NATIONAL TRANSPORTATION SAFETY BOARD

Virtual Meeting of February 21, 2024

(Information subject to editing)

Collapse of the Fern Hollow Bridge, Pittsburgh, Pennsylvania, January 28, 2022

HWY22MH003

This is a synopsis from the NTSB's report and does not include the Board's rationale for the findings, probable cause, and safety recommendations. NTSB staff is currently making final revisions to the report from which the attached findings and safety recommendations have been extracted. The final report and pertinent safety recommendation letters will be distributed to recommendation recipients as soon as possible. The attached information is subject to further review and editing to reflect changes adopted during the Board meeting.

Executive Summary

What Happened

On Friday, January 28, 2022, about 6:37 a.m. eastern standard time, the Fern Hollow Bridge, which carried Forbes Avenue over the north side of Frick Park in Pittsburgh, Allegheny County, Pennsylvania, experienced a structural failure. As a result, the 447-foot-long bridge fell about 100 feet into the park below. The collapse began when the transverse tie plate on the southwest bridge leg failed due to extensive corrosion and section loss. The corrosion and section loss resulted from clogged drains that caused water to run down bridge legs and accumulate along with debris at the bottom of the legs, which prevented the development of a protective rust layer or patina. Although repeated maintenance and repair recommendations were documented in many inspection reports, the City of Pittsburgh (City) failed to act on them, leading to the deterioration of the fracture-critical transverse tie plate and the structural failure of the bridge. At the time of the collapse, a 2013 New Flyer articulated transit bus, operated by the Port Authority of Allegheny County, and four passenger vehicles were on the bridge. A fifth passenger vehicle drove off the east bridge abutment after the collapse began and came to rest on its roof on the ground below. As a result of the collapse, the bus driver sustained minor injuries and two bus occupants were uninjured. Of the six passenger vehicle occupants, two sustained serious injuries, one sustained a minor injury, two were uninjured, and the injury status of one was unknown.

What We Found

We found that the southwest leg and transverse tie plate of the Fern Hollow Bridge, an uncoated weathering steel bridge, did not have the structural capacity to carry the bridge's load at the time of the collapse because they had sustained extensive corrosion and section loss. Although maintenance and repair recommendations were repeatedly made in the bridge inspection reports, the City failed to act on several of these recommendations, which led to progressive deterioration and the collapse of the bridge. We found that the Pennsylvania Department of Transportation's (PennDOT) insufficient oversight of the City's bridge inspection program contributed to the bridge's continued deteriorated condition that led to the collapse.

We also found that the bridge inspections performed by PennDOT contractors on behalf of the City were not in compliance with the Federal Highway Administration (FHWA) and American Association of State Highway and Transportation Officials (AASHTO) published guidance, and because the bridge was not properly evaluated, it remained open until its collapse. The legs of the bridge were not correctly identified in fracture-critical member plans by PennDOT contractors as fracture-critical members, and as a result, they did not undergo more in-depth, hands-on inspections.

During the on-site investigation, we found that the thickness of the bridge's asphalt wearing surface was nearly double the amount indicated in the inspection reports. Further, had the calculations and assumptions used in the bridge's load rating accounted for the correct thickness of the asphalt wearing surface, used the correct *k*-factor to estimate the axial load capacity of the bridge legs, and accounted for the localized effects of section loss on the southwest leg, this load rating calculation for the Fern Hollow Bridge would have caused the City to close the bridge.

We found that the City, in response to its failure to maintain the bridge which resulted in the bridge's collapse, made several postcollapse changes that have the potential to address the deficiencies identified in this investigation. We also found that PennDOT revised several of its policies and procedures in response to the collapse of the Fern Hollow Bridge. These revisions also have the potential to improve the identification of at-risk bridges in the future, but it is also necessary to provide proper oversight, including ensuring that maintenance and repair recommendations are appropriately coded, monitored, and completed in a timely manner. We found that in response to National Transportation Safety Board (NTSB) Safety Recommendation H-23-13, the FHWA has developed a data-driven process and encouraged its use by state departments of transportation and other bridge owners to help them identify, prioritize, and perform follow-up actions documented in inspections of bridges with uncoated weathering steel components. Finally, we found that the FHWA's data-driven reviews of targeted bridge populations should be

used to investigate specific bridge safety issues such as the validity of load ratings of bridges with advanced deterioration.

