PB84-916203

Highway Accident Report - Collapse of a Suspended Span of Interstate Route 95 Highway Bridge over the Mianus River Greenwich, Connecticut, June 28, 1983

(U.S.) National Transportation Safety Board
Washington, DC

19 Jul 84

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.: NTSB/HAR-84/03
2. Government Accession No.: PB84-916203
3. Recipient's Catalog No.:
4. Title and Subtitle: Highway Accident Report— Collapse of a Suspended Span of Interstate Route 95 Highway Bridge Over the Mianus River, Greenwich, Connecticut, June 28, 1983
5. Report Date: July 19, 1984
6. Performing Organization Code:
7. Author(s):
8. Performing Organization Report No.:
9. Performing Organization Name and Address: National Transportation Safety Board, Bureau of Accident Investigation, Washington, D.C. 20594
10. Work Unit No.: 3764A
11. Contract or Grant No.:
12. Sponsoring Agency Name and Address: NATIONAL TRANSPORTATION SAFETY BOARD, Washington, D. C. 20594
13. Type of Report and Period Covered: Highway Accident Report, June 28, 1983
14. Sponsoring Agency Code:
15. Supplementary Notes:

16. Abstract

At 1:30 a.m., e.d.t., on June 28, 1983, a 100-foot-long suspended span between piers 20 and 21 of the eastbound traffic lanes of the Interstate Route 95 highway bridge over the Mianus River in Greenwich, Connecticut, collapsed and fell 70 feet into the river below. Two tractor-semitrailers and two automobiles plunged into the void in the bridge and were destroyed by impact from the fall. Three vehicle occupants died, and three received serious injuries.

The National Transportation Safety Board determines that the probable cause of the collapse of the Mianus River bridge span was the undetected lateral displacement of the hangers of the pin and hanger suspension assembly in the southeast corner of the span by corrosion-induced forces due to deficiencies in the State of Connecticut's bridge safety inspection and bridge maintenance program.

17. Key Words: highway bridge; suspended span pins and hangers; expansion joints; windlock; drainage; bridge design; lateral movement; steel; bearing stress; out-of-plane movement; bridge safety; bridge maintenance; bridge cleaning.
18. Distribution Statement: This document is available through the National Technical Information Service, Springfield, Virginia 22161
19. Security Classification (of this report): UNCLASSIFIED
20. Security Classification (of this page): UNCLASSIFIED
21. No. of Pages: 111
22. Price:

NTSB Form 1765.2 (Rev. 9/74)

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

HIGHWAY ACCIDENT REPORT

Adopted: July 19, 1984

COLLAPSE OF A SUSPENDED SPAN OF INTERSTATE ROUTE 95 HIGHWAY BRIDGE OVER THE MIANUS RIVER, GREENWICH, CONNECTICUT JUNE 28, 1983

SYNOPSIS

At 1:30 a.m., e.d.t., on June 28, 1983, a 100-foot-long suspended span between piers 20 and 21 of the eastbound traffic lanes of the Interstate Route 95 highway bridge over the Mianus River in Greenwich, Connecticut, collapsed and fell 70 feet into the river below. Two tractor-semitrailers and two automobiles plunged into the void in the bridge and were destroyed by impact from the fall. Three vehicle occupants died, and three received serious injuries.

The suspended span which collapsed was attached to the bridge structure at each of its four corners. To support the weight of the northeast and southeast corners of the suspended span, each corner was attached to the girders of the cantilever arm of an adjacent anchor span by a pin and hanger assembly. The pin and hanger assembly includes an upper pin attached through the 2 1/2-inch-thick web of the girder of the cantilever arm and a lower pin attached through the 2 1/2-inch-thick web of the girder of the suspended span. One and one half-inch-thick steel hangers connect the upper and lower pins--one on the inside and one on the outside of the web.

Sometime before the collapse of the suspended span, the inside hanger in the southeast corner of the span came off of the inside end of the lower pin. This action shifted the entire weight of the southeast corner of the span onto the outside hanger. The outside hanger gradually worked its way farther outward on the pin, and over a period of time, a fatigue crack developed in the top outside end of the upper pin. The shoulder of the pin fractured off, the pin and hanger assembly failed, and the span collapsed into the river.

The National Transportation Safety Board determines that the probable cause of the collapse of the Mianus River bridge span was the undetected lateral displacement of the hangers of the pin and hanger suspension assembly in the southeast corner of the span by corrosion-induced forces due to deficiencies in the State of Connecticut's bridge safety inspection and bridge maintenance program.

INVESTIGATION

The Accident

At 1:30 a.m., e.d.t., eastbound traffic on Interstate Route 95 (I-95) was light as it approached the highway bridge over the Mianus River in Greenwich, Connecticut. An automobile was in the median lane of the three-lane eastbound roadway, a tractor-semitrailer was abreast in the center lane, and another tractor-semitrailer was in the curb lane and slightly ahead of the other two vehicles. According to the driver and passenger in a car following these three vehicles moving at highway speeds, there was a sudden flash of light and the highway overhead lighting on the bridge went out. The driver of the following car said that at the same time the brake lights of the two trucks came on, and the semitrailer of the truck in the curb lane began to change its alignment with the tractor as though it was starting to jackknife. Fearing an accident, the driver of the following car braked his vehicle hard, and suddenly the three vehicles ahead disappeared from view. The driver stopped the car in the center lane of the bridge. When he got out, he saw that the car was about 6 feet from the edge of a void where a section of the bridge had fallen into the river 70 feet below. (See figures 1 and 2.)

Because the driver and passenger were concerned about their car being struck from the rear, they moved away from the car quickly. The driver, who was not the car owner, left the car lights on but did not switch on the hazard warning signals. The driver saw an eastbound automobile approaching and tried to flag it to a stop by waving his arms. The automobile did not slow until it was too close to the edge of the void to stop. It plunged into the void and landed upside down in the river below. The passenger of the stopped car on the bridge, who was the car owner, returned to the car and switched on its hazard warning signals before any other vehicles approached. A few minutes later, an eastbound tractor-semitrailer slowed and stopped in response to the car driver's flagging, and as other eastbound traffic approached, the vehicles stopped before reaching the void.

Several persons on boats moored at a marina in the Mianus River 600 feet south of the bridge witnessed the bridge collapse. Some witnesses had their attention drawn to the bridge by a loud noise. One witness, who was lying on his back on the deck of a boat and looking up at the bridge, saw a lightpole and then a section of the eastbound traffic lanes on the bridge begin to shake and then fall into the river. Several witnesses saw the first tractor-semitrailer and the first automobile fall with the bridge. The tractor-semitrailer was "completely on top of the section of the bridge and was falling forward and down," according to a witness. As it fell, the cab of the tractor struck the bottom of the deck structure of the adjacent section of the bridge that remained standing. Witnesses said that the first automobile "came off" the falling span of the bridge and struck the left side of a pier about one-fourth of the way down the pier. The witnesses also saw the second tractor-semitrailer falling from the bridge "nose first." The truck had left about 150 feet of skidmarks in the right lane. The tractor struck the ground on the far side of the riverbank, and the semitrailer remained leaning against one of the piers that supported the bridge. Witnesses said that several seconds later, the second automobile fell off the bridge and into the river. (See figure 3.) The witnesses all agreed that the east end of the span fell first.

The Connecticut State Police and other emergency service agencies were notified by passersby and responded to the scene to perform rescue and salvage operations and control the traffic. Two Greenwich police officers arrived at the marina, borrowed a small boat from two of the witnesses at the marina, and went to the location in the river where the vehicles were. Firefighters from the Cos Cob and Sound Beach Volunteer Fire Departments responded to the River Street side of the Mianus River under the bridge, across the river from the accident vehicles. They then drove around to Buxton Landing, a street on the east side of the river immediately adjacent to the resting place of the vehicles.

The driver and only occupant of the first tractor-semitrailer was extricated from the tractor cab and was pronounced dead at the scene. Emergency response personnel rescued the driver of the second tractor-semitrailer and his wife, who was a passenger in

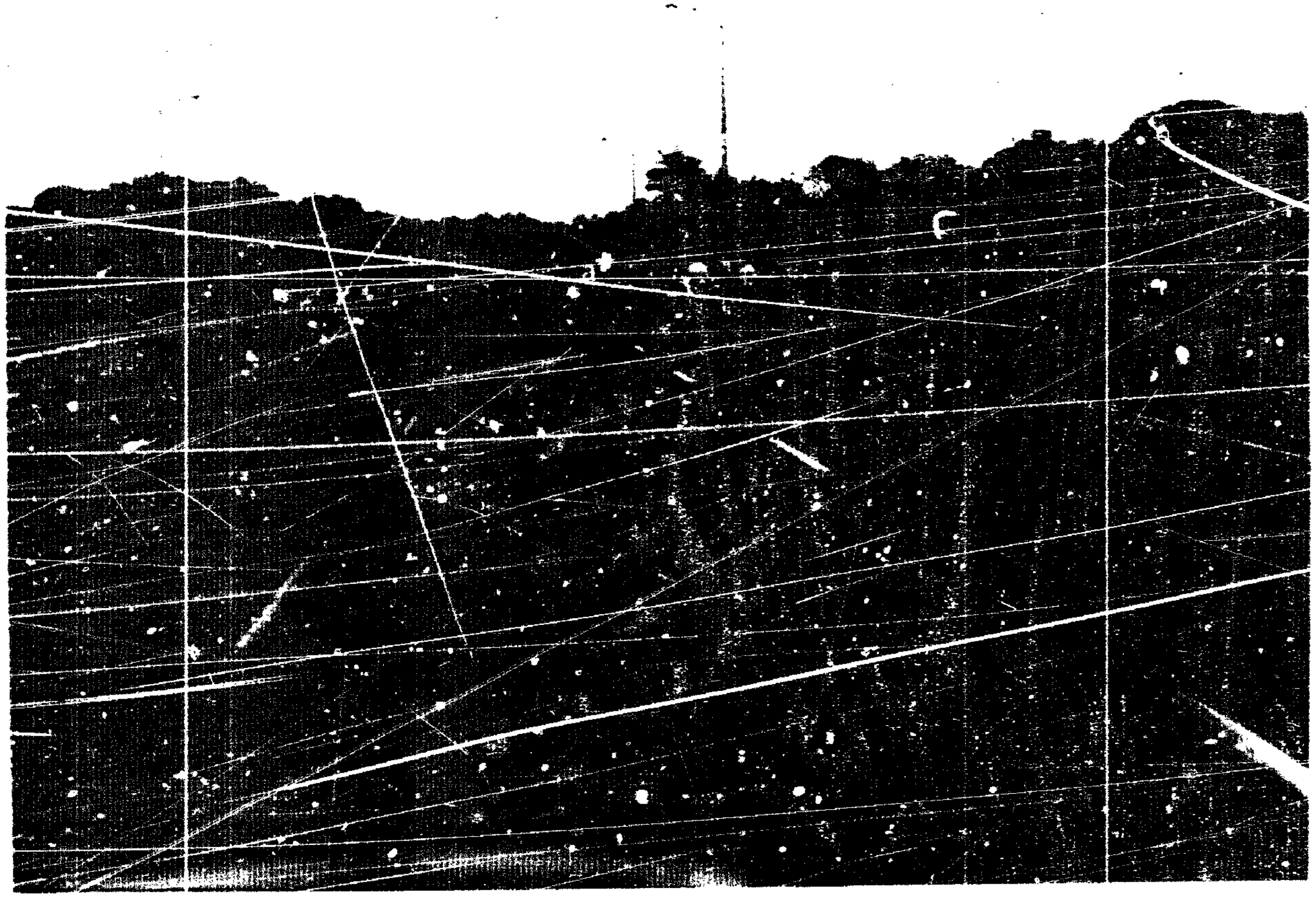


Figure 1.—Eastward view of roadway at the accident site showing void (a).

Figure 2.—Westward aerial view of the Mianus River bridge.

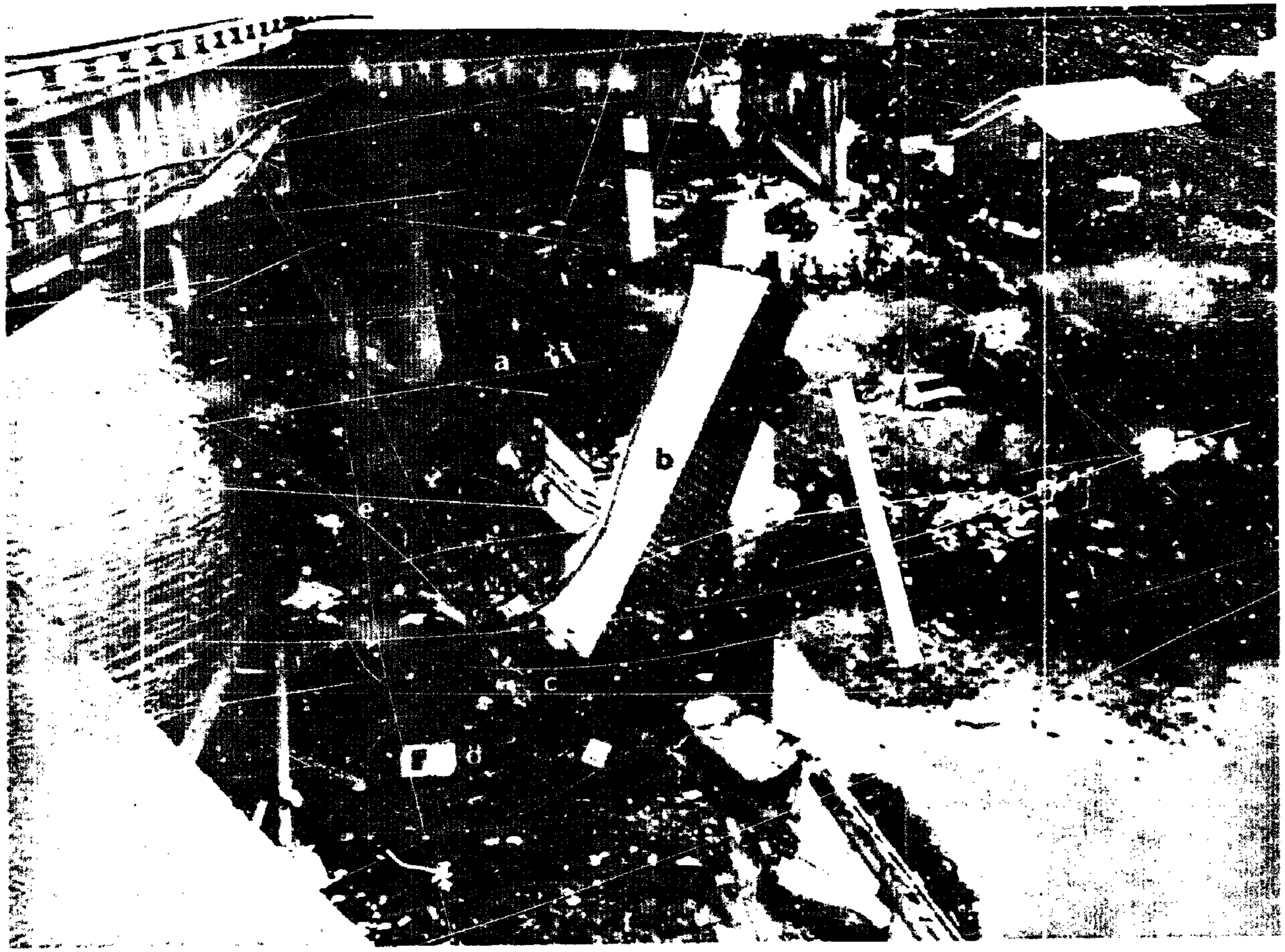


Figure 3.—Eastward view of vehicles at the accident site, showing (a) location where the first automobile landed, (b) trailer of the second truck, (c) tractor of the second truck, (d) the second automobile, (e) the tractor of the first truck, (f) the trailer of the second truck, and (g) the cargo of the first truck.

the tractor, both of whom were seriously injured. The first automobile was lying on its left side on the land approximately 20 to 30 feet beyond the water's edge. The driver and only occupant of the first automobile was seriously injured and was rescued by firefighters. The second automobile was found submerged on its top in the river. Its two male occupants were pronounced dead at the scene.

Injuries to Persons

	Drivers		Passengers		
	Automobiles	Trucks	Automobiles	Trucks	Total
Fatal	1	1	1	0	3
Serious	1	1	0	1	3
None	0	0	0	0	0
Total	2	2	1	1	6

Driver Information

(See appendix B.)

Vehicle Information

All of the vehicles that fell from the bridge were demolished. A postcrash examination of the four vehicles disclosed no mechanical defects that may have contributed to the accident. The speeds of the vehicles when they left the bridge were reconstructed by the Connecticut State Police and were estimated to be as follows:

Vehicle	Speed (mph)
First truck (52,700 pounds)	41 to 49
Second truck (75,011 pounds)	48 to 59
First automobile	about 37
Second automobile	about 31

(See appendix C for vehicle make, model year, ownership, and other information.)

Highway Information

In Connecticut, I-95 runs in a west-east direction parallel and close to Long Island Sound from the New York State border on the west to the Rhode Island State border on the east. From the New York State border to exit 76, just west of New London, Connecticut, I-95 is also known as the Connecticut Turnpike. The turnpike is primarily a toll facility, with the monies collected after payment for the operation of the toll facilities and debt retirement going into the State's general fund. The toll portion of the highway is not eligible for Federal-aid highway funds. Maintenance and inspection for the facilities are provided by the Connecticut Department of Transportation (ConnDOT). Besides being an important highway corridor for New England traffic, I-95 serves commuter traffic between southwestern Connecticut and New York, New York, and on the heavily developed corridor between Greenwich and New Haven, Connecticut. The average daily traffic count at the accident site is 90,000 vehicles.

Bridge Information

General.—The I-95 highway bridge over the Mianus River is a deck bridge, i.e., its floor elevation is above the elevation of the uppermost position of the superstructure. The bridge is 2,656 feet long and, at its highest point, is 70 feet above the river. Most of the structure actually is over land. It is of welded construction.

The highway is six lanes wide across the bridge. Each lane is 12 feet wide with three lanes in each direction separated by a median barrier. Each roadway is about 40 feet wide from curb to curb. The expansion joint down the center of the full length of the bridge in effect creates two parallel bridges that function independently of each other.

The bridge surface is of bituminous concrete overlay. On the bridge, the eastbound lanes have a measured dry coefficient of friction ranging from 0.71 to 0.79. The left and center eastbound lanes slope toward the median barrier at 1/8 inch per foot, and the right eastbound lane slopes at the same rate to the outside.

Spans.—The bridge structure is aligned in a west-east direction with its west abutment at highway station 229 + 40.37 and its east abutment at highway station 255 + 96.79. Supporting the structure between these two abutments are 23 piers, numbered from west to east. Between these abutments and piers are 24 bridge spans for each roadway--19 approach spans, 2 anchor spans, 2 suspended spans, and 1 main span.

The approach spans are between the west abutment and pier 17 and between the east abutment and pier 22. The distance between the piers supporting the approach spans varies, but is about 100 feet. Each of the approach spans has six stringer beams, steel floor members that are parallel to the bridge centerline. At piers 2, 6, and 10, the stringer beams are connected to box girders with pin and hanger assemblies of the recessed pin nut type.

The anchor span, suspended spans, and main span are between piers 17 and 22, where the bridge structure is over the Mianus River. (See figure 4.) Piers 17 through 22 are skewed 53.7 degrees so that they are parallel to the channel of the Mianus River. Each span is framed by two parallel steel girders that are 14 feet deep at the piers and 9 feet deep at the joints with the suspended spans. Each of the spans has floor beams spaced about 25 to 30 feet on centers, which frame into the two girders. Stringer beams frame into the floor beams. The girders are supported by rocker bearings at piers 18, 19, and 21 and by fixed-shoe bearings at piers 17, 20, and 22.

From west to east, a longitudinal section between piers 17 and 22 of each roadway consists of the following (see figure 4):

(1) Between piers 17 and 18: a 120-foot-long anchor span;

(2) Between piers 18 and 19: a 45-foot-long cantilever arm extending from the anchor span at pier 18; a 100-foot-long suspended span; and a 45-foot-long cantilever arm extending from the main span at pier 19;

(3) Between piers 19 and 20: a 205-foot-long main span;

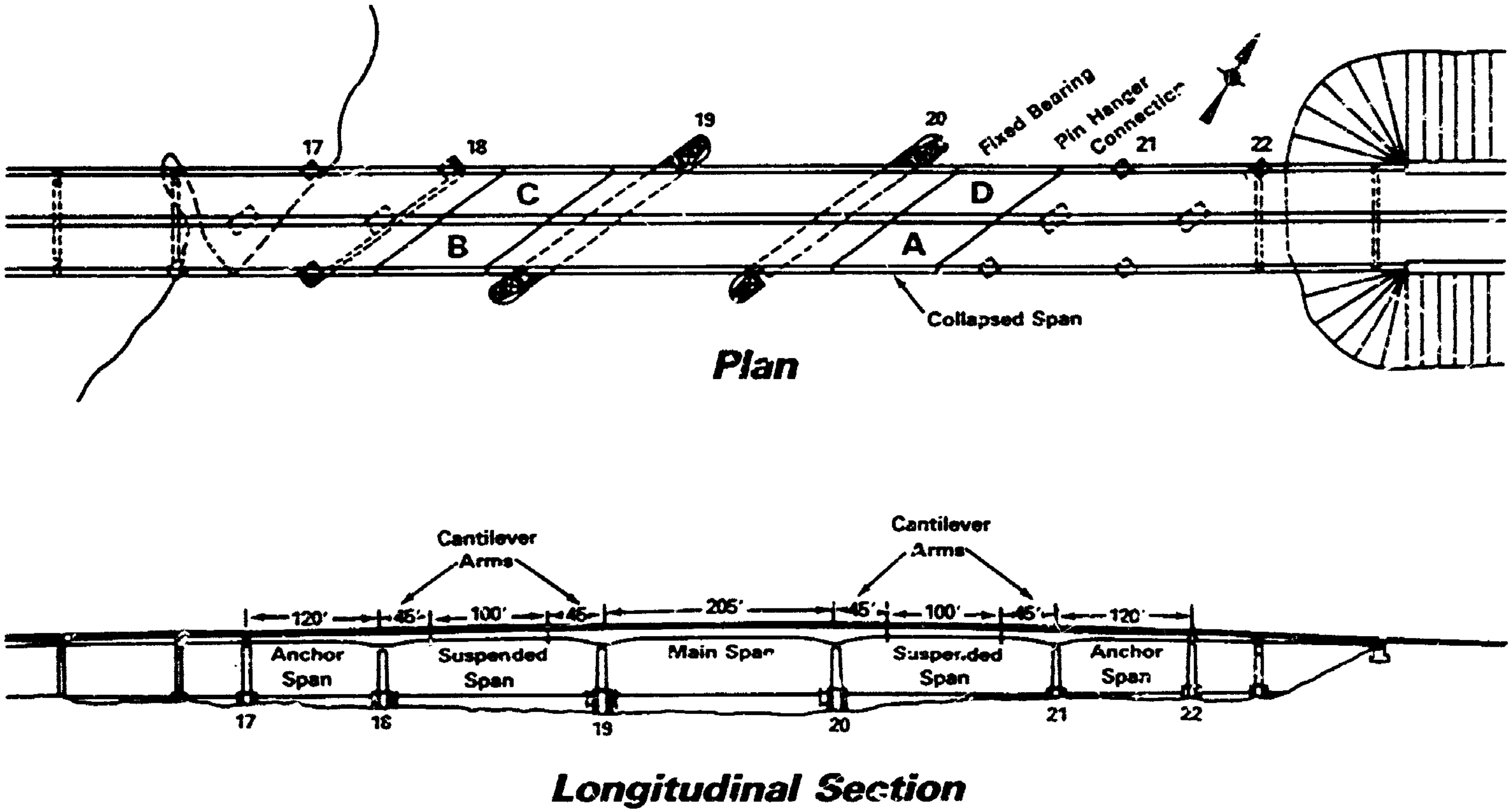


Figure 4.—Plan view (top) and longitudinal view (bottom) of the Mianus River bridge. (Note that the skew of piers 17 through 22 is not depicted in the longitudinal view.)

(4) Between piers 20 and 21: a 45-foot-long cantilever arm extending from the main span at pier 20; a 100-foot-long suspended span; and a 45-foot-long cantilever arm extending from the anchor span at pier 21:

(5) Between piers 21 and 22: a 120-foot-long anchor span.

Suspended spans.—The four suspended spans (marked A, B, C, and D in figure 4) are connected at one end to the cantilever arms of the anchor spans with a pin and hanger assembly. (See figure 5.) The pins are cylinders, 7 inches long and 7 inches in diameter. The pins have a 6 3/4-inch-wide grip with a 1/8-inch-wide chamfer at each end. Through the center of each pin is an 11 1/4-inch-long, 1-inch-diameter bolt. The upper pin passes through and is centered on the web of the cantilever arm; the lower pin passes through and is centered on the web of the suspended span. The clearance between the pin and the hole in the web, according to the design, was not to exceed 1/32 inch. The pin caps are 2 inches larger in diameter than the pins and completely cover the ends of the pins and the holes in the hangers. The ends of the pins and the hanger bearing surfaces cannot be seen once the caps are bolted in place. There is nominally a clearance of 1/16 inch between the pin caps and the hanger surfaces. The web of each girder at the pin and hanger assembly is 9 feet deep and 2 1/2 inches thick.

From the face of the web of each girder to each end of the bolt are the following:

- a 14-inch-outside diameter by 1/4-inch-thick washer welded to the web;
- a 14-inch-outside diameter by 1/4-inch-thick spacer washer in a 3/8-inch-wide space;
- a 1 1/2-inch-thick hanger, 6 feet 6 inches long by 1 foot 4 inches wide;
- a 4-inch-outside diameter by 1/4-inch-thick spacer washer between the end of the pin and the pin cap;
- a 9-inch-outside diameter, 5/16-inch-thick pin cap with a 5/16-inch-thick lip;
- a standard washer for a 1-inch-diameter bolt; and
- a standard hex nut (1 1/2 inch by 1 1/4 inch by 7/8 inch) welded to the bolt.

The four suspended spans are supported at the other end by the cantilever arms of the main spans with a bearing system, which consists of a 4 1/2-inch-diameter, 16 1/4-inch-long pin with a 6 1/2-inch-diameter, 1-inch-thick concentric flange on each end. The pins rest in 12-inch-wide by 14-inch-long pillow blocks, which are welded to the girders.

Expansion joints.--To provide for the expansion and contraction of the superstructure of the bridge due to changes in temperature, there is an interlocking finger plate expansion joint in the roadway between each suspended span and the cantilever arm of each anchor span. The design plans called for a lateral clearance of 1/4 inch between the interlocking fingers. A copper trough is installed beneath each expansion joint to catch water draining from the roadway and direct it to a downspout.

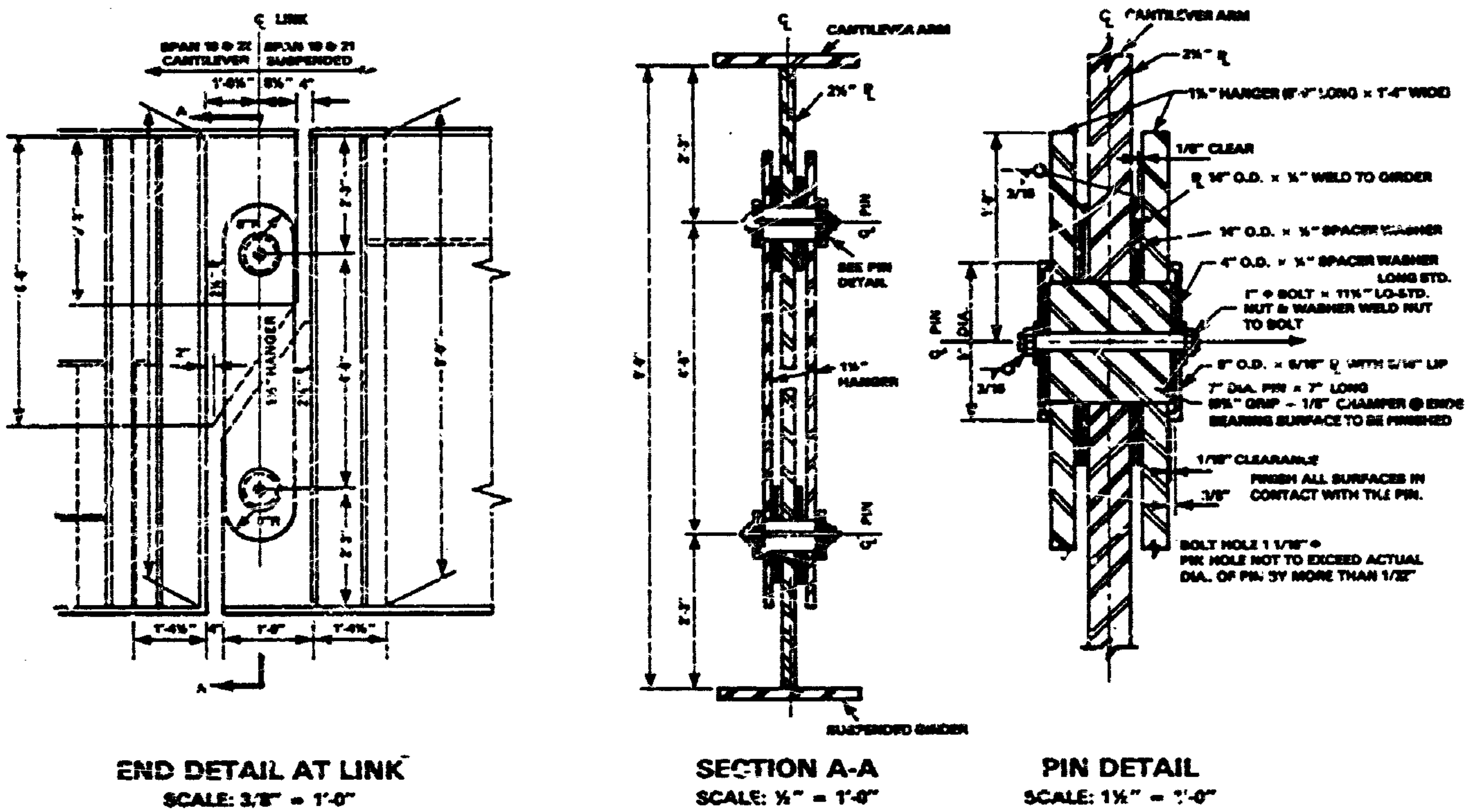


Figure 5.—Detail of pin and hanger assembly.

Windlocks.--The expansion end of each of the suspended spans is stabilized against lateral movement relative to the adjacent spans through a windlock at each end of the span. Each windlock connects the end floorbeam of the suspended span to the end floorbeam of the adjacent cantilever arm. The windlocks are installed just above the lower flange of the end floorbeams of the cantilever arm halfway between the girders.

The windlock located at the cantilever arm of the main span is a fixed windlock consisting of a structural "T" connection between the end floorbeams located equidistant from the girders. The flange of the "T" is welded to 1/2-inch-thick gusset plates, which in turn are welded to the web of the end floorbeams.

The windlock located at the cantilever arm of the anchor span is designed to allow movement in a longitudinal direction and to limit movement in the lateral direction. The windlock is an interlocking grip connector attached at one end to the end floorbeam of the cantilever arm and attached at the other end to the end floorbeam of the suspended span. It has a lateral clearance of 1/16 inch between interlocking elements so that the suspended span can move as much as 1/16 inch before the wind load is transferred from the suspended span to the cantilever arm. The vertical clearance between elements of the windlock is 1/2 inch. If the end floorbeam of the suspended span moves relative to the end floorbeam of the cantilever arm more than 1/2 inch, the windlock elements will contact each other.

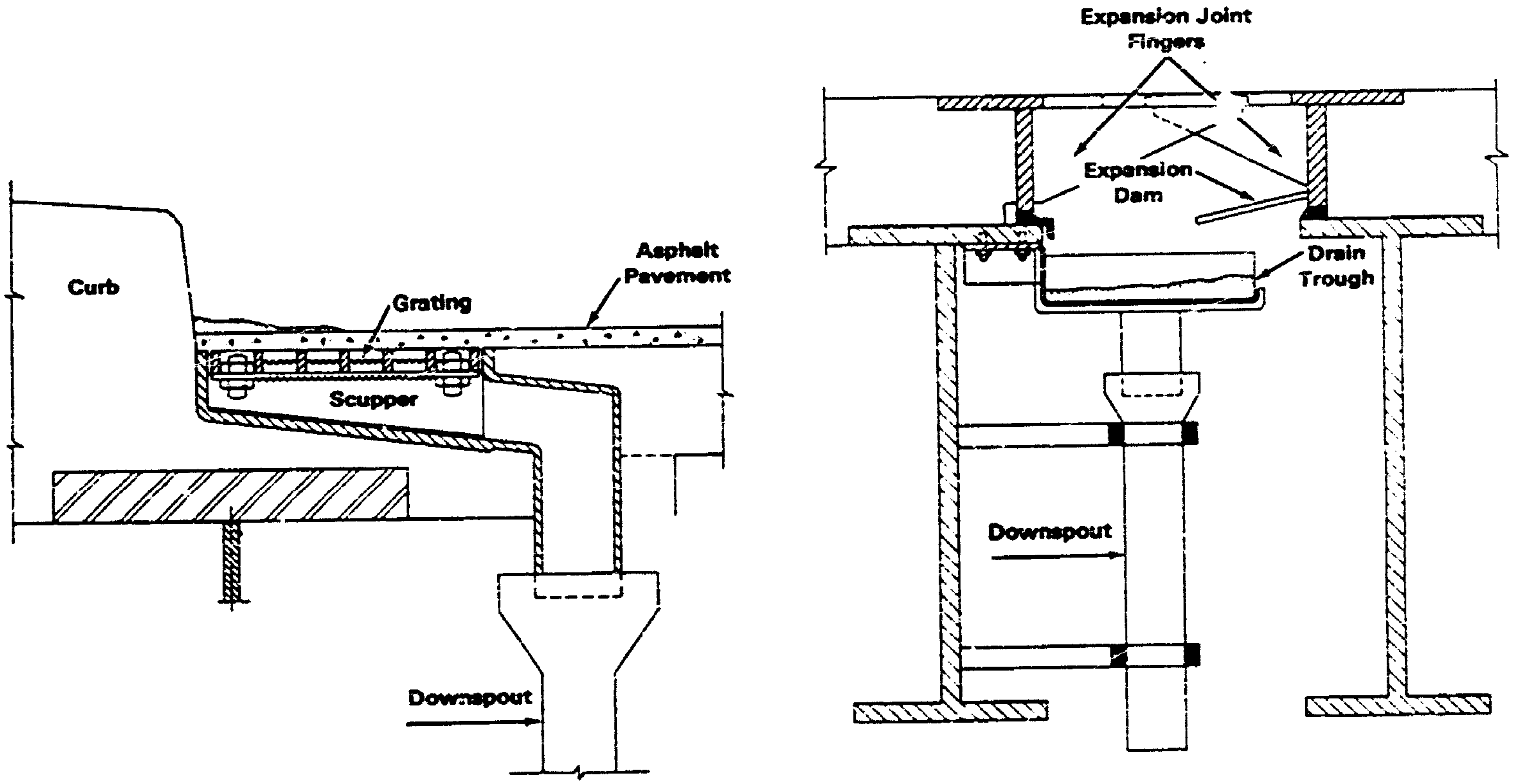
Drainage.--The drainage system on the bridge was designed to carry water, debris, and deicing salt away from the structural parts of the bridge and the pin and hanger assemblies in order to minimize corrosion. The drainage system consists of curb drains (scuppers) in the gutter line of the roadway. Between piers 1 and 16, scuppers are installed in the south side gutter line only. Between piers 16 and 23, which includes the suspended spans, the scuppers are installed on both sides of the eastbound and westbound roadways. The grates in these scuppers are installed below the level of the road surface and channel road surface water into downspouts, which funnel the water onto the land below or allow it to free-fall into the river. The system was designed so that only a small amount of the surface water would run through the expansion joints into the troughs where it would be channeled to a scupper at the median barrier. (See figure 6.)

Accident History.--The accident rate for I-95 on the Mianus River bridge for the period January 1, 1979, through December 31, 1981, was 1.14 accidents per million vehicle miles (MVM). The average accident rate for this type of road on bridges in Connecticut is 0.88 accidents per MVM. There has been no appreciable change in either accident rate over the past 5 years. During the same period, the ratio of the number of accidents occurring on wet pavement on the Mianus River bridge versus the number on dry pavement (wet/dry ratio) was 0.286, and the average ratio for all bridges on interstate highways in Connecticut was 0.396.

Design Factors.--The bridge was designed in 1955 according to the "Standard Specifications for Highway Bridges (1953)" of the American Association of State Highway Officials (AASHO), 1/ the "Standard Specifications for Welded Highways and Railroad Bridges--Design, Construction, and Repair (1947)" of the American Welding Society, the "Specifications for Highway and Bridge Design by Contracting Engineers (May 1954)" of the Connecticut State Highway Department, 2/ and the "Standard Specifications for Roads, Bridges and Incidental Construction Form No. 808 (January 1955)" of the

1/ AASHO is now known as the American Association of State Highway and Transportation Officials (AASHTO).
2/ The Connecticut State Highway Department is now known as the Connecticut Department of Transportation (ConnDOT).

SCUPPER DETAIL



SAFETY WALK CURB AREA

EXPANSION JOINT AREA

Figure 6.—Detail of drainage system.

Connecticut State Highway Department. Construction of the bridge began on February 6, 1956, and was completed on December 27, 1958. Construction was supervised and inspected by the same firm which designed the bridge.

