



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

A-517C

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In reply refer to: H-88-22

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Commissioner
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On April 5, 1987, two of the five spans of the New York State Thruway (I-90) bridge over the Schoharie Creek fell about 80 feet into a rain-swollen creek after pier 3, which partially supported the two spans, collapsed. Ninety minutes after the initial collapse, pier 2 and a third span collapsed. Four passenger cars and one tractor-semitrailer plunged into the creek, and 10 persons were fatally injured. 1/

After the collapse, examination of the area under the bridge revealed that the soil beneath the extreme upstream end of the pier 3 footing had been eroded. The upstream end of the footing had dropped into a scour hole that was 9 feet deep. (The deepest part of the hole was located about 3 feet west of the upstream end of the footing.) The downstream end of the pier had not moved.

Survey measurements indicated that pier 2 had settled along its entire length and was also tilted toward the west. The north end had settled about 5 feet below its originally constructed elevation. The north column settled an average of 3.9 feet. The south column settled an average of 2.1 feet. The north column remained standing after the collapse, and was removed during demolition.

1/ For more information, read Highway Accident Report--"Collapse of New York State Thruway Authority (I-90) Bridge Over the Schoharie Creek, Amsterdam, New York, April 5, 1987" (NTSB/HAR-88/02).

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Because the bridge was designed with spread footings and without piles, riprap protection against scour was essential to the survival of the bridge during floods. During construction, a thick layer of riprap was installed from the top of the footing (elevation 275 feet), sloping upward to the plinth to an elevation of about 279.5 feet around piers 2 and 3. This layer of riprap, which included large rocks, protected the pier foundations during the flood of record in 1955 and numerous smaller floods. The 1955 flood of record had the potential to move large quantities of riprap from the front of piers 2 and 3. Although the inspection report for the acceptance of the bridge on May 31, 1956, did not mention riprap movement, photographs taken on October 30, 1956, showed movement of riprap northward along piers 2 and 3. Other photographs taken from 1954 to 1977 during low water disclosed that some of the rocks had moved northward during that period of time.

The continued movement of riprap was revealed during inspections in 1977 and 1979. Due to the lower water velocities at pier 2, lesser amounts of cobble and other larger material may have been transported into the scour area at pier 2 than into the area around pier 3. After 1977, the frequency and magnitude of floods increased, and the movement of riprap away from pier 3 and its replacement with cobbles and streambed material probably increased.

Further, based on the magnitude of their flows, their direction, and their similarities in velocity, the floods of 1955 and 1987 (as demonstrated by photographic evidence and by the results of the physical models and the computer analyses conducted after the accident) had similar erosion capability. The Safety Board thus concludes that had the piers been protected by riprap at the time of the April 1987 flood as they were during the 1955 flood, the bridge probably would not have collapsed.

A review of the New York State Thruway Authority (NYSTA) maintenance records for the Schoharie Creek Bridge indicated that the bridge received regular maintenance such as painting of the superstructure, patching of the deck, and the sealing of joints. After the collapse, observations by Safety Board investigators of the remains of the deck, steel beams and girders, bearings, columns, and piers corroborated this. The maintenance records, however, did not include any entries concerning the maintenance of riprap around the piers.

From the time the Thruway was opened, the NYSTA, as did the New York State Department of Transportation (NYSDOT) and many other organizations, used maintenance personnel to inspect bridges for both maintenance needs and safety inspections. The inspections in the NYSTA Albany division were accomplished not by engineers, but by personnel whose primary responsibilities were in bridge maintenance. The Albany assistant division engineer (bridges) was not a professional engineer but had received the training and had the years of experience required by the Federal Highway Administration (FHWA) National Bridge Inspection Standards (NBIS) to qualify for conducting bridge inspections.

However, in his 1986 inspection of the bridge, and in previous inspections, the Albany assistant engineer (bridges) failed to evaluate the condition of the riprap at the piers properly, and he failed to take the dropline readings necessary to evaluate the conditions in the streambed. These two tasks were specifically required in the NYSDOT Bridge Inspection Manual (BIM-82) and earlier documents on bridge inspections. The fact that he overlooked these two tasks indicated that he either did not think they were important or he did not understand their importance. In addition, the engineer's supervisors, who should have reviewed his reports, apparently did not review his reports or failed to recognize the seriousness of the omissions and therefore did not attempt to correct the situation.