We determined that the probable cause of the collapse of the Fern Hollow Bridge in Pittsburgh, Pennsylvania, was the failure of the transverse tie plate on the southwest leg of the bridge, a fracture-critical member (nonredundant steel tension member), due to corrosion and section loss resulting from the City of Pittsburgh's failure to act on repeated maintenance and repair recommendations from inspection reports. Contributing to the collapse were the poor quality of inspections, the incomplete identification of the bridge's fracture-critical members (nonredundant steel tension members), and the incorrect load rating calculations for the bridge. Also contributing to the collapse was insufficient oversight by PennDOT of the City's bridge inspection program.

What We Recommended

As a result of this investigation, we issued 11 new recommendations and classified a previously issued recommendation. We asked PennDOT to lead the effort, and the City to work with PennDOT, to evaluate the effectiveness of the changes made by the City—including completing necessary bridge maintenance and repair recommendations and confirming that bridges have correct load ratings that account for deterioration—to ensure that bridges are safe for the traveling public. We also asked PennDOT to develop and implement a plan to publish yearly aggregate data on bridge maintenance and repair recommendations to monitor the completion of these recommendations. We issued a recommendation to the FHWA to establish a process for conducting targeted reviews of the safety issues identified in this investigation, to include at a minimum (1) an evaluation of bridge owners' determinations of the need to conduct new load ratings of bridges with advancing deterioration, and (2) an evaluation of inspection reports on bridges with advanced deterioration to determine if the assumptions and methods used in the load rating calculations are correct; and to incorporate the results of these reviews into the *National Bridge Inspection Program Compliance Review Manual* as necessary.

We also issued a recommendation to the FHWA to incorporate the findings of the Fern Hollow Bridge collapse investigation into its bridge inspection training courses and to use the Fern Hollow Bridge as a case study to emphasize the need to complete maintenance and repair recommendations from inspection reports, follow guidance to ensure that bridge inspections are properly performed, correctly identify fracture-critical members, and correctly calculate load rating analyses.

We issued one new recommendation to the FHWA to require state departments of transportation and other bridge owners to conduct a one-time review of the existing fracture-critical member (nonredundant steel tension member) inspection plans for bridges with nonredundant steel bridge leg designs in their inventory, and update these plans as necessary to ensure that all fracture-critical members, especially those in the legs, have been properly identified and accounted

for in the fracture-critical member inspection plans and inspections. We issued additional recommendations to the FHWA and AASHTO to update guidance in their published manuals that addresses the identification of localized tension zones and tension components in nonredundant steel members that are generally considered to be fully or partially in compression.

We asked the FHWA to update its *Bridge Inspector's Reference Manual* and bridge inspection training courses, as well as AASHTO to update its *Manual for Bridge Evaluation*, to include reference material on the selection, frequency of use, and application of non-destructive inspection methods for assessing the wearing surface thickness on bridge decks. We asked the City to establish a system to ensure that it maintains paving records indicating how much asphalt wearing surface is removed and how much is subsequently placed during every bridge resurfacing operation.

NTSB Safety Recommendation H-23-13 directed the FHWA to develop a risk-based, data-driven process and encourage its use by state departments of transportation, as well as federal agencies and tribal governments that own and operate bridges, to help them identify, prioritize, and perform follow-up actions documented in inspections of bridges with uncoated weathering steel components. We are classifying Safety Recommendation H-23-13 as Closed—Acceptable Action.

Findings

1. None of the following were factors in the collapse: (1) the use of uncoated weathering steel, (2) the design of the bridge, (3) the fabrication materials, (4) the deterioration of the welds, or (5) the qualifications of the 2005–2021 bridge inspection team leaders.
2. The emergency response was timely and adequate.
3. The Fern Hollow Bridge collapsed due to the extensive corrosion and section loss of its fracture-critical members, specifically the transverse tie plate, resulting in the failure of the southwest leg (B1R), which no longer had the structural capacity to carry the bridge's loads at the time of the collapse.
4. The significant corrosion and section loss on the southwest leg (B1R) resulted from the failure of the City of Pittsburgh to act on the repeated maintenance and repair recommendations documented in inspection reports from 2005 to 2021, leading to progressive deterioration and structural failure.
5. In response to National Transportation Safety Board Safety Recommendation H-23-13, the Federal Highway Administration developed a risk-based, data-driven process and encouraged its use by state departments of transportation, as well as federal agencies and tribal governments that own and operate bridges, to help them identify, prioritize, and perform follow-up actions documented in inspections of bridges with uncoated weathering steel components.
6. Multiple inspectors of the Fern Hollow Bridge, contracted by the Pennsylvania Department of Transportation on behalf of the City of Pittsburgh over a period

