POINT PLEASANT BRIDGE COLLAPSE

On December 15, 1967, the bridge connecting Point Pleasant, West Virginia, and Kanauga, Ohio, collapsed into the Ohio River, carrying 46 persons to their deaths. NBS experts played a prominent role in the laboratory examinations of steel members from the failed structure, providing key findings as to the underlying cause of the disaster. In brief, NBS found that corrosion in the head end of an eyebar led to the development of stress corrosion cracks; over a period of years one of these reached a depth of about 1/8 inch. At this point the metal, of a type having low resistance to fracture once a "notch" had been established, failed catastrophically, causing the bridge to collapse. NBS work in this investigation was done at the request of and with the financial support of the Bureau of Public Roads, Department of Transportation.

The bridge, built in 1928, was of the eyebar chain suspension type, with a 700-foot center span flanked by two 380-foot side spans. In essence, the eyebars performed the same supportive function as a cable in a suspension bridge. Although it is not uncommon for eyebars to be used in bridge construction, it is rare for the stiffening trusses of both the center and side spans to be framed into the eyebar chain. In fact, only three bridges have been built to this configuration: the collapsed Point Pleasant span; another 75 miles upriver at St. Marys, West Virginia, and the third in Brazil. The St. Marys bridge was closed about a year after the Point Pleasant disaster, and will soon be replaced with a new bridge of modern design. The Pt. Pleasant bridge has already been replaced.

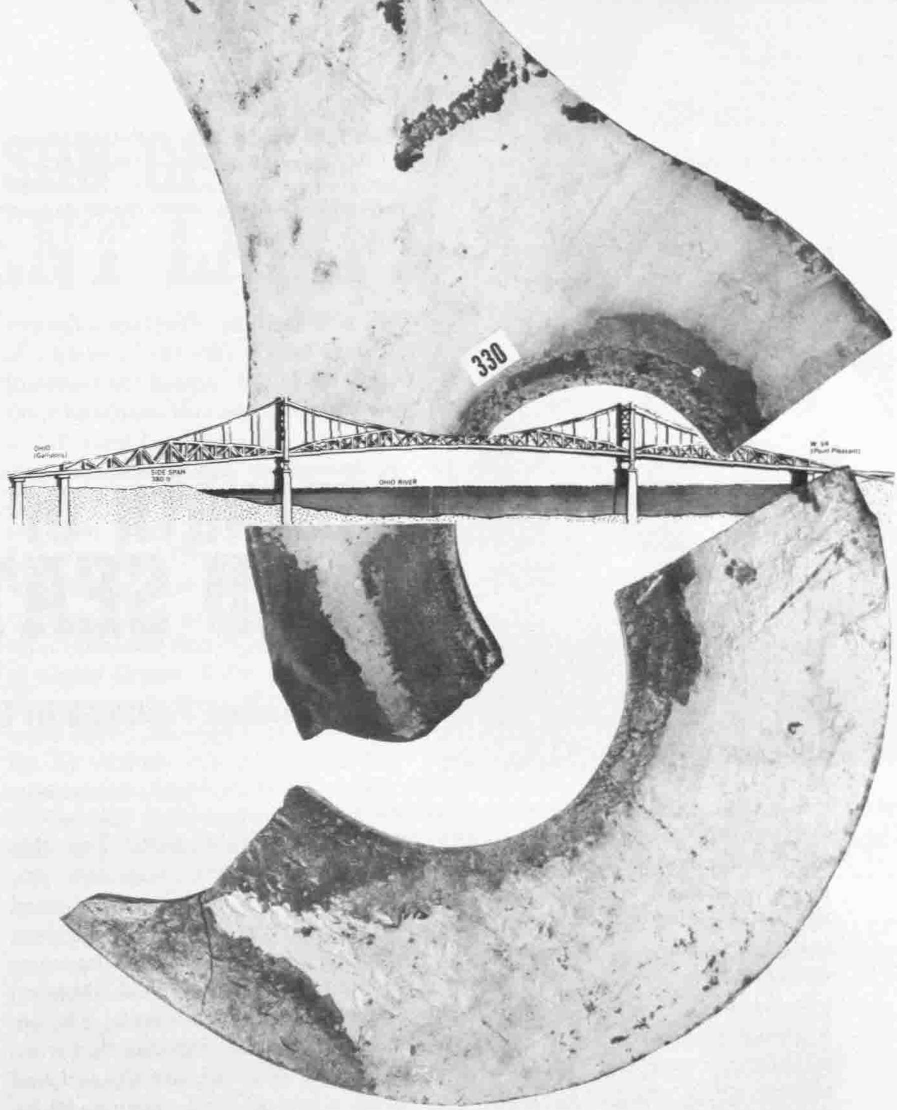
The eyebars used in the bridge are 45-55 feet long, up to two inches thick, and 12 inches wide in the shank. At either end there is a circular enlargement, pierced by a hole about 15 inches in diameter through which fastening pins were placed as the bridge was assembled. The bars were made of heat treated, rolled carbon steel, with forged heads, and were designed to break at ultimate loading in the shank, not the head.