The Albany assistant division engineer (bridges) may have assumed that the bridge was built on piles and therefore did not regard riprap maintenance as important. In his 1986 inspection of the bridge, he gave piles a rating of "9," indicating condition unknown, rather than "8," not applicable. At the Safety Board's public hearing, he also indicated that he thought the bridge was constructed on piles. Some of the bridge inspection reports that he signed as far back as 1970 indicate that he thought the bridge was built on piles, but other reports indicate the opposite.

Entries in the maintenance log of the Schoharie Creek Bridge date back to 1955. None of the entries address the maintenance of riprap. The Albany assistant division engineer (bridges) said that he did not recall riprap ever having been placed or maintained around the pier footings. Further, there is no evidence to indicate that riprap had ever been replaced around the piers after the bridge was opened to traffic in 1954.

In 1979, an engineering firm conducted bridge inspections for the NYSDOT to comply with the NBIS inventory requirements for off-system bridges. Sketches made by the assistant team leader during that inspection clearly showed that riprap around piers 2 and 3 was missing. The assistant team leader, who drew the sketches, stated that he could not recall if riprap was present. The assistant had drawn in "scattered stone" on the downstream end of the west side of pier 2 but did not recall its exact extent or shape; he said that it was large stone of at least basketball size. It may have been cobbles or riprap.

The measurements on the sketches, when compared with the original design plans, showed a significant decrement in the riprap cover of the footing. The measurements and photographs from the inspection clearly indicated that riprap was not piled at an even level around the plinth. This information should have alerted a person knowledgeable in river mechanics and structures that riprap had moved, posing a danger to the structure. However, the team leader, a registered professional engineer, gave both piers 2 and 3 a rating of 6 for its scour condition. This was the best rating that could be given if erosion or scour

had affected, in any way, the material above the bottom of the footing but had not undermined the footing. A rating of 7 would have indicated that there had not been any loss of material around the piers. The team leader also coded the pier-piles column in the bridge inspection report as "8," meaning that no piles were present under the piers.

The National Transportation Safety Board believes that the sketches showed that a significant amount of riprap had moved away from the upstream ends of the piers in 1979 and, especially since there were no piles, the engineering firm should have, in accordance with its agreement with the NYSDOT, immediately called the NYSDOT project manager to alert him. The call also should have been followed with a letter. However, there is no evidence that the firm so notified the NYSDOT (or the NYSTA) of the riprap deficiency.

When the NYSDOT received the report, it did not notify the NYSTA of the missing riprap, indicating either that NYSDOT personnel did not review the report or that they believed the missing riprap required no attention. It is quite likely that NYSDOT personnel did not review the report since they only reviewed some of the inspection reports and those they did review were generally reviewed for coding and format errors only.

When the NYSTA finally received the report in April 1980, it did not replace the missing riprap, indicating either that it also did not review the report or that it did not consider the situation serious enough to require correction. If the report was reviewed by the NYSTA, the sketches and the rating elements should have alerted the reviewer that the bridge was not built on piles and that the depletion of riprap was important. Further, the Seelye inspections should have relieved the NYSTA of the need to perform a bridge inspection that year; the time saved could have, and should have, been used to thoroughly analyze the report. (These inspections of the Schoharie Creek Bridge were on March 26 and August 15, 1979; the NYSTA's inspection was on October 21, 1979.)

In 1982, a major rehabilitation project greatly improved the superstructure and substructure above the water line based on inspections, reports, and plans prepared by an engineering firm hired by the NYSTA. Unfortunately, the plans finalized by NYSTA did not call for the replacement of missing riprap with 600 cubic yards of 600-pound riprap, as had been specified in these plans. Replacement riprap was removed from the plans at the direction of the NYSTA technician responsible for finalizing the plans.

Memoranda written in 1978 and 1980 by NYSTA personnel indicated that the assistant superintendent of maintenance (bridges), the director of construction and design, and the design unit head were aware that riprap had been called for as part of the rehabilitation plans. When the technician decided to delete riprap from the final plans, these same supervisors either checked the plans and agreed with his decision, or they did not

check the plans. The Safety Board believes that a failure of the supervisor to review this decision would have been a major deficiency in his oversight of a subordinate. In either case, however, the decision not to replace the riprap was a critical decision that contributed to the cause of the accident.