of more than 15 years, failed to (1) clean corrosion before measuring, (2) accurately quantify remaining material, (3) accurately rate the general bridge superstructure condition, and (4) recommend a structural review of the bridge legs; and these failures contributed to the bridge's inability to support the loads it was rated for before the collapse.

7. In the Fracture-Critical Identification Framing Plans, the Fatigue and Fracture Bridge Inspection Plan, and the handwritten notes contained in the earlier Fern Hollow Bridge inspection reports, Pennsylvania Department of Transportation contractors did not properly identify the bridge legs, including the transverse tie plates, as fracture-critical members (nonredundant steel tension members), and as a result, the legs did not consistently undergo a more in-depth, hands-on fracture-critical member inspection as required by 23 *Code of Federal Regulations* 650 Subpart C.
8. Had the bridge legs, including the transverse tie plates, been properly identified as fracture-critical members, the inspection recommendations related to repairing and reinforcing section loss and holes in the legs would likely have been assigned a priority code of 0 and prompted action within 7 days.
9. If the City of Pittsburgh had taken appropriate action to repair or reinforce the section loss on the fracture-critical bridge leg components, the collapse of the Fern Hollow Bridge could have been prevented.
10. The correct identification of fracture-critical members is crucial to ensuring that these members are properly maintained so that they do not fail and result in a partial or full bridge collapse.
11. Bridge inspectors lack adequate guidance from the Federal Highway Administration *Bridge Inspector's Reference Manual* and the American Association of State Highway and Transportation Officials *Manual for Bridge Evaluation* on the proper identification of localized tension zones and tension components to correctly identify fracture-critical members in preparation for and during bridge inspections.
12. The calculations and assumptions used in the 2014 load rating analysis overestimated the Fern Hollow Bridge's capacity, and if these calculations and assumptions had (1) correctly accounted for the amount of wearing surface on the bridge, (2) used the correct *k*-factor to estimate axial load capacity, and (3) correctly accounted for the localized effects of section loss, the result would have required the closure of the bridge.
13. The quality of the City of Pittsburgh's paving records was so poor that determinations could not be made about whether the actual asphalt wearing surface exceeded what was assumed in the design of the bridge or about how long the wearing surface had exceeded the as-designed thickness, which contributed to an incorrect load rating analysis.
14. The thickness of a bridge's wearing surface is an important component for calculating load ratings, and non-destructive techniques can provide a means of verifying the actual thickness of the wearing surface without introducing damage to the bridge.

15. The postcollapse actions completed by the City of Pittsburgh in response to its failure to maintain the Fern Hollow Bridge, which resulted in the bridge's collapse—increased staff in the Bridges and Structures Division, a streamlined funding process for bridge maintenance and repairs, review of load ratings, and approved funding for bridge rehabilitation projects—have the potential to address the deficiencies found in this investigation, including insufficient oversight of needed bridge maintenance and repair activities.
16. The Pennsylvania Department of Transportation's insufficient oversight of the City of Pittsburgh's bridge inspection program contributed to the bridge's continued deteriorated condition that led to the collapse.
17. The postcollapse actions completed by the Pennsylvania Department of Transportation—conducting field examinations of fracture-critical K-frame bridges, conducting file reviews of other K-frame bridges and bridges with steel-pier bents, and publishing a Technical Bulletin updating Pennsylvania's Bridge Safety Inspection Program and its Bridge Maintenance Program—have the potential to identify at-risk bridges throughout the state, but it is also necessary to provide proper oversight, including ensuring that maintenance and repair recommendations are appropriately coded, monitored, and completed in a timely manner.
18. The Federal Highway Administration should use data-driven reviews of targeted bridge populations to investigate specific bridge safety issues such as the validity of load ratings of bridges with advanced deterioration.
19. The Fern Hollow Bridge collapse demonstrates the consequences of failure to complete inspections in accordance with standards, failure to correctly identify fracture-critical members, failure to correctly perform a load rating analysis, and failure of the bridge owner to respond to inspection findings and complete maintenance recommendations in a timely manner.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the collapse of the Fern Hollow Bridge in Pittsburgh, Pennsylvania, was the failure of the transverse tie plate on the southwest leg of the bridge, a fracture-critical member (nonredundant steel tension member), due to corrosion and section loss resulting from the City of Pittsburgh's failure to act on repeated maintenance and repair recommendations from inspection reports. Contributing to the collapse were the poor quality of inspections, the incomplete identification of the bridge's fracture-critical members (nonredundant steel tension members), and the incorrect load rating calculations for the bridge. Also contributing to the collapse was insufficient oversight by the Pennsylvania Department of Transportation of the City of Pittsburgh's bridge inspection program.