Inspection of the wreckage brought to light an eyebar that had broken through the eye. The nature of the fracture showed that it had occurred under normal service loads, indicating that it was the initial fracture in the collapse. Fortunately, both pieces resulting from that fracture were recovered from the river by the Army Corps of Engineers, and brought to NBS for analysis. The Bureau was selected for this important phase of the investigation because of its competence in metallurgy and long experience in failure analysis. The "plan of attack" employed by NBS in examining the eyebar pieces was formulated in advance and agreed upon by the "parties of interest" (the states of West Virginia and Ohio, the designers and builders of the bridge, and two independent consulting engineering firms).

Visually, the two fractures on opposite sides of the broken eye are quite different. On one side the fracture is a straight line, the surface exposed by the break is quite brittle in appearance, and there is little evidence of plastic deformation adjacent to the break. The other fracture does not follow a straight line, has a very rough exposed surface, and shows extensive plastic deformation in the adjacent areas. The different appearance of the two fractures results from their nature and the sequence of events. The straight line fracture, an almost instantaneous event once the notch reached the critical depth of about 1/8 inch, occurred first. The failure then shifted an unsupportable load to the other side of the eye, which deformed extensively before breakage occurred. Careful cleaning of the specimens, followed by microscopic examination of various surfaces, revealed cracks penetrating into the metal from the hole surface, particularly in the area near the existing straight-line fracture, and in an area where there was heavy corrosion. The cracks not involved in failure were oxide-filled, indicating they had been open for some time.

Although the cracks had existed for some time, the location of the flaw was inaccessible to inspection. It is generally agreed that it could not have been detected by any inspection method known without disassembly of the eyebar chain. Further, in 1927, when the bridge was designed, the phenomenon of stress corrosion was not known to occur in the classes of bridge

Close-up view of the eyebar responsible for the Point Pleasant Bridge collapse, and an artist's drawing of the bridge. The straight line fracture, an almost instantaneous event once a notch, caused by stress corrosion, reached a critical depth of about 1/8 inch, occurred first. The failure then shifted an unsupportable load to the other side of the eye, which deformed extensively before breakage occurred.



material used under conditions of exposure normally encountered in rural areas.

Although preliminary observations indicated that the eyebar failure was responsible for the collapse, laboratory investigations were undertaken to answer many questions such as: Was the steel in the particular eyebar which fractured typical of the steel in other eyebars in the structure; did the eyebar meet construction specifications; was the crack sufficiently large to have caused the brittle fracture at the normal stress level expected at this location; and if so, what was the mechanism by which this defect grew to critical size?

Hardness and metallographic measurements showed that the chemical composition of the steel was in general conformance with the specifications for 1060 carbon steel. The tests showed that the steel met requirements stipulated in the material specifications for the structure. No evidence was uncovered to indicate that this bar was more prone to failure than other bars with a similar history.

The lower side of the eye (straight fracture) fractured under loads that were not sufficient to cause appreciable plastic deformation of the steel.

The faces of both the pre-existing crack associated with the main fracture and similar cracks in adjacent areas were covered with dark oxides of a distinctly different color and texture than surface rusting that developed on the remainder of the fracture surface. Microprobe analyses revealed the presence of more than normal amounts of sulfur in the crack surface. This indicated that sulfur bearing gases such as sulfur dioxide or hydrogen-sulfide in the atmosphere (air pollutants) may have been responsible for the stress-corrosion cracking.

Tests were also performed at the Battelle Memorial Institute and U.S. Steel, complementing the NBS investigation. Of particular interest were fracture toughness tests; these showed that the steel had very low resistance to crack propagation. Calculations based on the results indicated that the crack found in the eyebar was large enough to have initiated the catastrophic fracture under the normal loads to be expected on the bridge. In addition, the Battelle investigation revealed that four of thirty eyebar heads, which were recovered and investigated, had cracks on their pinhole surfaces. Other investigations eliminated the possibility of aerodynamic or traffic vibration excitation as being contributing factors in the bridge collapse.

As a result of the complete investigation, the President-appointed Task Force on Bridge Safety concluded[1] that a small crack, which started at a small corrosion pit and grew to critical size by the joint action of stress-corrosion cracking and corrosion fatigue, was responsible for the bridge collapse.

[1] Highway Accident Report—Collapse of U.S. 35 Highway Bridge Point Pleasant, West Virginia, December 15, 1967, NTSB-HAR-71-1.