Log # 555 & R-1

# National Transportation Safety Board

*Washington, D. C. 20594*

**Safety Recommendation**

**Date:** December 21, 1990

**In reply refer to:** H-90-107 through -109

Mr. Francis Francois
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and Transportation Officials
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On May 26, 1989, about 5:25 p.m. eastern daylight time, a 140-foot section of the 556-foot Harrison Road temporary bridge over the Great Miami River fell about 40 feet into the rain-swollen river after a pile bent collapsed. Seven witnesses reported that a passenger car and a pickup truck fell into the river. However, only a passenger car and the bodies of the car's two occupants have been recovered from the river. No other vehicles were found in the river nor are any persons reported missing in the Miamitown area. Witnesses reported an unusual amount of debris floating down the river and striking the pile bents of the bridge prior to the collapse. Although the weather was clear and dry, flooding conditions existed at the time of the collapse and the river had overflowed its banks onto the flood plain.[1]

In May 1990, the Safety Board contracted with the University of Maryland (UMD) to conduct structural calculations to determine the lateral load capacity of the collapsed structure and the ability of the bridge to meet American Association of State Highway and Transportation Officials (AASHTO) lateral load specifications. Two types of computer analysis were carried out to determine the lateral load capacity and the sequence of failure from both elastic buckling[2] and an elasto-plastic[3] type failure.

[1]For more detailed information, read Highway Accident Report--"Collapse of Harrison Road Bridge Spans, in Miamitown, Ohio, May 26, 1989" (NTSB/HAR-90/03).

[2]Elastic buckling analysis is a method used to determine the upper bound of the load-carrying capacity of a structure before buckling occurs.

[3]Elasto-plastic analysis is a method used to determine the upper bound of the load-carrying capacity of a structure before plastic deformation occurs.

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In performing its analysis, the UMD assumed that the pile bent failure resulted from some type of elasto-plastic yielding that led to the formation of plastic hinges. The UMD analysis indicated that at a combined impact and accumulated debris load of 7.5 tons, plastic hinges would begin to form. The UMD also concluded that collapse would occur when a critical number of plastic hinges[4] had developed throughout the substructure, at a combined impact and accumulated debris loading between 11 and 12.5 tons. Based on UMD's engineering analysis and the physical evidence, the Safety Board concludes that the collapse of pile bent 2 resulted from the formation of plastic hinges due to a combination of impact and accumulated debris loading on the upstream side of the pile bent.

Section 3.18 of AASHTO standard specifications for highway bridges states that all piers and portions of structures that are subjected to flowing water are to be designed to resist the maximum stresses induced by stream flow, floating ice, wind, and debris. The specifications provide detailed criteria for calculating the maximum expected loads and stresses for each of these conditions except debris. The specifications do not provide any guidance for calculating impact and accumulated debris loads.

According to testimony provided by the chairman of the Subcommittee on Bridges and Structures, debris loading is partly accounted for by the safety factor incorporated into the design and may also be estimated based on bridge site visits or historical data on river debris. Most structures that are built in accordance with AASHTO loading specifications for allowable working stress have a factor of safety of about 2 to compensate for unanticipated loads. However, this factor of safety is based on the assumption that the designer has tried to consider all known forces (vertical, lateral, and so forth) that may be imposed on the bridge during its service life. The factor of safety is intended to provide for variations in the different types of loads that are specifically considered.

Many permanent bridges are built with massive substructures to support the weight of the superstructure and, as a result, far exceed AASHTO criteria for lateral loads. These bridges are protected from debris loading by the inherent nature of the massive substructures. However, those bridges that do not have massive piers in the water, such as this bridge, are susceptible to being overstressed from loads caused by debris impact and accumulation. Therefore, it is imperative that all significant lateral forces, including debris loading, be considered in the design process. Because no specific guidance is provided by AASHTO for calculating debris loads, the Safety Board believes that AASHTO, in cooperation with the Federal Highway Administration and the U.S. Geological Survey, should conduct research to develop methods for estimating maximum debris loads, that is, frequency, size, and magnitude, for design purposes. The Safety Board believes that once these methods are developed, AASHTO should include in the "Standard Specifications for Highway Bridges" detailed criteria for calculating the maximum expected debris loads and should specify analytical methods for determining the stresses imposed by impact and accumulated debris loads on highway bridges.

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[4]When the number of plastic hinges formed exceeds those required for elastic stability, the overall collapse of the pile bent occurs.

Therefore, the National Transportation Safety Board recommends that the American Association of State Highway and Transportation Officials:

> Cooperate with the Federal Highway Administration and the U.S. Geological Survey in a research program to develop methods to estimate maximum debris loads for bridge design purposes. (Class II, Priority Action) (H-90-107)
>
> Cooperate with the Federal Highway Administration in establishing standard analytical methods to determine loads imposed by debris impact and by debris accumulation on bridge substructures. (Class II, Priority Action) (H-90-108)
>
> Following the development of debris loading design methodologies, include detailed criteria for calculating the maximum expected debris loads and stresses in the "Standard Specifications for Highway Bridges." (Class II, Priority Action) (H-90-109)

Also, as a result of its investigation, the Safety Board issued Safety Recommendation H-90-98 to the Hamilton County Engineer's Office; H-90-99 through -102 to the Ohio Department of Transportation; H-90-103 through -106 to the Federal Highway Administration; and H-90-110 to the U.S. Geological Survey.

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter. Please refer to Safety Recommendations H-90-107 through -109 in your reply.

KOLSTAD, Chairman, COUGHLIN, Vice Chairman, and LAUBER, BURNETT, and HART, Members, concurred in these recommendations.

James L. Kolstad

By: James L. Kolstad
Chairman