Recommendations

New Recommendations

To the Federal Highway Administration:

1. Require state departments of transportation, as well as federal agencies and tribal communities that own and operate bridges, to conduct a one-time review of the existing fracture-critical member (nonredundant steel tension member) inspection plans for bridges with nonredundant steel frame leg designs in their inventory, and update these plans as necessary to ensure that all fracture-critical members, especially those in the legs, have been properly identified and accounted for in the fracture-critical member inspection plans and inspections.

2. Update your *Bridge Inspector's Reference Manual* to include guidance that addresses the identification of localized tension zones and tension components in nonredundant steel members that are generally considered to be fully or partially in compression.

3. Update your *Bridge Inspector's Reference Manual* and bridge inspection training courses to include reference material on the selection, frequency of use, and application of non-destructive inspection methods for assessing the wearing surface thickness on bridge decks.

4. Establish a process for conducting targeted reviews of the safety issues identified in this investigation, to include at a minimum (1) an evaluation of bridge owners' determinations of the need to conduct new load ratings of bridges with advancing deterioration, and (2) an evaluation of inspection reports on bridges with advanced deterioration to determine if the assumptions and methods used in the load rating calculations are correct; and incorporate the results of these reviews into the *National Bridge Inspection Program Compliance Review Manual* as necessary.

5. Incorporate the findings of the Fern Hollow Bridge collapse investigation into your bridge inspection training courses and use the Fern Hollow Bridge as a case study to emphasize the need to complete maintenance and repair recommendations from inspection reports, follow guidance to ensure that bridge inspections are properly performed, correctly identify fracture-critical members, and correctly calculate load rating analyses.

To the Pennsylvania Department of Transportation:

6. Lead the effort to evaluate and publish a report documenting the effectiveness of the changes made by the City of Pittsburgh to ensure that bridges are safe for the traveling public. Evaluated changes should include completing

necessary bridge maintenance and repair recommendations and confirming that bridges have correct load ratings that account for deterioration.

7. Develop and implement a plan to publish yearly aggregate data on bridge maintenance and repair recommendations to monitor completion of these recommendations.

To the City of Pittsburgh:

8. Establish a system to ensure that you maintain paving records indicating how much asphalt wearing surface is removed and how much is subsequently placed during every bridge resurfacing operation.

9. Work with the Pennsylvania Department of Transportation to evaluate the effectiveness of the changes made by the City of Pittsburgh to ensure that bridges are safe for the traveling public. Evaluated changes should include completing necessary bridge maintenance and repair recommendations and confirming that bridges have correct load ratings that account for deterioration.

To the American Association of State Highway and Transportation Officials:

10. Update your *Manual for Bridge Evaluation* to include guidance that addresses the identification of localized tension zones and tension components in nonredundant steel members that are generally considered to be fully or partially in compression.

11. Update your *Manual for Bridge Evaluation* to include reference material on the selection, frequency of use, and application of non-destructive inspection methods for assessing the wearing surface thickness on bridge decks.

Previously Issued Recommendation Classified in This Report

To the National Federal Highway Administration:

Develop a risk-based, data-driven process and encourage its use by state Departments of Transportation, as well as highway-bridge-owning federal agencies and tribal governments, to help them identify, prioritize, and perform follow-up actions documented in inspections of bridges with uncoated weathering steel components. (H-23-13)

Safety Recommendation H-23-13 is classified Closed—Acceptable Action in section 2.3 of this report.