These incidents show that the review and analysis of the reports of the NYSTA bridge safety inspections of the underwater portions of the bridge were inadequate. Further, the NYSTA inspectors were not well supervised; their supervisors did not correct them when they failed to note and address missing riprap or when they failed to fill out the underwater section of the forms properly. Further, there was little quality control, especially of the information on the forms relating to the inspection of the underwater elements of the bridges.

These failures may have, in part, resulted from inadequate NYSTA (and NYSDOT) policies and guidelines about when conditions at the foundation of underwater members of bridges warranted maintenance. For example, the NYSTA assistant superintendent of maintenance (bridges), the bridge inspector's supervisor, said that the NYSDOT "Highway Maintenance Guidelines" stated that riprap should be replaced before "...scour progresses to a depth dangerous to the stability of a structure (1/2 of the thickness of the pier footing...)." The Safety Board is not aware of any specific guidance provided by the NYSTA to its inspectors about when riprap replacement was warranted. The Safety Board believes that the NYSDOT guidance was not proper and should be substantially modified. (In a December 7, 1987, memorandum, the NYSTA directed its employees to delete the reference to 1/2 the footing depth from the NYSDOT manual.)

Riprap must be maintained to prevent erosion of the soil around and beneath the footings. It is highly probable that had the NYSTA maintained riprap of a similar weight and to a similar level as that placed originally, the bridge would not have collapsed. In addition, if the NYSTA had replaced the missing riprap (Item 80) with 600-pound riprap, which was twice the weight specified in the original design of the bridge, the riprap would have been more difficult to move and, therefore, would have protected the footings more effectively.

The circumstances of this accident show that better guidance is needed. Inspectors (and some supervisors) from the NYSTA, the NYSDOT, and the engineering firm either failed to understand the importance of riprap or failed to recognize that sufficient riprap had migrated from piers 2 and 3 to pose a danger to the bridge.

The Safety Board believes that the inadequate guidance in the replacement of riprap provided to the NYSTA inspectors resulted, in part, from the lack of specific guidance available at the time from the FHWA or the American Association of State Highway and Transportation Officials (AASHTO). In fact, it is not clear that the situation is any better today. The Safety Board has reviewed literature from several organizations that provided guidance on bridge inspection and maintenance and has found no specific guidance on when to replace riprap and very little on when to repair scour damage at piers founded on spread footings. Many bridge engineers state that specific guidance cannot be provided, but that inspectors need to use their engineering judgment.

The Safety Board is concerned that bridges similar to the Schoharie Creek Bridge may not be receiving proper riprap maintenance because there is no proper guidance as to when to replace riprap. The Safety Board is aware that specific guidance cannot cover every possible condition and that bridge inspectors indeed need good engineering judgment. The Safety Board also recognizes that experienced bridge engineers may generally be able to recognize when riprap needs to be replenished or replaced or when other foundation repairs are required. However, most bridge inspectors are not now, and are not likely to be, experienced bridge engineers. The Safety Board is thus convinced that specific guidance must be provided to bridge inspectors.

The Safety Board believes that research is needed to determine the size and amount of riprap needed for scour protection and the degree of depletion that may occur before replacement is necessary. (The Safety Board recognizes that highway maintenance departments cannot replace each rock as it moves.) The Safety Board is concerned that bridges similar to the Schoharie Creek Bridge may not be receiving proper riprap maintenance because there is no proper guidance as to when to replace riprap. Therefore, the Safety Board believes that, until research is done to establish better guidance, AASHTO should provide guidance, and the NYSDOT should modify their guidance to specify that, after each inspection of a bridge that depends upon riprap for scour protection, any missing riprap must be replenished to design specifications or to a higher level of protection.

Despite the NYSDOT effort to comply with the NBIS by hiring consulting engineers to do bridge inspections, the information that the NYSDOT obtained was used primarily to satisfy items specified in FHWA's Structure Inventory and Appraisal Sheet. The NYSDOT did not analyze or otherwise use the results of the inspection of the bridge. Thus, the Safety Board concludes that the NYSDOT lost an opportunity to learn about the missing riprap at the Schoharie Creek Bridge and to alert the NYSTA to correct the situation.

