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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

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In reply refer to: H-86-07

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About 2:01 p.m. central standard time, on April 24, 1985, two 34-foot-long twin spans at the south end of the Chickasawbogue Bridge on U.S. 43 about 2 miles north of Mobile, Alabama fell into water ranging from 10 to 30 feet deep after a steel pile bent 1/ collapsed. Two of the three southbound vehicles on the bridge at the time stopped before reaching the edge of the bridge void. However, one vehicle, a 1979 Ford van, became airborne, struck one of the falling bridge spans, and entered the water. The lone occupant exited the van, swam to shore before the van sank in 20 feet of water, and sustained minor injuries in the accident.

In a postaccident examination of the bridge, divers for the State of Alabama reported that the exposed steel H-piles were severely corroded near the mud line of the creek. The State of Alabama last inspected the Chickasawbogue Bridge on April 3, 1985. However, none of the underwater bridge elements was examined during that inspection. The underwater elements of the bridge had not been inspected by the State since November 1969.

The Chickasawbogue Bridge was designed in accordance with the State Highway Department of Alabama Standard Specifications for Highways, Bridges, and Materials, dated 1950, and in accordance with the American Association of State Highway Officials (AASHO) Standard Specifications for Highway Bridges, dated 1953. 2/ Design on the bridge started in 1952, and the bridge was opened for vehicles in 1958. Initially, the bridge had an estimated design life of 75 years.

In the Gulf States, 3/ steel pile was widely used in the construction of bridge substructures during the 1950s because it was economical and accommodated the rapid construction of bridges. The 1953 AASHO standard specifications for highway bridges suggested the following precaution to compensate for corrosion of exposed steel piles: "1/16 inch depth of thickness shall be deducted from all exposed surfaces when computing the area of steel in piles or shells." This particular requirement was not

1/ For more details, read Highway Accident Report "Collapse of the U.S. 43 Chickasawbogue Bridge Spans near Mobile, Alabama, April 24, 1985 (NTSB/HAR-86/01).
2/ The American Association of State Highway and Transportation Officials, Standard Specifications for Bridges (The Association, Washington, D.C.) 1953, p. 204.
3/ The five States with coastlines on the Gulf of Mexico are Florida, Alabama, Mississippi, Louisiana, and Texas.

used in the design of the Chickasawbogue Bridge, nor was it a requirement in the Alabama Standard Specifications for Highways, Bridges, and Materials.

After the collapse, Safety Board investigators inspected the remaining bridge structure for horizontal and vertical misalignment. Span misalignment varied up to 3/8 inch in the horizontal direction and 1/4 inch in the vertical direction. Expansion joint openings varied from 1/32 inch at pile bent 5 to 1 1/2 inches at pile bent 6. At the time of the inspection, new steel H-piles were being installed to accommodate the reopening of the southbound lane for vehicle traffic.

The State of Alabama Highway Department (AHD) does not routinely record measurements for span misalignment or expansion joint openings on the bridge inspection report. On some occasions, bridge inspectors will note on the report obvious problems with misalignment. Misalignment is given a subjective rating by the inspector as part of the structural appraisal for bridges. Although AASHTO and Federal Highway Administration (FHWA) guidelines for bridge inspection suggest that measurements should be recorded, they do not provide any criteria for determining what the acceptable tolerance ranges should be for span misalignment or expansion joint openings.

At the time of the bridge collapse, the AHD inspected all bridges at 2-year intervals in accordance with the National Bridge Inspection Standards (NBIS) 4/ and inspected the underwater elements of "major" bridges at 5-year intervals. Although there is no universally accepted definition for a major bridge, the State of Alabama generally defines major bridges as those over rivers and those that include complex design, substructures, or foundations in deep water. The last inspection was made on April 3, 1985, 21 days before the collapse. Since the bridge was not classified as a major bridge, none of the underwater bridge elements were examined during these inspections. The Chickasawbogue Bridge had been inspected at the required 2-year intervals. The last reported inspection of the underwater elements was conducted in November 1969 after the FHWA Regional Office notified the State of the collapse of the Anclote Bridge in Florida due to the corrosion of exposed steel H-piles. At that time, the State examined the underwater elements of several bridges, including the Chickasawbogue Bridge. State highway officials did not uncover any apparent corrosion problems in the substructural elements of the Chickasawbogue Bridge after 11 years of service; as a result, no further underwater examinations were made.

As a result of the inspections prompted by the Anclote Bridge collapse, the AHD discovered underwater corrosion problems on three other bridges located closer to Mobile Bay. The AHD continued to monitor the condition of these bridges and in 1974, discovered that the bridge spans had begun to misalign, both in the transverse and longitudinal directions. The AHD reinforced the bridges with additional H-piles, but the condition became worse. In 1977, the AHD resolved the problems by encasing the steel piles in concrete from the water line to below the mud line on one bridge, and by replacing steel piles with concrete piles on the two other bridges. These three bridges and the bridge over the Chickasawbogue are over brackish water. 5/

Safety Board investigators contacted the FHWA's Division Administrator and Division Structural Engineer in Alabama and the FHWA Regional Structural Engineer in Atlanta, Georgia. These officials are responsible for ensuring compliance with the NBIS.