The design loads were based upon the specifications set forth in the AASHO publication. The specifications required that structures be proportioned for the following forces when they exist:

(1) dead load,
(2) live load,
(3) impact or dynamic effect of the live load,
(4) wind loads, and
(5) other forces. 3/

The maximum dead load reaction of the suspended span was 251,000 pounds and occurred at the obtuse corners. The design live load was calculated by the designer using an H-S loading (H20-S16-44), which consists of a tractor truck with semitrailer in each of the three traffic lanes. The highest live load reaction at the obtuse corner calculated by the designer was 103,000 pounds. The highest design impact load reaction at the obtuse corner was 22,000 pounds. The total maximum vertical load at the obtuse southeast corner of the suspended span was the sum of the dead, live, and impact loads and was calculated by the designer to be 376,000 pounds. (A consulting engineer hired by ConnDOT in conjunction with its investigation of this accident computed this load to be 398,000 pounds. The difference in the calculations is about 5 percent and is within acceptable limits of accuracy.)

The windlocks were designed to take the wind load. The thermal forces were accommodated in the design of the pin and hanger assembly, the expansion joint, and the windlocks.

Article 3.6.42.-Pins and Pin Nuts of the 1953 AASHO specifications states that members joined by pins ". . . shall be held against lateral movement on the pins." The article does not define the movements or the forces which might cause movement. The designer did not consider any lateral force or movement in the design of the pin and hanger assembly. The bridge designer's chief engineer testified that ". . . the retainer plate [pin cap] is to act as a guide, like a washer--all it is is an oversized washer. In this case it was not designed to take any lateral load, because there are no design forces that the code specifies concerning it, nor would you expect it to." The detail was adapted from a standard type in common use at the time. The engineer said that the washer was added to provide an additional plane for rotation should one side of the hanger freeze up.

The pin cap thickness set forth in the bridge design was 5/16 inch. The pin cap thickness recommended in the "Manual of Steel Construction" published by the American Institute of Steel Construction (AISC) is 12/16 inch. There is no documentation as to why a thinner plate was chosen by the designer. Tests are planned to determine what loads the 5/16-inch-thick pin cap is capable of withstanding. The pin cap detail has been carried virtually unchanged in the AISC "Manual of Steel Construction" since the first edition was published in 1934. The details do not state the reasoning for selecting 12/16 inch as the recommended thickness of the pin cap. The AISC pin cap detail does not identify the members it is designed to connect.

The bridge was built with structural carbon steel ASTM-A373 as specified, except for nonplated rolled beams with welded connections for which structural carbon steel

3/ "Standard Specifications for Highway Bridges," AASHO (Washington, D.C., 1953), p. 165.

ASTM-A7 was used. 4/ The allowable flexural tensile stress used in the bridge design was 18,000 psi.

The determination of the proper pin diameter in the pin and hanger assembly depended primarily on the bearing stress chosen. The AASHO specifications stated that the bearing stress to be used in calculating the minimum diameter was 12,000 psi for pins subject to rotation (not due to deflection) and 24,000 psi for pins not subject to rotation. The design calculations indicated that the maximum angular movement of the pin would be 4°20', which in 1953 was not considered to be rotation, and the designer chose a bearing stress of 12,000 psi. The design checker (employed by the same design firm) disagreed that this amount of movement was sufficient to be considered rotation and changed the bearing stress to 24,000 psi. The consulting engineer hired by ConnDOT in conjunction with its investigation of this accident stated that the higher bearing stress was a proper interpretation of the 1953 AASHO specifications. The designer's calculations indicated that the actual bearing stress on the pins in the Mianus River bridge design under both live and dead loads was 17,900 psi. The bearing stress due to the dead load only was calculated to be 11,900 psi.

The design of the suspended spans was characterized as "nonredundant" by some engineers who testified during the Safety Board's public hearing. However, other engineers believed that, if one hanger of a pin and hanger assembly failed and if the other hanger would support the entire load, then at least the assemblies were redundant. Most of the other spans of the bridge had redundancy because they employed a larger number of smaller girders; some of these spans had pin and hanger assemblies at each girder. The ends of the pins of these assemblies were threaded and fitted with large-diameter nuts secured by cotter pins.

The highway was designed to carry an average daily traffic volume of 30,800 vehicles by 1975. This estimate apparently was made by a consulting firm specializing in transportation studies and not by the design engineers. For the period between January 1, 1982, and December 31, 1982, available traffic counts taken on I-95 at the Greenwich toll station located about 3 miles west of the Mianus River bridge indicated that 81,000 passenger cars and 8,800 commercial vehicles used the Mianus River bridge daily from January 1983 to May 1983.

Maintenance and Repair.--The bridge had been maintained and repaired by ConnDOT since its construction in 1958. A large number of repairs have been required to the expansion bearings on the approach spans and the pier caps on which they sit. The bridge was last painted in 1970. On December 6, 1968, a contract was awarded for superstructure repairs and for a bituminous concrete resurfacing of the bridge. The roadway was resurfaced again in June 1973.

Maintenance personnel testified that the drains on the bridge were difficult to keep open because the scuppers and downspouts were too small and because the hydraulic slopes of the piping were too shallow and the changes in direction were too abrupt. They said that because of the placement and routing of the drainage piping, much of the drainage system was inaccessible and difficult to repair or replace without the aid of scaffolding or mechanical equipment, which was not available. Therefore, maintenance personnel had cut holes in parts of the drainage system to permit drainage. Also, some parts of the drainage system which had fallen off had not been replaced. Some persons testified that at one time maintenance workers had power nozzles, vacuum equipment, and scaffolding to work on the drains and keep them open, but that this equipment had not been available for at least 10 years. One of the bridge maintenance supervisors

4/ ASTM is the abbreviation for the American Society of Testing Materials.

testified that he did not think that the components of the drainage system had been designed to be easily repaired. The representative of the design firm testified at the Safety Board's public hearing that he did not think that any of the drainage system was designed to be selfcleaning.

One bridge maintenance worker testified that "in either the early or mid-1970's, the deck of the bridge was resurfaced under contract. Prior to the resurfacing, we were ordered to go out there and cover up the drains with steel plates." He said that he did not recall who gave the order. He said that he cut the 12-inch by 12-inch by 1/4-inch steel plates and welded them over the grates. He said that it was his impression that the plates were installed just to protect the drains while the paving was being done. However, the asphalt and steel plates were never removed and were still in place after the bridge span collapsed. Therefore, for at least 10 years before the accident, the road surface between curbs on the suspended spans was being drained only through the expansion joints. ConnDOT stated that at certain levels of rainfall, water would bypass the curb drains even when they were open. This statement was based on exceptional rains which happened once a year or once every 5 years.

While investigating a complaint from the Town of Greenwich made in March 1983 concerning water falling "profusely" from the Mianus River bridge onto motor vehicles traveling on River Road below the bridge, a bridge maintenance inspector discovered that the curb drains were paved over and that the surface water had drained down the bridge deck and leaked through an expansion joint onto the road below. This location was west of the suspended span that fell. No corrective action was taken.

The last preventive maintenance inspection of the Mianus River bridge before the accident was performed by bridge maintenance inspectors on September 8, 1982. The inspectors classified 17 out of 30 items on the maintenance inspection form as being in "poor" condition, but none was rated as "critical." The deck accounted for half of the "poor" items. The only "poor" item on the superstructure was the condition of the paint on the entire bridge.

Early in 1983, the State had developed plans for the replacement of the bridge deck. The deck was severely deteriorated, exhibiting many transverse cracks, map or alligator cracks, and efflorescence. The bituminous wearing surface also was deteriorated and was peeling. Crews had been called out several times to repair holes that were completely through the deck. The chloride content of the deck was measured in 1978 by sampling 88 locations, using either the core or the rotary hammer method. The average chloride content was 3.3 pounds per cubic yard. Sixty-eight samples had a chloride content of more than 2 pounds per cubic yard. 5/ The highest sample had a chloride content of 10.34 pounds per cubic yard; the second highest contained 6.5 pounds per cubic yard. The lowest concentration contained 0.55 pound per cubic yard; the second lowest was 0.94 pound per cubic yard.

<u>Inspections.</u>--Inspection reports on file in ConnDOT's Bridge Safety and Inspection Section revealed that the Mianus River bridge had been inspected regularly since 1962. (See appendix D.) The bridge had been inspected by the same inspector 12 times since July 1967. The same junior inspector had been assisting him in the inspections since April 1978. In only one instance since 1973 had the inspection interval exceeded 2 years, and then by only 4 months.

5/ FHWA-RD-74-5, "Evaluation of Portland Cement Concrete for Permanent Bridge Deck Repair," K.C. Clear.

The senior safety inspector assigned to the Mianus River bridge had approximately 10 years in bridge safety inspections and about 29 years of service in ConnDOT at the time of the accident. He attended bridge safety inspection training courses in 1972, 1975, 1979, and 1982. He is qualified to be a leader of a bridge inspection team according to the requirements of the National Bridge Inspection Standards issued by the Federal Highway Administration (FHWA). (See appendix E.) The junior safety inspector assigned to the bridge has worked in this capacity since March 8, 1978. He attended training courses in 1979 and 1982. Neither inspector had been tested on his knowledge of bridge design or inspection.

Bridge Inspection Reports for the bridge for the 10 years preceding the accident (bridges are inspected every 2 years) repeatedly carried the notation "20 grates plugged" or "20 plugged drains." The bridge safety inspector who made these inspections and notations testified that this meant that the curb drains were covered over with asphalt. The Transportation Associate Engineer who reviewed the Bridge Inspection Report stated that the comment "20 grates plugged" on the Bridge Inspection Report of September 16, 1982, for the Mianus River bridge meant to him "that the drainage system was plugged. I would have assumed at the time . . . that it was probably sand or something like that."

Access to the bridge superstructure is provided by three parallel catwalks extending from pier 17 to pier 22. One catwalk runs along the middle of the expressway between the north girder of the eastbound roadway and the south girder of the westbound roadway. The two other catwalks run along the centerline of each roadway. The steel grating walkway on the catwalks had separated from the angle iron supports at several locations, and, in some places, plywood had been overlaid to provide a walkway independent of the deteriorated steel grating.

The last safety inspection of the Mianus River bridge before the accident, which began on September 16, 1982, lasted 3 days. The two safety inspectors started their inspection on the west end of the bridge, checking bearings and piers from pier 1 up to pier 17, the last pier on land before the river. They used a pair of 7-power binoculars to aid their observations. On the second day of their inspection, the two safety inspectors started at the east end of the bridge, checking bearings and piers from pier 16 to pier 23. From the median catwalk they observed the hangers of the suspended spans. They did not notice any dishing of the pin caps. The inspectors had never been told or trained to make measurements of the pin caps or the position of the hangers relative to the girders. The inspectors said that they checked the pin and hanger assemblies, which they categorized as "bearings," on each of the cantilever arms and in the area of the suspended spans. They said that during this and previous inspections they could touch the upper pins and hangers in the median areas but could not get closer safely than the middle catwalk of each roadway to the pin and hanger assemblies connecting the outside girders of the bridge. They visually checked these assemblies from the catwalk and later from the ground, using the binoculars. One inspector testified that ". . .facing west on the catwalks, the hangers on our left had more rust than the ones on the right. There was heavy rust on the top pins, due to the fact that there is more water leaking on the left side than the right on the hangers. There was rust on the girder." The pin cap effectively hid the pin and hanger bearing surface and much of the deterioration from view.

From the roadway catwalk, the junior safety inspector walked on the bottom flanges of two skewed end floorbeams to the inside hanger of the north girder of the westbound span. He was able to observe the upper pin from about 4 feet away; he had observed the lower pin from the catwalk about 20 feet away. His walk on the floorbeams was precarious because there were no handholds or safety belt hooks. The bottom inside flanges were covered with pigeon excrement sometimes a foot deep. There were no routine periodic cleanings or provisions to have a maintenance crew clean the bridge structure before either safety or maintenance inspections.

The junior safety inspector testified that he reached behind the inside hanger in the pin and hanger assembly at the northeast corner of the span that later collapsed and found "flaking rust." He testified that the inspectors also had made this same finding during their 1980 inspection, and that each time the condition was reported as "laminated rust" in the "bearing" section on their bridge inspection report but was not considered serious enough to "red flag" the report. There is no space on the report form for a description of pins and hangers, and they are reported as "bearings," along with other types of bearings. The inspectors were not given specific instructions concerning the inspection of pin and hanger assemblies.

On the third day of their inspection, the two safety inspectors walked the deck taking photographs and making notes of deck problems. At the end of the day, the senior inspector wrote the inspection report, while the junior inspector filled in the appraisal sheet. The junior inspector wrote the senior inspector's initials in the appropriate column. The deck photographs showed pavement conditions and did not show the alignment of bridge members, bridge railings, or expansion joints. The report rated "alignment of members" at "8," the highest rating for an item which is not new.

The safety inspectors stated that they had never used scaffolding on this or any other bridge. The senior inspector stated that he had used a "snooper," a truck-mounted, selfcontained, articulated, hydraulic boom with suspended work platform used for bridge safety inspections and repairs, on the Mianus River bridge. The junior safety inspector did not indicate in his testimony that he had used a "snooper" on the bridge. Both inspectors made the safety inspection on this bridge in 1980, and neither their inspection report nor the records of the maintenance section indicates that the "snooper" was used during the 1980 inspection or any prior bridge safety inspection.

The safety inspectors testified that, although they had a copy of the "Field Bridge Inspection Booklet" issued by ConnDOT in 1972, which was based on the FHWA "Bridge Inspector's Training Manual," they did not follow the details in the guide. They did not have the training or the equipment to perform nondestructive tests of pins for cracks. The junior inspector stated that in his 5 years in the inspection program, no one had ever talked with him about the pin and hanger assemblies and their critical importance to the bridge. Neither inspector was familiar with the AASHTO maintenance manuals or the data therein related to pin and hanger assemblies. Although the AASHTO "Manual for Bridge Maintenance (1976)" states, "Rusting between the plates is very difficult to detect unless bearing is dismantled," a ConnDOT engineer testified that dismantling pin and hanger assemblies as a part of inspection was disruptive and too expensive. A ConnDOT engineer stated that dismantling had not been considered before the collapse of the span.

The senior safety inspector conducted most of his business with his supervisor, a Transportation Associate Engineer whose office was located about 40 miles away, by telephone. The business consisted largely of scheduling inspections and adjusting manpower to inspect the required number of bridges in the required maximum 2-year inspection cycle. The senior inspector testified that he saw his supervisor face-to-face only three times per year. The supervisor said that he sees his inspectors typically once a month. The supervisor said that he had partially read the "Manual for Bridge Maintenance (1976)," but that he thought it was "for maintenance."

Bridge Damage

General.—The span that fell (identified as span A in figure 4) was the most easterly of the two suspended spans in the eastbound traffic lanes. It had been attached to the cantilever arms of adjacent spans by pin and hanger assemblies at its northeast and southeast corners and by pin and pillow block assemblies at its northwest and southwest corners. The span came to rest northwest of its original suspended position before collapse. (See figure 7.) The concrete deck separated from the steel superstructure. The easterly portion of the south girder of the span was bent to the south with the web buckled outward. The end floorbeam was severely twisted.

Direct costs to the State of Connecticut resulting from the collapse of the bridge have exceeded $16 million. These direct costs include the work connected with the salvaging of the collapsed and damaged bridge structure; the purchase, installation and removal of a temporary span; costs of the retrofit of enlarged pins and hangers; the construction and installation of the replacement span; the modification of the Darien Maintenance Yard to accommodate the reconstruction of the fallen span; identification, security, and transportation of the damaged bridge structure; and the State's own accident and criminal investigations. It does not include the indirect costs such as traffic control, detours, loss of tolls, litigation, etc. These indirect costs are still developing and cannot be determined precisely at this time. About 90,000 vehicles per day had to be rerouted over U.S. Route 1 through Greenwich and Port Chester and Rye, New York, causing 24-hour-a-day traffic jams.

Southeast corner.—Remaining attached to the web of the girder of the cantilever arm at the south girder, where the southeast corner of the fallen span had been attached, was the upper pin, the inside hanger, most of the 1-inch-diameter pin bolt, and the inner pin cap end washers. The 14-inch-diameter spacer washers remained in place on both sides of the girder web. The pin bolt was broken off at the outer face of the upper pin. The top outer segment of the outer end of the upper pin had fractured and separated. The fracture surface contained an approximately 3/4-inch-deep curvilinear area extending from the top of the pin, which was noticeably discolored and had fracture characteristics indicative of fatigue cracking.

The lower pin, the lower pin bolt, the outside hanger, the inner and outer spacer washers, and the inner and outer pin caps from the lower connection of the pin and hanger assembly had either fallen into the river below or were still attached to the south girder of the fallen span in the river. The small washers, part of the outer end of the pin bolt, and the outer pin cap were missing from the outer end of the upper pin.

Corrosion damage was found at the upper pin connection, mainly between the 14-inch-diameter welded and spacer washers. The inside hanger still attached to the upper pin was shifted outward from the web. The outer-facing spacer washer of the upper pin was permanently dished outward from the web about 1 1/2 inches. Corrosion and/or debris was packed between the welded and the spacer washers. Measurements indicated that the origin of the previously described fatigue fracture on the upper pin was approximately 1 1/2 inches out from the girder web and in a direct vertical line with the outermost dishing of the spacer washer. The origin of the fatigue fracture on the upper pin also was approximately 1 inch from the outer-facing end of the pin. (A cross section through the upper pin showing the extent of corrosion and/or debris damage between the washers is depicted in figure 8. Figure 9 is a closer view of one area of this cross section.) The inside hanger was not noticeably deformed but contained heavy corrosion and/or breakout areas at the lower pin hole wall. The bearing surface of the hanger was irregular, making the circular hole appear out-of-round.

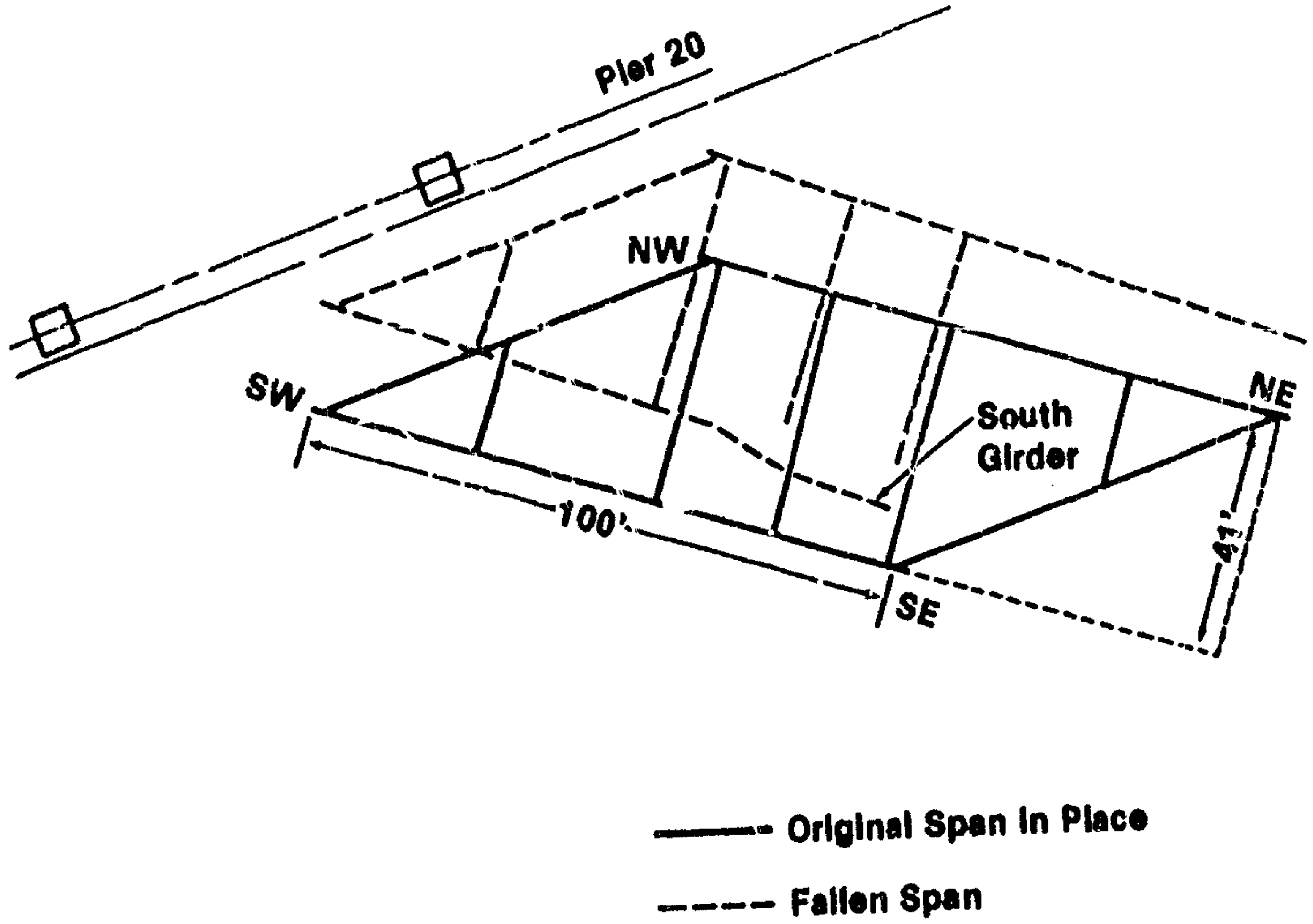


Figure 7.--Location of the steel superstructure of the suspended span in place and after collapse.

Both ends of the lower pin at the southeast corner of the fallen span were found to be substantially tapered and exhibited severe corrosion. The spacer washer on the lower pin between the hanger and the web of the south girder, designed originally to have a 1/8 inch clearance was extended about 1 inch outward from the washer welded to the web. The extended space was filled with corrosion products and/or debris. A pin cap with a 1-inch lateral bow deformation was found below the southeast corner of the fallen span. Another pin cap found in the same position exhibited about 1/4 inch out-of-flat bowing. It was not possible to establish the original location of these caps. The hanger found near the southeast corner was noticeably bent. This hanger has been identified as the outside hanger of the pin and hanger assembly at the southeast corner.

The lower pin and hanger connection at the southeast corner had sufficient corrosion between the welded washers and the spacer washers to severely reduce the bearing portion of the hangers on the pin. The bottom inner side of the lower pin at the

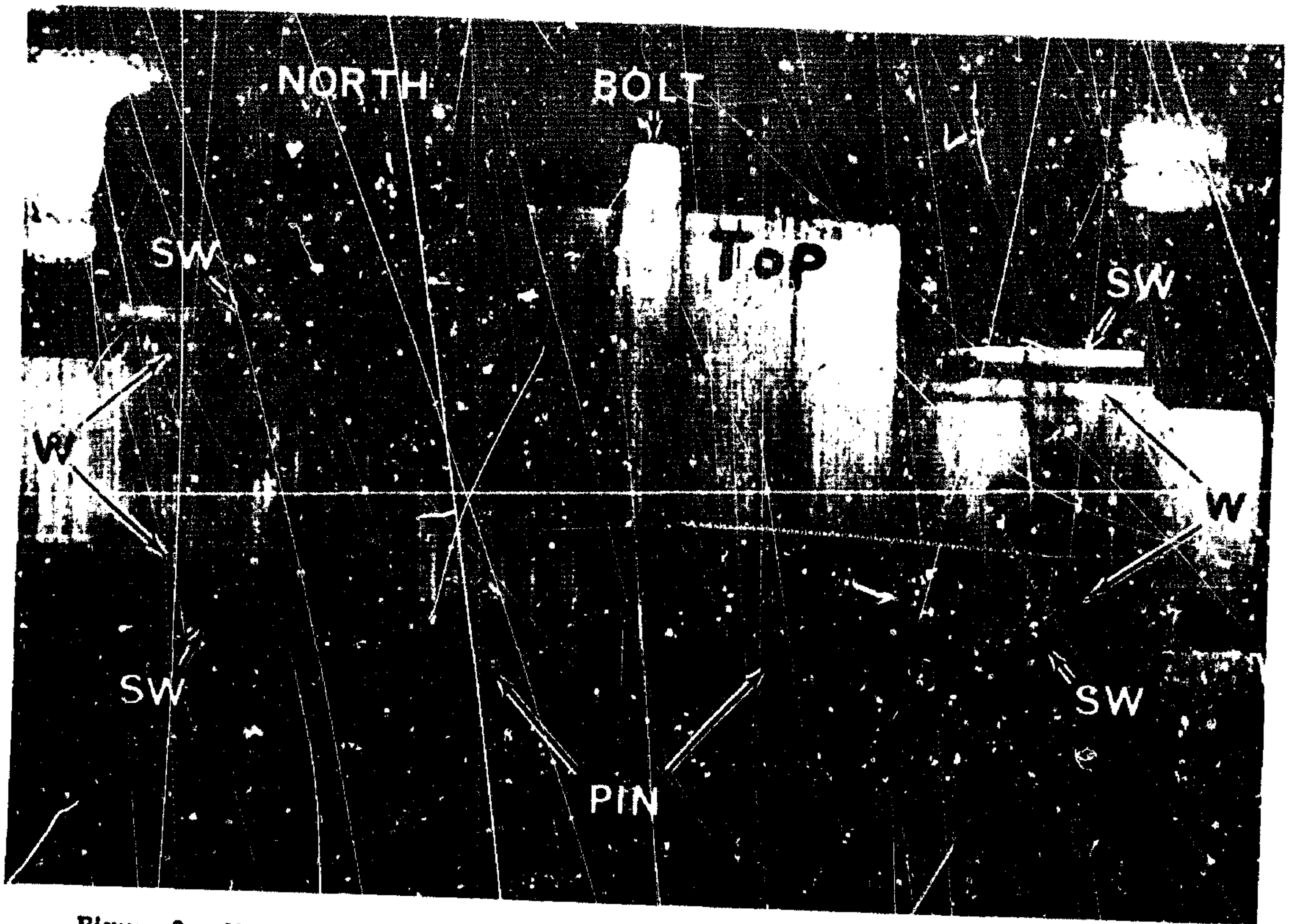


Figure 8.—Horizontal diametrical sawcut cross section through girder assembly at the upper southeast corner pin.
Arrows "W" and "SW" locate welded and spacer washers, respectively.

southeast corner was fractured and had separated. The horizontal distance along the bottom of the pin from the fracture to the projected outer end of the pin was approximately 3/4 inch, indicating that the inside hanger probably had been displaced laterally almost halfway off of the pin by the time this fracture occurred. Extensive corrosion scale masked the fracture.

The copper curb trough installed on the cantilever arm directly above the pin and hanger assembly at the southeast corner of the fallen span remained with the cantilever arm and was totally covered with sand and debris. The curb trough at the northeast corner of the fallen span also was covered with debris.

Water drainage indications with accompanying rust were present at the southeast corner of the cantilever arm adjacent to the fallen span, and multiple rusty-colored water stains were seen on the hanger itself. (See figure 10.) The stains on the hanger covered its length, and at the lower end of the path, the stains went into the heavily corroded section surrounding the pin hole. Rust streaks extended downward from the end of the flange of the girder on which the copper drainage box had rested. The west face of the skewed end floor beam on the cantilever arm, which was adjacent to the expansion joint, was spotted with rust.

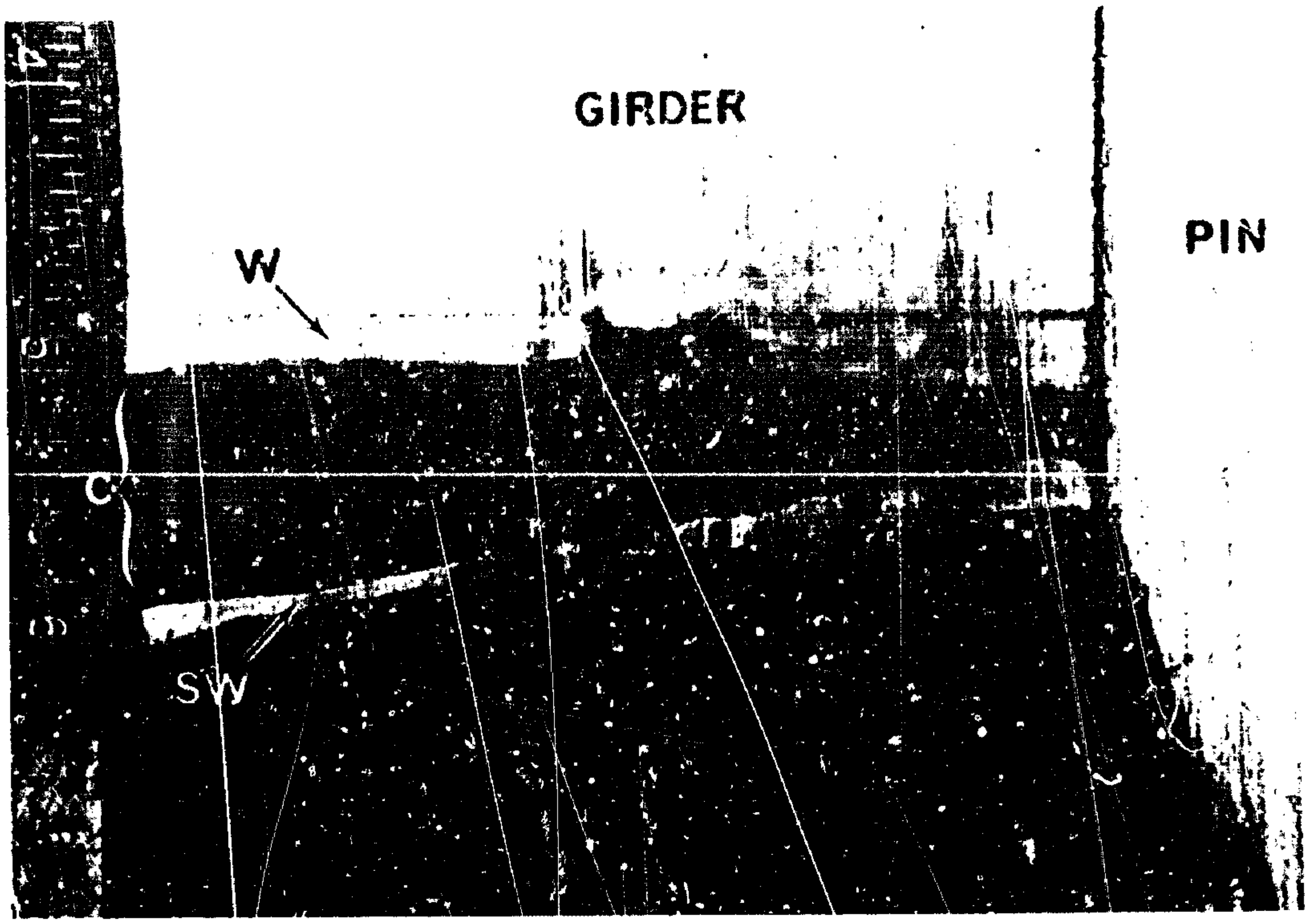


Figure 9.—Higher magnification view of the left lower portion of the cross section shown in figure 8.
Bracket "C" indicates corrosion and/or debris found between washers.

Northeast corner.—The upper pin remained in the web of the north girder cantilever arm, and two spacer washers were still in place on the upper pin. The pin and hanger assemblies on the northeast corner had only slight to moderate corrosion, and in general the assembly appeared to be in relatively good condition. The pin caps, bolts, and hangers were missing and presumed to have fallen into the river below.

Southwest corner.—Of the two pillow blocks and the pin, only the lower pillow block remained attached to the cantilever arm at the south girder where the southwest corner of the fallen span had been attached. The southeast corner of this 5-inch-thick steel block was peened down about 3/4 inch. The northwest corner of the plate above the upper pillow block was bent upward. The welds attaching the pillow block to the support steel of the cantilever span were fractured extensively. The support steel below the pillow plate was bent downward. The back edge of the pillow block was raised up off the steel flange. The pin and upper pillow block were recovered together, but not attached to the girder.

Northwest corner.—The lower pillow block and the pin remained intact and attached to the support steel of the north cantilever arm where the northwest corner of the fallen span had been attached. The flange portion of the pin on the south end was sheared off so that the top chord of the flange was leveled down to the bearing surface at the top of the pin. The welds were still intact. The upper pillow block remained attached to the north girder of the suspended span.

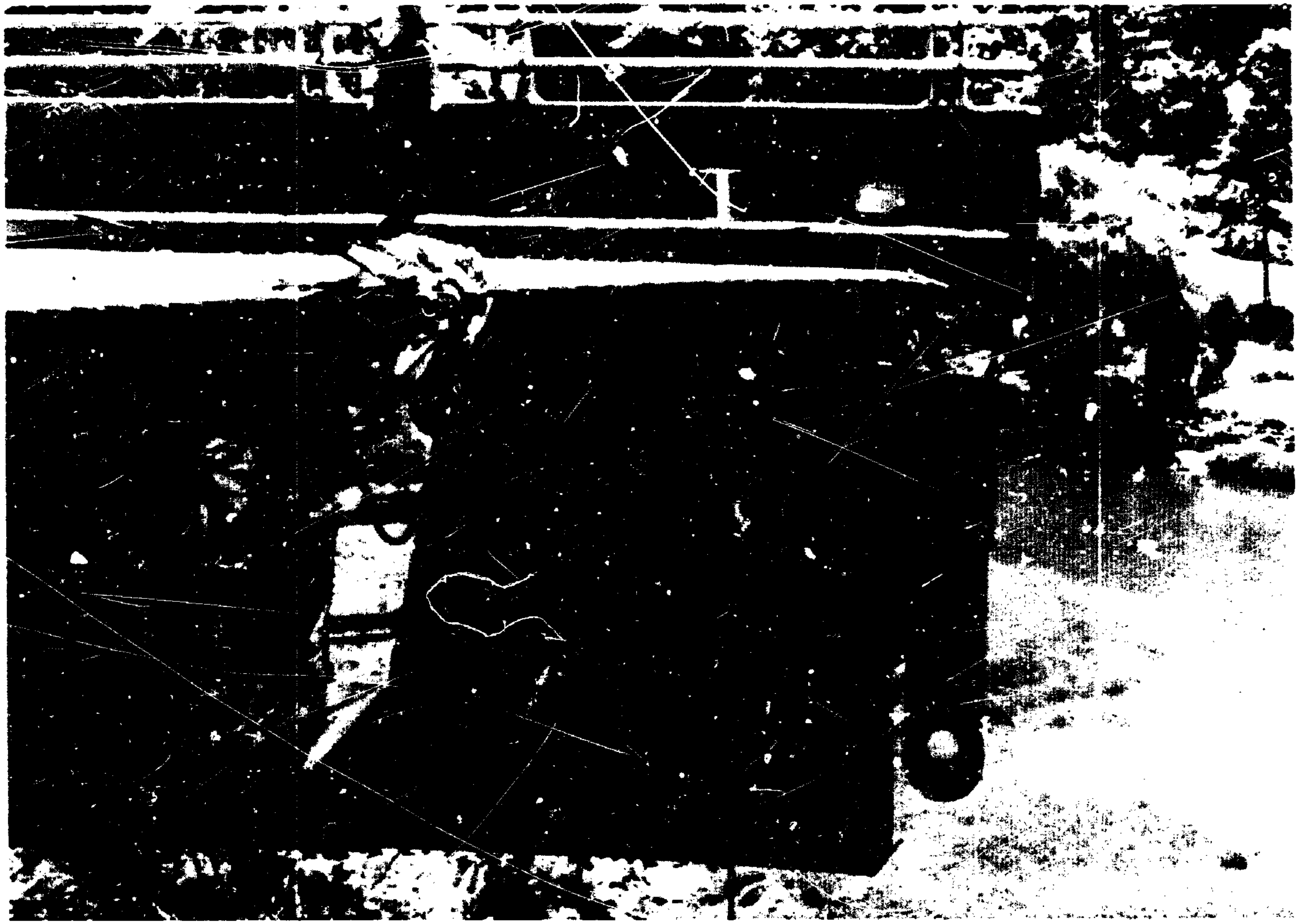


Figure 10.—Water and rust streaks on inside hanger and pin cap of the southeast corner.

Pin bolts.--Two of the three 1-inch-diameter pin bolts that fell from their installed locations were found. Because of the location in which they were found, it is presumed that one was from the lower pin of the southeast corner and one was from the northeast corner of the fallen span (whether it was the upper or lower pin could not be established). The pinbolt presumed to have come from the lower pin at the southeast corner was fractured just under the nut on one end. The other end still contained a 1-inch by 1 9/16-inch nut. Although corroded, the associated deformation and fracture plane orientation on the pin bolt appeared typical of ductile overstress separation. The pin bolt presumed to have come from the northeast corner was a 1-inch-diameter pin bolt, also fractured in the threaded end near the 1-inch by 1 9/16-inch nut also with ductile overstress characteristics.

Expansion joint.—At each of the two corners of the cantilever arm of the anchor span adjacent to the fallen span, some of the interlocking fingers of the expansion joint were bent toward the centerline of the eastbound roadway. At the southeast corner, four fingers were bent from about 45 degrees to about 15 degrees, with the bend fulcrum approximately at the one-third point into the fingers from the edge of the joint. A fifth finger also was slightly bent. At the northeast corner, eight fingers were bent toward the center of the roadway with a maximum bend of about 15 degrees, again with the bend point approximately one-third of the way from the pavement into the finger.

Windlock.—The windlock interlocking grip connector on the floorbeam of the cantilever arm of the anchor span to which the fallen span had been connected was deformed downward and to the northwest of its original position. It showed that, at some time, the floorbeam had moved about 2 inches to the east and 1/2 inch to the west of the position immediately before the collapse. The marks indicated that the movements were not recent.

The female end of the interlock on the cantilever arm of the main span to which the fallen span had been connected was worn by the male portion of the windlock on the fallen span to a depth of 1/16 to 1/8 inch at a location where there is normally a 1/2-inch vertical clearance. The wear pattern of the female end also was off-center laterally between 1/2 and 1 inch to the south of the design-intended center, and the wear pattern was wider than on the male portion of the windlock.

Meteorological Information

The surface weather observations for June 28, 1983, at an airport about 7 miles northwest of Greenwich at 12:45 a.m. and 1:45 a.m. showed no precipitation, visibility of 5 miles, and temperatures of 70° F to 72° F. At 12:45 a.m., the wind was calm, and at 1:45 a.m., the wind was from the north (360°) at 4 knots. The barometer was at 29.48 and was steady. According to the National Oceanic and Atmospheric Administration, the tide was almost high at 7.7 feet in Greenwich at 1:30 a.m.

