and 1987 TDOT inspection reports accurately identified the channel migration around column bent 70. The 1985 inspection report indicated that the channel had cut into the embankment at column bent 70 and 71; and in 1985, an accompanying maintenance recommendation to "protect piers 5, 6, 7, and 70 from scour" was developed by the regional inspection engineer and forwarded with the inspection report to the Structures Inventory and Appraisal (SI&A) section for evaluation. The 1987 inspection also indicated that there was erosion of the north bank around column bent 70, that the ground line was below the column bent 70 footing, and that underwater drift had accumulated at the column bent. The computer summary of this inspection transmitted to the SI&A section from the region also contained comments concerning the scour around column bent 70. Although there were no maintenance recommendations associated with these comments, the inspection report contained several separate indicators of scour, channel migration, and debris accumulation affecting column bent 70. As a result, the Safety Board concludes that the on-site inspections of the northbound U.S. 51 Bridge adequately identified the exposure of the column bent 70 footings and piles due to the northward migration of the Hatchie River channel.

Although the exposure of the column bent 70 footings and piles was identified in the 1987 inspection report, the bridge was only rated poor. TDOT indicated that an inspector would have to notice some settlement or leaning of a structure before it would be rated critical. As illustrated in this collapse, some simply-supported bridges are significantly affected by slight misalignment. Therefore, the Safety Board believes that TDOT should modify its bridge rating criteria to remove the requirement that a structure should show some settlement or leaning before it is rated critical.

Prior to the 1987 bridge inspection, the 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 was 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 might 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 might 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.

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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).

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.

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.

As a result of the Federal Highway Administration (FHWA) Technical Advisory (TA) on Scour,[4] TDOT initiated a program in September 1988 in cooperation with the United States Geological Survey (USGS) to identify scour critical bridges. TDOT indicated that this program should also identify those bridges subjected to lateral channel movements. Additionally, following the collapse, TDOT began to compile channel profile records for bridges over water and to compile a list of bridges with exposed footings and piles; and TDOT is using this information to assist regional bridge engineers with repair details for existing bridges. However, the TA recommends that States screen their existing bridges so that they can later be evaluated by an inter-disciplinary team of structural, hydraulic, and geotechnical engineers. It is the Safety Board's opinion that the program developed by TDOT in cooperation with the USGS should adequately identify those bridges that are scour critical. The Safety Board believes that TDOT should also establish an inter-disciplinary team of engineers to develop the repair and rehabilitation programs for those bridges that are determined to be scour critical. Further, the Safety Board believes that TDOT should immediately repair those bridges determined to have exposed friction piles.

The 1985, and 1987 inspection reports for the northbound U.S. 51 Bridge adequately identified the undermining of the column bent 70 piles. However, apparently neither the regional inspection engineer nor the SI&A evaluator determined that this condition was critical and required immediate action, even though the 1987 field inspection report recommended that column bent 70 be protected from scour. As a result, repairs were not performed to correct the channel migration underneath column bent 70.

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[4] Technical Advisory, "Scour at Bridges," T 5140.20, Federal Highway Administration, Washington, D.C., September 16, 1988.

At the time of the collapse, changes to the National Bridge Inspection Standards (NBIS) and the FHWA TA concerning scour and channel migration had just recently been issued. The TDOT evaluators may not have recognized the importance or potential of scour when they reviewed the 1987 inspection report. Therefore, the Safety Board believes that TDOT personnel involved in bridge inspections should be trained in accordance with the FHWA Technical Advisory "Scour at Bridges" and with other FHWA and AASHTO publications concerning the inspection of underwater bridge elements.

The 1985 and 1987 TDOT inspection reports for the northbound U.S. 51 Bridge adequately identified the undermining of the column bent 70 piles. However, apparently neither the regional inspection engineer nor the SI&A evaluator determined that this condition was critical and required immediate action, even though the 1987 field inspection report recommended that column bent 70 be protected from scour. As a result, repairs were not performed to correct the channel migration underneath column bent 70.

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.[5] 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.

Further, the TDOT permit office did not obtain weight per axle or axle spacing information for overweight vehicles under 150,000 pounds, when issuing overweight permits. This information is essential to accurately assess the damage an overweight vehicle can cause to a bridge. Therefore, the Safety Board believes that TDOT should obtain weight per axle and axle spacing information for overweight vehicles when issuing overweight permits.

As a result of the 1985 TDOT inspection of the northbound U.S. 51 Bridge, maintenance recommendations to protect column bent 70 from scour were issued to the region 4 director. During the Safety Board's public hearing the region 4 director testified that because of budget and manpower constraints, less than 50 percent of the annual computer-transmitted maintenance recommendations were accomplished. Therefore, the Safety Board concludes that because TDOT did not have sufficient resources to accomplish the majority of the maintenance recommendations, it missed the opportunity to correct the channel migration beneath column bent 70, or protect column bent 70 from scour, through routine preventive maintenance.

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

Although no maintenance was ever performed in response to the 1985 recommendations concerning scour, minor maintenance, such as drainage work and asphalt patching, was accomplished for the bridge. If the maintenance recommendations had been prioritized in 1985, it is likely that the recommendation concerning scour would have received greater attention and some maintenance may have been performed in response to the recommendation. Although, as a result of TDOT's modification to their organization, bridge maintenance and bridge inspection activities are now directed by each regional bridge engineer, there still is no priority ranking system for maintenance recommendations. The Safety Board believes that maintenance at all levels should be prioritized and that, therefore, TDOT should establish a priority ranking system for maintenance recommendations issued as the result of bridge inspections.

Therefore, the National Transportation Safety Board recommends that the Tennessee Department of Transportation:

Modify TDOT bridge rating criteria to remove the requirement that a structure show some settlement or leaning before it is rated critical. (Class II, Priority Action) (H-90-64)

Modify bridge inspection procedures to provide inspectors with available bridge design or as-built plans during on-site bridge inspections. (Class II, Priority Action) (H-90-65)

Expand TDOT bridge 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. (Class II, Priority Action) (H-90-66)

Establish an inter-disciplinary team of geotechnical, hydraulic, and structural engineers to develop the repair and rehabilitation programs for those bridges that are determined to be scour-critical. (Class II, Priority Action) (H-90-67)

Immediately repair those bridges determined to have exposed friction piles. (Class II, Priority Action) (H-90-68)

Train TDOT personnel involved in bridge inspections to evaluate scour in accordance with the FHWA Technical Advisory "Scour at Bridges" and other FHWA and AASHTO publications concerning the inspection of underwater bridge elements. (Class II, Priority Action) (H-90-69)

Modify bridge inspection report review procedures to require that hydraulic engineers review and evaluate all bridge inspection reports which identify the presence of scour or channel migration; and emphasize the identification and correction of channel movements and scour. (Class II, Priority Action) (H-90-70)

Obtain weight per axle and axle spacing information for overweight vehicles when issuing overweight permits. (Class II, Priority Action) (H-90-71)

Establish a priority ranking system for maintenance recommendations issued as the result of bridge inspections. (Class II, Priority Action) (H-90-72)

Also, as a result of its investigation, the Safety Board issued Safety Recommendations H-90 56 through -60 to the Federal Highway Administration, H-90-61 through -6? to the American Association of State Highway and Transportation Officials, and H-90-73 to the State of Tennessee. The Safety Board also reiterated Safety Recommendation H-89-72 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