4/ Reference 23 CFR 650.301 to 650.311, "National Bridge Inspection Standards," for details.

5/ Contains some salt.

The FHWA conducts an annual review of the State bridge inspection programs, renders technical assistance, and assists in training in bridge inspection. None of the FHWA officials were aware that Alabama had not been inspecting the underwater elements of nonmajor bridges. Safety Board investigators examined the Structure Inventory and Appraisal Sheet (SI&A) that the FHWA requires each State to complete for all bridges and the bridge inspection report form used by the AHD. Each document provides for a rating of the substructure of the bridge. Neither document provides for reporting that underwater elements are examined when each bridge is inspected.

As a result of the collapse of the bridge spans over Chickasawbogue Creek, the AHD launched an intensive inspection and repair program. The State inspected the underwater elements of 655 bridges and bridge culverts. These bridges were constructed with either steel or concrete piles. Twenty of the bridges inspected, ten on Interstate routes and ten on State routes, exhibited varying stages of corrosion of the steel piles. Corrosion was found on exposed steel piles in both fresh and brackish water. In addition, one county-owned and one city-owned bridge, each over brackish water, were inspected and were found to have extensive corrosion. These bridges were closed because of imminent danger of collapse. As a result of this intensive inspection program, the AHD indicated that it will continue to inspect the underwater elements of these bridges every 2 years.

Corrosion of exposed steel bridge piles is not unique to the State of Alabama. In December 1968, a portion of a 300-foot-long, 2-lane bridge collapsed into the Anclote River in Florida near the Gulf of Mexico. Corrosion below the concrete encasement had reduced significantly the cross section of immersed steel H-piles. After the Anclote River Bridge collapse, the State of Florida immediately initiated a program to inspect all bridges over water and found similar corrosion problems, including corrosion at the mud line, on several other bridges. Before this time, Florida had not conducted routine underwater examinations. Because of the bridge collapse and subsequent findings of the inspection, Florida immediately adopted a policy to inspect the underwater elements on all bridges over water at 2-year intervals.

The FHWA reported in 1984 that there were about 574,045 highway bridges on public roads in the United States. 6/ Approximately 87 percent of these bridges were over water. Currently, the FHWA has no data available to estimate how many of these bridges over water are constructed with exposed steel H-piles. A study by the Transportation Research Board 7/ indicated that only 15 States routinely inspect the underwater elements of bridges. Alabama is one of those 15 States listed. The study did not report whether the States inspected the underwater elements on all applicable bridges or just selected bridges during low water periods.

The Safety Board held a public hearing on this investigation in Atlanta in July 1985. Exhibits and testimony were entered into the record to assemble a comprehensive, factual docket of information on this accident and the bridge inspection programs within various States. Officials of the AHD, FHWA, AASHTO, AISI, U.S. Army Corps of Engineers, and the National Bureau of Standards (NBS) provided testimony on the

6/ U.S. DOT, FHWA--"Sixth Annual Report to Congress on Highway Bridge Replacement and Rehabilitation Program," published April 1985.

7/ National Cooperative Highway Research Program, Synthesis of Highway Practice 88, "Underwater Inspection and Repair of Bridge Substructures," Transportation Research Board, December 1981.

construction, maintenance, and inspection of the Chickasawbogue Bridge, and on the National Bridge Inspection Program, Federal oversight responsibilities, factors influencing the corrosion of exposed steel piles in marine environments, and appropriate countermeasures to retard corrosion.

FHWA officials who testified at the public hearing stated that the 5-year cycle for underwater inspection, suggested in the AASHTO manual, was not based on research but on the best engineering judgment available at the time the AASHTO manual was written. FHWA officials stated that they did not question the State's bridge inspection program or determination of "major" bridges because they felt the professional engineer in charge of the program was knowledgeable about the bridges within the State and was able to determine which bridges should and should not be subjected to underwater inspections. The FHWA officials stated also that in retrospect they probably should have asked more questions during the annual review process to clarify Alabama's policy on inspecting nonmajor bridges.

FHWA officials also stated that after the collapse of the Anclote River Bridge, only the States within the same FHWA region were notified of the circumstances and causes of the collapse. However, the results of the followup inspection program by the State of Florida were not disseminated. After the collapse of the Chickasawbogue Bridge spans, all 10 FHWA regions were notified and requested to take appropriate steps to make certain that all States had well-founded underwater inspection programs that identified the criteria, procedures, frequency, and followup methods necessary to comply with the requirements of the NBIS. Again, the results of the followup inspection program by the State of Alabama were not disseminated.