Medical and Pathological Information

The 44-year-old male driver of the first tractor-semitrailer died as a result of traumatic injuries received in the accident. There was no evidence that he had been wearing the available seatbelt. The 31-year-old male driver of the second automobile died from drowning when his vehicle fell into the river. The driver was wearing the available seatbelt. The 21-year-old male passenger in the second automobile also died from drowning. The passenger was not wearing the available seatbelt.

The 27-year-old male driver of the second tractor-semitrailer suffered chest injuries and compression fractures of the spine. He said that he was not wearing the available seatbelt. His 23-year-old wife suffered a scalp laceration, three deep lacerations of the lower left leg, multiple abrasions, and compression fractures of the spine. She said that she was not wearing the available seatbelt.

The 21-year-old female driver of the first automobile suffered fractures of the left clavicle and scapula, a left brachial plexus injury, and tibia and fibula fractures of the left leg, a cerebral concussion, and multiple lacerations of the head and knees. Rescue workers reported that they saw no evidence of the available seatbelt and shoulder harness having been in use.

Survival Aspects

The crash sequence after the vehicles went over the edge of the span was unusual and unique. The forces applied to the vehicles could not be predicted for vehicle design purposes. The circumstances which led to the survival or nonsurvival of the vehicle occupants in this accident were random, and taking measures to prevent injuries or fatalities in similar accidents would be difficult, if not impossible.

Of the six vehicle occupants, only one, the driver of the second automobile, was wearing an available seatbelt and shoulder harness, and he did not survive. He and the passenger in the second automobile experienced a fall of 70 feet, and the vehicle landed upside down in the water and submerged.

The tractor cab of the first tractor-semitrailer struck the end of the protruding expansion fingers in the cantilever arm. The steel fingers penetrated the cab so that objects at the rear of the cab were impaled in the extended fingers. The driver suffered severe head and chest injuries.

Tests and Research

Span alignment.--Postaccident inspection of the westbound suspended span adjacent to the fallen span (span D in figure 4) did not show any misalignment. Postaccident inspection of the adjacent suspended spans between piers 18 and 19 (spans B and C in figure 4) revealed that they were out of alignment vertically and horizontally. The railing of the remaining eastbound suspended span (span B) was about 1/2 inch lower than the railing of the cantilever arm at the southwest corner of the span. (See figure 11.) Also, the parapet was lower. In addition, measurements of the interlocking fingers at the expansion joint showed the fingers of the suspended span to be 1/2 to 9/16 inch below the fingers of the cantilever arm in the south side of the roadway. The westbound span was similarly misaligned vertically. The bridge railing parapet, slip joint, and interlocking fingers of the expansion joint were 1/2 to 9/16 inch lower than the corresponding railing and fingers of the cantilever arm. The fingers on the suspended span were darker than the fingers on the cantilever arm, and it was evident that the sunken fingers had not been polished recently by contact with motor vehicle tires.

Examination of the interlocking fingers of the expansion joint on the westbound suspended span (span C) in the horizontal direction showed that they were no longer centered horizontally, but had shifted so that the fingers of the suspended span were pressing northward against the sides of the fingers of the cantilever arm. The horizontal movement was about 1/4 inch. A piece of note paper could not be inserted at most of the points of contact on the span. The same phenomenon was found on the eastbound span (span B). The deck had shifted southward, and the sides of the fingers on the suspended

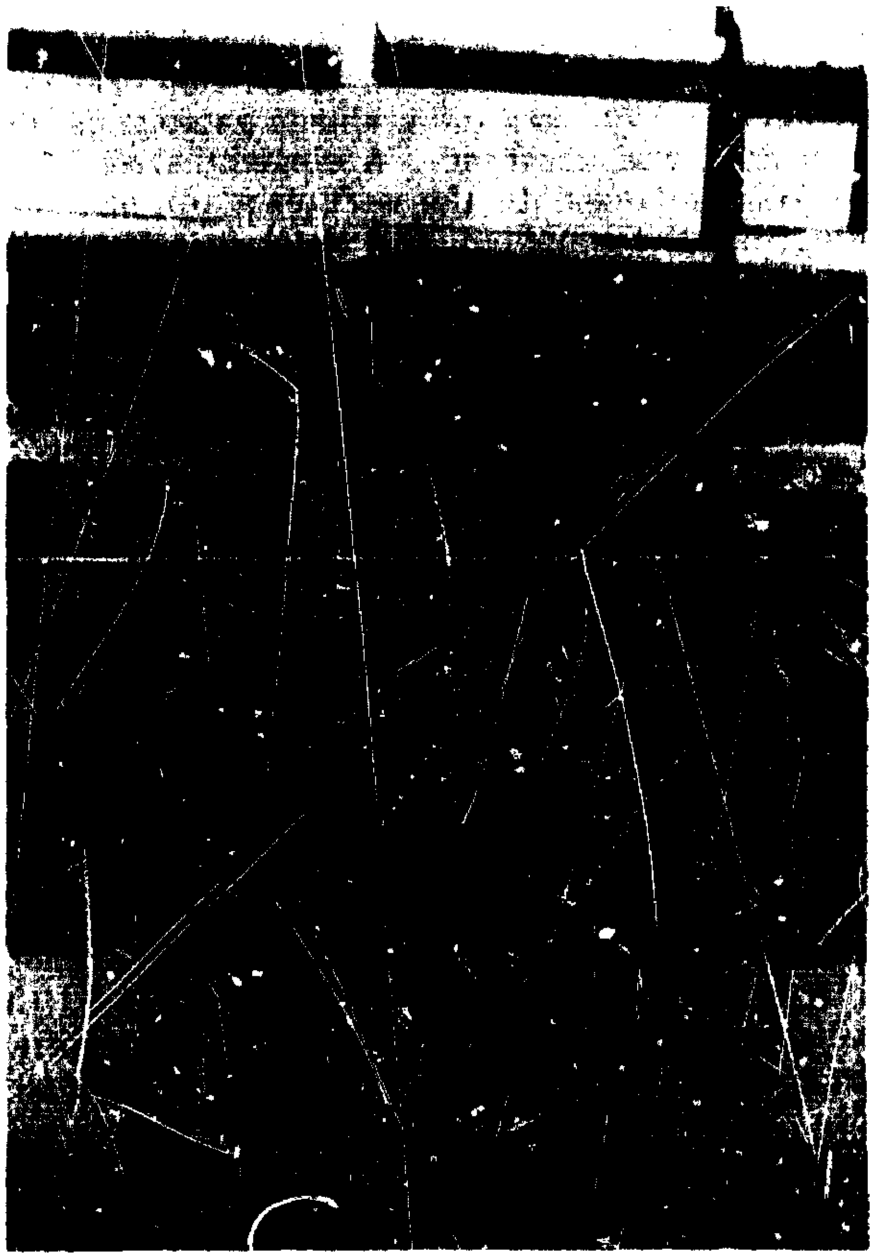


Figure 11.—View of bridge rail misalignment of eastbound span (span B).

span were pressing southward against the fingers of the cantilever arm. However, a number of the fingers were not quite touching each other—a piece of note paper could be inserted between a number of them.

When informed of the misalignment of these two suspended spans, the safety inspectors who had inspected the Mianus River bridge stated that they might have missed seeing the misalignment of the curbs and bridge rails during their safety inspection in September 1982 and during a bridge deck inspection the safety inspectors made in May 1983. The junior inspector stated that if they had observed the misalignment, it would not have been reported because it was not "severe enough."

Drainage.—Postaccident inspection of the suspended spans between piers 18 and 19 (spans B and C in figure 4) showed severe clogging of the grating formed by the interlocking fingers along the outer curb line. On the eastbound span, the joint was fully packed with sand, debris, and pieces of wood for about 1 1/2 feet from the curb toward the center of the roadway. A plant about 6 inches tall was growing out of this debris in the curb line of the westbound span. There was no vegetation on the eastbound span, but debris had collected about 1 inch deep near the curb. There was still an opening in the curb slip joint, and it appeared that water could pass through the curb slip joint on both spans.

The investigation revealed that all of the curb drains on the bridge deck on both the eastbound and westbound traffic lanes were paved over and closed. During the afternoon following the collapse, light rain fell and the drainage pattern on the westbound suspended span opposite the fallen span was observed. A concentrated fall of water was flowing through the expansion joint adjacent to the northeast pin and hanger assembly of that span. Instead of flowing into the scuppers, the water was flowing over the lower flange and into the river below. The pin and hanger assembly underneath the curb and adjacent to the flow was visibly corroded. The expansion joint was the only point of escape for water falling on the deck of the westbound span for a distance of more than 200 feet west of the expansion joint to the crest of the bridge.

Corrosion.—Postaccident inspection of the suspended spans between piers 18 and 19 (spans B and C in figure 4) revealed a light-colored rust between the interlocking fingers of the expansion joints of both spans which were in contact. Inspection of the area where the expansion joint had existed between the fallen span and the cantilever arm of the anchor span revealed that the interlocking fingers mounted on the fallen span had the same type of light-colored rust intermittently along the sides of the widest parts of the fingers. The fingers on the cantilever arm showed similar light-colored rust. The areas on which the rust appeared were consistent with the rust marks having been made by the fingers of the suspended span pressing against those of the cantilever arm and attempting to move the cantilever arm to the south.

Postaccident inspection of the pin and hanger assemblies of the suspended spans between piers 18 and 19 (spans B and C in figure 4) revealed that the inner pin caps were generally much less dished than the outer pin caps. Gaps between girder webs and hangers, particularly at the lower pin caps, were evident and generally correlated with the dishing of the pin caps. The normal design would allow for a 5/8-inch gap. The largest gap between the web and hangers was found to be 1 3/8 inch to 1 1/2 inch at the outer pin and hanger assembly at the eastbound span. Inspection of the lower pin at the southwest corner of the eastbound span revealed that the rust buildup and the offset position of the pin relative to the hanger were so pronounced that no reading could be obtained. The pin and hanger assembly was relieved of its load, and the pin cap was removed for closer inspection. The retaining nut was burned off in order to free the pin cap. When the pin cap was removed, black rust flowed out of the connection. (See figure 12.) The Chief of the Review and Analysis Branch, Bridge Division of the FHWA who witnessed the pin cap removal testified at the public hearing: ". . .there is no way that I would have ever believed or conceived that the amount of deterioration behind that pin cap would have been there. I never in my wildest days have seen that amount of deterioration, and I don't think short of taking that pin cap off, anyone else could judge that that would be the case."

The south side of the girder of the westbound suspended span adjacent to the fallen span (span D in figure 4), which had no open joint or drainage element above it, was relatively unspotted by rust. In the water fall zone under the expansion joint of this span, corrosion was much heavier on the lower flange than on a nearby lower flange not exposed to drainage water. The pin and hanger assembly adjacent to the water fall at the northeast corner of this span was heavily rusted, and flanges beneath were rusted also. What appeared to be remnants of severely deteriorated portions of washer material were found adhering to the pin and hanger at the southeast corner of this span. Rust streaks on the hanger were directly above the corroded portions of the hanger, washer, and pin.

Figure 12.—Pin and hanger assembly at southwest corner of the remaining eastbound suspended span.

Concerning the lateral forces that could be exerted by corrosion and ice against the hangers of pin and hanger assemblies, a consulting engineer hired by the insurance carrier of the bridge stated,

> . . . our investigation indicated that the failure initiated at the southeast corner and led to the subsequent collapse of the whole span. The cause for the movement of the hangers horizontally away from the center line of the girder, in our opinion, is due to some combination of rusting and ice formation.
>
> We have performed calculations which indicated that the pressures generated by rusting surfaces which are constrained from movement are sufficient to cause the hangers to move laterally. That is, as metal corrodes or rusts, there is a tendency for the material to expand because the rust products themselves had a larger volume than the parent metal. 6/

In performing his calculations, the consultant assumed a coefficient of static friction between the hanger and the pin of 0.75. 7/ His calculations indicated that a little less than 1,800 psi pressure is required to overcome friction. (Another source calculates pressures exerted by expansion of corrosion products in a range of 4,000 to 7,000 psi. 8/)

The consultant conducted similar calculations related to pressures exerted by the formation of ice between the hangers and the web of the girder. Using a coefficient of friction of 0.75 and considering the pressures at which ice would crack as well as pressures generated by a constraint, his calculation indicated that ice could initiate a pressure of 700 psi. Therefore, he concluded that corrosion forces alone could move the hangers laterally on the pin and that ice formation would contribute to such movement but was not necessary to move the hanger laterally.

Out-of-plane movement.--On behalf of the Safety Board, an engineering consultant firm developed a computer model of the Mianus River bridge to study the pin and hanger assemblies and look for forces and/or movements which might have directly or indirectly led to the failure of the assemblies. The primary objective was to provide the Safety Board with a refined estimate of the out-of-plane relative movement of the pins in the pin and hanger assemblies.

The consultant performed 21 three-dimensional, space frame analyses of the Mianus River bridge, utilizing the "STRESS" computer program. 9/ In these analyses, various structural parameters, such as torsional properties, bearing conditions at the piers, lateral bracing, and plate action of the deck, were varied to develop a computer simulation model that, within the limits of a space frame analysis, best represented the behavior of the bridges. Several loadings were applied to the model. The largest calculated out-of-plane response was caused by placing three HS-20-44 trucks (the standard design truck loading used in United States design practice) each aligned with its middle axle on the end

6/ Michael J. O'Rourke, P.E., Consulting Engineer, "Interim Report on Failure Investigation of Mianus River Bridge," August 13, 1983.
7/ Sears and Zemansky, University Physics, (1970), p. 24.
8/ "Wedging Action of Solid Corrosion Products During Stress Corrosion of Austenitic Stainless Steel," Pickering, Beck and Fontana, "Corrosion," Volume 18, Number 6, June 1962, pp. 230+ - 239+.
9/ The computer program "STRESS" used for this study was developed by the Massachusetts Institute of Technology for solving structural engineering problems using the matrix stiffness method. The program is widely used by the structural engineering profession.

floorbeam (hanger end) of the suspended span (one in each of the three traffic lanes). The static weight of the trucks was used, i.e., no impact was added, and the full weight of the trucks was applied. This loading produced estimated differential lateral movements between the top and bottom pins of 5/32 inch (maximum) in the outside hanger assembly and 1/32 inch (maximum) in the north hanger assembly. It also resulted in an uneven distribution of live load forces in the hangers of both hanger assemblies. The effect of dead load on out-of-plane deflections was not investigated by the Safety Board's consultant because of the lack of information on erection detail. Neither the State's records nor the bridge designer's records contain any data on this subject.

The comparison of the forces and displacements in pin and hanger assemblies on this skewed bridge with a right-angle model indicated that, while both skewed and right-angle bridges have lateral movements and uneven live load distribution in the hanger assemblies, the movements and uneven loadings are much larger in the skewed model. While the skewed model has a net out-of-plane movement due to live load of 5/32 inch (maximum) at the southeast corner, the right-angle model has a net out-of-plane movement of 2/32 inch (maximum), or less than one-half the amount found in the skewed model. At the northeast corner, the out-of-plane movement is about 1/32 inch (maximum) in both models.

The difference in the outside and inside hanger axial loads due to live loads at the southeast corner pin and hanger assembly in the right-angle model is about 15,000 pounds; in the skewed model, the difference is almost 87,000 pounds. In the northeast corner assembly, the difference in axial hanger loads for the right-angle model is also 15,000 pounds, while the difference for the skewed model is almost 59,000 pounds. The much greater out-of-plane movements and variation in live-load axial loadings in the skewed model would more likely contribute to structural problems.

The consulting engineer hired by ConnDOT in their investigation of this accident stated that forces associated with out-of-plane movements were instrumental in the collapse of the span. 10/ ConnDOT's consultant proposed a theory of the collapse of the suspended span, which considers the three-dimensional aspects of the bridge and which predicts lateral hanger movements due to forces associated primarily with the 53.7-degree skew. These considerations are based on assumptions not fully known to the Safety Board. The consultant has not yet made his final evaluations and analysis. Therefore, they are not examined in this report.

Another ConnDOT consultant, who prepared the plans for the retrofit of the bridge's pin and hanger assemblies, stated that he believed that the bridge failure was caused by a combination of out-of-plane deformations, the buildup of rust between the hangers and girders, and the high bearing stresses of the hangers on the pins. The consultant for the insurance carrier on the bridge did not mention out-of-plane movements in his report. The consulting firm responsible for the design of the bridge questioned ". . . if in fact these forces existed." 11/

10/ State of Connecticut, "Connecticut Department of Transportation Findings, Conclusions, and Recommendations Drawn from the Investigation of Collapse of a Section of the I-95 Bridge over the Mianus River, Greenwich, Connecticut, June 28, 1983," p. 9.
11/ Tippetts-Abbett-McCarthy-Stratton, "Evaluation of Factual Materials and Recommendations Concerning the Collapse of the Mianus River Bridge," December 19, 1983, p. 20.

Tests.—Physical and metallurgical tests, which include but are not limited to plastic flow, accelerated corrosion, fatigue, friction characteristics, tensile strength fractography, and charpy v notch tests, are continuing at Lehigh University. The bearing stresses and the skew design also are being studied.

Repairs.—Based on the findings of the lateral movement of the hangers, ConnDOT as an immediate safety measure sand-blasted and flushed the corrosion and debris out of the spaces between the hangers and the webs of the girders, and then installed large steel retainer plates with high-strength bolts over each pin cap on all of the pin and hanger assemblies on all of the remaining suspended spans. The tightening of the bolts allowed the hangers to be squeezed back onto the corroded pins to nearly their original position in the lateral condition. Somewhat later, the pin and hanger assemblies were replaced, using a recessed pin nut, thicker hangers, and various other changes.

Other Information

National Bridge Inspection Standards.—The Federal-Aid Highway Act of 1968 amended Section 116 of Title 23, United States Code by adding:

> (d) The Secretary in consultation with the State highway departments and interested and knowledgeable private organizations and individuals shall as soon as possible establish national bridge inspection standards in order to provide for the proper safety inspection of bridges. Such standards shall specify in detail the method by which inspections shall be conducted by the State highway departments, the maximum time lapse between inspections and the qualifications for those charged with the responsibility for carrying out such inspections. Each State shall be required to maintain written reports to be available to the Secretary pursuant to such inspections together with a notation of the action taken pursuant to the findings of such inspections. Each State shall be required to maintain a current inventory of all bridges.
>
> (e) The Secretary shall establish, in cooperation with the State highway departments, a program designed to train appropriate employees of the Federal Government and the State governments to carry out bridge inspections. Such a program shall be revised from time to time in light of new or improved techniques. For the purposes of this section the Secretary may use funds made available pursuant to the provisions of section 104(a) and section 307(a) of this title.

This amendment was prompted mainly as a response to the collapse of the Silver Bridge at Point Pleasant, West Virginia, on December 15, 1967, in which 46 people died. 12/

On September 14, 1970, the FHWA issued a notice that it was considering implementation of Section 116 by adopting national bridge standards for bridge inspection (35 FR 14864). The proposed standards were based generally on the "Manual for Maintenance Inspections of Bridges," published in 1970 by AASHTO. More than half the State highway departments, as well as subdivisions of the States, private organizations, and government officials, commented on the notice. On April 20, 1971, the FHWA issued the National Bridge Inspection Standards (23 CFR Part 650, Subpart C, Sections 650.301-650.311), which were similar to the standards originally proposed. The recommendations emanating from the Safety Board's investigation of the Silver Bridge accident aided in the development of the standards.

12/ "Collapse of U.S. 35 Highway Bridge, Point Pleasant, West Virginia, December 15, 1967" (NTSB-SS-H-2).

Through the application of these standards, many deficient bridges have been identified, leading the Congress to establish a discrete bridge improvement program which by fiscal year 1986 is expected to grow to a $2 billion-per-year Federal-aid program to assist the States and local governments to repair or rehabilitate defective bridges. The Mianus River bridge and other bridges along the toll portion of the Connecticut Turnpike do not qualify for Federal-aid bridge funds because they were built with private funds and are toll roads. However, the inspection standards apply to all structures defined as a "bridge" 13/ and forming a portion of a public road.

The standards require that: (1) all States have a bridge inspection organization, (2) inspectors meet minimum qualifications, (3) each structure be rated as to its safe load-carrying capacity, and (4) inspection records and bridge inventories be prepared and maintained in accordance with the standards. (See appendix E.) The standards further require that every bridge in a public road be inspected at regular intervals not to exceed 2 years. The depth and frequency of inspections depend on such factors as age, traffic characteristics, state of maintenance, and known deficiencies. The evaluation of these factors is entirely the responsibility of the individual in charge of the inspection program; the weight to be given these factors is not specified in the standards.

The standards set forth qualifications for personnel involved in the bridge inspection program. Title 23 CFR 650.307 requires:

(a) The individual in charge of the organizational unit that has been delegated the responsibilities for bridge inspection, reporting, and inventory shall possess the following minimum qualifications:

(1) Be a registered professional engineer; or

(2) Be qualified for registration as a professional engineer under the laws of the State; or

(3) Have a minimum of 10 years experience in bridge inspection assignments in a responsible capacity and have completed a comprehensive training course based on the "Bridge Inspector's Training Manual" [14/] which has been developed by a joint Federal-State task force.

(b) An individual in charge of a bridge inspection team shall possess the following minimum qualifications:

(1) Have the qualifications specified in paragraph (a) of this section; or

(2) Have a minimum of 5 years experience in bridge inspection assignments in a responsible capacity and have completed a comprehensive training course based on the "Bridge Inspector's Training Manual," which has been developed by a joint Federal-State task force.

13/ A bridge is defined as "a structure including supports, erected over a depression or an obstruction, such as water, a highway, or railway, having a track or passageway for carrying traffic or other moving loads and having an opening measured along the center of the roadway of more than 20 feet." ("AASHO Highway Definitions," AASHO (Washington, D.C.) 1968, p. 2.)

14/ "Bridge Inspector's Training Manual," U.S. Department of Transportation, Federal Highway Administration, 1970.

The standards do not require that either the individual in charge of bridge inspections or the team leader be tested on their knowledge of bridge inspection procedures. The standards require that inspection reports contain the minimum data listed in section 3 of the AASHTO "Manual for Maintenance Inspection of Bridges."

The FHWA reviews compliance by the States with the standards to determine that a State has qualified inspectors and that it is following through on the inventory inspections and appraisal requirements. The FHWA provides technical assistance and evaluates program progress. The reviews comprise an office audit to check the records and a brief field check to observe procedures and conditions during onscene inspection. The reviews are conducted on three levels: (a) the FHWA Division Office conducts a review of the State's bridge inspection program and discusses with State officials the State's compliance with the minimum requirements of the standards; (b) the FHWA Regional Office conducts additional reviews to be sure that the Division Office audit is reasonable and sound; and (c) the FHWA Headquarters in Washington, D.C., conducts five to nine reviews a year of the regional programs to be sure that they are stressing pertinent items. The chief of the FHWA Headquarters Design and Inspection Branch, which monitors the program, testified that the FHWA reviews indicate that all of the States have the ability to satisfactorily conduct bridge inspection programs and that while some improvements are desirable, the FHWA has never considered it necessary to impose sanctions on any State for lack of compliance.

Connecticut Bridge Inspection Program.--Prior to May 1973, Connecticut's bridges were inspected by ConnDOT's District Bridge Maintenance Section. With the promulgation of the National Bridge Inspection Standards, ConnDOT established a Bridge Safety and Inspection Section in May 1973. The new section assumed responsibility for performing safety inspections, maintaining the bridge safety files, and recommending needed repairs. The section's goal is to ensure the safety of the public traveling on the bridges of the State of Connecticut. ConnDOT attempts to achieve this goal through periodic safety inspections of all bridges and by evaluating the results of the inspections. If the results of the inspection and evaluation indicate problems, the Bridge Safety and Inspection Section recommends repair, load restrictions, or closure of any bridge which is found to be unsafe for traffic. Preventive maintenance inspections of bridges remained the responsibility of the District Bridge Maintenance Sections.

In May 1973, four newly established bridge safety inspection teams were staffed with experienced personnel from ConnDOT's Office of Construction and Office of Maintenance. In 1977, an additional Transportation Associate Engineer and an additional bridge inspection team were added, bringing the number of teams to five. This was necessary to accomplish an initial inventory and inspection of all non-Federal-aid bridges in the State, including town bridges having a clear span of more than 20 feet.

On November 19, 1980, the FHWA notified ConnDOT that, under the provisions of the Surface Transportation Act of 1978, all 1,200 town bridges which are not on the Federal-aid system must be inspected on the same 2-year cycle as is required for State bridges. A sixth bridge inspection team was established, and certain vacant positions were filled. Early in April 1981, the Bridge Safety and Inspection Section was brought to its full staffing level which has been maintained with little turnover of personnel.

The Bridge Safety and Inspection Section is a part of ConnDOT's Bureau of Highways, Office of Engineering, Division of Engineering Services. The section is headed by the Engineer of Bridges and Structures, who is a registered professional engineer as required by the standards. Directly under him are two Transportation Associate Engineers, each of whom supervises the bridge safety activities in three areas of the

State. Each area is assigned two inspectors--Transportation Bridge Safety Inspectors I and II, of whom the inspector II is senior. In addition, there are bridge safety inspection divers, consisting of a crew leader and maintainers IV and V. The divers perform underwater inspections and repairs in all six areas. If a bridge inspector is sick or on vacation, his partner is usually reassigned to another area until he returns. Occasionally, one of the two bridge inspectors from the main office takes an absent inspector's place.

The Engineer of Bridges and Structures reports to the Manager of Engineering Services. He, in turn, reports to the Director of Engineering, who reports to the Chief Engineer of the Bureau of Highways. The Chief Engineer reports to both the Deputy Commissioner and the Commissioner of Transportation.

Each two-person bridge inspection team is assigned one of six geographical areas of the State, and each team is responsible for approximately 800 bridges that must be inspected at least every 2 years. Problem bridges are inspected every 6 months, or more often if necessary. Every 6 months the Bridge Safety and Inspection Section supplies to the safety inspectors in the field a list of the bridges which require an inspection within the next 6 months. From this list, the inspectors determine which bridges they will inspect each day. Each morning, the senior inspector calls the main office (usually speaking to the Transportation Associate Engineer in charge of his or her area), to report which bridge or bridges the inspectors will inspect that day and which bridges were inspected on the previous day. Any messages, special instructions, or changes in selection are discussed at that time. No other communications occur during the day, unless initiated by the inspector. According to the ConnDOT records and testimony at the Safety Board's public hearing, the office staff engineers did not supervise the bridge inspection teams in the field. The staff engineers make field checks only under extreme conditions when alerted by the inspectors, who are not engineers and who are limited in their expertise.

The area covered by the bridge safety inspection team responsible for the Mianus River bridge is Inspection Area IV, comprising 33 towns in western Connecticut. The Area IV inspection team assembles in its area office in New Milford every day at the start of the work day. After calling the main office in Newington and taking care of usual housekeeping chores, the safety inspectors leave for the bridge or bridges selected for inspection that day. Travel times vary, but travel to bridges located in the farthest areas (such as those in Greenwich) requires about 1 1/2 hours. Since their work day is 7 hours, only 4 hours (including lunch and rest periods) are available at remote sites for inspections and filling out Bridge Inspection Reports.

The bridge inspection process usually follows the outline of a two-page Bridge Inspection Report (BRI-18 Ed. 1-81) developed by ConnDOT. (See appendix D.) Inspections normally progress from west to east or from south to north, generally following the abutment and pier numbering system of the bridge. The rating codes used by the inspectors are based on the "Recording and Coding Guide for the Structures Inventory and Appraisal of the Nation's Bridges," developed by the FHWA and published in January 1979. The Bridge Inspection Report developed by ConnDOT includes a section on "alignment of members" distinct from other forms of misalignment. However, it does not quantify the relationship between measurements of misalignment and alignment rating numbers. The recording and coding guide does not include any mention of alignment of members.

Entries on the Bridge Inspection Report are arranged by classes of structure and problems, rather than by a sequence of movement over the bridge. The report form requires the inspector to consolidate statements on the condition of several bridge elements of the same class; it provides no specific space for recording the condition of the many individual elements which necessarily have to be inspected in order to arrive at overall ratings, nor is there an intermediate report form for consolidating the observation of alignment at many locations into the overall rating which the report requires. There is a "Remarks" section which could be used for appropriate observations or comments pertinent to the inspection.

The Bridge Inspection Reports are forwarded by the bridge safety inspectors to the office of the Transportation Associate Engineer who supervises the inspection team. The reports are reviewed initially by the office staff and then by the Transportation Associate Engineer who is to initial and date the appraisal sheet. If the Transportation Associate Engineer determines that something associated with a bridge needs correction, his office notifies the maintenance division. The bridge safety instructors have been instructed to fill out supplemental reports, add additional pages to the Bridge Inspection Report, or use the "remarks" section of the Bridge Inspection Report when necessary to give additional information. The data from the Bridge Inspection Reports are compiled and sent to the FHWA.

The FHWA's last review of ConnDOT's bridge safety inspection program was made on September 21 and 22, 1982, about 9 months before the span collapsed. The review, four pages plus photos, included six sections: (1) Compliance with the National Bridge Inspection Standards, (2) Highway Bridge Replacement and Rehabilitation Program, (3) Current and Proposed Bridge Programs, (4) Field Review, (5) Sundry Other Information, and (6) Commentary. It covered the examination of only two bridges. The FHWA review of ConnDOT's compliance with the National Bridge Inspection Standards was summarized in less than one page. The FHWA found that, except for item 90, "Inspection Date," on the "Structure Inventory and Appraisal Sheet," data checks of the National Bridge Inventory indicated that ConnDOT's records were very complete. The "Commentary" section added: "After a routine method of updating the date of inspections [is adopted]... Connecticut can be considered in excellent compliance with Federal requirements pertaining to the bridge programs."

The following weaknesses in organization and inspection responsibilities were noted in an internal review conducted by ConnDOT after this accident: 15/

(1) There is no rotation of inspectors between teams or areas. Rotation would increase the competence of the teams by working with others and would discourage shortcut inspections by a team that inspected the same bridges year after year.

(2) No recognition is given to the size or complexity of the bridge to be inspected. The inspection team leader determines the length of time to be spent on each bridge rather than the supervising engineer.

(3) While the inspection team leader is given a list of the bridges in his area which must be inspected in the next six months, there is no established procedure for scheduling the individual bridge inspections. The office personnel keep a running count of the number of bridges that have been inspected during the six-month period but apparently the supervisors take no action until near the end of the period. Typically, the supervisor will reassign a team that completes its assigned bridges early to an area which is falling behind so that all bridges are done every two years or less.

15/ "Internal Review of the Bridge Inspection Policies and Procedures," Connecticut Department of Transportation, September 1983, pp. 50-59. (Hereafter to be referred to as "internal review.")

On November 21, 1972, ConnDOT purchased a "snooper," a truck-mounted, selfcontained, articulated, hydraulic boom with suspended work platform which allows inspectors to inspect the outside and underside of bridges. To use a "snooper" on a bridge without full shoulders, such as the Mianus River bridge, requires closing the right lane of the highway. The Mianus River bridge, along with 79 other bridges in the State, was listed by ConnDOT as a "snooper" bridge. 16/ This designation requires that a "snooper" be used for an adequate inspection, except where certain hazards would make its use usafe. ConnDOT's internal review found that a "snooper" is required for adequate inspection of 162 bridges. 17/

The "snooper" was last used in August 1982. On September 1, 1982, a safety inspection revealed that extensive and costly repairs would have to be made to the "snooper" before it could be safely operated. On October 27, 1982, the "snooper" was determined to be unfit for use, and no action was taken to obtain a replacement. After the "snooper" was placed out of service, no "snooper" was utilized until after the bridge collapse. At that time, a "snooper" was made available by the State of Rhode Island. On June 20, 1983, the Engineer of Bridges and Structures included in his fiscal year 1985 budget a request for funds to purchase a new "snooper" for the Bridge Safety and Inspection Section.

During the 9 years 8 months that the "snooper" was available, the unit logged 36,769 miles of travel. From January 1, 1979, to August 1982, its last month of service, the "snooper" was used 403 hours for inspections and 257 hours for other use, such as maintenance. According to the records, the "snooper" was used on the Mianus River bridge nine times beginning in 1978; the records did not indicate the reason for its use on the bridge. The senior bridge safety inspector responsible for the Mianus River bridge, who was first involved in the inspection of this bridge in 1967, stated that he had used the "snooper" in his inspections of the bridge. The Engineer of Bridges and Structures stated that the senior bridge safety inspector had told him that he used the "snooper" on the bridge on May 3, 1978. The Engineer of Bridges and Structures also stated that he was informed that on March 26 and 28, 1980, and on April 5 and 29, 1982, the "snooper" was used for a maintenance inspection and for work on pier 16 of the Mianus River bridge.

Training courses in bridge safety inspection were conducted by ConnDOT at its training center in West Hartford, Connecticut, in 1972, 1975, 1979, and 1982. The courses were based on a course developed for the FHWA by the Link Division of the Singer Company, Silver Spring, Maryland, using the FHWA's "Bridge Inspector's Training Manual." The methods of inspection and reporting set forth in the manual are general guidelines rather than specific instructions on how to inspect various types of bridges.

The ConnDOT course was required training for all bridge safety inspectors. The Bridge Safety and Inspection Section also invites bridge maintenance personnel and, on occasion, inspectors from municipalities on a space-available basis. This provides a pool of potential bridge inspectors and increases the skills of other personnel who have bridge inspection duties.

In March 1972, ConnDOT compiled a "Field Bridge Inspection Booklet" for handy reference in the field. The pamphlet consists of excerpts from the FHWA "Bridge Inspector's Training Manual," including all of Chapter V, "What To Look For During Inspection." The guidance concerning the hangers of "cantilevered bridges" is as follows:

16/ Interview with Robert L. Thomas, Transportation Associate Engineer, Connecticut Department of Transportation, August 9, 1983.
17/ "Internal Review," p. 48.

i. On cantilevered bridges, check hinges and hangers to see that they are functioning freely and without restraint due to scoring, jamming, dirt or corrosion.

(1) If a hanger link is out-of-plumb beyond the limits expected for normal temperature variations, a further investigation should be made.

The following excerpts from the section on steel beams and girders are pertinent to the inspection of the Mianus River bridge:

a. Inspect steel for corrosion and deterioration especially at the following places:

* * * * *

(4) At cantilever hanger and pin connections.

* * * * *

(6) At any point where two plates are in face to face contact and water can enter (such as between a cover plate and a flange). If rusting occurs at this interface, the expansive force created will be great enough to spread the plates. [Emphasis added.]

b. If rusting and deterioration is evident, check the members for possible reduced cross-sectional area, using callipers, rulers, corrosion meters, or section templates. [18/]

The booklet did not include excerpts from the "Bridge Inspector's Training Manual" regarding alignment.

The FHWA "Bridge Inspector's Training Manual" has references to the inspection of "cantilevered bridges" on pages 3-8, 4-2, 4-4, 5-1, 5-41, and 5-43. The guidance on page 4-4 is particularly pertinent to the Mianus River bridge collapse:

> Where the main load of the bridge is carried by a single member, or element whose failure would result in the collapse of the structure, the member should be inspected very thoroughly for cracks and flaws either by visual inspection or by a non-destructive technique, such as ultrasonics or radiography. The pins and hangers on the suspended span of a two-girder cantilever bridge, or pins in a pin-connected truss, are typical examples of such members. [Emphasis added.]

The ConnDOT Director of Maintenance transmitted copies of the following AASHTO documents on maintenance to the Bridge Safety and Inspection Section: "Manual for Bridge Maintenance (1976)," "Guide for Bridge Maintenance Management (1976)," and "Manual for Maintenance Inspections of Bridges (1978)." The Engineer of Bridges and Structures did not give any direction requiring their use to the bridge safety inspectors in the Bridge Safety and Inspection Section.

18/ The FHWA "Manual for Maintenance Inspections of Bridges (1970)" also advocated measurements of spaces between members.

Connecticut Bridge Maintenance Program.—In addition to bridge safety inspections, ConnDOT conducts bridge maintenance inspections. While the bridge safety inspections are primarily for checking the structural integrity of the bridge and its ability to carry its design loads safely, the bridge maintenance inspections are performed annually to document the need for preventive maintenance, such as cleaning, repairing, painting, or replacing missing components.

Unlike bridge safety inspections there is no predetermined schedule for annual bridge maintenance inspections. As a result, it is difficult to ensure that all bridges are inspected annually for maintenance purposes. Bridge maintenance inspection reports are not routed to the Bridge Safety and Inspection Section. The maintenance inspection form identifies needed maintenance, but there are no guidelines to define "good, fair, poor, and critical" to avoid variations in interpretations among the maintenance inspectors. (See appendix F.)

Bridge maintenance and maintenance inspections are the responsibility of the four maintenance districts, each headed by a District Maintenance Manager. These managers report to the Director of Maintenance, who reports to the Chief Engineer of the Bureau of Highways. The Director of Maintenance is assisted by a Maintenance Planning Manager and a Maintenance Operations Manager. According to the ConnDOT criteria, no one on the staff of the Director of Maintenance is required to be a registered or graduate engineer. The formal line of communication between the Director of Maintenance and the Directors of Engineering and Construction in the Bureau of Highways is through the Chief Engineer. Memoranda and informal contacts, usually by telephone, also are used by the directors. Direct communications occasionally take place among the lower units in the organizational hierarchy of the maintenance, engineering, and construction sections.

In Maintenance District III, which includes the Mianus River bridge, there are three Bridge Supervisors, each of whom reports to the Bridge General Supervisor, who reports to an Operations Superintendent, who reports to a District Maintenance Operations Manager. The bridge maintenance function is four levels removed from the Office of the Director of Maintenance. Bridge maintainers, on the bottom rung of the organizational ladder, report to crew leaders, who report to the bridge supervisors. In addition, each district has two Bridge Maintenance Inspectors, who report to one of the Bridge Supervisors. The supervisor of the bridge maintainers responsible for making repairs on the Mianus River bridge is not the same supervisor in charge of the bridge maintenance inspectors. Day-to-day central control of all maintenance activities is administered by the Operations Manager, who is on the staff of the Director of Maintenance.