At the time of the collapse, the NYSDOT was developing criteria and methods for performing underwater inspections. It had established a list of bridges that were to receive an underwater inspection, which included a list of bridges from NYSTA; the Schoharie Creek Bridge was on the list. However, the issuance of a contract for the underwater inspections was delayed because, according to the NYSDOT, New York State's share of Federal highway funds was exhausted. Apparently, no NYSDOT official ever notified NYSTA officials of the delay and the NYSTA took no other action. In the meantime, the Schoharie Creek Bridge collapsed.

The Safety Board believes that a proper underwater inspection of the Schoharie Creek Bridge piers before their collapse may have uncovered a lack of adequate riprap or other manifestations of scour, such as a scour hole in the streambed. Such additional evidence of scour may have sufficiently motivated the NYSTA to replace the missing riprap.

Evidence available to the Safety Board suggests that the NYSTA attempted to cooperate with the NYSDOT in its effort to comply with the inventory requirements of the NBIS by providing the NYSDOT with the inspection data it was collecting. However, the NYSDOT had no authority to compel the NYSTA or any other authority or municipality to cooperate in complying with the NBIS.

As a result of the collapse of the Schoharie Creek Bridge, the NYSDOT has also improved its bridge inspection program, formalizing many of its previously unwritten inspection procedures, especially its procedures for inspecting bridges over water. Inspections are scheduled for periods of low water to permit visual inspection of the substructural members and probing beneath the water surface for evidence of scour at the bridge piers, in the streambed, or at the bank. This will also facilitate improved documentation of the foundation and the streambed. When substructural members cannot be visually inspected, then followup diver inspections are required. Bridges with spread footings in water will receive inspections that consider scour susceptibility.

Hydraulic evaluations will be made of bridges over water. This will identify changes in the streamflow velocities, changes in the streambed conditions, both upstream/downstream of the bridge and at the bridge site, and permit the NYSDOT to update the scour susceptibility of the bridge as compared to original design conditions.

Immediately after any flood, the NYSDOT will implement emergency inspections to check bridges in the flood areas for tilt, sag, movement, or other evidence of damage to substructural/superstructure members, and for evidence of scour at the bridge site. If any critical discrepancies are detected, then the bridge(s) will be closed immediately or monitored continuously to see if conditions that would warrant a bridge closure have changed.

The NYSDOT is also evaluating scour detection equipment. Three State inspection teams of two persons each have been added to bring the total to 26 teams. The bridge inspection inventory items are being scrutinized to determine if changes in the system are warranted. Computer checks are being made on the coding of bridge inspection items for quality control by cross checking various items including ratings and also for consistency with the original design specifications. The Safety Board believes that these changes will improve the NYSDOT bridge inspection program.

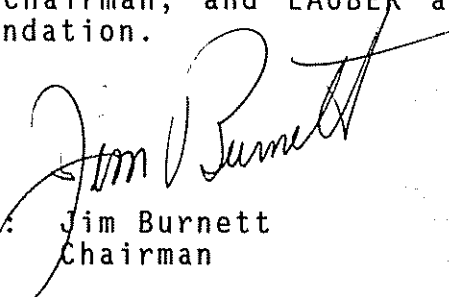
Therefore, the National Transportation Safety Board recommends that the New York State Department of Transportation:

Modify the guidance provided in the New York State Department of Transportation Highway Maintenance Guidelines to require that, following each inspection of bridges that are dependent upon riprap for scour protection, the riprap be replenished to meet the design specifications, and remove the sentence in Section 4.4.5.2 of the guidelines, which states, "Repairs should be made, using heavy stone fill or riprap before scour progresses to a depth dangerous to the stability of a structure (1/2 of the thickness of pier footing)." (Class II, Priority Action) (H-88-22)

Also, the Safety Board issued Safety Recommendations H-88-12 through -15 to the American Association of State Highway and Transportation Officials; H-88-16 through -20 to the Federal Highway Administration; H-88-21 to the U.S. Department of Transportation; and H-88-23 to the American Association of State Highway and Transportation Officials, the International Bridge, Tunnel and Turnpike Association, the National Association of Counties, the National League of Cities, and the National Association of Towns and Townships.

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "... to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any actions taken as a result of its safety recommendations and would appreciate a response from you regarding action taken or contemplated with respect to the recommendation in this letter. Please refer to Safety Recommendation H-88-22 in your reply.

BURNETT, Chairman, KOLSTAD, Vice Chairman, and LAUBER and NALL, Members, concurred in this recommendation.

By: 
Jim Burnett
Chairman