Of the seven State highway departments in FHWA Region 4, representatives from four--Florida, Mississippi, North Carolina, and Tennessee--testified on the underwater bridge inspection programs within their respective States. 8/ Except for Tennessee, all of the States have bridges over brackish waters. Representatives from two of the four States said that they have existing programs for inspecting the underwater elements of bridges. Florida and North Carolina perform underwater inspections on every bridge over water every 2 years; Tennessee and Mississippi inspect the underwater elements of their bridges only when problems are suspected (i.e., scour caused by weather conditions or damage caused by collision with ships).

In its "Sixth Annual Report to Congress," 9/ the FHWA concluded that compliance with the NBIS was not adequate. The report noted that many bridges are not being inspected at the required frequency, and that there are nationwide variations in the level of inspections. The report states that "According to current National Bridge Inventory (NBI) data, a significant number of Federal-aid system and off-system bridge inspection dates are more than 3 years old."

This general attitude towards compliance with the NBIS has also permeated the underwater bridge inspection programs by many States. Section 2.3 of the NBIS specifies that all highway bridges be inspected within a 2-year period and also states:

> The depth and frequency to which bridges are inspected will depend on such factors as age, traffic, characteristics, and known deficiencies. The evaluation of these factors will be the responsibility of the individual in charge of the bridge inspection program.

8/ State Highway officials in Kentucky, South Carolina, and Georgia did not participate.
9/ See footnote 6.

A strict interpretation of this standard would mean that every bridge, including all the substructure elements, should receive a detailed inspection every 2 years. However, the bridge inspection guidelines provided in the AASHTO Manual for Maintenance Inspection of Bridges suggest that the underwater elements of bridges be inspected on a 5-year cycle.

Based on testimony provided at the public hearing, the 5-year cycle for underwater inspection suggested in the AASHTO manual was not derived from research. Until research is conducted to establish the appropriate inspection cycle, the suggested 5-year cycle should probably be used. The Safety Board believes that the FHWA should require each State to conduct an inspection of the underwater structural elements on all applicable bridges that have not had such inspections. If a State has adopted a shorter inspection cycle or is aware of known deficiencies on a bridge, the inspection cycle should be adjusted accordingly. Because of the large variances in the environmental conditions and the differences in construction, design, and materials used for the underwater structural elements of bridges, the FHWA should conduct research to establish the appropriate inspection cycle and procedural guidelines for examining bridge substructural elements in marine environments.

At this time, many States do not comply with either the 2-year inspection cycle specified in the NBIS or the 5-year inspection cycle suggested in the AASHTO manual for underwater inspections. A 1980 study prepared by the Transportation Research Board indicated that 35 States do not routinely inspect bridge substructures below the waterline. Out of the 15 States that do conduct routine underwater inspections, 14 perform these inspections every 5 years or less. Because of the apparent lack of uniform policy on the underwater inspection of bridge elements, most States perform these inspections only when problems are suspected.

The detail, type, and frequency of the underwater inspections are left to the discretion of the State highway officials. Both FHWA and AASHTO provide only suggested guidelines on underwater inspections, guidelines that do not identify specific details for inspecting the underwater elements of bridges based on the foundation type, substructure complexity, and water conditions the bridge is subject to. The Safety Board believes effective criteria are needed to assist the States in developing programs for the underwater inspection of bridges.

In addition to the lack of underwater inspection criteria, the FHWA and AASHTO do not provide effective criteria for determining acceptable tolerances for bridge span misalignment or expansion joint openings. The AASHTO manual suggests that measurements be recorded, but does not provide the methodology for recording measurements or for identifying potential causes of span misalignment or abnormal expansion of joint openings or closures. The FHWA Bridge Inspector's Training Manual, on the other hand, does stress that excessive misalignment should raise questions regarding the condition of the bridge. However, the manual does not provide written, objective, dimensional standards for measuring the alignment of bridge structural members. If alignment measurements are recorded routinely during the normal above-water bridge inspection, the bridge inspector may determine if a substructural member has shifted, and may request a detailed underwater inspection to identify the cause(s) of shifting. The Safety Board believes that objective criteria should be developed to assist States in these areas.

As a result of its investigation of this accident, the National Transportation Safety Board recommended that the American Association of State Highway and Transportation Officials:

Work with the Federal Highway Administration to develop a bridge inspection procedure for examining the substructural elements below water which consider the size, type, and complexity of the bridge design, and the marine environment, and develop effective criteria for determining acceptable tolerances for bridge span misalignment and expansion joint openings or closures which identify dimensional standards for the alignment of bridge spans. (Class II, Priority Action) (H-86-7)

GOLDMAN, Acting Chairman, and BURNETT, LAUBER, and NALL, Members, concurred in this recommendation.

By: Patricia A. Goldman
Acting Chairman