Maintenance District III had about 20 bridge maintenance workers in the early 1970's when the drains on the Mianus River bridge were paved over. By 1983, because of budget cuts, there were only five bridge maintenance workers in District III, of whom two were "part-time" workers; all workers were working a 35-hour week.

ConnDOT received at least three maintenance documents published by AASHTO: "Manual for Bridge Maintenance (1976)," "Guide for Bridge Maintenance Management (1976)," and "Manual for Maintenance Inspections of Bridges (1978)." Senior ConnDOT officials forwarded these documents downward through the chain of the ConnDOT maintenance organization, and they said that they believed that the documents were in the hands of the bridge safety inspectors. Personnel at all levels of the maintenance organization, including the Director of Maintenance, testified that they either had not received them or were not familiar with their contents. (See table 1.) There are no formal provisions for regular communications or contact between bridge safety and bridge maintenance inspectors.

Table I.—Familiarity of ConnDOT maintenance employees with AASHTO bridge maintenance and inspection documents

Title of Employee	Document	Familiarity
Transportation Chief Engineer	1/ 3/	None
Director of Maintenance	1/ 2/ 3/	Had seen them and passed them on to Districts. Never required that they be used.
Maintenance Planning Manager	1/ 3/ 2/	Familiar with 1/ but not familiar with 3/. Worked on 2/ committee. Forwarded documents to Districts.
District Maintenance Manager, District III	1/ 3/	None
Bridge General Supervisor, District III	1/ 3/	Had seen 1/ but not read it. Had not seen 3/
Bridge Supervisor (Maintenance) District III	1/ 3/	None
Bridge Maintenance Inspector District III	1/ 3/	None

1/ AASHTO "Manual for Bridge Maintenance (1976)"
Contains warning of difficulty detecting rusting between plates of pin and hanger bearings unless bearing is dismantled. Contains mention of essentiality of cleaning troughs under expansion joints to prevent corrosion of steel.

2/ AASHTO "Guide for Bridge Maintenance Management (1976)"
Contains chart of bridge bearing problems, but does not address pin and hanger bearings.

3/ AASHTO "Manual for Maintenance Inspections of Bridges 1978"
Describes difficulty of inspecting around connection details to determine if corrosion is beginning and warns against overlooking these areas. Describes checks to see whether drains discharge water where it may be detrimental to structure.

As part of the maintenance program, the AASHTO documents on maintenance were examined by a person on the staff of the Director of Maintenance and transmitted to district offices. At the district offices, the AASHTO documents remained in supervisors' bookcases and were not available to maintenance inspectors, many of whom said that they did not know of the documents or did not know their content. No direction as to the use of the AASHTO documents had been given by the Director of Maintenance. The AASHTO documents were not used in training ConnDOT maintenance personnel. Bridge maintenance inspection personnel got their training on an optional basis and went only to the bridge safety inspectors' training schools, which were based on the FHWA's "Bridge Inspector's Training Manual," not the AASHTO documents.

Senior ConnDOT supervisors with maintenance responsibilities had taken part in the development of various AASHTO documents in the past. The Director of Maintenance and his staff person who distributed the AASHTO manuals to district offices had both served on AASHTO committees which prepared the maintenance documents. AASHTO procedures require that each document be voted on by the entire committee. Those voting are expected to be familiar with the material on which they cast their ballot.

The FHWA has prescribed maintenance guidelines for interstate highways so that interstate routes will be maintained at design levels. Critical elements of these guidelines are found in the Code of Federal Regulations (23 CFR 635.505). The specific elements appropriate to this bridge concern drainage and bridges. Title 23 CFR 635.505(4), "Drainage. Preservation of hydraulic capacity for which originally designed," states in part: "Preservation of the structural and operational characteristics for which originally designed. These include safe, smooth . . . surfaces; proper surface drainage; and adequately functioning bearing devices. . . ." Because this section of I-95 is a toll facility and was not part of the Federal-aid system, these guidelines were not enforceable. However, according to State personnel, the Federal maintenance guidelines for interstate highways were being followed on the Mianus River bridge.

In a report to Connecticut's General Assembly in July 1981, ConnDOT discussed "deferred maintenance" as a factor that might lead to a bridge collapse. 19/ ConnDOT did not state specifically why deferred maintenance might lead to a collapse by identifying specific problems on bridges in the State. The report was largely in terms of increased costs if bridge deterioration were not arrested. The possibility of fatalities or injuries from a bridge collapse were stated in terms of money loss to the State through civil suits that might result. ConnDOT asked for increased funding, but it was not granted.

ConnDOT policy and procedures for controlling snow and ice are formalized in a 37-page document entitled "Snow and Ice Control Policy." On multi-lane highways, such as the Connecticut Turnpike, ConnDOT has a "bare pavement" policy, which calls for application of straight salt (432 pounds per two-lane mile). When abrasives are required, sand is to be spread straight. ConnDOT has reduced its use of salt from 180,000 tons per year in 1969-70 to about 90,000 tons. The average during the past 10 years was 97,000 tons per year. Of the four maintenance districts, District III uses the least amount of salt, 15,900 tons per year (average during the last 10 years).

19/ Report to General Assembly by Connecticut Department of Transportation, July 1981, p. 2.

Safety Board investigators examined ConnDOT's handling of citizen complaints concerning the precollapse condition of the Mianus River bridge. Complainants interviewed by Safety Board investigators described unusual and alarming noises, thumping noises, water leaks, high-pitched sounds, objects hanging or falling from the bridge, and vibrations of house windows and furniture. Most of the persons interviewed had not made any complaints in writing to ConnDOT or any other agency.

The Connecticut State Police conducted an extensive investigation of ConnDOT's handling of complaints. 20/ They identified 49 persons who said that they were concerned about the bridge's precollapse condition. The State Police identified 9 persons who made a total of 17 telephone calls to some ConnDOT official between January 1981 and the time of the bridge collapse. These 17 calls involved complaints of bridge noises, overgrown weeds, and a broken drain pipe. No ConnDOT record could be found of the receipt of these calls nor was there any record of any action having been taken on these complaints, although the statements of bridge maintenance personnel indicate that some corrective responses were made, and this was confirmed by some of the complainants. According to those maintenance personnel interviewed at the Greenwich, New Milford, and New Canaan garages, telephone complaints were recorded on a piece of note paper and left for the maintenance supervisor. When the supervisor had taken care of the complaint, the paper was discarded, leaving no record of the complaint or its disposition. Telephone calls were the most common method of making complaints. Letters of complaint were found in the files, and all had been responded to.

There was no clear policy on how such complaints should be recorded and handled. On May 30, 1979, the District Maintenance Manager of District III sent a memorandum to his District III supervisors outlining a procedure to be followed in receiving, recording, and responding to complaints received by telephone. However, there is no evidence that this procedure was ever implemented or is now being followed. Most employees, including the district management personnel, were unaware of the policy; none was following it.

After the bridge collapse, ConnDOT issued Administrative Memorandum No. 83 outlining department-wide procedures for handling telephone complaints. Calls or letters complaining about bridges are to be referred to the Bridge Safety and Inspection Section for action. Other divisions that may act on a complaint are required to notify the Bridge Safety and Inspection Section of the complaint and its disposition.

Overweight vehicles.—Permits for oversized or overweight vehicles or cargoes are issued by the ConnDOT Motor Carrier Operations Unit. During 1982, the unit issued 35,000 permits, 60 percent of them for overweight vehicles and 40 percent for oversized vehicles. The unit issues permits by telephone and on its own authority for loads up to 120,000 pounds. It may issue permits for loads greater than 120,000 pounds if the weight rating of the highways and structures on the route to be followed are known by the unit to be capable of taking the load safely. There are no procedures requiring consultation with the Bridge Safety and Inspection Section to develop a safe route for heavy loads to follow.

Congress established truck weight limitations for the interstate system in the Federal-aid Highway Act of 1956 to prevent serious damage to highway structures such as bridges. In Connecticut, trucks weighing more than 100,000 pounds are not allowed by ConnDOT on I-95 between New Haven and New York because of the weight restrictions on the bridges, including the Mianus River bridge. However, on December 30, 1982, transportation permits were issued for two five-axle trucks with a gross weight of

20/ Connecticut State Police case No. G-83-259200, "An Investigation Into State Department of Transportation Processing of Complaints Concerning the Mianus River Bridge."

120,000 pounds. The approved route was partly over I-95 but utilized the Mianus River bridge on Route 1 through Greenwich. These permits were later revoked by the Connecticut State Police because the vehicles did not follow the assigned routes. One vehicle actually weighed 224,000 pounds and is suspected of having crossed the Mianus River bridge on I-95 on January 5, 1983--a critical event. 21/ The second unit weighed 185,000 pounds, and it too is suspected of having crossed the Mianus River bridge in violation of its permit. However, due to the lack of procedures, no one in ConnDOT's Bridge Safety and Inspection Section was informed of these incidents, and the bridge was not examined for possible structural damage.

To be eligible to receive Federal highway funds, each State must certify annually to the FHWA that it has an effective vehicle weight enforcement program. 22/ Connecticut's enforcement program is carried out by the State Police, a division of the Department of Public Safety. The Connecticut State Police Commercial Vehicle Enforcement Unit was formed in November 1975, with one enforcement squad consisting of three troopers and a sergeant. In February 1977, Connecticut was cited by the Federal government for not having an adequate weight enforcement program. Connecticut agreed to increase the number of full-time personnel engaged in weight enforcement, to install scale pits, and as part of a long-range program, to construct fixed scales on major routes.

FHWA-AASHTO Relationship.--The FHWA and AASHTO operate side by side in the area of bridge design and maintenance standards, as well as in developing other highway standards. The Federal agency and the private association both develop technical documents; they conduct this activity in close relationship, and the resulting documents contain information, guidelines, and standards that relate to circumstances such as the detection of the deterioration that led to the collapse of the Mianus River bridge. The relationship is authorized by Title 23 of the U.S. Code which authorizes the Federal-aid highway program and requires that the aid be channeled through the State programs. Section 109, which sets forth the standards to be applied to the program, contains numerous references for consultation by the FHWA with the States in developing standards.

AASHTO is a private association of 52 active members—officials of the departments of transportation or State highway agencies of the 50 States, the District of Columbia, and Puerto Rico. The U.S. Department of Transportation is a dues-paying member and has *ex officio* status on all committees. AASHTO develops and issues technical documents intended primarily for use by member departments and reflecting the best-regarded procedures, practices, tests, specifications, or standards from the perspective of the States or the Nation as a whole. In this role, AASHTO serves as a voluntary standard-setting organization, providing a source of technical guidance or reference for all the States, from the perspective of the States. Each State is free to modify or adopt the resulting materials to conform to its own circumstances.

The standards are developed by committees made up of employees of the member States, FHWA officials, and other experts in the subject matter under consideration, selected under AASHTO authority. A two-thirds vote of all committee members is required before a standard can become effective. AASHTO also develops and monitors new technology and disseminates it among the States. In these activities, AASHTO

21/ A critical event is considered by ConnDOT to be the passage of a vehicle which exceeds the allowable highway bridge loading weight of 100,000 pounds over a structure on the State highway system.
22/ Title 23 CFR 657.1. The Federal requirements are for enforcement of vehicle size and weight on Federal-aid highways only.

committees make liberal use of relevant research efforts by the Transportation Research Board, the National Cooperative Highway Research Program, the FHWA's Offices of Research, Development, and Technology, and others.

The chairmen of AASHTO committees are voting members and are rotated periodically. The secretaries of AASHTO committees and subcommittees are nonvoting FHWA officials with <u>ex officio</u> status. The secretaries' tasks include coordinating the work of committee members and planning meeting agenda. The titles of the AASHTO subcommittees closely parallel the FHWA organizational structure. For example, the secretary of the AASHTO Bridges and Structures Subcommittee is the Chief of the FHWA Bridge Division, and the secretary of the Maintenance Subcommittee is the Chief of the FHWA Construction and Maintenance Division.

The AASHTO "Manual for Maintenance Inspections of Bridges," intended to inform bridge inspectors of what to look for during inspections, was first issued in 1970 and was prepared by the AASHTO Bridges and Structures Subcommittee. This manual was incorporated by reference in the National Bridge Inspection Standards and thereby became an enforceable standard. The AASHTO "Manual for Bridge Maintenance" was first issued in 1976 and was prepared by the AASHTO Maintenance Subcommittee. Page 182 of this manual contained the following specific hazard advisory on pin and hanger bearings: "Rusting between the plates is very difficult to detect unless bearing is dismantled." Both AASHTO manuals were approved by the AASHTO Standing Committee on Highways, whose secretary was the FHWA Associate Administrator for Engineering and Operations. As the FHWA Associate Administrator, he coordinated the activity of the two FHWA divisions involved with bridge design, inspection, and maintenance. The chiefs of these two divisions also were secretaries to the two AASHTO subcommittees which prepared the AASHTO manuals. Employees of the FHWA Construction and Maintenance Division worked on details of the AASHTO manuals as part of their Federal employment. The manuals were published by AASHTO, and copies were sent to the States by the FHWA. The FHWA regarded this work on the AASHTO manuals as part of its responsibility to help transfer technology.

Whenever new technical information about bridge maintenance is developed from any source, it can be published as an FHWA document or as an AASHTO voluntary guideline. In this instance, the hazard advisory and dismantling information on pin and hanger bearings was published only in the AASHTO "Manual for Bridge Maintenance." The FHWA secretary of the Operating Subcommittee on Maintenance said that he was not aware of any policy that would have prevented putting the hazard advisory also in the "Manual for Maintenance Inspections of Bridges." The latter manual was revised twice after its initial version was issued, and the hazard advisory was not included in either revision. He also said that the hazard advisory could have been added to the FHWA "Bridge Inspector's Training Manual" as an improvement. However, the FHWA did not modify the "Bridge Inspector's Training Manual" at any time during the 13 years after it was issued. Neither the FHWA nor AASHTO did any further study on the subject of pin and hanger assembly inspection, and no research has been proposed to address the subject.

The AASHTO Maintenance Subcommittee did not keep minutes of its meetings or of the decisions reached therein. Therefore, no information could be found concerning the rationale for publishing the hazard advisory in the "Manual for Bridge Maintenance" issued in 1976, for omitting it from later editions of the "Manual for Bridge Maintenance," or for not including it in other manuals. The secretary, chairman, and several members of the subcommittee in 1976 and later subcommittees were interviewed, but none could remember any specific details of what took place at the subcommittee meetings.

Suspended Bridge Spans.--The use of suspended spans has been common, and there are numerous suspended span structures nationwide. The pin and hanger assembly is commonly used to make the connection from a cantilever arm to a suspended span. Connecticut has 72 other bridges with suspended spans. Sixty-five of these are connected with pin and hanger assemblies; the others have a seated connection. New York State reported that it has 21 two-girder suspended span bridges of major proportions with pin and hanger connections. The chief bridge engineer of the company that designed the Mianus River bridge stated that "the two-girder design is still popular and always has been." The use of the two-girder system today, however, usually involves continuous spans.

A poll of State highway engineers 23/ revealed that there are at least 2,000 bridges with suspended spans in the United States, that the overwhelming majority of the suspended spans have pin and hanger assemblies similar to those on the Mianus River bridge, and that the most common method of fastening pins is with a recessed pin nut and cotter pin inserted to prevent nut movement. Only three States reported that pin caps or pin nuts are removed during inspections.

Following the collapse of the bridge, the FHWA notified its 10 Regional Directors of the basic design of the bridge and the suspected mode of failure. The directors were instructed to notify each of the State highway departments in their district, to inform them of the fracture critical details of the bridge, and to instruct them that all similar bridges in their State should be identified and inspected as soon as possible. The use of apportioned Highway Bridge Replacement and Rehabilitation Program and Highway Planning and Research funds was authorized. On March 8, 1984, the FHWA informed the Safety Board that the States had identified 302 fracture-critical suspended span girder bridges and that, with few exceptions, all were reported in good condition.

Events Preceding the Accident.--After hearing news reports of the accident, two truckdrivers reported incidents on the bridge that occurred shortly before the accident. One truckdriver stated that about 12:45 a.m., on June 28, 1983, he was driving his tractor-semitrailer eastbound in the right traffic lane on the bridge when he saw and then struck a large crack across the road. He said that the force of the impact caused him to almost lose control of his vehicle. He described the crack as running diagonally across the road and being about 6 to 8 inches wide and 4 inches deep. Another truckdriver said that he was driving his tractor-semitrailer eastbound in the right traffic lane on the bridge about 1:10 a.m., when he struck what he thought was a pothole with so much force that it caused his vehicle to swerve into the left lane and almost strike the median guardrail. Both truckdrivers said that they were driving between 50 and 55 mph, that they drive the highway regularly 5 nights a week, and that the road surface had been bad because of potholes and getting worse, but that they had never hit anything like this before. They both thought that the incidents occurred in the vicinity where the bridge span fell. Neither of the truckdrivers reported their experiences until after the accident.

A civil engineer, who was taking his boat up the river to a marina about 8:30 p.m. on the night before the accident, said that as he passed under the bridge, he heard a loud sound which he described as being similar to the breaking of a reinforcing rod in a tensile test machine. After the accident, no broken reinforcing rods were found.

23/ American Road and Transportation Builders Association questionnaire of October 19, 1983, to State Highway Engineers Concerning Mianus River Bridge Construction Details.

ANALYSIS

Suspended Span Collapse

The evidence provides a clear basis for identifying the pin and hanger assembly which failed first and the sequence of events leading to the eventual collapse of the bridge span. The final at-rest position of the fallen span parallel to and northwest of its original suspended position and the deformation of its superstructure indicate that the collapse started at the southeast corner of the span. The severe twisting and buckling of the eastern end of the south girder of the span indicate that the southeast corner struck the ground/water first and that the rest of the span shifted slightly to the north and west, and then fell into the water. The relatively minor damage sustained by the north side of the superstructure supports this conclusion. Witness testimony also indicates that the east end of the span fell first.

The damage to the components of the pin and hanger assembly at the southeast corner of the fallen span shows a multistage failure of the support system at the southeast corner. (See figure 13.) The initial event in the sequence probably occurred many weeks or even years before the bridge collapse when the inside hanger was displaced laterally and separated from the lower pin. The lower end of the inside hanger had been at least partially off its pin and moved out from the web by at least 1 1/4 inches for some time--long enough for heavy corrosion to develop in the space. The inside hanger was straight and still attached to the upper pin after the bridge collapse, indicating that it was not subjected to loads at the lower pin connection during the collapse. An examination of the inner end of the lower pin disclosed that the pin was substantially tapered and that the taper existed on both the upper surface of the pin, which was not under any direct bearing stress, and on the lower part of the pin, which was under direct bearing stress. The taper would have induced a lateral force on the inside hanger because of the span load. There is no explanation for the taper on the upper surface of the pin other than corrosion. The bearing surface of the lower hole of the inside hanger was destroyed by corrosion and breakout areas.

When the inside hanger at the southeast corner moved laterally and separated from the lower pin, the horizontal alignment of the span changed and the windlock parts came into contact. The off-center wear pattern of the windlock of the fallen span shows that the span was not aligned laterally with the cantilever arm for a lengthy time. The fact that the wear pattern on the female part of the windlock connection was wider than the male part of the windlock connection indicates that the male part of the windlock, while misaligned, moved downward, stayed in the center long enough to cause some wear, and then moved laterally to widen the wear pattern. Such movement and misalignment also was evidenced by the rust marks on the sides of the fingers of the expansion joint. Moreover, the same lateral shift at the expansion fingers and sag at the deck level was found in two of the other suspended spans on the bridge.

When the separation of the inside hanger from the lower pin occurred, the full load at the southeast corner would have been transferred to the outside hanger. When the outside hanger slipped off the upper pin because of the fracture of a segment on the top of the outer end of the upper pin, the span collapsed relatively quickly. The unstable span, now supported primarily at three corners, acted to rotate and pry itself from its northeast connection. About the same time, the connection at the southwest corner separated, overloading the northwest corner connection and fracturing off the flange on the roller, and the span fell.

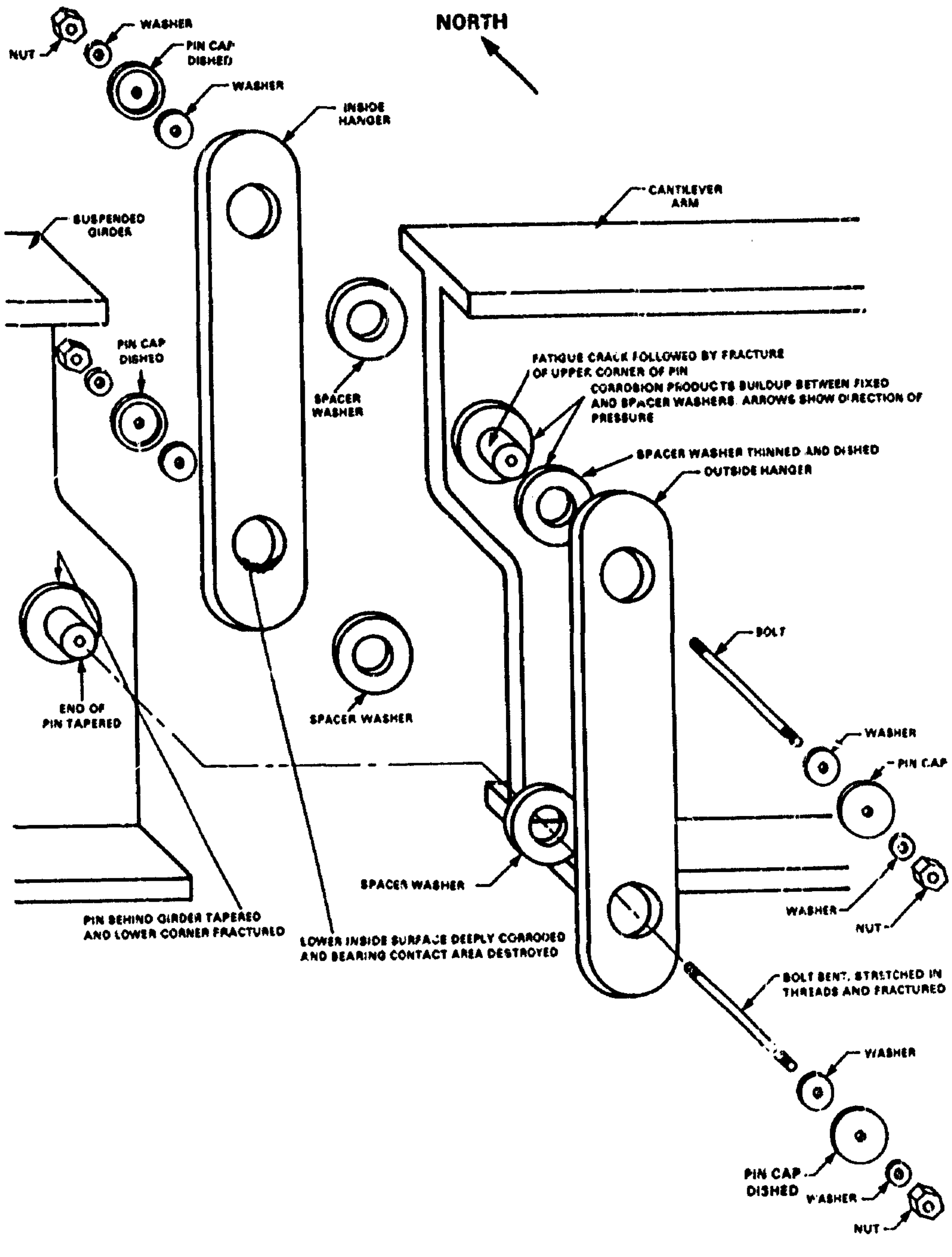


Figure 13.--Sequence of failure of the pin and hanger assembly.

The outer spacer washer on the upper pin of the pin and hanger assembly at the southeast corner was found to be concave outward, and the space between the spacer washer and the welded washer was filled with debris and corrosion products. The Safety Board concludes that corrosion pushed the spacer washer outward and distorted it into a concave shape and that the continuing pressures on the spacer washer in turn pushed the outside hanger out from the web and reduced the bearing area. When the total weight of the southeast corner was transferred to the outer end of the upper pin, the upper pin began to progressively crack by fatigue under live loads from the bridge deck.

The amount of force that can be generated by corrosion is tremendous. According to the National Association of Corrosion Engineers, corrosion forces can cause pressures of from 3,000 to 100,000 psi depending on the location of the corrosion in a confined area. The consultant for the insurance carrier for the bridge calculated that the pressures generated by corrosion between the spacer washer and the web of the girder was between 4,000 and 7,000 psi. In addition, he calculated the pressures necessary to overcome friction between the pin and hanger to be something less than 1,800 psi. The magnitude of the corrosive forces pushing the washer and hanger outward therefore would have overcome easily any forces caused by friction. If a conservative estimate of 3,000 psi is used for calculating corrosion pressures, and the entire area under the 14-inch-diameter spacer washer is considered, the lateral force would be about 350,000 pounds. If only a part of the area under the washer is used for calculating this theoretical force, say one-fourth of the area, the force would still amount to almost 90,000 pounds.

The Safety Board's space frame analyses, which considered only live loads, found that out-of-plane movement (upper pin relative to lower pin) of up to 5/32 inch was theoretically possible at the southeast corner pin and hanger assembly. The movement apparently was the result of a combination of torsional rotation of the main girder and the tendency of the cantilever arm and anchor span members to sway laterally into an out-of-plane position when the pin and hanger end of the suspended span was loaded. However, if the maximum theoretical out-of-plane movement had, in fact, occurred, it would have resulted in a lateral shear force of only about 800 pounds at each pin and hanger connection and a moment of only 2,100 foot-pounds applied to each hanger. This force and moment is low in relation to the size of the connections, and the movement could be absorbed readily in the designed clearances between members. Therefore, while lateral movement due to out-of-plane forces may have been a contributing factor in the failure of the pin and hanger assembly in this accident to the extent that it could have accelerated the effect of corrosion, it was not the primary factor in the failure of the pin and hanger assembly.

The space frame calculations also showed that there could be lateral movement of the girders adjacent to the hangers due to traffic loads on the deck and that it was much less on the acute angles of the skewed spans than at the obtuse angles. At the fallen span, the amount of lateral movement and corrosion at the southeast corner (an obtuse angle) was, in fact, found to be much greater than at the northeast corner (an acute angle). However, the largest displacement of a hanger on a pin in another suspended span of the bridge, where the bearing area was reduced to only 5/8 inch, occurred at an acute angle. In the fallen span and two others, the location where the hangers moved the most on the pins was where there was the greatest corrosion without regard to whether it was an acute or obtuse corner. Thus, the amount of movement of the hangers correlated with the extent of corrosion and did not correlate with the calculated out-of-plane movements of the girders.

Bridge Design

Lateral movement.—The AASHO specifications used in the design of this bridge required that members joined by pins be held against lateral movement. However, there were no design provisions made to "hold" the hangers against lateral movement on the pins of the suspended spans. The only element that resembled a retainer was the pin cap, but it was not designed to take any lateral load. Obviously, there were lateral forces and movement of the hanger on the pin leading to pressure on the pin cap, but these forces were primarily due to corrosion which the designer did not consider. Neither did the designer consider torsional forces which might cause out-of-plane movement. Testimony at the Safety Board's public hearing indicated that the foregoing corrosion and torsional forces and resulting movements normally would not have been considered in 1955 in designing a pin and hanger assembly, nor would they normally be considered today.

In view of the large corrosive pressures which were present in the assemblies, it is doubtful that the choice of a thicker pin cap would have prevented the failure. If anything, the thinner plate could have served to give an early warning of a problem, if the bridge inspectors had been able to see and had correctly interpreted the concave dishing or the paint cracking on some of the pin caps. The pin cap effectively hid the joint and much of the deterioration from view. Connections that are not hidden and are easily accessible are more likely to be inspected carefully and frequently maintained. The pin cap detail used in this design appeared in the AISC manual as an approved design, but there were superior pin connections described, i.e., the turned bolt and nut, which could have been used and which would not have involved the problem of hiding a critical element of the connection. The pin cap detail in the AISC manual is an accepted detailing practice; however, it either should be accompanied by a warning about the difficulties in detecting corrosion and deterioration and in maintaining the connection or should be deleted from the manual.

Corrosion.—When the bridge designer chose to connect the girder webs of the cantilever arms and suspended spans with pins and hangers, he added a 14-inch-outside diameter by 1/4-inch-thick spacer washer in a 3/8-inch-wide space. The bridge designer's engineer said that the washer was added to provide an additional plane for rotation should the hanger freeze up. Its presence, however, provided an additional source of corrosion. The washer not only provided much of the iron ions in the electrochemical process of corrosion but provided an added catching place for corrosion debris.

By designing the outside face of the hanger to sit on the edge of the pin, the designer did not allow for any possible lateral outward movement of the hanger on the pin; any slight lateral movement by the hanger would result in less than the full 1 1/2-inch bearing surface called for in the design.

The bearing stress on the pin at the southeast corner of the fallen span under the dead load, combined with the maximum live load, was calculated to be 17,900 psi. This stress is lower than the 24,000 psi allowed by the 1953 AASHO "Standard Specifications for Highway Bridges" for pins not subject to rotation, but more than the 12,000 psi allowed for pins subject to rotation. The use of 24,000 psi in the original design was in accordance with accepted engineering design at the time. That is, in selecting the bearing stress, the pins in the pin and hanger assembly were not considered rotating members. The design specifications for suspended bridges have been changed or clarified over the years, and the allowable bearing stress in the design of a similar assembly today would be 14,000 psi for the design of a pin, (see 1983 AASHTO "Interim Specifications, Bridges"), or about 29 percent higher than the calculated stress achieved under maximum live-load loading. Assuming 17,900 psi stress actually occurs, it is still only about 50 percent of the yield strength.

Although bearing stresses will never be equally distributed over the pin (that is, localized stresses may be higher or lower than the average), the collapse cannot be directly attributed to the bearing stress selected for the design. There may have been fretting corrosion 23/ causing some deterioration, but fretting can occur under even small loads and small movements and would not have been sufficient to be significant as a cause of the collapse.

Skew.--The State's consulting engineer stated that the 53.7-degree skew would have produced large lateral forces in the pin and hanger assemblies and that these forces were primarily responsible for causing the hangers to move laterally off of the pins. Using a computer model, the Safety Board conducted a comparison of the out-of-plane forces in pin and hanger assemblies of a 53.7° skewed bridge and a right-angle bridge. The comparison indicated that while both the skewed and right-angle bridges had lateral movements and uneven live-load distribution in the hanger assemblies, the movements and uneven loadings were much larger in the skewed model. While the right-angled model had a net out-of-plane movement of 2/32 inch (maximum) at the southeast corner due to live loading, the skewed model had a net out-of-plane movement of 5/32 inch (maximum), or more than twice the amount found in the right-angled model. At the northeast corner, the out-of-plane movement was about 1/32 inch (maximum) in both models. The differences in the outside and inside hanger axial loads due to live loads was also much greater in the skewed model than the right-angle model. For the right-angle model, the differences are about the same at both the northeast and the southeast corners, namely 15,000 pounds, while in the skewed model the differences are almost 4 times larger at the northeast corner and 6 times as much at the southeast corner.

Skewed bridges are built to be compatible with approach roadways or, in this case, with the river channel. Simple skewed bridges have exhibited movement at the expansion joints due to creep toward the acute corner. The cause of this movement is not precisely known but may be caused by unusual loads caused by temperature changes, a pushing in of abutments, and/or ice buildup in the expansion joints. In the view of the Safety Board, the flexibility of the supports of the suspended spans of the Mianus River bridge not found in a simple skewed bridge support would eliminate the occurrence of creep as a cause of lateral movement of hangers off the pins.

The primary factor in the failure of the pin and hanger assembly was corrosion. The changes made to the bridge since the accident have restored the geometry of the pins and hangers at the other suspended spans and reduced the bearing stresses. Since the major structure of the spans is essentially unchanged, and so long as corrosion is controlled, this circumstance offers an opportunity to observe whether the skewed design of the spans and the calculated out-of-plane movement of the large longitudinal girders actually causes the hangers to move outward on the pins in the absence of corrosion. Notwithstanding its findings, the Safety Board would encourage capitalizing on the opportunity to test the structure to determine whether the calculated out-of-plane movements occur. A similar opportunity to observe tendencies to movement of hangers on pins in skewed spans in the absence of corrosion exists at other skewed-span bridges on the Federal Highway System. The FHWA should conduct detailed inspections of the Mianus River bridge and other representative bridges having a skewed and nonskewed suspended span design with pin and hanger assemblies to determine whether there is a significant difference between the two designs in terms of the movement of hangers on pins due to either dead or live loading.

23/ Fretting corrosion is "destruction of metallic compounds and the production of oxide debris. Members must be under load with repeated motion." Corrosion Engineering, Fontana, M. and Greene, N., New York: McGraw Hill Co., 1978, p. 88.

Redundancy.--The Safety Board's investigation suggests that the concept of redundancy was not well-defined in bridge design in 1955 nor is it today. While the Mianus River bridge had a redundant pin and hanger connection, there was not redundancy in the suspended span structure. The Safety Board believes that redundancy of the basic structure model should be required. At the southeast corner, when the inside hanger slipped off the lower pin, the load it had been carrying was immediately transferred to the outside hanger. The outside hanger carried the full load of the southeast corner of the suspended span before the outside hanger fractured the pin and the connection failed. When this failure occurred, the span began to fall because there was no longer any support at the southeast corner. With only two girders supporting the suspended span, the failure of one of the four connections left no redundancy to prevent the span from falling. Safety Board calculations indicate that a single hanger had the strength to support the full load of the connection, and the hanger did not fail and, moreover, that the pin fractured only because there was not a full-width bearing surface. How long the outside hanger carried the full weight of the southeast corner of the span is not known at this time.

While the design of the suspended span of the Mianus River bridge that collapsed was not redundant, redundancy was not a specified design consideration when the bridge was designed in 1955. Indeed, redundancy is not required even today. However, the 1977 AASHTO "Standard Specifications for Bridges" require a reduction in the allowable range of stress in structures subject to repetitive loadings where there is nonredundant load path structures, i.e., "structure types with a single load path where a single fracture can lead to catastrophic collapse." The Safety Board is concerned that the concept of redundancy is not well-defined and that disagreements among experts as to what is meant or intended by redundancy have not been resolved. The concept needs to be clarified in the interest of the safety of future designs.

Inspectability and maintainability.--The Safety Board has concluded that at the time the Mianus River bridge was designed, standards for designing stuctures did not give sufficient attention to ensuring inspectability and maintainability. Inspectability and maintainability are not prominent goals in the state-of-the-art of bridge design even now. These considerations, which are elements of "reliability and maintainability," essentially require that a structure be designed so that it can be inspected and maintained as a reliable system. Inspection manuals and maintenance manuals, when based on a specific bridge and its environment, are of more value to workers than general instruction books such as the "Bridge Inspector's Training Manual." This manual was not used by inspectors because it was not targeted toward specific bridges and because it contained much material that had no application. The Safety Board believes that the Bridge Safety and Inspection Section should review the plans for a new bridge to determine if the structure can be safely and adequately inspected and maintained. Inspectors also should conduct a postconstruction survey of a new bridge to ensure that specifications for inspection and maintenance have been met by the builder.

Bridge Inspection

Checklist.--The bridge inspectors did not use a written checklist specific to this bridge on the job. They did not follow the details in the ConnDOT "Field Bridge Inspection Booklet" and the FHWA "Bridge Inspector's Training Manual" during their inspections. Both documents contained considerable detail not applicable to the Mianus River bridge, and this may explain why they were not used. Moreover, the items to be inspected were not arranged in a sequence of movement over the bridge. The inspectors apparently had worked out their own sequence of inspection, but it was not in a written form. The bridge reports were filled out from notes and memory after the inspectors had left the bridge. This method did not ensure that all items were observed.

Alignment.—The bridge inspector's report of September 1982 rated "alignment of members" at "8," a rating that means the rated part is subjectively judged to be in as good condition as when built. There were no written, objective, dimensional standards for measuring "alignment of members," even though the FHWA "Bridge Inspector's Training Manual" makes it clear that misalignment raises questions regarding the condition of bearings. Misalignment found in other spans after the accident was due to corrosion, which does not develop in a short time. Therefore, the Safety Board believes that at least three of the four suspended spans had been misaligned vertically (sagged) and/or laterally for some time, that the spans may have been misaligned at the time of the September 1982 bridge inspection, and that the alignment may not have been inspected adequately. The high rating assigned to "alignment of members" was misleading and may have prevented the engineers in the inspection program who reviewed the reports from being alerted to the serious problems which misalignment can indicate.

Pin and hanger assembly.—After the inside hanger had been displaced off the end of the lower pin at the southeast corner, the inside hanger would have moved along the upper pin so as to be at least 1/2 inch farther away from the girder than when it was installed. The spacer washers on the upper pin were observed to be dished outward by rust anywhere from 1/2 to 1 inch; they would have been occupying the additional space between the inside hanger and the girder. The junior safety inspector's finding of a "handful of flaked rust" in the joint did not cause him to record anything more than the general entry "laminated rust" in the "bearing" section of the inspection form, without any designation of which "bearing" (pin and hanger). Neither inspector noticed the change of dimensions that was observable, possibly because they did not get close enough, and an opportunity to detect the problem and prevent the collapse was missed.

Only the catwalk between the north girder of the eastbound lanes and the south girder of the westbound lanes provided arm's length access to the adjacent pin and hanger assemblies on those girders, and then only to the upper pins. To inspect the lower pins, an inspector had to lie on his stomach and reach below the catwalk; even then it was difficult to view the lower pins adequately. A portion of the inside hangers of the assemblies could be touched while standing on the superstructure and by reaching through the space between the webs of the cantilever arms and suspended spans. Measurements could have been made of the alignment of the webs relative to each other and the distance of the outside hangers from the web.

The junior inspector who examined the Mianus River bridge testified that he had walked along the bottom flanges of the skewed end floorbeams to "inspect" the pin and hanger assembly connecting the north girder at the northwest corner of the westbound suspended span (span C in figure 4) to the adjacent cantilever arm of the anchor span of the westbound roadway. He gained access to these floorbeams from the north catwalk. He did not take any measurements and only observed the upper pin at close range. He reached over the top of the hanger into the space between the web and the hanger and on removing his hand found it covered with flaked rust. Such an observation should have suggested a critical fact—that severe corrosion was taking place. The inspection report should have reflected more than just a routine notation of "bearings--laminated rust," and the report should have been flagged for the immediate attention of a supervisor.

There were no handgrips on the beams, so walking on them was treacherous. It was made even more difficult by the presence of large amounts of pigeon excrement. The beams could have been designed or fitted with handgrips or handrails, but apparently this was not considered in the design or as an addition that would help make inspections easier. There is no indication that the inspectors ever asked for such additions, and they made inspections for more than 20 years without them.

One of the most important pieces of equipment to facilitate the effective inspection of large bridges is the "snooper," yet it apparently had been used only once to inspect the Mianus River bridge. There is no indication in any of the Mianus River bridge inspection reports (which date back to January 23, 1962) that a "snooper" was ever used on this bridge in a safety inspection. There is no place on the bridge inspection report specifically for noting the use or non-use of a "snooper." The junior safety inspector's efforts to gain access to the pin and hanger assembly, however, implies that if a "snooper" had been available at the southeast corner of the suspended span during the September 1982 inspection, he could have examined the pin and hanger assembly more closely.

The 1 inch or more spacing between the inside hanger and the web at the pin and hanger assembly at the southeast corner of the fallen span should have been visible if a close examination had been made during the September 1982 inspection. Heavy corrosion products should have been visible in the open space. Also, if the inside hanger was still in place on the lower pin at that time with a displacement of more than 1 inch, the inner lower pin cap probably was dished to a degree that would have been noticeable. (If the inside hanger had been completely displaced, this would have been even more evident.) If the bridge safety inspectors had observed these conditions, particularly the latter, they might have made a more thorough inspection. Therefore, the lack of a catwalk and the absence of a "snooper" were critical in the inspectors' failure to discover pin and hanger assembly problems. The inspectors could have used the slower and more hazardous method of inspecting the connections using a bosun's chair or scaffolding, or they could have rented a "snooper" or shared one with another State. Perhaps these avenues were not pursued because of the limited time available for inspecting each bridge.

Neither the FHWA nor AASHTO have developed a written inspection technique to detect hanger displacement. Measurement of spaces between members was advocated in both the FHWA "Manual for Maintenance Inspections of Bridges (1970)" and the ConnDOT "Field Bridge Inspection Booklet." The FHWA was aware of the problem because the AASHTO "Manual For Bridge Maintenance (1976)" contained the hazard advisory about the difficulty of pin and hanger bearing inspection. However, the FHWA did not initiate a project to address the inspection problem, and no action was taken by either AASHTO or the FHWA to develop a workable inspection technique. Such action was within the FHWA's technical development responsibilities with respect to bridge inspection.

A ConnDOT engineer stated that dismantling of the pin and hanger assembly for inspection had not been considered before the collapse of the span. Had such consideration been given, and dismantling then been found too disruptive or costly, the need to address the uninspectable condition in some other way would have been obvious. It would have been logical, had the problem actually been studied, to direct closer attention to the presence of rust or to changes in span alignment, for example. Despite the hazard advisory in the AASHTO maintenance manual, ConnDOT did not realize, before this accident, that the safety of the bridge could not be ascertained with certainty without careful pin and hanger assembly inspections.

In light of the techniques used successfully after the accident, it now appears that the pin and hanger assemblies could, in fact, have been inspected for severe damage and rust without dismantling the hangers. Cleaning to remove rust which had developed between washers probably would have uncovered the problem. Holes could have been drilled in pin caps to permit examination of the end of the bearing surfaces. Measurements of hanger location and misalignment of spans to indicate bearing trouble could have been specified. These methods did not require large research projects, but they did require some study. However, even though the AASHTO manual had advised that bearing inspections were critical and that dismantling of the pin and hanger assembly was advised, neither AASHTO nor the FHWA initiated a study of the problem.

The advisory statement on dismantling hangers in AASHTO's "Manual for Bridge Maintenance" was clear, but the fact that a bridge might collapse if bad bearings were not discovered was not explained. Further, the AASHTO statement did not actually "recommend," much less assert the critical need for a detailed inspection, much less one involving dismantling of bearings. Given the nature of the AASHTO advisory, failure to dismantle was most understandable. The advisory was based on the technical judgment of AASHTO that good practice calls for dismantling for inspection, but AASHTO did not word the statement in a way that clearly suggested an imperative need to follow this practice. AASHTO's failure to include the advisory in subsequent revisions of the "Manual for Maintenance Inspections of Bridges" left the problem unaddressed in any current AASHTO document. The original AASHTO document seems to have made little or no impression on ConnDOT employees. The purpose of the National Bridge Inspection Standards—to avoid a repetition of a previous catastrophic bridge collapse—was thereby defeated.

It appears that the AASHTO "maintenance" documents were not considered sources of safety information by ConnDOT bridge safety inspectors. Although the documents were distributed to the Bridge Safety and Inspection Section and were distributed at the working level in the ConnDOT maintenance organization, no direction mandating their use was given. Apparently, "maintenance" was considered to be a different function from safety inspection and was not directed primarily toward ensuring safety. AASHTO's "Manual for Bridge Maintenance (1976)" which contained the hazard advisory about dismantling pin and hanger assemblies had been only partially read by the immediate supervisor of bridge safety inspectors, who thought it was "for maintenance."

Updating of Federal training materials also might have alerted ConnDOT bridge safety inspectors to the critical need of inspecting pin and hanger assemblies carefully. ConnDOT inspectors received recurrent federally funded training, but it did not alert them to the need to inspect pin and hanger assemblies closely or how to do it. The training relied on the FHWA "Bridge Inspector's Training Manual," which had not been revised significantly since 1970. Thus, publication of the AASHTO "Manual for Bridge Maintenance" in 1976, with its advisory about the need for and the difficulty of inspecting pin and hanger bearings, did not help users of the "Bridge Inspector's Training Manual."

The "Bridge Inspector's Training Manual" should have been improved since 1970 in several ways beyond the addition of AASHTO technical information. It should have been issued in a looseleaf format to ease updating. The manual should have been designed to complement bridge inspection forms used by the States. It should have trained inspectors to develop an inspection sequence checklist for each bridge. Descriptions of critical failures and objective measurements should have been included. The manual should have been organized so that pages could be arranged to refer to specific bridges.

Inspectors.—The legislative history of the National Bridge Inspection Standards makes it clear that the law intended that inspections be thorough, not cursory. It is apparent that, in some respects at least, the inspection of the Mianus River bridge was cursory and that the mandate of the National Bridge Inspection Standards was not fulfilled in this case. Two persons cannot thoroughly inspect a six-lane, 2,656-foot-long bridge with 24 spans, 60 columns, and 464 bearings in 12 hours, the approximate time the inspectors spent on this interstate bridge every 2 years.

The National Bridge Inspection Standards call for all bridges to be inspected at a minimum of every 2 years. This cycle was followed on the Mianus River bridge. ConnDOT inspects its "problem" or weight-restricted bridges more frequently. The National Bridge Inspection Standards guidelines suggest the need for more frequent and thorough inspections of certain bridges depending on such factors as age, traffic characteristics, maintenance conditions, and known deficiencies. If ConnDOT had given these factors serious consideration, the Safety Board believes that the Mianus River bridge would have been inspected more thoroughly. For example, the bridge had had bearing problems for some 20 years. The bridge traffic had increased far beyond expectations, heavy truck traffic was a high percentage of the total traffic, and the quality of State maintenance had decreased. The Safety Board believes that these factors should have alerted ConnDOT to direct more attention to the bridge, its total condition, and the status of its critical elements—the pin and hanger assemblies.

FHWA review.—There is nothing inherently wrong with the in-depth bridge inspections being conducted by State inspectors. However, action must be taken to verify that these inspections are adequate to ensure safe bridges. The FHWA "paper reviews," whether by FHWA divisions, regions, or headquarters, are not sufficient to ensure this. These limited "paper reviews" are not much more than making sure that the State checks off the proper boxes on the structures inventory and appraisal form. The FHWA field reviews are also inadequate--observing a State crew inspect a bridge which is apparently preselected so that the State crew inspectors are aware in advance that they will be observed. Beyond this, a sample of 1 or 2 bridges out of more than 3,000 in the State is far too small to be of much significance.

Proper audit of the State's procedures should include, among other things: a careful review and evaluation of a substantial number of bridge inspection reports, especially those concerning the more complex bridges, and covering each inspection team; a review of hours spent on inspection at specific bridges; surprise visits to bridges during regular inspections; review of the use of equipment employed in inspection (such as a "snooper," scaffolding, ultrasonic, radiographic, etc.); and a review of management policies and procedures and of the inspectors' training programs.

Although Federal requirements call for bridge inspections at a minimum of every 2 years, they do not specify the depth of the inspections. Periodic in-depth inspections, probably at least every 10 years, should be required both to extend the useful life of the bridge and to ensure the safety of bridge users. Such inspections were in fact recommended by the FHWA in a memorandum to the States in 1968. 24/ Inspections also should be more frequent or in greater depth when the bridge is subject to such adverse conditions as heavy truck traffic and use of deicing salts. Periodic in-depth inspections are made of other structures. For example, aircraft major overhauls are done periodically (in addition to routine maintenance), depending on such variables as numbers of landings and takeoffs. Ships are inspected annually while afloat, and in more depth while on drydock about every 2 years, depending on the time the ship spends in salt water.

The General Accounting Office (GAO) issued a report in 1975 concerning the FHWA's program for identifying, improving, and replacing unsafe bridges on the Federal-aid highway system. 25/ The report emphasized the need for more attention to

24/ U.S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads, Instructional Memorandum 40-1-68, 32-40, Subject: Bridge Safety Inspections, March 12, 1968.
25/ "Unsafe Bridges on Federal-Aid Highways Need More Attention," Comptroller General of the United States, General Accounting Office, Report to Congress, July 2, 1975 (RED-75-385).

the problem at both the Federal and State levels. It concluded that the FHWA did not actually require the 3-week inspection training course based on its "Bridge Inspector's Training Manual," and that relatively little use had been made of the course. In Connecticut, for example, the course has been condensed to a 4- or 5-day session and is given on a 3-year cycle. The FHWA's review of ConnDOT's compliance with the National Bridge Inspection Standards did not review the adequacy of their training course--in fact, it did not even mention that one existed. The FHWA should review each State's bridge inspection training program during the annual bridge inspection program audit.

The GAO report recognized that identification of structural defects, corrosion, and fatigue was becoming more important because many bridges were old and the heavy truck traffic was increasing. It identified a need to develop inspection equipment for use by bridge inspectors to detect structural defects not visible to the eye so as to protect the public against bridge failures. Research has been done in this area, but the resulting technology has not yet filtered down to the inspection level. The inspectors of the Mianus River bridge, for example, did not have and never used equipment to perform nondestructive tests. The FHWA's review of ConnDOT's compliance with the National Bridge Inspection Standards did not address the need for such equipment by the inspection teams.

In August 1981, the GAO issued another report on bridges, which said there was a need for better compliance by the States with the National Bridge Inspection Standards. 26/ The report indicated that some States have fallen short of the intent of the standards and expressed the view that it is not enough for the States to meet the minimum requirements of the standards. Furthermore, it contended that the annual review by the FHWA does little to determine that State compliance with the standards produces the ultimate goal of ensuring against the collapse of bridges. Connecticut technically followed the standards, but its bridge inspection program was still inadequate to prevent the collapse of the Mianus River bridge span.

The DOT's Inspector General should review the FHWA's audit program to identify and correct shortcomings and to strengthen the program's evaluations of State compliance with the National Bridge Inspection Standards to meet the intent of the Congress of promoting the safety of the American public driving and riding across the Nation's bridges.

Bridge Maintenance

Drainage.—An examination of the bridge drainage system disclosed a number of problems such as: (1) the design of the system; (2) the clogging of downspouts and scuppers; (3) the overpaving of the curb drains; and (4) missing drainage system components.

In the original bridge design, three curb drains were provided on each side of the road between the crest of the bridge and the expansion joint, a distance of about 240 feet. The lowest was only about 10 feet from the expansion joint so that there would be only limited drainage and then into an expansion joint and a curb trough. There was a history of difficulty in keeping the curb drains open which was exacerbated as the work force and maintenance funding decreased. The Safety Board concludes that the decision in 1973 to pave over the curb drains was intended by ConnDOT to be a permanent solution to the continued problem of cleaning the curb drains.

26/ "Better Targeting of Federal Funds Needed to Eliminate Unsafe Bridges," Comptroller General of the United States, General Accounting Office, Report to the Honorable James R. Sasser, United States Senate, August 11, 1981.

After the closure of the curb drains of the fallen span, the expansion joint trough and the smaller curb trough became the first collectors for water-borne sand, salt, dirt, and debris from the 240 feet of pavement above the expansion joint, a condition that was not predicted or predictable in the original design. Based on the amount of road surface originally drained by the expansion joint and the curb drains, it is estimated that the water and salt flow into the expansion joint increased by at least a factor of 10 after the curb drains were paved over. Approximately the same increase occurred at all four suspended spans which were affected by the overpaving in the same way. Those spans were found to have clogged expansion joints as well as severe pin and hanger corrosion.

It is well known that the use of salt to deice bridges in winter accelerates corrosion, especially where drainage conditions allow salty water to contact and remain on the steel structure. Salt not only accelerates corrosion, it increases the degree of corrosion. ConnDOT had taken deck samples which indicated that there were excessive amounts of chloride in the bridge deck. Seventy-six percent of the 88 test core samples taken in 1978 contained more than the maximum acceptable chloride content. This knowledge should have raised questions about the reason for the excessive chloride, which should have revealed the plugged drains and disabled drainage system. It also should have resulted in a closer inspection of the steel superstructure. Use of salt is generally accepted because it is assumed that correct drainage and maintenance will prevent any kind of drainage water from contacting the critical parts of the structure. In this instance, the drainage system did not prevent water from flowing over the structure and pins and hangers; when that water contained salt, it accelerated corrosion. The use of deicing salt contributed to the corrosion and eventual bridge collapse only to the degree that the altered system was unable to carry the salt away from the pin and hanger assembly.

The 1976 AASHTO "Manual for Bridge Maintenance" advocated that bridge decks and structures subject to salt water tidal action and deicing salt should be specifically flushed with fresh water to keep the structure clean and free of salt. Deicing salts promote corrosion by increasing the conductivity of solutions, by keeping the corroding surfaces wet for longer periods of time, and by providing aggressive anions, such as chloride, that permeate and destroy protective oxide films and enhance the growth of pits by autocatalysis. Corrosion is resisted by keeping steel clean and providing a protective coating, such as paint.

It was inevitable after the curb drains were paved over that the expansion joint troughs and the curb troughs would become overloaded with sand, dirt, and debris. Without preventive measures such as sweeping the bridge deck or cleaning the troughs, the troughs would become clogged and would fail because of the added weight. While the original drainage design was not specified to be selfcleaning and seemed difficult to maintain, it probably was adequate to preclude overloading the expansion joint trough and the curb troughs on the fallen span and consequently the extensive corrosion of the pin and hanger assemblies. The amount of water which flowed into the expansion joint above the pin and hanger assemblies did not become significant until the curb drains were paved over. The weight of dirt and debris deposited in the troughs also would not have been significant, even with minimal cleaning, until the drains were paved over.

In the original bridge design, the hydraulic slope of the expansion joint trough was established by the 1-percent cross-slope (1/8 inch per foot) from each side of the crown of the bridge deck. The path of the expansion joint trough along the skew of the bridge decreased the effective hydraulic slope to 62.5 percent of the slope designed across the bridge deck. This change in slope was not shown on the drawings. At the fallen span, the skewed expansion joint was on a downgrade of the road which made the south end of the trough higher than the north end. Therefore, the drainage was actually from the south side to the north side at a 1-percent downgrade slope in the original design. A 1-percent slope is marginal for carrying away large amounts of water, and is ineffective for carrying away sand, dirt, and debris. However, only small amounts of water and other materials would have entered the expansion joint above the trough in the original design, and periodic cleaning was a design consideration. While water might bypass the curb drains even when fully open in the event of exceptional rainfall which might occur from time to time, normal rainfall would not have loaded the expansion joint trough and the curb troughs with sufficient water to wet the pin and hanger assembly.

The water flow pattern on the hangers at the southeast corner of the fallen span indicated that the water had come down onto the girder upper flange which once held the curb trough. Near the center of the roadway, the heavy corrosion on the end floor beam of the cantilever arm indicated that water had been falling through the expansion joint directly onto the flanges of the end floorbeams. Heavy corrosion at this location meant that the expansion joint trough was either overflowing or had not been in place for some time. The fall of water seen at the northeast corner of another span was heavy and adjacent to the pin and hanger assembly but did not include flow over the main girder. There was no similar flow of water coming directly out of the southeast corner of that span. These differences show that the paved-over drainage system led to unpredictable water flow concentrations.

At the southeast corner of the fallen span, the water marks clearly showed that water did flow over the hangers and pins and that parts of the troughs, which remained in place but which were filled with dirt and debris, prevented the normal direction of water away from the pin and hanger assembly. Water flow marks on the inside hanger indicate that the corroded area was subject to repeated wettings and a repeated water flow pattern. The heavily corroded lower end of the pin and hanger assembly showed water marks on both sides. The marks were above and below the areas of greatest corrosion.

Other than the drainage system, there were no other features to protect the pins and hangers from continual wetting or from corrosion. This was acceptable practice because it could be anticipated that failure of the drainage system would be detected by the bridge inspectors. In fact, the failures were seen and reported, but not corrected. It was stated that missing or damaged drainage troughs were not repaired because they were difficult to reach and because the concrete-mounted corroded bolts to which they were attached were very difficult to replace. However, this rationale was not applicable to other parts of the drainage system that also were not replaced. Moreover, no alternative remedy was taken. Holes were cut in the drainage systems, damaged or missing drainage system sections were not replaced, and drains were paved over by ConnDOT as a direct consequence of the need to minimize maintenance expenditures.

The paved-over curb drains were not addressed in the 10 years since the National Bridge Inspection Standards had come into effect. Although bridge safety inspectors knew that drains had been paved over on the Mianus River bridge, the knowledge was not effectively reported to upper management. No direction was given to correct the paving for safety reasons because the chief of the Bridge Safety and Inspection Section was not aware of the need.

The reviewer of bridge safety inspectors' reports said that he believed that the drains reported as "plugged" were plugged with sand. It is understandable that a bridge inspector long familiar with the bridge and its drainage problems and the gradual reduction of maintenance workers might accept paving over as an officially condoned action. However, the next reviewer of reports, the Transportation Associate Engineer, had the duty to question each report that came before him. Even if he believed, as he said, that the drains were all plugged with sand, he still should have been concerned.

There was no functional difference between drains paved over and drains plugged with something else, and the entry should have been cause for concern and inquiry. It is apparent that the report reviewer did not act on the warning regarding clogged drains given in the FHWA "Bridge Inspector's Training Manual." The Safety Board considers that because of the large number of plugged drains, an inquiry should have been made. The report reviewer, however, had little face-to-face contact with his inspectors and used the telephone to talk to them. The contacts were most often for the purpose of controlling movements and workload. ConnDOT should increase the attention given to reviewing bridge inspection reports and provide for face-to-face discussions of reports on selected bridges by reviewing officials and inspectors.

Cleaning.—The steel superstructure on the Mianus River bridge was not kept clean. The bottom flanges of some of the steel were covered with pigeon excrement sometimes a foot deep. Not only did this add to the corrosive process (pigeon excrement contains urea, an ammonia salt), but it also discouraged the inspectors from walking the steel for closeup examinations of the pin and hanger assemblies. The ConnDOT maintenance policy did not call for the flushing of bridge superstructures. Steel should be kept free not only of bird excrement but also of dirt, which can accumulate and hold moisture, which along with oxygen will cause corrosion of unprotected structural steel.

Deferred maintenance.--Among ConnDOT's responsibilities is managing and carrying out programs for maintaining public roads and bridges. This job requires estimating resources needed, presenting and defending budgets, and allocating resources. Reduced personnel and efforts to reduce maintenance man-hours were a factor in the changes made to the drainage system on this bridge, changes which accelerated the corrosion which led to the collapse of the span. The cessation of bridge cleaning contributed to both the extent of corrosion and the inspector's failure to detect its extent. The lack of a "snooper" made it almost impossible for inspectors to closely and thoroughly inspect some of the pin and hanger assemblies. The "snooper" was taken out of use because it needed an expensive overhaul. Under a reduced maintenance budget, the "snooper" overhaul could not be funded, and funds to buy a new "snooper" were not budgeted until fiscal year 1985. The lack of a "snooper" was one aspect of the "deferred maintenance" backlog which ConnDOT reported to the Connecticut legislature in 1981. 27/ In requesting more funds from the Connecticut General Assembly, ConnDOT management pointed out "deferred maintenance" as a specific problem which might lead to bridge collapse. ConnDOT proposed increased funds in 1981, almost 2 years before the bridge collapsed. Reduced appropriations do not necessarily cause hazards, but they present an increased challenge to administrators to provide adequate safety which may become insurmountable.

In describing its needs to the General Assembly, ConnDOT did not in fact say specifically why deferred maintenance might lead to bridge collapse. It was not possible for ConnDOT to identify specific problems on the thousands of Connecticut bridges which might pose a threat of complete collapse of a bridge. The report to the General Assembly was, therefore, largely in terms of increased costs if bridge deterioration was not arrested. Even the possibility of fatalities or injuries from bridge collapse was couched only in terms of money loss to the State, i.e., "damage suits" might ensue. Significantly, ConnDOT did not report that the inspection system itself might suffer under a deferred maintenance policy. Having stated a concern that without more funds there might be more emergency closures of bridges, and in light of its own "deferred maintenance" response to insufficient funds, it might be expected that ConnDOT would have placed more reliance on bridge inspection. It is true that the existing number of bridge

27/ Report to General Assembly by Connecticut Department of Transportation, July 1981.

inspection personnel was preserved, but the task of inspection became more difficult because of the critical absence of the "snooper" and the cessation of bridge cleaning. The situation was epitomized by the plight of the bridge inspector who pushed his way through pigeon excrement in order to see one end of one pin and hanger assembly on one span. He did not repeat the effort.

At the same time, ConnDOT was not heeding the relevant hazard advisory in the AASHTO "Manual for Bridge Maintenance" that called for dismantling hangers for inspection. This advisory had been published by AASHTO after ConnDOT's deferred maintenance policy began to take effect, but apparently the advisory was not noticed. On the other hand, ConnDOT was not required by the FHWA to use this or any other particular inspection method to be considered in compliance with the National Bridge Inspection Standards and to be eligible for Federal funding assistance.

Advisory Manuals

AASHTO publications.—The concept of AASHTO publications, that they serve only to help States exchange technical knowledge and they are purely advisory, was well illustrated in this instance. For example, two pieces of advice in AASHTO manuals--that hangers should be dismantled for inspection and that designed drainage should be preserved by cleaning--were worded so as not to suggest that they were mandatory and were placed in publications that were not enforceable. States may be unable to follow all of the technical advice in AASHTO documents for such reasons as lack of funds. However, the failure to follow AASHTO advice in this case involved reasons other than money. ConnDOT supervisors had the documents but did not even bother to read them in many cases. The bridge inspectors most in need of the advice never received the manuals. The advice in the AASHTO publications was not considered and then rejected for any studied reason; it was simply unassimilated. The reviewer of bridge safety inspection reports did not believe the AASHTO maintenance publications had any bearing on "safety," and the Director of Maintenance had given no instructions to use the manuals, even though he had personally participated in developing some of them. For these reasons, the guidance in the AASHTO manuals, which carried potentially life-saving information, was ineffective in triggering action by ConnDOT that probably would have prevented the collapse of the Mianus River bridge span. Their content did not command the same response as the National Bridge Inspection Standards, which carried no advisory about the need to dismantle hangers.

FHWA publications.—It is a specific part of the FHWA's responsibilities to transfer bridge, bridge maintenance, and bridge inspection technology gathered from all sources to the States, and to develop bridge technology through federally sponsored research. The AASHTO hazard advisory on hanger dismantling was not published in the FHWA "Bridge Inspector's Training Manual;" therefore, it was not taught in bridge inspector training courses. The "Bridge Inspector's Training Manual" had not been revised by the FHWA between the issuance of the first edition in 1970 and the bridge collapse in 1983. The Federal system thus failed to transfer the information that pin and hanger assemblies need to be dismantled for inspection, a critical piece of bridge technology. Moreover, in the light of the size of the Federal highway program, it is inconceivable that no other new bridge inspection information requiring a revision of the manual surfaced in 13 years.

AASHTO's system of voluntary industry standards failed to trigger a response in Connecticut; the AASHTO advisory of the difficulty of inspecting pin and hanger assemblies without dismantling did not get to the people who needed it. At least part of the problem was that the National Bridge Inspection Standards, which although they are minimum requirements commonly regarded as acceptable, did not include an advisory requiring pin and hanger inspections, and ConnDOT relied on the sufficiency of the Federal standards.

The FHWA should have known of the inspection problem because the FHWA official who served as secretary to the AASHTO Maintenance Subcommittee which developed the advisory also was involved in the FHWA's bridge maintenance division. Thus, the FHWA apparently exercised a choice not to include the information in the AASHTO manuals in the National Bridge Inspection Standards and the "Bridge Inspector's Training Manual." While other means of inspection of the pin and hanger assemblies might have been deemed sufficient, it appears that no further study on the problem was done by the FHWA after the advisory of the inspection difficulty had been published by AASHTO.

The Safety Board has been hindered in further investigation of this matter by the lack of minutes of the AASHTO subcommittee meetings. Advisory committees to Federal agencies are required to keep detailed minutes of each meeting, in a manner prescribed by the Federal Advisory Committee Act. The keeping of minutes by AASHTO committees is important for safety and for hazard identification and should be resumed and required. The Federal government has a very real investment in these meetings, not merely as a dues-paying member of AASHTO, but because the meetings are a primary source of new safety knowledge and the need for regulations. Furthermore, the FHWA has a function to be sure that safety technology actually is transferred to those who are in a position to need it.

The effectiveness of the National Bridge Inspection Standards depends on the inclusion of all relevant technical information developed by AASHTO and FHWA, because there is currently no other way of mandating technical standards for bridge construction. The Federal-aid Highway Acts of 1968 and 1970 did not require the Secretary of Transportation to establish objective and enforceable standards for bridges. The Secretary may establish standards only on the question of required levels of training for inspectors. Thus, the integrity of bridges is dependent entirely on the training, knowledge, skill, and dedication of the individual inspectors. In this case, that knowledge was limited severely by weaknesses in the AASHTO and FHWA information transfer process.

FHWA-AASHTO Relationship

The Safety Board has discussed the FHWA-AASHTO relationship in previous reports: "Safety Effectiveness Evaluation of Traffic Barrier Systems" (NTSB-SEE-80-5), pp. 23, 24, and 26, and "Federal Highway Administration Non-Interstate Resurfacing, Restoration, and Rehabilitation Program" (NTSB SEE-81-40), pp. 2-3. Both of these Board reports discuss the dominant role of AASHTO in the FHWA-AASHTO relationship. In general, AASHTO develops the standards, and the FHWA approves and endorses them.

An FHWA official, who was the secretary of AASHTO's Maintenance Subcommittee, stated that he believed that AASHTO is one of the most efficient organizations he knew, and said that it is "very sensitive to over-regulation by the Federal government, and addressed the needs of the States." He did not think that it would "encourage the States to document good practice" if the FHWA were to use AASHTO documents for enforcement.

The close relationship between AASHTO and the FHWA has been affected somewhat in recent years by the FHWA's increasing use of an informal public rulemaking process and by a U.S Court of Appeals ruling in 1978 that the relationship is to be limited to that permitted by the Federal Advisory Committee Act. In 1978, a U.S. Court of Appeals ruling 28/ limited the AASHTO/FHWA interaction to the extent that the FHWA cannot

28/ Center for Auto Safety v. Cox, 580 F. 2d 689 (D.C. Cir. 1978).

now seek the "advice" of AASHTO in matters concerning the Federal-aid highway program, without involving the full provisions of the Federal Advisory Committee Act which opens the proceedings to the public and requires notice of meeting. All FHWA officials serving as secretaries on AASHTO committees have been cautioned not to violate the court's ruling. FHWA officials continue to serve as secretaries to AASHTO committees and participate in AASHTO meetings.

Vehicle Size and Weight

Connecticut's Motor Carrier Operations Unit should maintain a close relationship with the State Police enforcement unit in order to learn promptly of oversize/overweight permit violations and traffic conditions that may influence compliance. It also needs to keep the ConnDOT Bridge Safety and Inspection Section informed of permit violations, when grossly overloaded vehicles travel across bridges that may not have been capable of sustaining the load without being structurally damaged. There was no such notification of the suspected crossing of the Mianus River bridge by the 185,000- and 224,000-pound overloaded trucks in January 1983.

The FHWA is responsible for monitoring State practices to be sure they are adequate to meet the Federal legislative intent. In a recent audit report, 29/ the DOT Inspector General recommended that the FHWA, "increase its leadership and on-going involvement in vehicle weight enforcement operations to assure that the State efforts are sufficient to achieve intended program results." The report includes recommendations for effective deterrants, control of vehicles at loading or unloading points, and State permit procedures. All three are pertinent to the Connecticut program.

Vehicle and Driver Involvement

An analysis of the highway vehicle skidmarks and other physical evidence, including the trajectories of the vehicles as they fell from the bridge, indicates that the drivers of the tractor-semitrailers and the first automobile had no chance to stop their vehicles in time to avoid falling. The speeds of the vehicles were not excessive, but permitted no evasive action by the drivers.

The analysis also indicates that the fall of the span was not instantaneous, and that the driver of the first tractor-semitrailer must have seen something which caused him to apply the truck brakes in a panic. In order to lay down 150 feet of skidmarks, the truck must have been about 250 feet from the western end of the suspended span when the truckdriver saw a problem and reacted. The truck was still partially supported by the sagging bridge deck when it reached the other side of the falling span, and the roof of the tractor cab struck the exposed expansion fingers of the decking on the cantilever arm. Assuming the truck's average speed during braking was 40 to 45 mph, the time between the truckdriver detecting a problem ahead, reacting, and braking was at least 6 to 8 seconds.

The driver of the second automobile might have been able to stop his vehicle short of the span collapse if he had seen and reacted to the warning gestures of the driver of the stopped car sooner and had taken immediate evasive action. He might have been more readily warned or have better recognized the warning if the normal overhead bridge lighting had been illuminated or if the hazard warning signals on the stopped car had been

29/ Office of the DOT Inspector General, Audit of FHWA Monitoring of State Enforcement of Vehicle Weight Requirements in Region One, Report No. RI-FH-3-034, January 7, 1983.

activated. Given the circumstances of the emergency stop, the Safety Board believes that the car driver's failure to activate the hazard warning signals immediately was understandable.

Although the inappropriate use of hazard warning signals may lead to driver misconceptions in some cases, the Safety Board believes that the majority of drivers understand that sighting hazard warning signals operating on vehicles ahead of them signifies that an unusual situation exists and that caution is required. Section 12-220 of the Uniform Vehicle Code (UVC), the comprehensive model for State motor vehicle and traffic laws, authorizes the use of hazard warning signals on all vehicles that present a traffic hazard to other motorists on the highway. 30/ However, the model statute is permissive rather than mandatory and many States do not require the use of hazard warning signals. The National Committee on Uniform Traffic Laws and Ordinances should modify the UVC to require the use of hazard warning signals whenever a motor vehicle becomes a hazard to motorists on a highway.

CONCLUSIONS

Findings

1. The final at-rest position of the fallen span and the deformation of its superstructure indicate that the collapse started at the southeast corner of the span, confirming eyewitness accounts of the collapse.

2. The damage to the components of the pin and hanger assembly at the southeast corner of the fallen span indicate that the support system failed at that corner before the collapse.

3. The lower end of the inside hanger at the southeast corner moved outward approximately half its width off the inner end of the lower pin due to forces of corrosion.

4. The lateral movement of the lower end of the inside hanger at the southeast corner reduced the bearing area on the end of the lower pin and in combination with corrosion caused the inside hanger to separate from the lower pin.

5. The outside hanger was carrying approximately twice its normal load because of the separation of the inside hanger from the lower pin.

6. The upper end of the outside hanger moved outward on the upper pin due to the pressure created by corrosion and dirt between the spacer washer and the girder, the corrosion-induced tapering of the end of the upper pin, the possible out-of-plane movements of the assembly, and the heavier-than-normal load the outside hanger carried.

7. The outer end of the upper pin at the southeast corner of the fallen span fractured in fatigue because the outside hanger which was carrying the entire load of the southeast corner was displaced outward on the upper pin.

30/ "Uniform Vehicle Code and Model Traffic Ordinance, Revised-1983," National Committee on Uniform Traffic Laws and Ordinances, Section 220, Northwestern University Traffic Institute, Evanston, Illinois.

8. A space frame analysis commissioned by the Safety Board which examined various possible bridge loadings found a maximum theoretical 5/32 inch net out-of-plane movement of the southeast pin and hanger assembly due to live loads.

9. If the 5/32-inch maximum out-of-plane movement of the southeast pin and hanger assembly had been present, the resulting lateral shear force and moment would have been low in relation to the size of the connections and the movement could have been absorbed readily in the designed clearances between members.

10. While lateral movement due to out-of-plane forces may have been a contributing factor in the failure of the southeast pin and hanger assembly to the extent that it could have accelerated the forces of corrosion, it was not the primary factor in the failure of the pin and hanger assembly.

11. Corrosion at the southeast pin and hanger assembly was greatly accelerated by modifications of the bridge drainage system, which resulted in an increased number of wettings of the assembly, partially due to dirt and debris deposited in the expansion joint above the assembly.

12. The water flow which repeatedly wetted the southeast pin and hanger assembly was caused by the clogged expansion joint fingers and drainage trough and by a clogged or buried curb trough at the south end of the expansion joint, coupled with an increase in the flow of water over the expansion joint due to paved-over drains to the west of the joint.

13. The expansion joint troughs, although not designed to carry off large volumes of water, probably would have handled the normal flow of water if curb drains to the west had been functioning adequately and if the troughs had been cleaned regularly.

14. The removal of the central portions of the expansion joint troughs between the fallen span and the cantilever arm did not have a direct influence on the corrosion of the southeast pin and hanger assembly.

15. Salt used to deice the bridge surface probably accelerated the corrosion of the southeast pin and hanger assembly and similar assemblies and bearings, but the salt would have had a limited adverse effect if the drainage system had functioned as designed.

16. Funding limitations resulted in deferral of the cleaning of the bridge structure and the maintenance of the drainage system and led to the unavailability of the "snooper" for bridge inspections.

17. The Connecticut Department of Transportation's decision to defer maintenance and reduce maintenance personnel in the face of funding limitations was a factor in the curb drains being paved over and left in that condition for 10 years.

18. The budget of the Connecticut Department of Transportation submitted to the Connecticut General Assembly in 1981, which warned of the possibility of emergency bridge closings and collapse if maintenance was not increased, did not report that the inspection system itself might suffer under a deferred maintenance policy and did not result in increased funding.

19. The September 1982 bridge safety inspection of the Mianus River bridge was cursory, as indicated by the relatively short time devoted to the inspection of the bridge (12 hours or less) and considering the number of features to be inspected.

20. The observations recorded by the safety inspectors during the September 1982 and previous inspections were inadequate to describe the actual condition of this bridge at the time of the inspection.

21. The criteria used to rate bridge deficiencies were too subjective and inadequate to enable safety inspectors to uniformly report the conditions of the components of the bridge.

22. Abnormal wear of the windlock of the fallen span indicated that the fallen span had sagged at least 1/2 inch well before the span collapsed.

23. Before the collapse of the suspended span, the other three major suspended spans on the bridge were sagging 1/2 inch or more at the expansion joint end and also had shifted laterally at least 1/4 inch.

24. The pin caps effectively hid the pin and hanger bearing surfaces and their deteriorated condition from view and prevented easy observation and access to the connections, thereby making inspection difficult.

25. The bridge inspectors did not have access to a "snooper" with which to inspect the bridge properly during the September 1982 safety inspection.

26. The Connecticut Department of Transportation did not respond to the hazard advisory about the advisability of dismantling hangers for inspection which was published in the American Association of State Highway and Transportation Officials "Manual for Bridge Maintenance," in 1976, and its employees were unaware of the importance of careful inspections of pin and hanger assemblies and the possible need to dismantle them.

27. The high traffic volumes, especially heavy trucks, the reduction in maintenance resources, and known maintenance problems should have alerted Connecticut Department of Transportation officials to give increased attention and more thorough inspections to the Mianus River bridge.

28. The Connecticut Department of Transportation did not consider dismantling pin and hanger assemblies to inspect bearing surfaces prior to the collapse of the Mianus River bridge span and apparently did not realize that the procedure might be necessary.

29. The Connecticut Department of Transportation bridge inspection program was governed in practice by the minimum requirements of the National Bridge Inspection Standards and did not incorporate more detailed technical advice published by the American Association of State Highway and Transportation Officials.

30. The National Bridge Inspection Standards do not contain any inspection requirements for inspecting bridges or bridge components other than the frequency of inspections.

31. The States determine the level of thoroughness of bridge inspections.

32. Pin and hanger assemblies can be inspected without dismantling the connections using at least three possible inspection techniques, namely (1) drilling inspection ports in the pin caps; (2) measurement of spaces between members; and (3) cleaning members to remove rust.

33. The technical advice offered to States by the American Association of State Highway and Transportation Officials concerning pin and hanger assembly inspection and preservation of drainage by cleaning made little impression on the Connecticut Department of Transportation partly because the information was presented in a document that was advisory in nature and not regulatory.

34. The Federal Highway Administration did not fulfill its mission regarding the transfer of technology and technical development in connection with the pin and hanger inspection problem identified by the American Association of State Highway and Transportation Officials in a hazard advisory.

35. The lack of minutes of American Association of State Highway and Transportation Officials committee meetings precluded a reconstruction of the technical background of the pin and hanger inspection advisory.

36. The Federal Highway Administration's responsibility for the general administration of the National Bridge Inspection Standards required it to review related training programs from time to time and to make improvements in the curriculum.

37. The Federal Highway Administration in failing to revise the Bridge Inspector's Training Manual periodically to add new information, such as the hazard advisory that hanger assemblies should be dismantled for inspection did not meet the intent of 23 U.S.C. 116(e).

38. The National Bridge Inspection Standards do not require periodic refresher training for bridge inspectors.

39. The Connecticut Department of Transportation bridge inspector training program should have included detailed instructions to the inspectors assigned to the Mianus River bridge regarding the inspection of pin and hanger assemblies.

40. The Federal Highway Administration's audit of Connecticut's compliance with the National Bridge Inspection Standards was inadequate because it did not examine and evaluate the inspectors' training program; did not review the comprehensiveness of inspections, time spent on individual inspections, or the use of appropriate equipment for inspection of complex bridges; and did not consider a large enough sample of inspection reports of selected bridges.

41 The car that stopped on the bridge after the span collapsed might have presented a more effective warning to approaching vehicles if its hazard warning signals had been activated immediately. The Uniform Vehicle Code should require the use of hazard warning signals whenever a motor vehicle becomes a hazard to other motorists on a highway.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the collapse of the Mianus River bridge span was the undetected lateral displacement of the hangers of the pin and hanger suspension assembly in the southeast corner of the span by corrosion-induced forces due to deficiencies in the State of Connecticut's bridge safety inspection and bridge maintenance program.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board made the following recommendations:

—to the Connecticut Department of Transportation:

Reopen the paved-over drains on the Mianus River bridge and any other bridge in Connecticut which may have paved-over drains, institute a program to modify the bridge drainage systems so that they provide for proper runoff of surface water and to require regular cleaning and maintenance of drainage systems. (Class II, Priority Action) (H-84-31)

Establish and enforce a policy of reviewing and evaluating proposed modifications of bridge drainage systems to preclude reducing the effectiveness of the systems. (Class II, Priority Action) (H-84-32)

Require the cleaning of critical elements of bridges and access routes thereto immediately before or in the course of major bridge safety inspections. (Class II, Priority Action) (H-84-33)

Improve the quality of review of bridge inspection reports, and provide for face-to-face reviews of reports on a selected sample of bridges by reviewers and inspectors. (Class II, Priority Action) (H-84-34)

Revise Bridge Inspection Form BRI-18 (Ed. 1-81) to provide for the recording of information regarding:

(1) specified critical elements with individual ratings supported by a narrative explanation;
(2) observations and measurements of alignment of members; and
(3) use of specialized equipment to gain access to the bridge area being inspected or the reasons why specialized equipment was not used. (Class II, Priority Action) (H-84-35)

Prepare individual inspection and maintenance manuals for large or complex bridges within Connecticut. (Class III, Longer Term Action) (H-84-36)

After consultation with the Bridge Safety and Inspection Section, install as necessary, handholds, safety belt connections, handrails, catwalks, and safety wires on existing bridges to assist inspectors in safely moving through the superstructures and gaining access to critical elements of the bridge. (Class III, Longer Term Action) (H-84-37)

Review the bridge safety inspection manuals and bridge maintenance manuals and voluntary standards of the American Association of State Highway and Transportation Officials and incorporate those which affect bridge safety into the Connecticut Department of Transportation bridge safety inspection procedures and bridge maintenance practices. (Class II, Priority Action) (H-84-38)

Require that a representative of the Bridge Safety and Inspection Section review the plans for new bridges for safe and effective inspectability and maintainability before acceptance of the design. (Class II, Priority Action) (H-84-39)

—to the Federal Highway Administration:

Develop a detailed and comprehensive integrated bridge inspection procedure using all available source materials, including but not limited to the Federal Highway Administration's "Bridge Inspector's Training Manual" and the American Association of State Highway and Transportation Officials' "Manual for Bridge Maintenance (1976)" and "Manual for Maintenance Inspection of Bridges (1978)." (Class II, Priority Action) (H-84-40)

Amend 23 CFR 650.303 to include an integrated bridge inspection procedure in its entirety or to incorporate such a procedure by reference. (Class III, Longer Term Action) (H-84-41)

Develop a model bridge inspector's field handbook in a convenient checklist format which encompasses all the elements of an integrated bridge inspection procedure to be prescribed by 23 CFR 650.303 if amended as recommended by the Safety Board. (Class II, Priority Action) (H-84-42)

Establish a bridge inspection enforcement program that will assure compliance with 23 CFR 650.303 if amended as recommended by the Safety Board. (Class II, Priority Action) (H-84-43)

Develop and disseminate procedures for inspection of hidden elements of pin and hanger assemblies which do not involve the dismantling of the assemblies. (Class III, Longer Term Action) (H-84-44)

Prescribe objective dimensional standards for the alignment of bridge spans to facilitate detection of misalignment caused by deterioration of pin and hanger assemblies. (Class II, Priority Action) (H-84-45)

In cooperation with the States, identify bridges that have a pin and hanger assembly design using bearing stresses above those allowed by the 1983 Interim Specification--Bridges, 1983 of the American Association of State Highway and Transportation Officials, and designate them for frequent inspection. (Class II, Priority Action) (H-84-46)

Augment the current inventory and rating methodology of the National Bridge Inspection Standards, which emphasizes an overall rating for planning large-scale replacement or rehabilitation funding, to require inspections and ratings of sufficient depth and detail to address all elements critical to safety. (Class II, Priority Action) (H-84-47)

Require that the design of any Federal-aid bridge include an analysis of inspectability and maintainability. (Class II, Priority Action) (H-84-48)

Conduct detailed inspections of the Mianus River bridge and other representative bridges having a skewed and nonskewed suspended span design with pin and hanger assemblies to determine whether there is a significant difference between the two designs in terms of the movement of hangers on pins due to either dead or live loading and whether such movement is acceptable. (Class III, Longer Term Action) (H-84-49)

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. (Class II, Priority Action) (H-84-50)

Prescribe criteria for in-depth inspections of pin and hanger assemblies based on objective measures of the risk of hidden deterioration, such as the time since the last inspection, and/or whether the pin and hanger assembly is dismantled. (Class II, Priority Action) (H-84-51)

Prescribe an objective standard for repair or replacement of pin and hanger assemblies according to measured conditions of misalignment, distortion, or changes in the position of elements of the assembly. (Class II, Priority Action) (H-84-52)

Change the format of the "Bridge Inspector's Training Manual" to provide for page-change updating, to key the manual to inspection forms, to prescribe mandatory examinations and inspector evaluations of individual critical elements as well as overall conditions, and to describe an optional methodology for effective on-site inspection. (Class II, Priority Action) (H-84-53)

Include in the annual bridge inspection program audit a review of the State's bridge inspection training programs. (Class II, Priority Action) (H-84-54)

—to the American Association of State Highway and Transportation Officials:

Modify Article 1.7.27 of the "Standard Specifications for Highway Bridges (1977)" and succeeding "Interim Specifications" to describe forces which might result in lateral movements of members on pins to be considered in designing pinned assemblies. (Class II, Priority Action) (H-84-55)

—to the U.S. Department of Transportation:

Direct the DOT Inspector General to review the Federal Highway Administration's bridge inspection audit program for its sufficiency in establishing State compliance with the National Bridge Inspection Standards. (Class II, Priority Action) (H-84-56)

—to the American Institute of Steel Construction:

Review the pin cap detail shown in the AISC Manual of Steel Construction to determine if it should be deleted from the manual or if qualifying conditions should be attached to its use. (Class II, Priority Action) (H-84-57)

—to the National Committee on Uniform Traffic Laws and Ordinances:

Modify Section 12-220 of the Uniform Vehicle Code to require the use of hazard warning signals whenever a motor vehicle becomes a hazard to motorists on a highway. (Class III, Longer Term Action) (H-84-58)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ G.H. PATRICK BURSLEY
Member

/s/ VERNON L. GROSE
Member

July 19, 1984

APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

Investigation

The National Transportation Safety Board was notified of the accident at 3:03 a.m., on June 28, 1983, by the Connecticut State Police through the Safety Board's New York Field Office. Investigators were dispatched from the Washington, D. C., Headquarters and arrived at the accident site at 10 a.m. on June 28, 1983.

Parties to the investigation were representatives of the Connecticut State Police; the Connecticut Department of Transportation; the engineering company of Tippetts, Abbett, McCarthy, and Stratton, the designers of the bridge; and the Federal Highway Administration.

Hearing

The Safety Board held a public hearing in Greenwich, Connecticut, from September 19 to September 22, 1983, and received into the record a large number of exhibits and the testimony of 28 witnesses. Included were eyewitnesses to the bridge collapse and the vehicles falling off the bridge; professional personnel who testified as to their investigations and observations; officials of the Federal Highway Administration; officials of the Connecticut Department of Transportation who described the State organization, functions, and operations for the inspection and maintenance of State bridges; the bridge safety inspectors who performed the last safety inspection of the Mianus River bridge; and one of the bridge maintenance inspectors who performed the last maintenance inspection of the Mianus River bridge.

APPENDIX B

DRIVER INFORMATION

The vehicle operators and occupants involved in this accident were the following:

1. 1979 Toyota Supra, 2-door sedan
Ms. Eileen M. Weldon - survivor

Ms. Weldon was the driver and only occupant of the Toyota. Ms. Weldon, age 21, was en route from New York City to her residence. She held a valid Connecticut driver license. She had been driving for about 5 1/2 years and was familiar with both the vehicle and the route traveled.

2. 1983 Freightliner tractor, 1977 Trailmobile refrigerator semitrailer
Mr. Harold W. Bracy - deceased

Mr. Bracy was the driver and only occupant of the tractor-semitrailer. He held a valid Louisiana operator license that authorized him to drive a tractor-semitrailer. Mr. Bracy, age 45, was en route from Springfield, Missouri, to North Haven, Connecticut. He was familiar with both the vehicle combination he was driving and the route traveled.

3. 1977 Mack tractor, 1969 Strickland van semitrailer
Mr. David A. Pace - survivor

Mr. Pace was the driver of the tractor-semitrailer. He was accompanied by his wife, Helen Pace. Mr. Pace, age 27, held a valid Georgia operator license that authorized him to drive a tractor-semitrailer. He was en route from Matawan, New Jersey, to Merrimack, New Hampshire. Mr. Pace was familiar with the vehicle he was driving but not with the route he was traveling.

4. 1981 BMW Model 320i, 2 door sedan
Mr. Luis Zapata - deceased

Mr. Zapata was the driver of the BMW. He held a valid Connecticut driver license with no restrictions. Mr. Zapata, age 31, was en route from New York City to his residence. He was accompanied by a coworker, Reginald Fisher, age 21, who also died in the crash.

According to a record check by the Connecticut State Police, none of the drivers except Mr. Zapata had any record of any traffic violation convictions or previous accidents. Mr. Zapata's driving record had evidence of two convictions for speeding and stop sign violations and one previous accident.

APPENDIX C

VEHICLE INFORMATION

KLM Truck.--The first truck was owned by KLM Nationwide Carrier, Inc., of Jackson, Mississippi. The tractor was a 1983 Freightliner cab-over-engine. The tractor's vehicle identification number (VIN) was 1FUEYRYBODH215824, and its 1983 Texas registration plate was R-12-287. The tractor was towing a 1977 refrigerated Trailmobile box semitrailer, VIN B62773, also owned by KLM. The cargo was 50,000 pounds of packaged meat, and the combination weighed 73,011 pounds. The vehicle had left Springfield, Missouri, on June 23, 1983, destined for New Haven, Connecticut.

Fastway Truck.--The second truck was owned by the father of the driver. The tractor was a 1977 Mack cab-over-engine tractor equipped with a sleeper berth. The tractor VIN was 74751149. The tractor was towing a 1969 Strickland van-semitrailer, VIN 112294, owned by the Fastway Transportation Company of Matawan, New Jersey. The semitrailer was transporting about 26,000 pounds of empty beer bottles from Matawan to Merrimack, New Hampshire, and the combination weighed 52,700 pounds.

Toyota.--The first automobile was a 1979 two-door Toyota Supra sedan. The automobile was owned by the mother of the driver. The VIN was MA46021519.

BMW.--The second automobile was a 1981 BMW 320i, two-door sedan owned by the driver. The VIN was WBAAG3306B8014970.

APPENDIX D

INSPECTION REPORTS OF THE INTERSTATE 95 HIGHWAY BRIDGE OVER THE MIANUS RIVER JANUARY 1962 THROUGH SEPTEMBER 1982

STATE HIGHWAY DEPARTMENT
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

TOWN Greenwich R. NO. 95:16 MILES 4.6?
BRIDGE OVER Mianus River NO. SPANS 24
TYPE Rolled Beam and Girder SPAN LENGTH 2661'
INSPECTION MADE BY Golino and McManus DATE 1/23/62

OBSERVATIONS

WATERWAY	PIERS AND ABUTMENTS	CONCRETE STRUCTURES AND FLOORS	STEEL CONSTRUCTION	TIMBER STRUCTURES AND FLOORS
ADEQUACY	UNDERMINING	CRACKING	CONDITION OF PAINT	WEAR
SCOUR	SETTLEMENT	SCALING	CORROSION	DECAY
OBSTRUCTIONS	CRACKING	DISINTEGRATION	EXPANSION JOINTS	STRUCTURAL DEFECTS
UNDERGROWTH	DISINTEGRATION	EXPANSION JOINTS	RAILINGS	RAILINGS
CHANNEL SHIFTING	DECAY (TIMBER)	RAILINGS	SHOES	FLOOR DRAINAGE
OTHER FEATURES	POINTING MASONRY	WATERPROOFING	FLOOR DRAINAGE	OTHER DEFECTS
	OTHER DEFECTS	FLOOR DRAINAGE	RIVETS	
	PILE FOUNDATIONS	OTHER DEFECTS	OTHER DEFECTS	
		SIDEWALKS	SIDEWALKS	SIDEWALKS

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (V) MARK TO INDICATE "OK" OR "NONE" FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY

REMARKS

(USE SECOND SHEET WHEN SPACE BELOW IS NOT SUFFICIENT; ALSO LIST CAUSE OF ALL DEFECTS WHEN POSSIBLE.)

1. Reinf. steel rusting through outside parapet wall at s.w. wing, west abutment
2. Water leaking through at end of slab, west abutment
3. Two bolts and plywood form work left in place, under deck at n.w. wing, west abutment
4. Hanger bolt from deck forms, left in place at pier #6
5. Wooden strips from joint at center pier #6, hanging down
6. Cracks in deck east and west bound lanes - water seeping through - should be sealed, river spans very bad
7. Gutters and scuppers full of sand - not functioning at all.
8. Section of deck on east bound lane, 5' east of lamp station #G-251 scaling should be repaired with hot asphalt concrete
9. Concrete broken at center pier in center mall 60' east of lamp sta. G-251
10. One nut missing from anchor bolt east abutment, others not tightened down, east side.
11. Cracks in curbs east and west bound lanes.

MAINTENANCE RECOMMENDATIONS

NO.	DESCRIPTION OF WORK TO BE DONE—WHEN POSSIBLE SHOW QUANTITIES	EST. COST

FORM HG. 801-10 20-1M
STATE HIGHWAY DEPARTMENT
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

TOWN Greenwich R. NO. 95 16 MILES 4.35
BRIDGE OVER Byram River NO SPANS 24
TYPE Rolled Beam and Girder SPAN LENGTH 2,662'
INSPECTION MADE BY Jacobson and Cowles DATE 7/23/62

OBSERVATIONS

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY	X	UNDERMINING	X	CRACKING 15-14	X	CONDITION OF PAINT	9	WEAR	
SCOUR	X	SETTLEMENT	X	SCALING 13-10	X	CORROSION	X	DECAY	
OBSTRUCTIONS	X	CRACKING	X	DISINTEGRATION	X	EXPANSION JOINTS	X	STRUCTURAL DEFECTS	
UNDERGROWTH	X	DISINTEGRATION	X	EXPANSION JOINTS	12-7	RAILINGS	8	RAILINGS	
CHANNEL SHIFTING	X	DECAY (TIMBER)	X	RAILINGS	X	SHOES	4	FLOOR DRAINAGE	
OTHER FEATURES	X	POINTING MASONRY 6-5-3-2-1		WATERPROOFING	X	FLOOR DRAINAGE	X	OTHER DEFECTS	
		OTHER DEFECTS -16	X	FLOOR DRAINAGE	X	RIVETS	X		
		PILE FOUNDATIONS?	X	OTHER DEFECTS 11	X	OTHER DEFECTS	X		
				SIDEWALKS	X	SIDEWALKS	X	SIDEWALKS	

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (V) MARK TO INDICATE "OK" OR "NONE" FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY

REMARKS

(USE SECOND SHEET WHEN SPACE BELOW IS NOT SUFFICIENT. ALSO LIST CAUSE OF ALL DEFECTS WHEN POSSIBLE.)

1. Large spall in E. abut. S. fascia side under 1st girder. (5' x 4' x 1') jacked with H piling.
   Spall developing under 2nd girder S. fascia side. Crack through pad and in abut. (5'x2'x1')
2. Movement in deck above E. abut. curtain wall. Small spall developing.
3. Spall in 7th stringer pedestal S. fascia side. 1st pier from E. abut. Floor beams jacked with H piling.
4. Shoes in contraction W. abut. due to thrust (± 70°)
5. Pavement slab movement over W. abut. curtain wall.
6. Pier #1 from W. abut. appears to have been pushed forward due to thrust.
7. Center mall jt. needs resealing (± 2,600')
8. Railings need painting (5,370' lineal)
9. Bridge paint poor.
10. Scaling in Span #10 next to center mall W. bound lane (10 sq. ft. x 1/4")
    Scaling in Span #17 N. curb line W. bound lane (10 sq. ft. x 1/4") also at center mall curb (40 sq. ft. x 1/2")
    Scaling in Span #14 next to S. curb line E. bound (15 sq. ft. x 1")
11. Small spall - Span #15 inside of S. parapet wall (6"x3" x 1/4")
    Start of a small spall on Span #15 in S. parapet wall (1' x 2' x 1/4")
    Small spall in deck Span #16 next to parapet curb 15' from end of span #15 (1'x6"x1/4")
12. Joints need resealing at end of spans #1,3,5,7,9,11,13,15,17,19,20.
13. Scaling in Span #23 along S. parapet curb (55 sq. ft. x 1/4")
14. Transverse Hairline cracks in all spans E. and W. bound.
15. Hairline cracks N & S parapet walls and curbs, all spans.
16. Space between cheekwall and abut. jt. (± 1½") due to thrust, N.W. and S.W. corners.

Note: Relief joints have been cut and placed in this structure.

MAINTENANCE RECOMMENDATIONS

NO.	DESCRIPTION OF WORK TO BE DONE—WHEN POSSIBLE SHOW QUANTITIES	EST. COST
7	Should be resealed	$1,000
8	Railings to be painted	11,000
9	Bridge to be painted	62,000
1-3	Has to be repaired	5,000
12	Joints to be resealed	1,000

Form No. BRI 18 ED 1-47
State Highway Department
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

TOWN GREENWICH 00015 R. No. 95 MILES 4.3
BRIDGE OVER Mianus River No. SPANS 24
TYPE Rolled Beam and Girder SPAN LENGTH 2,66
INSPECTION MADE BY Jacobson and Priga DATE 6/23/65

OBSERVATIONS Page One of nine

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY	X	UNDERMINING	X	CRACKING 12-9-5-1		CONDITION OF PAINT	X	WEAR	X
SCOUR	X	SETTLEMENT	X	SCALING	X	CORROSION	X	DECAY	X
OBSTRUCTIONS	X	CRACKING	X	DISINTEGRATION	X	EXPANSION JOINTS	X	STRUCTURAL DEFECTS	X
UNDERGROWTH	X	DISINTEGRATION	X	EXPANSION JOINTS	6	RAILINGS	X	RAILINGS	X
CHANNEL SHIFTING	X	DECAY (TIMBER)	X	RAILINGS	X	SHOES	X	FLOOR DRAINAGE	X
OTHER FEATURES	X	POINTING MASONRY	X	WATERPROOFING	X	FLOOR DRAINAGE	X	OTHER DEFECTS	X
		OTHER DEFECTS	X	FLOOR DRAINAGE 11-7-4		RIVETS	X		
		PILE FOUNDATIONS	X	OTHER DEFECTS 14-13-10-9-2		OTHER DEFECTS	X		
				SIDEWALKS	X	SIDEWALKS	X	SIDEWALKS	X

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (✓) MARK TO INDICATE "OK" OR "NONE" FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY

REMARKS

(Use second sheet when space below is not sufficient: Also list cause of all defects when possible)

Eastbound from West:

Span #1

1. Transverse cracking in deck
2. Space between parapet wall and end post (± 3/4")

Span #2

4. Scuppers full of sand
5. Transverse cracking in deck
6. Expansion joints need sealing between spans 1 & 2 (30 L.F.)

Span #3

7. Scuppers full of sand
8. Transverse cracking in deck
9. Stringer joint plate pulled away from center mall curb
10. Small pop-outs in bridge deck, slow lane total (2 sq. ft. x 1/2")

Span #4

11. Scuppers full of sand
12. Transverse cracking in deck
13. Small piece of concrete breaking out of N. fascia side of S. parapet wall at 2nd construction joint (6"x1"x1")
14. Center mall finger joint plate missing between spans 4 and 5

MAINTENANCE RECOMMENDATIONS

No.	Description of Work to be Done — When Possible Show Quantities	Est. Cost
4-7-11	- Should be cleaned out	$100.00
6	- Should be resealed (30 L.F.)	25.00
9-14	- Should be replaced	100.00
10	- Should be patched (2 sq. ft. x 1/2")	25.00
13	- Should be repaired (6"x1"x1")	20.00

7/15/65

State Highway Department
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

[illegible]
BRIDGE OVER Mianus River — No. SPANS 24
TYPE Rolled Beam Girder — SPAN LENGTH 2,6[illegible]
INSPECTION MADE BY Jacobson and Priga — DATE 6/23/65

OBSERVATIONS — Page Two of nine

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY	X	UNDERMINING	X	CRACKING 25-20-16		CONDITION OF PAINT	X	WEAR	X
SCOUR	X	SETTLEMENT	X	SCALING	X	CORROSION	X	DECAY	X
OBSTRUCTIONS	X	CRACKING	X	DISINTEGRATION	26	EXPANSION JOINTS	X	STRUCTURAL DEFECTS	X
UNDERGROWTH	X	DISINTEGRATION	X	EXPANSION JOINTS	22	RAILINGS	X	RAILINGS	X
CHANNEL SHIFTING	X	DECAY (TIMBER)	X	RAILINGS	X	SHOES	X	FLOOR DRAINAGE	X
OTHER FEATURES	X	POINTING MASONRY	X	WATERPROOFING	X	FLOOR DRAINAGE	X	OTHER DEFECTS	X
		OTHER DEFECTS	X	FLOOR DRAINAGE 24-19-15		RIVETS	X		X
		PILE FOUNDATIONS	X	OTHER DEFECTS 21-17		OTHER DEFECTS 23-18			
				SIDEWALKS	X	SIDEWALKS		SIDEWALKS	X

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (x) MARK TO INDICATE "OK" OR "NONE". FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY

REMARKS

(Use second sheet when space below is not sufficient. Also list cause of all defects when possible.)

Eastbound:

Span #5-

15. - Scuppers full of sand
16. - Transverse cracking in deck
17. - Spalling in center lane 20' from span 4 (50 sq. ft. x 1/4 to 1/2")
18. - Center mall flex beam bent 10' from span 6 (10 L.F.)

Span #6-

19. - Scuppers full of sand
20. - Transverse cracking in deck
21. - Scaling in bridge deck slow lane 2' from span #5 - (1 sq. ft. x 1/8")
22. - Expansion joints need resealing between spans #5 and #6 (10 l.f.)
23. - Center mall flex beam bent (20 L.F.)

Span #7

24. - Scuppers full of sand
25. - Transverse cracking in deck
26. - Disintegration in edge of pavement at expansion joint between spans 7 & 8. (2 sq. ft. x 1")

MAINTENANCE RECOMMENDATIONS

No.	Description of Work to be Done — When Possible Show Quantities	Est. Cost
15-19-24	- Should be cleaned out	$100.00
17	- Should be repaired (50 sq. ft. x 1/4" to 1/2")	400.00
18-23	- Should be replaced (30 L.F.)	30.00
21-	- Should be repaired (1 sq. ft. x 1/8")	25.00
22-	- Should be resealed (10 L.F.)	3.00
26-	- Should be repaired (2 sq. ft. x 1")	40.00

3/18/65

Form No. BR. 18 EO 1-47
State Highway Department
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

TOWN GREENWICH 00015 R. No. 95 MILES 4.35
BRIDGE OVER Mianus River No. SPANS 24
TYPE Rolled Beam and Girder SPAN LENGTH 2,66?
INSPECTION MADE BY Jacobson and Priga DATE 6/23/65

OBSERVATIONS Page Three of nine

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY	X	UNDERMINING	X	CRACKING 34-33-29	28	CONDITION OF PAINT	X	WEAR	✓
SCOUR	X	SETTLEMENT	X	SCALING	X	CORROSION	X	DECAY	✓
OBSTRUCTIONS	X	CRACKING	X	DISINTEGRATION	37	EXPANSION JOINTS	X	STRUCTURAL DEFECTS	✓
UNDERGROWTH	X	DISINTEGRATION	X	EXPANSION JOINTS	X	RAILINGS	X	RAILINGS	
CHANNEL SHIFTING	X	DECAY (TIMBER)	X	RAILINGS	X	SHOES	X	FLOOR DRAINAGE	✓
OTHER FEATURES	X	POINTING MASONRY	X	WATERPROOFING	X	FLOOR DRAINAGE	X	OTHER DEFECTS	✓
		OTHER DEFECTS	X	FLOOR DRAINAGE 30-35-32-27		RIVETS	X		
		PILE FOUNDATIONS	X	OTHER DEFECTS	36	OTHER DEFECTS	31		
				SIDEWALKS	X	SIDEWALKS	X	SIDEWALKS	✓

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (✓) MARK TO INDICATE "OK" OR "NONE" FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY.

REMARKS

(Use second sheet when space below is not sufficient. Also list cause of all defects when possible.)

Eastbound:

Spans 8 and 9:

27. Scuppers full of sand
28. Transverse cracking in deck

Span 10:

29. Transverse cracking in deck
30. Scuppers full of sand
31. Center mall flex beam bent - 10 L.F.

Spans 11 and 12:

32. Scuppers full of sand
33. Transverse cracking in deck

Span 13:

34. Transverse cracking in deck
35. Scuppers full of sand
36. Small pop-outs in center lane - 10' from span 14 - total 1 sq. ft. x 1".
37. Disintegration to pavement edge at expansion joints between spans 13 and 14. Total 6 sq. ft. x 1")

MAINTENANCE RECOMMENDATIONS

No.	Description of Work to be Done — When Possible Show Quantities	Est. Cost
27-32-30-35	- Should be cleaned out	$100.00
31	- Should be replaced - 10 L.F.	10.00
36-37	- Should be repaired - 7 sq. ft. x 2")	150.00

8/18/65
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State Highway Department
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

BRIDGE OVER Mianus River — NO. SPANS 24
TYPE Rolled Beam and Girder — SPAN LENGTH 2,[illegible]
INSPECTION MADE BY Jacobson and Prigs — DATE 6/23/65

Page Four of nine

OBSERVATIONS

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY	X	UNDERMINING	X	CRACKING 50-46-43-39		CONDITION OF PAINT	X	WEAR	X
SCOUR	X	SETTLEMENT	X	SCOURING	X	CORROSION	X	DECAY	X
OBSTRUCTIONS	X	CRACKING	X	DISINTEGRATION 48-47-44 40		EXPANSION JOINTS	X	STRUCTURAL DEFECTS	X
UNDERGROWTH	X	DISINTEGRATION	X	EXPANSION JOINTS	X	RAILINGS	X	RAILINGS	X
CHANNEL SHIFTING	X	DECAY (TIMBER)	X	RAILINGS	X	SHOES	X	FLOOR DRAINAGE	X
OTHER FEATURES	X	POINTING MASONRY	X	WATERPROOFING	X	FLOOR DRAINAGE	X	OTHER DEFECTS	X
		OTHER DEFECTS	X	FLOOR DRAINAGE 49-45-42 38		RIVETS	X		X
		PILE FOUNDATIONS	X	OTHER DEFECTS	X	OTHER DEFECTS	41		
				SIDEWALKS	X	SIDEWALKS	X	SIDEWALKS	X

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (✓) MARK TO INDICATE "OK" OR "NONE" FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY

REMARKS

(Use second sheet when space below is not sufficient. Also list cause of all defects when possible.)

Eastbound:

Span 14

38. Scuppers full of sand
39. Transverse cracking in deck
40. Disintegration in bridge deck adjacent to parapet curb (100 sq. ft. x 1" to 2")
41. Center wall finger joint plate missing

Span 15

42. Scuppers full of sand
43. Transverse cracking in deck
44. Disintegration to top of S. parapet wall at construction joints #5,[illegible],7 - total (2 cu. ft.)

Span 16

45. Scuppers full of sand
46. Transverse cracking in deck
47. Disintegration in deck adjacent to parapet curb (2 sq. ft. x 1/2")
48. Disintegration in deck at expansion joint between spans 16 and 17 (3 sq. ft. x 1/2")

Span 17

49. Scuppers full of sand
50. Transverse cracking in deck.

MAINTENANCE RECOMMENDATIONS

No.	Description of Work to be Done — When Possible Show Quantities	Est. Cost
	38-42-45-49 - Should be cleaned out	$100.00
	40-47-48 - Should be repaired (105 sq. ft. x 1/2 to 2")	1000.00
	41- - Should be repaired	7[illegible].00
	44- - Should be repaired - 2 cu. ft.	2[illegible].00

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Form No. CR 18 ED 1-47
State Highway Department
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

TOWN GREENWICH 00015 Rt. No. 95 MILES 4.35
BRIDGE OVER Mianus River No. SPANS 24
TYPE Rolled Beam and Girder SPAN LENGTH 2,661
INSPECTION MADE BY Jacobson and Priga DATE 6/23/65

OBSERVATIONS Page Five of nine

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY	X	UNDERMINING	X	CRACKING 64-60-59-56-55-52		CONDITION OF PAINT	X	WEAR	X
SCOUR	X	SETTLEMENT	X	SCALING	X	CORROSION	X	DECAY	X
OBSTRUCTIONS	X	CRACKING	X	DISINTEGRATION 63-62-53		EXPANSION JOINTS	X	STRUCTURAL DEFECTS	X
UNDERGROWTH	X	DISINTEGRATION	X	EXPANSION JOINTS	X	RAILINGS	X	RAILINGS	X
CHANNEL SHIFTING	X	DECAY (TIMBER)	X	RAILINGS	X	SHOES	X	FLOOR DRAINAGE	X
OTHER FEATURES	X	POINTING MASONRY	X	WATERPROOFING	X	FLOOR DRAINAGE	X	OTHER DEFECTS	X
		OTHER DEFECTS	X	FLOOR DRAINAGE 61-58-57-54-51		RIVETS	X		
		PILE FOUNDATIONS	X	OTHER DEFECTS	X	OTHER DEFECTS	X		
				SIDEWALKS	X	SIDEWALKS	X	SIDEWALKS	X

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (✓) MARK TO INDICATE "OK" OR "NONE" FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY.

REMARKS

(Use second sheet when space below is not sufficient. Also list cause of all defects when possible.)

Eastbound:

Span 18 - 51. Scuppers full of sand
52. Transverse cracking in deck
53. Disintegration in slow lane 1' from span 19 (1 sq.ft. x 1")

Span 19 - 54. Scuppers full of sand
55. Transverse cracking in deck

Span 20 - 56. Heavy transverse cracking in deck
57. Scuppers full of sand

Spans 21 and 22
58. Scuppers full of sand
59. Transverse cracking in deck

Spans 23 60. Transverse cracking in deck
61. Scuppers full of sand
62. Disintegration in edge of pavement between spans 22 and 23 (3 sq. ft. x 1")
63. Disintegration in parapet curb adjacent to span 22 (10 sq. ft. x 1")

Span 24 64. Transverse cracking in deck

MAINTENANCE RECOMMENDATIONS

No.	Description of Work to be Done – When Possible Show Quantities	Est. Cost
51-54-57-58-31	Should be cleaned out	$120.00
56	Should be sealed	200.00
53-62-63	Should be repaired - 14 sq. ft. x 1"	150.00

8/18/65

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State Highway Department
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

TOWN GREENWICH 00015 R No 95 MILES 4.35
BRIDGE OVER Mianus River No. SPANS 24
TYPE Rolled Beam and Girder SPAN LENGTH 2,661
INSPECTION MADE BY Jacobson and Friga DATE 6/23/65

OBSERVATIONS Page Six of nine

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY	X	UNDERMINING	X	CRACKING 13-9-8-5-2		CONDITION OF PAINT	X	WEAR	X
SCOUR	X	SETTLEMENT	X	SCALING 1	X	CORROSION	X	DECAY	X
OBSTRUCTIONS	X	CRACKING	X	DISINTEGRATION 11-6		EXPANSION JOINTS	X	STRUCTURAL DEFECTS	X
UNDERGROWTH	X	DISINTEGRATION	X	EXPANSION JOINTS	X	RAILINGS	X	RAILINGS	X
CHANNEL SHIFTING	X	DECAY (TIMBER)	X	RAILINGS	X	SHOES	X	FLOOR DRAINAGE	X
OTHER FEATURES	X	POINTING MASONRY	X	WATERPROOFING	X	FLOOR DRAINAGE	X	OTHER DEFECTS	X
		OTHER DEFECTS	X	FLOOR DRAINAGE 12-10-7		RIVETS	X		
		PILE FOUNDATIONS	X	OTHER DEFECTS 4-3	X	OTHER DEFECTS	14		
				SIDEWALKS	X	SIDEWALKS	X	SIDEWALKS	X

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (X) MARK TO INDICATE "OK" OR "NONE" FOR ITEMS NEED NO EXPLANATION. MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY.

REMARKS

(Use second sheet when space below is not sufficient. Also list cause of all defects when possible.)

Westbound from W.

Span 1 - 1. Transverse cracking in deck

Spans 2,3,4,5,6,7 - 2. Transverse cracking in deck
3. Scuppers full of sand

Span 8
4. Scuppers full of sand
5. Transverse cracking in deck
6. Disintegration to North parapet curb (2 sq. ft. x 1")

Span 9
7. Scuppers full of sand
8. Transverse cracking in deck

Span 10
9. Transverse cracking in deck
10. Scuppers full of sand
11. Disintegration in high speed lane adjacent to center rail curb (10 sq. ft. x 1/2")

Span 11
12. Scuppers full of sand
13. Transverse cracking in deck
14. Center mall flex beam bent (10 L.F.)

MAINTENANCE RECOMMENDATIONS

No.	Description of Work to be Done - When Possible Show Quantities	Est. Cost
3-4-7-10-12	- Should be cleaned out	$150.00
6-11	- Should be repaired (12 sq. ft. x 1/2" to 1")	100.00
14	- Should be replaced (10 L.F.)	20.00

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State Highway Department
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

[illegible] [illegible] R No. 95 MILES [illegible]
BRIDGE OVER Mianus River No. SPANS 24
TYPE Rolled Beam Girder SPAN LENGTH 2,65[illegible]
INSPECTION MADE BY Jacobson and Price DATE 6/23/65

OBSERVATIONS Page Seven of nine

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY	X	UNDERMINING	X	CRACKING 25-24-20-19-16		CONDITION OF PAINT	X	WEAR	X
SCOUR	X	SETTLEMENT	X	SCALING	1	CORROSION	X	DECAY	X
OBSTRUCTIONS	X	CRACKING	X	DISINTEGRATION 17-22		EXPANSION JOINTS	X	STRUCTURAL DEFECTS	X
UNDERGROWTH	X	DISINTEGRATION	X	EXPANSION JOINTS	X	RAILINGS	X	RAILINGS	X
CHANNEL SHIFTING	X	DECAY (TIMBER)	X	RAILINGS	X	SHOES	X	FLOOR DRAINAGE	X
OTHER FEATURES	X	POINTING MASONRY	X	WATERPROOFING	X	FLOOR DRAINAGE	X	OTHER DEFECTS	X
		OTHER DEFECTS	X	FLOOR DRAINAGE 26-23-21		RIVETS	X		
		PILE FOUNDATIONS	X	OTHER DEFECTS 18-15	27	OTHER DEFECTS	X		
				SIDEWALKS	X	SIDEWALKS	X	SIDEWALKS	X

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (X) MARK TO INDICATE OK OR NONE. FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY.

REMARKS

(Use second sheet when space below is not sufficient. Also list cause of all defects when possible.)

Span 12 - 15. Scuppers full of sand
16. Transverse cracking in deck
17. Disintegration in parapet curb (3 sq. ft. x 1")

Spans 13 and 14-

18. Scuppers full of sand
19. Transverse cracking in deck

Spans 15
20. Transverse cracking in deck
21. Scuppers full of sand
22. Disintegration to center mall curb (6'x4"x4")

Spans 16
23. Scuppers full of sand
24. Transverse cracking in deck

Span 17
25. Transverse cracking in deck
26. Scuppers full of sand
27. Spalling along gutter line, slow lane - (15 sq. ft. x 1/2")

MAINTENANCE RECOMMENDATIONS

No.	Description of Work to be Done — When Possible Show Quantities	Est. Cost
15-18-21-23-26	Should be cleaned out	$150.00
17-	Should be repaired (3 sq. ft. x 1")	70.00
22-	Should be repaired (6'x4"x4")	50.00
27-	Should be repaired (15 sq. ft. x 1/2")	150.00

8/15/65
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Form No. BRI 10 ED 1-47
State Highway Department
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

TOWN GREENWICH 00015 R. No. 95 MILES 4.35
BRIDGE OVER Mianus River No. SPANS 24
TYPE Rolled Beam and Girder SPAN LENGTH 2,
INSPECTION MADE BY Jacobson and Price DATE 6/23/65

OBSERVATIONS

Page Eight of nine

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY	X	UNDERMINING	X	CRACKING 37-36-32		CONDITION OF PAINT	X	WEAR	X
SCOUR	X	SETTLEMENT	X	SCALING	X	CORROSION	X	DECAY	X
OBSTRUCTIONS	X	CRACKING	X	DISINTEGRATION 30-29-28		EXPANSION JOINTS	X	STRUCTURAL DEFECTS	X
UNDERGROWTH	X	DISINTEGRATION	X	EXPANSION JOINTS	X	RAILINGS	X	RAILINGS	X
CHANNEL SHIFTING	X	DECAY (TIMBER)	X	RAILINGS	X	SHOES	X	FLOOR DRAINAGE	X
OTHER FEATURES	X	POINTING MASONRY	X	WATERPROOFING	X	FLOOR DRAINAGE	X	OTHER DEFECTS	X
		OTHER DEFECTS	X	FLOOR DRAINAGE 38-35-31		RIVETS	X		
		PILE FOUNDATIONS	X	OTHER DEFECTS	33	OTHER DEFECTS 39-34			
				SIDEWALKS	X	SIDEWALKS	X	SIDEWALKS	X

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (✓) MARK TO INDICATE "OK" OR "NONE". FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY.

REMARKS

(Use second sheet when space below is not sufficient. Also list cause of all defects when possible.)

SPAN #17 (Continued)

28. Disintegration of center mall (6 sq. ft. x 2")
29. Disintegration of bridge deck adjacent to center mall (50 sq. ft. x 1/2")
30. Disintegration in edge of slab between spans 17 and 18 (2 sq. ft. x 1")

SPAN #18

31. Scuppers full of sand
32. Transverse cracking in deck
33. Pop outs in slow lane, center of span (5 sq. ft. x 1")
34. Center mall flex beams bent with one stanchion loose (20 L.F.)

SPAN 19

35. Scuppers full of sand
36. Transverse cracking in deck

SPAN 20

37 - Transverse cracking in deck
38 - Scuppers full of sand
39 - Center mall flex beams bent (30 L.F.)

MAINTENANCE RECOMMENDATIONS

No.	Description of Work to be Done — When Possible Show Quantities	Est. Cost
	31-35-38 - Should be cleaned out	$100.00
	28-29-30 - Should be repaired (58 sq. ft. x 1")	200.00
	34-39 - Should be replaced (50 L.F.)	100.00
	33 - Should be patched (5 sq. ft. x 1")	75.00

8/18/65

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State Highway Department
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

TOWN: GREENWICH 00055 — R. No. 95 — MILES 4.3[illegible]
BRIDGE OVER: Mianus River — No. SPANS 24
TYPE: Rolled Beam and Girder — SPAN LENGTH 2,6[illegible]
INSPECTION MADE BY: Jacobson and Prigs — DATE 6/21/65

OBSERVATIONS Page Nine of nine

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY	X	UNDERMINING	X	CRACKING	46-42	CONDITION OF PAINT	X	WEAR	X
SCOUR	X	SETTLEMENT	X	SCALING	X	CORROSION	X	DECAY	X
OBSTRUCTIONS	X	CRACKING	X	DISINTEGRATION	47-44-40	EXPANSION JOINTS	X	STRUCTURAL DEFECTS	X
UNDERGROWTH	X	DISINTEGRATION	X	EXPANSION JOINTS	X	RAILINGS	X	RAILINGS	X
CHANNEL SHIFTING	X	DECAY (TIMBER)	X	RAILINGS	X	SHOES	X	FLOOR DRAINAGE	X
OTHER FEATURES	X	POINTING MASONRY	X	WATERPROOFING	X	FLOOR DRAINAGE	X	OTHER DEFECTS	-
		OTHER DEFECTS	X	FLOOR DRAINAGE	45-41	RIVETS	X		-
		PILE FOUNDATIONS	X	OTHER DEFECTS	X	OTHER DEFECTS	43		
				SIDEWALKS	X	SIDEWALKS	X	SIDEWALKS	X

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (X) MARK TO INDICATE "OK" OR "NONE" FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY.

REMARKS

(Use second sheet when space below is not sufficient. Also list cause of all defects when possible.)

SPAN 20 (Continued)

40. Disintegration in bridge deck, slow lane, center of span (3 sq. ft. x 1")

SPAN 21

41. Scuppers full of sand
42. Transverse cracks in deck
43. Center wall flex beams bent - 30 l.f.
44. Disintegration in pavement, slow lane between spans 21 and 20 (1 sq. ft. x 2")

SPAN 22

45. Scuppers full of sand
46. Transverse cracking in deck
47. Disintegration in pavement, slow lane, 20' from span 23 (1/2 sq. ft. x 1")

MAINTENANCE RECOMMENDATIONS

No.	Description of Work to be Done — When Possible Show Quantities	Est. Cost
	41-45 - Should be cleaned out	$50.00
	40-44-47 - Should be repaired (4½ sq. ft. x 1½")	100.00
	43 - Should be replaced (30 l.f.)	60.00

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Form No. SR. 18 ED [illegible]
State Highway Department
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

TOWN [illegible] R. No. [illegible] MILES [illegible]
BRIDGE OVER Mianus River No. SPANS 24
TYPE Rolled Beam and Girder SPAN LENGTH 2,6[illegible]
INSPECTION MADE BY Jacobson and Prigs DATE 10/4/66

OBSERVATIONS Page One of Two

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY	X	UNDERMINING	X	CRACKING	6	CONDITION OF PAINT	X	WEAR	X
SCOUR	X	SETTLEMENT	X	SCALING 4-1 -	7	CORROSION	X	DECAY	X
OBSTRUCTIONS	X	CRACKING	X	DISINTEGRATION	X	EXPANSION JOINTS	X	STRUCTURAL DEFECTS	X
UNDERGROWTH	X	DISINTEGRATION	X	EXPANSION JOINTS	X	RAILINGS	X	RAILINGS	X
CHANNEL SHIFTING	X	DECAY (TIMBER)	X	RAILINGS	X	SHOES	X	FLOOR DRAINAGE	X
OTHER FEATURES	X	POINTING MASONRY	X	WATERPROOFING	X	FLOOR DRAINAGE	X	OTHER DEFECTS	X
		OTHER DEFECTS	X	FLOOR DRAINAGE	7	RIVETS	X		
		PILE FOUNDATIONS	X	OTHER DEFECTS 1 to 5 / 2-3-5-13- 8 to 12		OTHER DEFECTS	X		
				SIDEWALKS	X	SIDEWALKS	X	SIDEWALKS	X

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (X) MARK TO INDICATE "OK" OR "NONE". FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY.

REMARKS

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EASTBOUND DECK FROM WEST:

Span 3 - 1. Popouts in slow lane - 2 SF x 1"
Span 7 - 2. Failure to edge of pavement adjacent to Span 8 - 1/4 SF x 1/2"
Span 13- 3. Popouts in center lane - 2 SF x 1"
4. Failure to edge of pavement adjacent to Span 14 - 1/4 SF x 1/2"
Span 14- 5. Three small popouts - 1 SF x 1/2"
6. Poor texture to concrete in deck
Span 16- 7. Light scaling in South gutter line - 1 SF x 1/2"
Span 17- 8. Failure to edge of pavement adjacent to Span 18 - 2 SF x 1/2"
Span 18- 9. Pop-outs in deck - 3 SF x 1/2"
Span 20-10. Pop-outs in deck - 1 SF x 1"
Span 21-11. Pop-outs in deck - 1/2 SF x 1/2"
Span 22-12. One small pop-out - 1/2 SF x 1/4"
Span 23-13. Failure to edge of pavement - 2 SF x 1/2"

WESTBOUND FROM WEST:

Span 10 -1. Medium scaling to deck adjacent to center mall - 10 SF x 1" to 1½"
Span 13 -2. Pop-outs in deck - 1 SF x 1"
Span 18 -3. Failure to edge of pavement adjacent to Span 19 - 1 SF x 1/2"
4. Light scaling various spots in deck
Span 19 -5. Pop-outs in deck - 3 SF x 1"
Span 21 - Pop-outs in deck - 6 SF x 1"
Span 22 - Pop-outs in deck - 1 SF x 1"
Span 23 - Pop-outs in deck - 1 SF x 1"

MAINTENANCE RECOMMENDATIONS

No.	Description of Work to be Done - When Possible State Quantities	Est. Cost
1 to 5 -, 8 to 12-	Concrete repair to deck - total 12½ SF x 1/2"	
13-2-3-5	Concrete repair to deck - 14 SF x 1"	

Form No. BRI 10 ED 1-47
State Highway Department
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

TOWN GREENWICH - 00015 R. No. 95 MILES 4.35
BRIDGE OVER Mianus River No. SPANS 21
TYPE Rolled Beam and Girder SPAN LENGTH 2,6[illegible]
INSPECTION MADE BY Jacobson and Friga DATE 10/4/66

Page Two of Two

OBSERVATIONS

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY	X	UNDERMINING	X	CRACKING	6	CONDITION OF PAINT	X	WEAR	X
SCOUR	X	SETTLEMENT	X	SCALING	X	CORROSION	X	DECAY	X
OBSTRUCTIONS	X	CRACKING	11	DISINTEGRATION	10	EXPANSION JOINTS	X	STRUCTURAL DEFECTS	X
UNDERGROWTH	X	DISINTEGRATION	X	EXPANSION JOINTS	X	RAILINGS	9	RAILINGS	X
CHANNEL SHIFTING	X	DECAY (TIMBER)	X	RAILINGS	X	SHOES	X	FLOOR DRAINAGE	X
OTHER FEATURES	X	POINTING MASONRY	X	WATERPROOFING	X	FLOOR DRAINAGE	8	OTHER DEFECTS	X
		OTHER DEFECTS	12-13	FLOOR DRAINAGE	7	RIVETS	X		
		PILE FOUNDATIONS	X	OTHER DEFECTS	X	OTHER DEFECTS	X		
				SIDEWALKS	X	SIDEWALKS	X	SIDEWALKS	X

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (X) MARK TO INDICATE "OK" OR "NONE". FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY.

REMARKS

(Use second sheet when space below is not sufficient. Also list cause of all defects when possible.)

GENERAL FOR DECK:

6. Transverse cracks various spans
7. All scuppers and dams full of sand
8. Expansion dam covers on center mall missing - total - 3
9. Center mall flex beams bent - total 110 L.F.
10. Disintegration to top of South parapet wall - Span 15 Eastbound - total 2 CF
    Disintegration in parapet curb - Span 23 - Eastbound - 10 SF x 1"
    Disintegration to various spots of center mall
11. Crack in corner of girder pad - 17 pier from West, first pier from North
12. Spall in East abutment under first girder jacked with piling
    Spall developing in East abutment under second girder
13. Pier 1 from West abutment appears to have been pushed forward due to thrust.

MAINTENANCE RECOMMENDATIONS

No.	Description of Work to be Done — When Possible Show Quantities	Est. Cost
	10/12/66 [illegible]	

Form No. BR-10 ED 4-56
State Highway Department
STATE OF CONNECTICUT

BRIDGE INSPECTION REPORT

TOWN Greenwich R. No. I-95 - 1/0 MILES
BRIDGE OVER Mianus River No. SPANS 24
TYPE Plate Girder BRI. No. 15 SPAN LENGTH 2661'
INSPECTION MADE BY White & D'Amato DATE 9/1/67

OBSERVATIONS

WATERWAY		PIERS AND ABUTMENTS		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER STRUCTURES AND FLOORS	
ADEQUACY		UNDERMINING		CRACKING	2	CONDITION OF PAINT	7	WEAR	
SCOUR		SETTLEMENT		SCALING	3	CORROSION		DECAY	
OBSTRUCTIONS		CRACKING	1	DISINTEGRATION	4	EXPANSION JOINTS	8	STRUCTURAL DEFECTS	
UNDERGROWTH		DISINTEGRATION		EXPANSION JOINTS		RAILINGS	7	RAILINGS	
CHANNEL SHIFTING		DECAY (TIMBER)		RAILINGS	4	SHOES		FLOOR DRAINAGE	
OTHER FEATURES		POINTING MASONRY		WATERPROOFING	5	FLOOR DRAINAGE		OTHER DEFECTS	
		OTHER DEFECTS		FLOOR DRAINAGE	6	RIVETS			
		PILE FOUNDATIONS		OTHER DEFECTS		OTHER DEFECTS			
				SIDEWALKS		SIDEWALKS		SIDEWALKS	

MAKE ABOVE OBSERVATIONS FOR EACH PART OF STRUCTURE AND NOTE WITH (✓) MARK TO INDICATE "OK" OR "NONE" FOR ITEMS NEEDING EXPLANATION MARK WITH A CIRCLE WITH A NUMBER INSERTED TO REFER TO THE CORRESPONDING REMARKS LISTED BELOW. AMPLIFY ON SECOND SHEET AND INCLUDE SKETCHES WHEN NECESSARY

REMARKS

(Use second sheet when space below is not sufficient. Also list cause of all defects when possible.)

Built 1958

1. First & second girder pads east abutment south end cracked completely thru at anchor bolts, areas each 4 sq. ft. 10" deep. Damage result of previous pavement thrust. Both girders braced with steel piling.

2. Heavy transverse cracking in (3) spans over river.

3. Eastbound deck has scaling 65 sq. ft. 1" to 21" deep. Westbound deck has scaling 55 sq. ft. 1" to 4" deep. North curb has scaling 15 l.f. 1" to 2" deep. South curb has scaling 20 l.f. 1" to 4" deep. Popouts in westbound deck 60 sq. ft. 1" to 4" deep. Popouts in eastbound deck 40 sq. ft. 1" to 4" deep.

4. South parapet has disintegration 5 l.f. 2" deep. Center median has disintegration 40 sq. ft. 2" to 4" deep.

5. Deck joints need sealing approx. 300 l.f.

6. (30) deck basins plugged.

7. Railings very rusty - 5,332 l.f. beams have light to medium rust. Center median flex beam needs painting 1265 l.f. 25 l.f. on EB side is bent.

8. Expansion joint troughs are filled with sand. 25' of trough is missing over Pier #6 from west end. Expansion dam covers on center wall missing Total (3) Conc. pave. both ends 2' relief joints provided

MAINTENANCE RECOMMENDATIONS

No.	Description of Work to be Done — When Possible Show Quantities	Est. Cost
D	Structure on list "K" of bridge maint. program for repair by contract 1967-69.	None

STATE OF CONNECTICUT
HIGHWAY DEPARTMENT
BRIDGE INSPECTION
Form No.

TOWN [illegible] ROUTE [illegible] BRIDGE NO. [illegible]
STRUCTURE [illegible]
GENERAL CONDITION OF STRUCTURE - GOOD ___ FAIR ✓ POOR ___ CRITICAL ___
INSPECTED BY [illegible] DATE [illegible]

AUDIT for YEAR 19__
REVIEWED BY: [illegible]

FIELD OBSERVATION (1 GOOD, 2 FAIR, 3 POOR, 4 CRITICAL) — REMARKS (Print or Type)
RECOMMENDATION — [illegible] — INSPECTION [illegible] — PROGRAM — REMARKS

A. DECK	1	2	3	4	Remarks	Recommendation Remarks
1. Slab - Concrete					Tr. Cracking	
2. Bearing Surface					40 S.Y. - L. S.Sp. 1-4"	50 S.Y. - [illegible]
3. Joints - Exp. (16)					(Steel) - plugged w/ sand	L.S. - [illegible]
4. - Fixed						
5. - Const.						
6. - Longl.					500 L.F. - Median	[illegible]
7. Curb					30 L.F. - S.Sp. 1-4"	[illegible]
8. Sidewalk						
9. Parapet						
10. Rail - ~~Conc. or~~ Steel						
11. Floor Drainage					[illegible]	[illegible]
12. Median					35 S.Y. S.Sp. 1-4"	[illegible]
13. Paint					5330 L.F. Rails	[illegible]
14.						

B. SUPERSTRUCTURE — Concrete ✓ Steel ✓ Wood ___ Masonry ___ [illegible]

B. SUPERSTRUCTURE	1	2	3	4	Remarks	Recommendation Remarks
1. Structural Beam						
2.						
3. Bracing						
4. Paint					5166 Ton SS	[illegible]
5. Bearing - Exp.						
6. - Fixed						
7. Rivets & Bolts						
8. Drainage System					25 L.F. missing [illegible]	[illegible]
9.						

C. SUBSTRUCTURE — Concrete ✓ Steel ___ Wood ___ Masonry ___ [illegible]

C. SUBSTRUCTURE	1	2	3	4	Remarks	Recommendation Remarks
1. Pier - Footing						
2. - Stem						
3. - Cap						
4. Abutment - Footing						
5. - Stem						
6. - Seat						
7. Bearing Pad					2 S.F. 4" chipped	[illegible]
8. Curtain Wall						
9. Wingwall						
10. Arch						
11.						

D. MISC. STRUCTURAL AND ROADWAY ELEMENTS — Approach Roadway Flexible ___ [illegible]

D. MISC. STRUCTURAL AND ROADWAY ELEMENTS	1	2	3	4	Remarks	Recommendation Remarks
1. Approach Joint						
2. Approach Pavement					T. Sp. & "D" Cracking	L.S. - [illegible]
3. Approach Slab						
4. Relief Joints						
5. Waterway						
6. Alignment						

Sufficiency Rating ______ Estimated Cost [illegible]

STATE OF CONNECTICUT HIGHWAY DEPARTMENT PAGE 1
BRIDGE INSPECTION REPORT FOR 1968
TOWN GREENWICH ROUTE 095 BRIDGE NO. 00015
STRUCTURE OVER MIANUS RIVER PLATE GIRD.-DECK PLATE GIRDER 24
GENERAL CONDITION OF STRUCTURE GOOD FAIR & POOR CRITICAL
INSPECTED BY [illegible] REVIEWED BY RJS DATE 06-04-68

FIELD OBSERVATION	REMARKS	RECOMMENDATIONS KEEP UNDER OBSERVATION INSPECTION IN DEPTH PROGRAM - M OR C COST
A. DECK		
1. WEAR.-COURSE	[illegible] CRACKING	
2. BEARING SURFACE	[illegible] LS SP [illegible]	50,00ST 2000
3. JOINTS-EXP.	STEEL PLUGGED W/ SAND	LS 500
4. -FIXED		
5. -CONST.		
6. -LONGL.	[illegible]OLF MEDIAN	3,00LF 1500
7. CURB	[illegible]OLF S SC [illegible]	10,00LF 400
8. SIDEWALK		
9. PARAPET		
10. RAIL		
11. FLOOR DRAINAGE	DECK GRATES PLUGGED	LS 400
12. [illegible]	[illegible] S SC [illegible]	50,00ST 250
13. PAINT	[illegible]OLF RAILS	2,00LF
14.		
B. SUPER-STRUCTURE	CONCRETE & STEEL & WOOD	MASONRY
1. STRUCTURAL BEAM		
2.		
3. BRACING		
4. PAINT	[illegible] TONS SS	25,00TO,127500
5. BEARING-EXP.		
6. -FIXED		
7. RIVETS + BOLTS		
8. DIAPHRAGM STEEL	[illegible] MISSING HOLES [illegible]	LS 500
9.		
C. SUB-STRUCTURE	CONCRETE & STEEL WOOD	MASONRY
1. PIER-FOOTING		
2. -STEM		
3. -CAP		
4. ABUT.WALL-FOOTING		
5. -STEM		
6. -SEAT		
7. BEARING PAD	[illegible] CHIPPED	CA 200
8. CURTAIN WALL		
9. WINGWALL		
10. [illegible]		
11.		
D. [illegible]	[illegible]	[illegible]
1. APPROACH [illegible]		
2. APPROACH PAVEMENT	[illegible] CRACKING	LS 500
3. APPROACH [illegible]		
4. [illegible] JOINTS		
5. [illegible]		
6. [illegible]		

[illegible] ESTIMATED COST $ 133[illegible]

STATE HIGHWAY DEPARTMENT
STATE OF CONNECTICUT

BRIDGE INSPECTION

Town: GREENWICH Route: 95 Bridge No.: 0.0.0.
Structure: PLT GIR O MIANUS RIVER
General condition of structure — Good ___ Fair ✓ Poor ___ Critical ___
Inspected by: WHITE & D'AMATO Date: 05 01 69

Report for 19 69
Reviewed by: RTS

	FIELD OBSERVATION					RECOMMENDATIONS				
	1 Good	2 Fair	3 Poor	4 Critical	REMARKS (Print or type)	1 Keep under observation	2 Inspection in depth	3 Maintenance	4 Contract	COST
A DECK										
1. Slab-Concrete		✓			TY CRACKING	✓				
2. Wearing surface			✓		SEE E. GEN REMARKS					
3. Joints-Exp.										
4. -Fixed	✓									
5. -Const.	✓									
6. -Longit.			✓		600 L.F. SEAL				✓	3 LF 1,800
7. Curb		✓			SEE REMARKS					
8. Sidewalk										
9. Parapet	✓				YT CRACKS	✓				
10. Rail-Steel		✓			(4) RAIL SECTIONS BENT			✓		LS 100
11. Floor drainage			✓		(25) GRATES PLUGGED			✓		LS 500
12. Median		✓			SEE REMARKS					
13. Paint			✓		5330 LF RAILS				✓	2 LF 10,660
14.										
B SUPERSTRUCTURE (Concrete ✓ Steel ✓ Wood ___ Masonry ___)										
1. Structural beam	✓									
2.										
3. Bracing	✓									
4. Paint			✓		5100 TON				✓	30 TON 152,000
5. Bearings-Exp.		✓			INSUFFICIENT MOVEMENT	✓				
6. -Fixed	✓									
7. Rivets & bolts	✓									
8. Drainage system					CLEAN TROUGHS-25 LF REPL			✓		LS 500
9.										
C. SUBSTRUCTURE (Concrete ✓ Steel ___ Wood ___ Masonry ✓)										
1. Pier-Footing	✓									
2. -Stem		✓			2 SF M. SC			✓		25 SF 50
3. -Cap		✓			DEBRIS			✓		LS 00
4. Abutment-Footing										
5. -Stem	✓									
6. -Seat	✓				DEBRIS			✓		LS 50
7. Bearing pad			✓		(1) PAD 2 SF L.S.SP. 4"			✓		50 SF 100
8. Curtain wall	✓				YT CRACKS	✓				
9. Wingwall										
10. Arch										
11.										
D. MISC. STRUCTURAL AND ROADWAY ELEMENTS (Approach roadway: Flexible ___ Rigid ✓)										
1. Approach joint	✓									
2. Approach pavement			✓		JSP. & "D" CRACKING			✓		
3. Approach slab										
4. Relief joints	✓									
5. Waterway	✓									
6. Alignment	✓									

E. GENERAL REMARKS DECK REPAIR & COATING IN PROGRESS

Sufficiency rating ______ Estimated total cost 166,860

STATE HIGHWAY DEPARTMENT
STATE OF CONNECTICUT

BRIDGE INSPECTION

Town: GREENWICH Route: 95
Structure: PLT GIR O MIANUS RIVER
Inspected by: WHITE & D'AMATO Date: 04283

Report for 19 70

Reviewed by: RJS

FIELD OBSERVATION / **RECOMMENDATIONS**

REMARKS / COST

A. DECK

Item	No.	Field Observation Remarks	Recommendations	Cost
1. Slab-Concrete	43	✓ 10 SF LS SP 2" (BOTTOM)	✓ 20 SF	200
2. Wearing Surface	45	✓ 20 SY ASPHALT WORN OFF	✓ LS	1000
3. Joints-Exp. STEEL	47	✓		
4.	49	✓		
5.	51			
6.	53	✓ 800 LF SEAL · 10 LF I.SP 3"	✓ 8 LF	2430
7.	55	✓ 60 LF H.SC	✓ 5 LF	300
8.	57			
9. Parapet	59	✓ 10 LF S.SC. 3"	✓ 20 LF	200
10.	61	✓ 30 LF REPAINT	✓ 3 LF	150
11.	63	✓ (44) GRATES	✓ LS	[illegible]
12.	65	✓		
13.	67	✓ 5330 LF RAILS	✓ 2 LF	10,66[illegible]
14.	69			

B. SUPERSTRUCTURE Concrete ✓ Steel ✓

Item	Field Observation Remarks	Recommendations	Cost
1.	✓		
2.			
3. Bracing	✓		
4. Paint	✓ 5100 TON	✓ 30 TON	153,[illegible]
5.	✓ INSUFF. CLEAR	✓ LS	100,0[illegible]
6.	✓		
7.	✓		
8. Drainage	✓ CLEAN TROUGHS REPLACE PIPE	✓ LS	50[illegible]
9.			

C. SUBSTRUCTURE Concrete ✓

Item	No.	Field Observation Remarks	Recommendations	Cost
1. Pier - Footing	27	✓		
2.	29	✓ 2 SF H.SC	✓	
3. - Cap	31	✓		
4. Abutment	33			
5.	35	✓		
6.	37	✓		
7. Bearing Pad	39	✓ 2 SF LS SP 4" (1) PAD	✓ 25 SF	50
8. Curtain Wall	41	✓ VT CRACKS	✓	
9. Wingwall	43			
10.	45			
11. FENDER RACK	47	✓ (8) BOARDS REPL PIER IV	✓ LS	10[illegible]

D. MISC. STRUCTURAL AND ROADWAY ELEMENTS

Item	No.	Field Observation
1. Approach	50	✓
2. Approach Pavement	52	✓
3. Approach Slab		
4. Relief Joints	56	✓
5. Waterway	58	✓
6. Alignment		✓

E. GENERAL REMARKS LAST PAINT 1970 PROJ. 56-117 • EXP BEARING REPAIR 1971-73

Sufficiency Rating

Estimated Total Cost 269,040

FORM NO. BRI-18 [illegible]
STATE HIGHWAY DEPARTMENT
STATE OF CONNECTICUT

BRIDGE INSPECTION

TOWN GREENWICH ROUTE 95 BRIDGE NO. 00.015
STRUCTURE PLT GIR O MIANUS RIVER
GENERAL CONDITION OF STRUCTURE: GOOD [illegible] FAIR ✓ POOR [illegible] CRITICAL [illegible]
INSPECTED BY WHITE & D'AMATO DATE 06 14 71

REPORT FOR 19 71
REVIEWED BY R J S

FIELD OBSERVATION / RECOMMENDATIONS

(PRINT OR TYPE)

A DECK

Item	Code	Good	Fair	Poor	Critical	Remarks	Code	Keep under observation	Inspection in depth	Maintenance	Contract	Cost
1. SLAB-CONCRETE	43		✓			10 SF LS SP 2" (BOTTOM)	44	✓				
2. WEARING SURFACE	45	✓				ASPHALT COVER	46					
3. JOINTS-EXP. STEEL	47	✓					48					
4. -FIXED	49		✓			20 SF J.SP. 2" (ASPHALT)	50			✓		10 SF 200
5. -[illegible]	51						52					
6. -[illegible]	53			✓		800 LF SEPL	54	✓				
7. CURBS	55		✓			60 LF H.SC.	56			✓		5 LF 300
8. SIDEWALK	57						58					
9. PARAPET	59		✓			12 LF S.SC. 3"	60			✓		10 LF 120
10. RAIL- STEEL	61		✓			25 LF REPAIR	62			✓		10 LF 25[illegible]
11. FLOOR DRAINAGE	63			✓		CLEAN BASINS (44)	64			✓		LS 200
12. MEDIAN	65	✓					66					
13. PAINT	67	✓					68					
14.	69						70					

B SUPERSTRUCTURE

CONCRETE ✓ STEEL ✓ [illegible] ____ [illegible] ____

Item	Code	Good	Fair	Poor	Critical	Remarks	Code	Keep under observation	Inspection in depth	Maintenance	Contract	Cost
1. [illegible] BEAM	9	✓					10					
2.	11						12					
3. BRACING	13	✓					14					
4. PAINT	15	✓					16					
5. [illegible]	16			✓		INSUFF CLEAR	17	✓				
6. [illegible]	18		✓				19					
7. [illegible]	20	✓					21					
8. DRAINAGE [illegible]	22			✓		CLEAN SCUPPERS	23			✓		LS 500
9. CATWALK TREAD	24			✓		825 LF REPAIR	25			✓		2 LF 165

C SUBSTRUCTURE

CONCRETE ✓ STEEL ____ [illegible] ____ [illegible] ____

Item	Code	Good	Fair	Poor	Critical	Remarks	Code	Keep under observation	Inspection in depth	Maintenance	Contract	Cost
1. PIER-FOOTING	27	✓					28					
2. -STEM	29		✓			2 SF S.SC. 24	30			✓		25 SF 30
3. -CAP	31	✓					32					
4. ABUTMENT-FOOTING	33						34					
5. -STEM	35	✓					36					
6. -SEAT	37	✓					38					
7. BEARING [illegible]	39		✓			VT CRACK PIER # 22 So.	40	✓				
8. CURTAIN WALL	41	✓				VT CRACKS	42	✓				
9. WINGWALL	43	✓					44					
10. APRON	45						46					
11. FENDER RACK	47		✓			(3) BOARD REPLACE PIER 18	48			✓		LS 10[illegible]

D. MISC. STRUCTURAL AND ROADWAY ELEMENTS

APPROACH ROADWAY FLEXIBLE ____ RIGID ✓

Item	Code	Good	Fair	Poor	Critical	Remarks	Code	Keep under observation	Inspection in depth	Maintenance	Contract	Cost
1. APPROACH JOINT	50	✓					51					
2. APPROACH PAVEMENT	52	✓					53					
3. APPROACH SLAB	54						55					
4. RELIEF JOINT	56		✓			3" HIGH (HWY MAINT)	57	✓				
5. WATERWAY	58	✓					59					
6. [illegible]	60		✓				61					

E. GENERAL REMARKS PIER & BEARING MOVEMENT SURVEY UNDERWAY

SUFFICIENCY RATING ____

ESTIMATED TOTAL COST 337[illegible]

FORM NO. BRI-[illegible]
STATE HIGHWAY DEPARTMENT
STATE OF CONNECTICUT

BRIDGE INSPECTION

TOWN: GREENWICH ROUTE: 95 BRIDGE NO.: 0001[illegible]
STRUCTURE: PLT GIR O MIANUS RIVER
GENERAL CONDITION OF STRUCTURE — GOOD ___ FAIR ✓ POOR ___
INSPECTED BY: WHITE & DEMATO DATE: 042472

REPORT FOR 19 78

REVIEWED BY: R.J.S.

FIELD OBSERVATION / RECOMMENDATIONS

(PRINT OR TYPE) REMARKS

RECOMMENDATIONS: NEEDS UNDER SCRUTINY / CORRECTION BY DEPT. / MAINTENANCE / CONTRACT / COST

A. DECK

Item	Col.	Good	Fair	Poor	Critical	Remarks	Recommendations
1. Slab-Concrete	43		✓			10 SF LSSP 2.5" TV CRACK BTM	✓
2. Wearing Surface	45		✓			ASPHALT OVER	
3. Joints-Seal	47		✓			FILLED W/ SAND	✓
4. -[illegible]	49		✓			30 SF 2½" BROKEN OFF [illegible] SEAL	✓
5. -[illegible]	51	✓					
6. -[illegible]	53		✓			10 SF [illegible] 3" BTM [illegible]	✓
7. Curb	55		✓			60 LF [illegible] VT CRACKS	✓
8. Sidewalk	57						
9. Parapet	59		✓			14 LF SSC .3" VT CRACKS	✓
10. Rail-Conc./Steel	61		✓			(4) RAILS BENT	✓
11. [illegible]	63		✓			(20) GRATES PLUGGED	✓
12. Median	65	✓					
13. Paint	67	✓					
14.	69						

B SUPERSTRUCTURE

CONCRETE ✓ STEEL ✓ [illegible] ___

Item	Col.	Good	Fair	Poor	Critical	Remarks	Recommendations
1. [illegible]	8	✓					
2.	10	✓					
3. Bracing	12	✓					
4. Paint	14		✓				
5. Bearings-[illegible]	16		✓			INSURE MAINT CLEAN & PAINT	✓
6. -[illegible]	18		✓			POSSIBLE REALIGNMENT PIER 12	✓
7. Rivets & Bolts	20	✓					
8. Drainage System	22		✓			25 LF REPLACE	✓
9. CAT WALK	24		✓			1-8" SAND CENTER WALK	✓

C SUBSTRUCTURE

CONCRETE ___ STEEL ___ [illegible] ___

Item	Col.	Good	Fair	Poor	Critical	Remarks	Recommendations
1. Pier-Footing	27	✓					
2. -Stem	29		✓			9 SF SSC 2"	✓
3. -Cap	31		✓			VT CRACKS PIER RC CENTER	✓
4. Abutment-Footing	33						
5. -Stem	35	✓					
6. -Seat	37		✓			DEBRIS	
7. Bearing Pad	39		✓			(1) PAD VT CRACKS PIER 22 SO.	
8. Curtain Wall	41	✓				VT CRACKS	
9. Wingwall	43	✓					
10. [illegible]	45						
11. FENDER RACK	47		✓			WALERS PIER #18	

D. MISC. STRUCTURAL AND ROADWAY ELEMENTS

APPROACH ROAD [illegible] FLEXIBLE ___ RIGID ✓

Item	Col.	Good	Fair	Poor	Critical	Remarks	Recommendations
1. Approach Joint	50	✓					
2. Approach Pavement	52	✓					
3. Approach Slab	54	✓					
4. Relief Joint	56	✓					
5. Waterway	58	✓					
6. Alignment	60	✓					

E. GENERAL REMARKS

SUBMITTED FOR BEARING REPAIR BY CONTR 1971-73

SUFFICIENCY RATING ______ ESTIMATED TOTAL COST ______

FORM BRI-18 ED. 5/72
STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS
BRIDGE INSPECTION
SHEET 1 OF 2

ROUTE I95 BRIDGE NO. 00015 TOWN GREENWICH
TYPE PLT GIR CROSSING MIANUS RIV. YR. BUILT 1958
INSPECTED BY WHITE + McNAMARA DATE 1-29-73

	COND.	RAT.	REMARKS
58 DECK	9-0	9-5	9-0
1 Wearing Surf.	• •	8	ASPHALT — INSPECTORS COND. RAT. 7
2 Deck-Str. Cond.	7	• •	LSSP. TV
3 Curbs	• •	6	SSC VT
4 Median	• •	8	INSUFF CLEAR FLEX BM . Rep
5 Sidewalks	• •	7	
6 Parapet	• •	6	SSC VT
7 Railing	• •	6	(9) RAILS BENT (1) POST PULLED LOOSE
8 Paint	• •	8	
9 Drains	• •	5	20 GRATES PLUGGED
10 Lighting Standard	• •	6	(1) BROKE OFF
11 Utilities	• •	7	
12 Joint Leakage	• •	6	RESEAL
13 Exp. Joints	• •	8	
59 SUPERSTRUCTURE			9-0
1 Bearing Devices	5	• •	INSUFF. MOVEMENT ✓ — INSPECTORS COND. RAT. 5 — RUST
2 Stringers	6	• •	
3 Girders or Beams	8	• •	
4 Floor Beams	8	• •	
5 Trusses - General	/	• •	
Portals	• •	/	
Bracing	• •	/	
6 Paint	• •	6	STRUCT STEEL
7 Machinery Mov. Span	/	• •	
8 Rivets & Bolts	• •	7	TIPPED
9 Welds - Cracks	• •	8	
10 Rust	• •	6	BEARING AREA: GIR FLOOR BM
11 Timber Decay	• •	/	
12 Concrete Cracking	• •	7	TV DN - VT CURBS + PARAPETS
13 Collision Damage	• •	6	
14 Deflection und. Load	• •	• •	NORMAL ☒ EXCESSIVE ☐
15 Alignment ...	• •	8	
16 Vibration ...	• •	• •	NORMAL ☒ EXCESSIVE ☐
60 SUBSTRUCTURE			9-0
1 Abutments - Stem	• •	8	INSPECTORS COND. RAT 6
Backwall	• •	5	VT. LSSP
Footing	• •	NV	
Erosion	8	• •	
Settlement	8	• •	
Wingwalls	• •	8	
2 Piers or Bents - Caps	8	• •	
Column	6	• •	SSC VT
Footing	• •	8	
Scour	8	• •	
Settlement	8	• •	
3 Pile Bent	/	• •	
4 Concrete Crack - Spall	• •	7	VT. PAD
5 Steel Corrosion	6	• •	SCUPPERS
6 Timber Decay	/	• •	
7 Debris on Seats	• •	7	
8 Paint	• •	5	SCUPPERS
9 Collision Damage	8	• •	

FORM NO. BRI-18 ED. 5/72
STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

BRIDGE NO. 00015 OVERALL LENGTH 2166
SUFFICIENCY RATING ______ DATE 1-21-75

BRIDGE INSPECTION
SHEET 2 OF 2

	COND.	RAT.	REMARKS
61 CHANNEL & CHANNEL PROTECTION	9-0	9-5	INSPECTORS COND. RAT. (9-5): 6
1 Channel Scour	• •	8	
2 Embankment Erosion	• •	8	
3 Debris	• •	6	Boat sunk at pier #2D ✓
4 Vegetation	• •	8	
5 Channel Change	• •	8	
6 Fender System	• •	6	(3) planks missing (2) planks(s) (?) posts
7 Spur Dikes & Jetties	• •	8	
8 Rip Rap	• •	7	
9 Adequacy of Opening	• •	8	
62 CULVERT & RETAINING WALLS			INSPECTORS COND. RAT. (9-0): NA
1 Barrel			
Concrete	/	• •	
Steel	/	• •	
Timber	/	• •	
2 Headwall	• •	/	
3 Cutoff Wall	• •	/	
4 Adequacy	• •	/	
5 Debris	• •	/	
6 Retaining Wall-Stem	/	• •	
Footing	/	• •	

63 EST. REMAINING LIFE — YEARS 36

64 PERMIT CAPACITY Unknown

	COND.	RAT.	REMARKS
65 APPROACH ALIGNMENT			INSPECTORS COND. RAT. (9-5): 7
1 Alignment	• •	7	Curved
2 Approach Slab	• •	8	
3 Relief Joints	• •	8	
4 Approach-Guide rail	• •	8	
Pavement	• •	8	
Embankment	• •	8	
66 RATED LOADING			
1 Posted Loading	• •	• •	TONS: SINGLE UNIT — SEMI-TRAILER —
2 Advance Warning	• •	• •	YES ☐ NO ☐
3 Legibility	• •	/	
4 Visibility	• •	/	

67 STRUCTURAL CONDITION — INSPECTORS APPRAISAL OF GENERAL CONDITION OF STRUCTURE (2-0): 6

Is OH Clearance 14'-6" or less? — POSTED? — ADVANCE WARNING? —

ADDITIONAL NOTES

✓ Maint. (E.R.) advised 3/4/75

FORM BRI-38 REV. 3/75
STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS
BRIDGE INSPECTION
SHEET 1 OF 2

ROUTE 95 BRIDGE NO. 00015 TOWN GREENWICH
TYPE PLT GIR CROSSING [illegible] RIV. YR. BUILT [illegible]
INSPECTED BY WHITE - D.D & P.B DATE 5-17-77

	COND.	RAT.		
58 DECK	9-0	9-5		9.
1 Wearing Surf.	• •	8	ASPHALT OVER	INSPECTORS
2 Deck-Str. Cond.	7	• •	L.S. sp - TV w/EFFLOR BOTTOM	COND. RAT.
3 Curbs	• •	5	REPAIRED VERT. (HL)	
4 Median	• •	8		
5 Sidewalks	• •			
6 Parapet	• •	8	REPAIRED VERTICAL (HL)	
7 Railing	• •	8	REPAIRED	
8 Paint	• •	8		
9 Drains	• •	3	(20) GRATES PLUGGED	
10 Lighting Standard	• •	7	(1) BROKE OFF	
11 Utilities	• •			
12 Joint Leakage	• •	6	RESEAL	
13 Exp. Joints	• •	8		

	COND.	RAT.		
59 SUPERSTRUCTURE				9.
1 Bearing Devices	6	• •	INSUFFICIENT MOVEMENT [illegible]	INSPECTORS COND. RAT.
2 Stringers		• •		
3 Girders	8	• •	LIGHT RUST	
4 Floor Beams	8	• •	" "	
5 Trusses - General		• •		
Portals	• •			
Bracing	• •			
6 Paint	• •	7	GIR, BEARINGS, FLR B BMS	
7 Machinery Mov. Span		• •		
8 Rivets & Bolts	• •	7	TIPPED	
9 Welds - Cracks	• •	5		
10 Rust	• •	6	BEARINGS, GIR, FLOOR BMS	
11 Timber Decay	• •			
12 Concrete Cracking	• •	7	TV DK, VERT. CURBS - PARAPETS	
13 Collision Damage	• •	5		
14 Deflection und. Load	• •	• •	NORMAL ☒ EXCESSIVE ☐	
15 Alignment of Members	• •	8		
16 Vibration und. Load	• •	• •	NORMAL ☒ EXCESSIVE ☐	

	COND.	RAT.		
60 SUBSTRUCTURE				9.
1 Abutments - Stem	• •	8		INSPECTORS
Backwall	• •	7	L.S. sp VERT. (HL)	COND. RAT. 6
Footing	• •	NV		
Erosion	8	• •		
Settlement	8	• •		
Wingwalls	• •	8		
2 Piers - Caps	5	• •	VERT. (HL)	
Columns	6	• •	S. sc VERT (HL) RUST STAINS	
Footing	• •	8		
Scour	8	• •		
Settlement	8	• •		
3 Pile Bent		• •		
4 Concrete Crack - Spall	• •	7	(3) PIERS L.S. sp VERT. & [illegible]	
5 Steel Corrosion	7	• •	SCUPPERS HEAVY RUST	
6 Timber Decay		• •		
7 Debris on Seats	• •	5		
8 Paint	• •	5	SCUPPERS	
9 Collision Damage	8	• •		

FORM BRI-18 REV. 3/75
STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS
BRIDGE INSPECTION
SHEET 2 OF 2

BRIDGE NO. 00015 OVERALL LENGTH 2666'
SUFFICIENCY RATING DATE 5-12-77

	COND.	RAT.	REMARKS
61 CHANNEL & CHANNEL PROTECTION	9-0	9-5	INSPECTORS COND. RAT. 9
1 Channel Scour	• •	8	
2 Embankment Erosion	• •	8	
3 Debris	• •	8	
4 Vegetation	• •	8	
5 Channel Change	• •	8	
6 Fender System	• •	6	(3) PLANKS MISSING (6) PLANKS (6) BEST...
7 Spur Dikes & Jetties	• •	8	
8 Rip Rap	• •	X	
9 Adequacy of Opening	• •	8	
62 CULVERT & RETAINING WALLS			INSPECTORS COND. RAT. 9
1 Barrel			
Concrete	X	• •	
Steel	X	• •	
Timber	X	• •	
2 Headwall	• •	X	
3 Cutoff Wall	• •	X	
4 Adequacy	• •	X	
5 Debris	• •	X	
6 Retaining Wall-Stem	X	• •	
Footing	X	• •	

63 EST. REMAINING LIFE YEARS 31

64 PERMIT CAPACITY

	COND.	RAT.	REMARKS
65 APPROACH ALIGNMENT			INSPECTORS COND. RAT. 9
1 Alignment	• •	7	CURVED
2 Approach Slab	• •	8	
3 Relief Joints	• •	8	
4 Approach-Guide rail	• •	8	
Pavement	• •	8	
Embankment	• •	8	
66 RATED LOADING			
1 Posted Loading	• •	• •	TONS: SINGLE UNIT — SEMI-TRAILER —
2 Advance Warning	• •	• •	YES ☐ NO ☐
3 Legibility	• •	X	
4 Visibility	• •	X	

67 STRUCTURAL CONDITION INSPECTORS APPRAISAL OF GENERAL CONDITION OF STRUCTURE 9

Is O.H. Clearance 14'-6" or less? POSTED? ADVANCE WARNING?

ADDITIONAL NOTES

Traffic Safety Feature 1011

FORM BRI-18 REV. 3 75
STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS
BRIDGE INSPECTION
SHEET 1 OF 2

ROUTE 95 BRIDGE NO. [illegible] TOWN [illegible]
TYPE [illegible] CROSSING [illegible] YR. BUILT [illegible]
INSPECTED BY [illegible] DATE 8-2-79

	COND.	RAT.		
58 DECK	9-0	9-5		0.
1 Wearing Surf. Asphalt	• •	6	[illegible]	INSPECTORS
2 Deck-Str. Cond.	7	• •	[illegible]	COND. RAT. –
3 Curbs	• •	5	[illegible]	
4 Median	• •	5	[illegible]	
5 Sidewalks	• •	N		
6 Parapet	• •	5	[illegible]	
7 Railing	• •	5	[illegible]	
8 Paint	• •	6	[illegible]	
9 Drains	• •	5	[illegible] clogged [illegible]	
10 Lighting Standard	• •	5		
11 Utilities	• •	N		
12 Joint Seepage	• •	6	[illegible]	
13 Exp. Joints Steel	• •	6	[illegible]	
59 SUPERSTRUCTURE				9.
1 Bearing Devices	5	• •	[illegible]	INSPECTORS
2 Stringers	5	• •	Light Rust	COND. RAT. 5
3 Girders or Beams	5	• •	Med. Rust	
4 Floor Beams	5	• •	Med. Rust	
5 Trusses - General		• •		
Portals	• •	N		
Bracing	• •	6		
6 Paint	• •	6	[illegible]	
7 Machinery Mov. Span		• •		
8 Rivets & Bolts	• •	5		
9 Welds - Cracks	• •	5		
10 Rust	• •	6	[illegible]	
11 Timber Decay	• •	N		
12 Concrete Cracking	• •	6	[illegible]	
13 Collision Damage	• •	5		
14 Deflection und. Load	• •	• •	NORMAL [x] EXCESSIVE [ ]	
15 Alignment of Members	• •	8		
16 Vibration und. Load	• •	• •	NORMAL [x] EXCESSIVE [ ]	
60 SUBSTRUCTURE				9-[illegible]
1 Abutments - Stem	• •	8		INSPECTORS
Backwall	• •	5	[illegible]	COND. RAT. 6
Footing	• •	N		
Erosion	8	• •		
Settlement	8	• •		
Wingwalls	5	8		
2 Piers or Bents - Caps	7	• •	[illegible]	
Columns	6	• •	[illegible]	
Footing	• •	8		
Scour	8	• •		
Settlement	8	• •		
3 Pile Bent	N	• •		
4 Concrete Crack - Spall	• •	7	[illegible]	
5 Steel Corrosion	6	• •	[illegible]	
6 Timber Decay	N	• •		
7 Debris on Seats	• •	8		
8 Paint	• •	5	[illegible]	
9 Collision Damage	8	• •		

FORM BRI-18 REV. 3/75
STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

BRIDGE NO. 02015 OVERALL LENGTH 566'

SUFFICIENCY RATING ______ DATE 8-2-79

BRIDGE INSPECTION SHEET 2 OF 2

61 CHANNEL & CHANNEL PROTECTION	COND. 9-0	RAT. 9-5	REMARKS
1 Channel Scour	• •	[illegible]	INSPECTORS COND. RAT. 9-[illegible]: 6
2 Embankment Erosion	• •	[illegible]	
3 Debris	• •	[illegible]	
4 Vegetation	• •	[illegible]	
5 Channel Change	• •	[illegible]	
6 Fender System	• •	[illegible]	Planks - post missing [illegible]
7 Spur Dikes & Jetties	• •	[illegible]	
8 Rip Rap	• •	8	
9 Adequacy of Opening	• •	8	

62 CULVERT & RETAINING WALLS	COND.	RAT.	REMARKS
1 Barrel			INSPECTORS COND. RAT. 9-[illegible]: N
Concrete	N	• •	
Steel	[illegible]	• •	
Timber	[illegible]	• •	
2 Headwall	• •	N	
3 Cutoff Wall	• •	[illegible]	
4 Adequacy	• •	[illegible]	
5 Debris	• •	[illegible]	
6 Retaining Wall-Stem	N	• •	
Footing	[illegible]	• •	

63 EST REMAINING LIFE YEARS 29

64 PERMIT CAPACITY Unknown

65 APPROACH ALIGNMENT	COND.	RAT.	REMARKS
1 Alignment	• •	7	Curved — INSPECTORS COND. RAT. 9-[illegible]: 6
2 Approach Slab	• •	N	
3 Relief Joints	• •	6	1-2" High
4 Approach-Guide rail	• •	5	Poor
Pavement	• •	6	Potholes [illegible]
Embankment	• •	6	

66 RATED LOADING	COND.	RAT.	REMARKS
1 Posted Loading	• •	• •	TONS: SINGLE UNIT N SEMI-TRAILER N
2 Advance Warning	• •	• •	YES [illegible] NO [illegible]
3 Legibility	• •	N	
4 Visibility	• •	N	

67 STRUCTURAL CONDITION — INSPECTORS APPRAISAL OF GENERAL CONDITION OF STRUCTURE 9-[illegible]: 6

U/OH Clearance 14'-6" or less? No POSTED? No ADVANCE WARNING? No

ADDITIONAL NOTES

[illegible] pier 14 pad 7 & 12, pier 21 pad 7 [illegible] chunks
pier 2 [illegible] Pulled [illegible]
[illegible]
#6703 (9) dated [illegible]

STRUCTURE INVENTORY SHEET

Form No. BRI-19 8/72
Dept. of Transportation
State of Connecticut
Bureau of Highways

Town Greenwich Route 95 Bridge No. 00215
Structure Plate Girder
Prepared by White & Everest Date 8/2/79

IDENTIFICATION

1. State Connecticut 091
2. Hwy. District 4, Area 4
3. County 001 4. City/Town 0880
5. Inventory Rte. On ☐ Under ☐
6. Features Intersected [illegible]
7. Facility Carried by Str.
8. Structure No. 1 of
9. Location
10. Min. Vert. Clearance, Inv. Rte.
11. Milepoint
12. Road Section No.
13. Defense Bridge Description
14. Defense Milepoint
15. Defense Section Length
16. Latitude
17. Longitude
18. Physical Vulnerability
19. By-pass, Detour Length
20. Toll Bridge ☐ On Toll Rd. ☐ On Free Rd. ☐
21. Custodian
22. Owner
23. F.A.P. No.

CLASSIFICATION

24. Fed. Aid System Interstate, urban (02)
25. Administrative
26. Functional

STRUCTURE DATA

27. Year Built
28. Lanes on Str. Under
29. ADT 91,200 30. Year 1976
31. Design Load
32. Appr. Rdwy. Width w/Shl'd
33. Br. Median ☐ None ☐ Open ☐ Closed
34. Skew
35. Structure Flared ☐ Yes ☐ No
36. Traffic Safety Feature 101
37. Date of Last Inspection 8/2/79
38. Navigation Control ☐ Yes ☐ No
39. Vertical ft
40. Horizontal ft
41. Bridge Open or Closed A
42. Type Service
43. Structure Type-Main
44. -Approach
45. No. of Spans-Main
46. Approach
47. Total Horiz. Clearance ft
48. Max. Span Length ft
49. Structure Length ft
50. Sidewalk Rt ft Lt ft
51. Br. Rdwy Width (curb-curb) ft
52. Deck Width (out-out) ft
53. Vert. Clearance over Deck ft
54. Underclearance-Vertical ft
55. Lateral-Right ft
56. -Left ft
57. Wearing Surface

REMARKS: [illegible] 1-22-80

STRUCTURE APPRAISAL SHEET

Form No. Fri-20 7/71
Dept. of Transportation
State of Connecticut
Bureau of Highways

Town Greenwich Route 95 Bridge No. 00115
Structure Pl G.

Date: 8-2-79

CONDITION	Material	Condition Analysis	Rating (9-0)	Rated By
58. Deck	RC Slab w/Asphalt	Asphalt potholes - worn conc. Scaling & cracking	7	JC
59. Superstructure	PLG - Pl Bm - Stringers	Rust - Paint	5	JC
60. Substructure	Concrete	Scaling	6	JC
61. Channel & Channel Protection			8	JC
62. Culvert & Retaining Walls			N	JC
63. Estimated Remaining Life • • • • • • • • • • •		29	• • • •	JC
64. Operating Rating • • • • • • • • • • • • • •			• • • •	
65. Approach Roadway Alignment • • • • • • • • •			7	JC
66. Inventory Rating • • • • • • • • • • • • • •			• • • •	

APPRAISAL	Deficiencies	Rating	Rated By
67. Structural Condition	Paint Structure Deck - piers - Bearing - ends Scaling	6	JC
68. Deck Geometry	41' - 41' Clear Roadway	8	JC
69. Under-clearances-Vertical&Lateral	14'-6" vert lateral	8	JC
70. Safe Load Capacity			
71. Waterway Adequacy		8	JC
72. Approach Roadway Alignment		7	JC

Items 58 thru 72 - Approved By: ________

PROPOSED IMPROVEMENTS

73. Year Needed ______ Completed ______ Describe (item 75) ______
74. Type of Service ______
75. Type of Work ______
76. Improvement Length ______ ft ______
77. Design Loading ______
78. Roadway Width ______ ft ______
79. Number of Lanes ______
80. ADT ______
81. Year ______
82. Prop. Rdwy. Improvement-Year ______
83. " " " -Type ______
84. COST OF IMPROVEMENTS ______ $___,___,000

Items 73 thru 84 - Recommended By: ______

Remarks ______

FORM BRI-18 REV. 3-80
STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

ROUTE [illegible] BRIDGE NO. [illegible] TOWN [illegible]
TYPE [illegible] OVER-UNDER [illegible] YR BUILD [illegible]
INSPECTED BY [illegible] DATE [illegible]

BRIDGE INSPECTION SHEET 1 OF 2

58 DECK	COND	RAT		
1 Overlay [illegible]		[illegible]	[illegible]	INSPECTORS COND. RAT. 7
2 Deck-Str. Cond.	[illegible]		[illegible]	
3 Curb		7	[illegible]	
4 Median		7	[illegible]	
5 Sidewalks		N		
6 Parapet		5	[illegible]	
7 Railing		7	(4) Rails bent [illegible] missing	
8 Paint		7	Rails	
9 Drains		5	[illegible] plugged	
10 Lighting Standard		5		
11 Utilities-Type & Size		N	[illegible]	
12 Construction Joints [illegible]		6	[illegible] Reseal	
13 Exp. Joints		6	[illegible] Reseal	

59 SUPERSTRUCTURE	COND	RAT		
1 Bearing Devices	[illegible]		[illegible]	INSPECTORS COND. RAT. 5
2 Stringers	6		[illegible] Rust [illegible]	
3 Girders	5		[illegible] Rust	
4 Floor Beams	5		[illegible] Rust	
5 Trusses - General	N			
Portals		[illegible]		
Bracing		[illegible]		
6 Paint		6	[illegible]	
7 Machinery Mov. Span	N			
8 Rivets & Bolts		7	[illegible]	
9 Welds Cracks		5		
10 Rust		6	[illegible]	
11 Timber Decay		N		
12 Concrete Cracking		6		
13 Collision Damage		5		
14 Deflection und. Load			NORMAL ☑ EXCESSIVE ☐	
15 Alignment of Members		5		
16 Vibration und. Load			NORMAL ☑ EXCESSIVE ☐	

60 SUBSTRUCTURE	COND	RAT		
1 Abutments - Stem		8		INSPECTORS COND. RAT. 6
Backwall		7	[illegible]	
Footing		[illegible]		
Erosion	5			
Settlement	5			
Wingwalls		5		
2 Piers or Bents - Caps *	7		[illegible]	
Columns	6		[illegible]	
Footing		[illegible]		
Scour	N			
Settlement	5			
3 Pile Bent	N			
4 Concrete Crack - Spall		6	[illegible]	
5 Steel Corrosion	6		[illegible] Rust	
6 Timber Decay	N			
7 Debris on Seats		5		
8 Paint		5	[illegible]	
9 Collision Damage	5			

FORM BRI-18 REV. 3-80
STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

BRIDGE NO. 00045 OVERALL LENGTH 2666'
SUFFICIENCY RATING ______ DATE 10 23 80

BRIDGE INSPECTION SHEET 2 OF 2

61 CHANNEL & CHANNEL PROTECTION

	COND 9-0	RAT 9-3	REMARKS
1 Channel Scour	• •	5	
2 Embankment Erosion	5	• •	
3 Debris	• •	5	
4 Vegetation	• •	5	
5 Channel Change	• •	5	
6 Fender System	• •	6	(9) Planks missing (1) Post missing
7 Spur Dikes & Jetties	• •	5	
8 Rip Rap	• •	6	
9 Adequacy of Opening	• •	5	

INSPECTORS COND RAT 9-5: 6

62 CULVERT & RETAINING WALLS

	COND	RAT	REMARKS
1 Barrel			
Concrete	N	• •	
Steel	|	• •	
Timber	|	• •	
2 Headwall	• •	N	
3 Cutoff Wall	• •	|	
4 Adequacy	• •	|	
5 Debris	• •	|	
6 Retaining Wall-Stem	N	• •	
Footing	|	• •	

INSPECTORS COND RAT 9-6: N

63 EST. REMAINING LIFE

YEARS 25

64 PERMIT CAPACITY

Unknown

65 APPROACH ALIGNMENT

	COND	RAT	REMARKS
1 Alignment	• •	7	Good
2 Approach Slab	• •	7	Rough
3 Relief Joints	• •	7	1" High
4 Approach Guide rail	• •	6	(6) Post Rods at SE
Pavement	• •	N	
Embankment	• •	5	
5 Traffic Safety Feature	• •	• •	1011

INSPECTORS COND RAT. 9-5: 7

66 RATED LOADING

	COND	RAT	REMARKS
1 Posted Loading	• •	• •	TONS SINGLE UNIT N	SEMI-TRAILER N
2 Advance Warning	• •	• •	YES ☐ NO ☐
3 Legibility	• •	N	
4 Visibility & Location	• •	|	

9-0

67 STRUCTURAL CONDITION 6 INSPECTORS APPRAISAL OF GENERAL CONDITION OF STRUCTURE

Record OH Clearance if 14'-6" or less: N/A Record Posted Clearance: N/A Advance Warning: N/A

Record Speed Limit at Bridge if any ______

Character of Traffic ______

ADDITIONAL NOTES: * Pier #16 - Ped #7 Vert Crack [illegible] - Pier #22 [illegible] Bearing Ped Vert Crack [illegible] - Pier #23 Ped #7 [illegible]

East Catwalk NB Section Loss Severe Rust

FORM RI-20 REV. 10/79
STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

STRUCTURE APPRAISAL SHEET

TOWN Greenwich BRIDGE NO. 00015
ROUTE - STREET 95
OVER [illegible] TYPE Plate Girder

CONDITION

	Material	Condition Analysis	Rating (9-0)	By
58 Deck	R.C. Slab (Bit. Conc. Overlay)	[illegible] asphalt worn	3	[illegible]
59 Superstructure	[illegible]	[illegible]	[illegible]	[illegible]
60 Substructure	Concrete	Heavy [illegible]	[illegible]	[illegible]
61 Channel & Channel Protection		[illegible]	6	[illegible]
62 Culvert & Retaining Walls			3	[illegible]
63 Estimated Remaining Life		22 years	N	[illegible]
64 Operating Rating				[illegible]
65 Approach Roadway Alignment		Horizontal Curve		
66 Inventory Rating			7	[illegible]

APPRAISAL

	Deficiencies	Rating (9-0)	By
67 Structural Condition	[illegible]		
68 Deck Geometry	41' Clear Roadway	4	[illegible]
69 Underclearances - Vertical & Lateral	18'-06" Vert., 10' [illegible] Lat.	6	
70 Safe Load Capacity		6	[illegible]
71 Waterway Adequacy			
72 Approach Roadway Alignment		6	[illegible]
		7	[illegible]

Items 58 thru 72 - Reviewed by [illegible] 2/[illegible]
[illegible] 2/18/82

PROPOSED IMPROVEMENTS

73 Year Needed ________ Completed ________
74 Type of Service ________
75 Type of Work ________
76 Improvement Length ________ ft.
77 Design Loading ________
78 Roadway Width ________ ft.
79 Number of Lanes ________
80 ADT ________
81 Year ________
82 Proposed Rdwy. Improvement- Year ________
83 Proposed Rdwy. Improvement- Type ________

ITEM 75 DESCRIPTION

84 Cost of Improvements ________ $___,___,000
85 Preliminary Engineering ________ $___,___,000
86 Demolition ________ $___,___,000
87 Substructure ________ $___,___,000
88 Superstructure ________ $___,___,000
89 ________ $___,___,000
90 Inspection Date 10/21/80

Items 73 thru 90 - Recommended By ________

Remarks Update Items 29, 30, 90 220,1973
32 [illegible]
41 A
[illegible]
[illegible]

BRI 16 REV 8-81
STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

BRIDGE INSPECTION
SHEET 1 OF 2

ROUTE I-95 BRIDGE NO. 00015 TOWN Greenwich
TYPE PLG OVER/UNDER Mianus River YR BUILT 1958
INSPECTED BY White & Everest DATE 9-16-82

58 DECK	CONDITION 90	RATING 93	Remarks	92
1 Overlay Bit Conc	• •	5	Pocketing, Leaving, Patches, Tr. Tcs (CS)	INSPECTORS COND. RAT. 3
2 Deck-Str. Cond	3	• •	L.S.Sp. Tr. E.S.P. ... Cracking	
3 Curbs	• •	6	S.Sc. - Vert HL Crs	
4 Median	• •	6	S.Sc.-Tcs.-Popouts, S.Sc. Shallow Rebars; Bottom ...	
5 Sidewalks	• •	N		
6 Parapet	• •	7	S.Sc.	
7 Railing	• •	6	Heavy Rust-(1) Post ... Rail ...	
8 Paint	• •	5	Rails	
9 Drains	• •	5	20 Grates plugged	
10 Lighting Standard	• •	5		
11 Utilities-Type & Size	• •	N		
12 Construction Joints	• •	3	L.Sp. - S.Sc. Rebars Exposed	
13 Exp. Joints	• •	8		

59 SUPERSTRUCTURE	CONDITION	RATING	Remarks	92
1 Bearing Devices	6	• •	Frozen - Heavy Rust	INSPECTORS COND RAT 6
2 Stringers	7	• •	Light Rust	
3 Girders	6	• •	Light to med Rust - Some Lamination	
4 Floor Beams	6	• •	Heavy Rust - Some Lamination	
5 Trusses - General	N	• •		
Portals	• •	N		
Bracing	• •	|		
6 Paint	• •	3	Stringers, Girders, FL Bms	
7 Machinery Mov. Span	N	• •		
8 Rivets & Bolts	• •	7	Tipped - Hvy Rust	
9 Welds - Cracks	• •	5		
10 Rust	• •	6	Stringers - Girds FL Bms & Bearings	
11 Timber Decay	• •	N		
12 Concrete Cracking	• •	N		
13 Collision Damage	• •	|		
14 Deflection und. Load	• •	• •	NORMAL ☒ EXCESSIVE ☐	
15 Alignment of Members	• •	8		
16 Vibration und. Load	• •	• •	NORMAL ☒ EXCESSIVE ☐	

60 SUBSTRUCTURE	CONDITION	RATING	Remarks	90
1 Abutments - Stem	• •	5		INSPECTORS COND RAT. 5
Backwall	• •	6	L.S.Sp. - Vert HL Cr	
Footing	• •	UW		
Erosion	6	• •	North embankment under median Joint	
Settlement	8	• •		
Wingwalls	• •	7	Popouts - Shallow Rebars	
2 ~~Piers or Bents~~ - Caps *	5	• •	L.S.Sp. - Popouts Shallow Rebars	
Columns	5	• •	S.Sc. Rebars exposed. Popouts - ... Shallow Rebar	
Footing	• •	6	Paint Cap Steel	
Scour	UW	• •		
Settlement	5	• •		
3 Pile Bent	N	• •		
4 Concrete Crack - Spall	• •	6	Backwall, Wings, Pier caps & Stems	
5 Steel Corrosion	6	• •	Rebars - Scuppers	
6 Timber Decay	N	• •		
7 Debris on Seats	• •	6	Sand	
8 Paint	• •	3	Scuppers	
9 Collision Damage	8	• •		

[illegible]
STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

BRIDGE NO. ccs15 OVERALL LENGTH 2666

SUFFICIENCY RATING ______ DATE 9-16-82

BRIDGE INSPECTION SHEET 2 OF 2

	CONDITION	RATING	REMARKS	
61 CHANNEL & CHANNEL PROTECTION	90	93		95
1 Channel Scour	• •	8		INSPECTORS COND RAT. 6
2 Embankment Erosion	8	• •		
3 Debris	• •	8		
4 Vegetation	• •	8		
5 Channel Change	• •	8		
6 Fender System	• •	6	(9) Planks & (6) Post missing	
7 Spur Dikes & Jetties	• •	8		
8 Rip Rap	• •	N		
9 Adequacy of Opening	• •	8		

	CONDITION	RATING	REMARKS	
62 CULVERT & RETAINING WALLS				97
1 Barrel				INSPECTORS COND RAT N
Concrete	N	• •		
Steel	|	• •		
Timber	|	• •		
2 Headwall	• •	N		
3 Cutoff Wall	• •	|		
4 Adequacy	• •	|		
5 Debris	• •	|		
6 Retaining Wall Stem	N	• •		
Footing	|	• •		

63 EST. REMAINING LIFE YEARS 26

64 PERMIT CAPACITY Unknown

65 APPROACH ALIGNMENT				95
1 Alignment	• •	7	Horiz Curve	INSPECTORS COND RAT 5
2 Approach Slab	• •	5	Temp Cat. Bitumin - Jsp	
3 Relief Joints	• •	6	2" high. Breaking up	
4 Approach Guide rail	• •	6	(4) Post Tipped Cable loose at Abut	
Pavement	• •	5	Tv Cap C.S	
Embankment	• •	8		
5 Traffic Safety Feature	• •	• •	1011	
66 RATED LOADING				
1 Posted Loading	• •	• •	TONS SINGLE UNIT N SEMI TRAILER N	
2 Advance Warning	• •	• •	YES ☐ NO ☑	
3 Legibility	• •	N		
4 Visibility & Location	• •	|		

67 STRUCTURAL CONDITION INSPECTORS APPRAISAL OF GENERAL CONDITION OF STRUCTURE [illegible] 90

Record Vertical Clearance if 14' 6" or less (NC) Record Posted Clearance (N) Advance Warning (N)

Record Speed Limit at Bridge if any None

Character of Traffic Heavy - Trucks - Cars - Bus

ADDITIONAL NOTES # Pier #22 - Pad #7 NB LSup - 1 6' Section of Railing Missing South end NB Catwalk. Heavy Scale Rust to catwalks

FORM BRI-20 REV 10/79
STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

STRUCTURE APPRAISAL SHEET

TOWN Greenwich BRIDGE NO. [illegible]
ROUTE - STREET 95
OVER Mianus R, River & Strickland Rd TYPE Plate Girder

CONDITION

	Material	Condition Analysis	Rating (9-0)	By
58 Deck	R.C. Slab (Bit Conc Overlay)	[illegible]	[illegible]	[illegible]
59 Superstructure	PLG	[illegible]	6	[illegible]
60 Substructure	Concrete	[illegible]	[illegible]	[illegible]
61 Channel & Channel Protection			[illegible]	[illegible]
62 Culvert & Retaining Walls			N	[illegible]
63 Estimated Remaining Life		26 years	[illegible]	[illegible]
64 Operating Rating				
65 Approach Roadway Alignment		[illegible]	5	[illegible]
66 Inventory Rating				

APPRAISAL

	Deficiencies	Rating (9-0)	By
67 Structural Condition			
68 Deck Geometry	41' Clear Roadway, [illegible]	[illegible]	[illegible]
69 Underclearances - Vertical & Lateral	[illegible] Vert, [illegible] Lat	[illegible]	[illegible]
70 Safe Load Capacity			
71 Waterway Adequacy	[illegible]	8	[illegible]
72 Approach Roadway Alignment		[illegible]	[illegible]

Items 58 thru 72 - Reviewed by

PROPOSED IMPROVEMENTS

73 Year Needed ______ Completed ______
74 Type of Service ______
75 Type of Work ______
76 Improvement Length ______ ft.
77 Design Loading ______
78 Roadway Width ______ ft.
79 Number of Lanes ______
80 ADT ______
81 Year ______
82 Proposed Rdwy. Improvement- Year ______
83 Proposed Rdwy. Improvement- Type ______

ITEM 75 DESCRIPTION

84 Cost of Improvements ______ $__,__,000
85 Preliminary Engineering ______ $__,__,000
86 Demolition ______ $__,__,000
87 Substructure ______ $__,__,000
88 Superstructure ______ $__,__,000
89 ______
90 Inspection Date 9/16/82

Items 73 thru 90 - Recommended By ______

Remarks Update Items 29. 88900
30. 1980
32. 101 N/C
41. A N/C
[illegible] 10/6/[illegible]

APPENDIX E

NATIONAL BRIDGE INSPECTION STANDARDS
23 CFR PART 650
SUBPART C

Subpart C—National Bridge Inspection Standards

SOURCE: 36 FR 7851, Apr. 27, 1971, unless otherwise noted. Redesignated at 39 FR 10430, Mar. 20, 1974.

§ 650.301 Application of standards.

The National Bridge Inspection Standards in this part apply to all structures defined as bridges located on all public roads. In acordance with the AASHTO (American Association of State Highway and Transportation Officials) Highway Definitions Manual, a "bridge" is defined as a structure including supports erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet between undercopings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening.

(23 U.S.C. 104, 116(d), 315; 49 U.S.C. 1655; 23 CFR 1.48(b))

[44 FR 25435, May 1, 1979]

§ 650.303 Inspection procedures.

(a) Each highway department shall include a bridge inspection organization capable of performing inspections, preparing reports, and determining ratings in acordance with the provisions of the AASHTO Manual [1] and the Standards contained herein.

(b) Bridge inspectors shall meet the minimum qualifications stated in § 650.307.

(c) Each structure required to be inspected under the Standards shall be rated as to its safe load carrying capacity in accordance with section 4 of the AASHTO Manual. If it is determined under this rating procedure that the maximum legal load under State law exceeds the load permitted under the Operating Rating, the bridge must be posted in conformity with the AASHTO Manual or in accordance with State law.

(d) Inspection records and bridge inventories shall be prepared and maintained in accordance with the Standards.

(23 U.S.C. 144, 116(d), 315; 49 U.S.C. 1655; 23 CFR 1.48(b))

[36 FR 7851, Apr. 27, 1971. Redesignated at 39 FR 10430, Mar. 20, 1974, and amended at 44 FR 25435, May 1, 1979]

§ 650.305 Frequency of inspections.

(a) Each bridge is to be inspected at regular intervals not to exceed 2 years in accordance with section 2.3 of the AASHTO Manual.

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

[36 FR 7851, Apr. 27, 1971. Redesignated at 39 FR 10430, Mar. 20, 1974, and amended at 39 FR 29590, Aug. 16, 1974]

§ 650.307 Qualifications of personnel.

(a) The individual in charge of the organizational unit that has been delegated the responsibilities for bridge inspection, reporting, and inventory shall possess the following minimum qualifications:

(1) Be a registered professional engineer; or

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[1] The "AASHTO Manual" referred to in this part is the "Manual for Maintenance Inspection of Bridges 1978" published by the American Association of State Highway and Transportation Officials. A copy of the Manual may be examined during normal business hours at the office of each Division Administrator of the Federal Highway Administration, at the office of each Regional Federal Highway Administrator, and at the Washington Headquarters of the Federal Highway Administration. The addresses of those document insepction facilities are set forth in Appendix D to Part 7 of the regulations of the Office of the Secretary (49 CFR Part 7). In addition, a copy of the Manual may be secured upon payment in advance by writing to the American Association of State Highway and Transportation Officials, 444 N. Capitol Street, NW., Suite 225, Washington, D.C. 20001.

(2) Be qualified for registration as a professional engineer under the laws of the State; or

(3) Have a minimum of 10 years experience in bridge inspection assignments in a responsible capacity and have completed a comprehensive training course based on the "Bridge Inspector's Training Manual,"[2] which has been developed by a joint Federal-State task force.

(b) An individual in charge of a bridge inspection team shall possess the following minimum qualifications:

(1) Have the qualifications specified in paragraph (a) of this section; or

(2) Have a minimum of 5 years experience in bridge inspection assignments in a responsible capacity and have completed a comprehensive training course based on the "Bridge Inspector's Training Manual," which has been developed by a joint Federal-State task force.

(23 U.S.C. 144, 116(d), 315; 49 U.S.C. 1655; 23 CFR 1.48(b))

[36 FR 7851, Apr. 27, 1971. Redesignated at 39 FR 10430, Mar. 20, 1974, and amended at 44 FR 25435, May 1, 1979]

§ 650.309 Inspection report.

The findings and results of bridge inspections shall be recorded on standard forms. The data required to complete the forms and the functions which must be performed to compile the data are contained in section 3 of the AASHTO Manual.

[39 FR 21690, Aug. 16, 1974]

§ 650.311 Inventory.

(a) Each State shall prepare and maintain an inventory of all bridge structures subject to the Standards. Under these Standards, certain structure inventory and appraisal data must be collected and retained within the various departments of the State organization for collection by the Federal Highway Administration as needed. A tabulation of this data is contained in the structure inventory and appraisal sheet distributed by the Federal Highway Administration as part of the Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges (Coding Guide) in January of 1979. Reporting procedures have been developed by the Federal Highway Administration.

(b) All bridges subject to these Standards shall be inventoried by December 31, 1980, as required by section 124(a), and (c) of the Surface Transportation Assistance Act of 1978. Newly completed structures or any modification of existing structures which would alter previously recorded data on the inventory forms shall be entered in the State's records within 90 days.

(23 U.S.C. 144, 116(d), 315; 49 U.S.C. 1655; 23 CFR 1.48(b))

[44 FR 25435, May 1, 1979]

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[2] The "Bridge Inspector's Training Manual" may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

APPENDIX F

BRIDGE MAINTENANCE FORM MAINT-15

BRIDGE MAINTENANCE
FORM MAINT-15 REV. [illegible]

STATE OF CONNECTICUT
BUREAU OF HIGHWAYS

ROUTE ________ TOWN ________ BRIDGE # ________

TYPE ________ FEATURE CROSSED ________

COST [illegible] DATE ________ YEAR BUILT ________ SPANS ________ LENGTH ________

INSPECTED BY ________

ACT CODE	ELEMENTS INSPECTED	GOOD	FAIR	POOR	CRIT	WORK DESCRIPTION	QUANTITY	BY MAINT	BY [illegible]	[illegible]	[illegible]
	DECK										
241	Railing/Fencing										
242	Slab Concrete/Wood										
242	Wearing Surface Bit/Conc										
242	Wearing Surface Wood/Grid										
259	Joints Finger/Transfer										
256	Joints Misc. Trans.										
256	Joints Misc. Long										
244	Curb Concrete/Granite/B										
244	Sidewalk Concrete/B./Wood										
244 251	Parapet Concrete/Steel/Wall										
244 251	Rail Conc/Steel/Mas [illegible]										
244 251	Drainage										
244 251	Median										
	SUPERSTRUCTURE										
241	Beam/Girder/Truss										
251	Beam/Girder/Truss										
244	Arch/Rigid Frame										
251	Bracing										
251	Bearings Exp/Fixed										
259	Rivets/Bolts										
248	Drainage										
	SUBSTRUCTURE										
241	Pier Col./Bracing/Bearing										
244	Pier Footing										
244 251	Pier Stem										
244 251	Pier Cap										
244	Abutment Footing										
244	Abutment Stem										
244	Abutment Seat										
251	Anchor Bolts										
244	Bearing Pad										
244	Curtain Wall										
244	Wing Footing										
244	Wing Cap										
244	Wing Stem										
[illegible]	Culvert, Metal Arch										
244	Culvert, Conc. Box										
[illegible]	Fender System/[illegible]										
	MISCELLANEOUS ELEMENTS										
	Approach Joint										
	Approach Slab/Pavt										
	Relief Joint										
	Waterway Slopes/Embankments										
	REMARKS:										

*U.S. GOVERNMENT PRINTING OFFICE : 1984 0-421-828/10018