The 1967 collapse of the Silver Bridge, which connected West Virginia to Ohio, was simultaneously the most devastating vehicular bridge collapse in American history—killing 46 people—and the most important, because it led to the creation of a nationwide, standardized bridge inspection program. (Read “Bridge Inspections Come of Age,” page 68.)

The tiny communities of Point Pleasant, West Virginia, and Gallipolis, Ohio, straddle the Ohio River near the boundaries of Appalachia and the Midwest. The bridge was the brainchild of physician and surgeon Charles Holzer, who thought it “never will fail.”

For decades the Silver Bridge was an economic boon to the communities along the river as well as a source of civic pride. In 1928, 685 vehicles crossed the bridge each day. By 1967, the year it collapsed, vehicle crossings had risen to 9,400. In 1941, according to Bullard et al., the bridge was extensively renovated. Its original wooden plank roadway was widened and replaced by a steel grid filled with concrete.

Construction of the bridge began in 1926, the crossing opened on May 30, 1928. Officially it was called the Point Pleasant Bridge, but it quickly became known by a more colorful name: the Silver Bridge, owing to the fact it was coated with aluminum paint.

Ten thousand people attended the Memorial Day opening, still the largest crowd ever assembled in Point Pleasant. Attended by political dignitaries from both states, the opening featured an airplane squad, automobile parade, and fireworks and was capped off with a dance. The bridge was nearly 2,235 ft long, including a main span of 700 ft and two side spans of 380 ft each. Its suspension chains were composed of parallel eyebars made of heat-treated steel.

Finally, the bridge would be the first in the country to use heat-treated steel, which had a strength that was unprecedented at the time: 120,000 psi. “Because chain links made of such steel could carry more load relative to their own weight,” Petroski wrote, “the bridge itself would be a lighter and thus less costly structure.”

Tracy W. Brown, P. E., the bridge engineer for District 1 of the West Virginia Department of Transportation, speculates that engineers at the time likely figured that “they had it covered with the high strength of those eyebars.” The system was “so overdesigned,” he says, that the engineers probably thought it “never will fail.”

The bridge towers were not rigidly fixed on their piers, but rocked back and forth “in response to slight changes in cable pull,” according to Petroski, which caused the bridge to sway some.

An early design, by the Baltimore firm J.E. Greiner Company, called for a “familiar combination of steel-wire cables and a distinct stiffening truss,” according to Henry Petroski, Ph.D., P. E., Dist M ASCE, the Aleksandar S. Vesic professor of civil engineering at Duke University, in his book To Forgive Design: Understanding Failure (Belknap Press of Harvard University Press, Cambridge, Massachusetts, 2012). But Holzer’s company chose the U.S. Steel subsidiary American Bridge Company to build the bridge instead, and it proposed a novel and less expensive design. Rather than suspension cables, it would use chains of eyebars—each eyebar being 50 ft long, 1 ft wide, and 2 in. thick. The eyebars, Petroski noted, “would be linked together in a bicycle-chain style with steel pins to form the main part of the suspension system.”

The suspension chains also doubled in some places as the “top chord of the trusses that stiffened the roadway, a system that had not previously been used in the United States,” Petroski wrote. In all, 1,460 ft of common links served as the top chords of trusses and suspension chains.

“Each segment of suspended chain was composed of two parallel eyebars,” Bullard et al. stated. “At every connection point, four eyebars converged and were linked together by a single pin.”
Once the suspension chain was severed, the bridge was doomed.

46 died; 37 drowned and nine died from trauma. Survivors, ironically, were treated at a hospital that was named after Charles Holzer.

One survivor, Charlene Wood, saw the bridge collapse up close. Pregnant with twins, she had just driven onto the sus-

ension span when she felt a strong shake. It was so severe that it stalled the motor in her car. She put her car in neutral and coasted back onto the approach. The bridge collapsed a moment later, leaving her as the last car standing on the eastern approach. (The bridge approaches on either side did not fall.)

“It was like someone had lined up dominoes in a row, and
gave them a push,” Wood later recounted in The Silver Bridge Disaster, “and they all came falling down and there was a
great big splash of water. I could see car lights flashing as they
were tumbling into the water. The car in front of me went in.

Then there was silence.”

Thirty-eight vehicles were on the bridge when it fell. Twenty-four fell into the river, seven fell onto the riverbank,
and seven remained on the bridge approaches.

First responders and volunteers reached the disaster site quickly, but conditions were difficult. It was dark and cold—
21 degrees F, with a water temperature in the low 40s. Never-
theless, people tried to help survivors trapped in the water.

President Lyndon Johnson set up a task force to inves-
tigate why the bridge had collapsed, as well as to plan a
new bridge and assess bridge safety across the country. In-
vestigators with the National Transportation Safety Board
considered a variety of reasons to explain the Silver Bridge
disaster, including sabotage, tower failure, vehicle colli-
sion, scour, and wind failure. Inspectors eventually found
the culprit—eyebolt number 330, on the north side of the bridge, 50 ft west of the
Ohio-side bridge tower. The collapse was
due to a 1/8 in. cleavage fracture, which,
says Brown, had “propagated due to stress
corrosion and corrosion fatigue.” It’s an un-
imaginably small crack to have caused so
much destruction. “You could put two
of your thumbsails together and have an
eighth of an inch,” he says.

Once that eyebolt broke, the change in
the forces caused the adjacent eyebolt to dip
off the end of its connecting pin. Once the
susension chain was severed, the bridge
was doomed. According to a 2009 report
by the National Institute of Standards and Technology (ar-
chived at http://archive.is/OGm7), “The adjacent tower was
subjected to an asymmetrical loading that caused it to rotate
and allow the western span to twist in a northerly direction.
This span crashed down on the western shore, folding over on
top of the fallen cars and tracks. Loaded by the whole weight
of the center span, which had now become unsupported on its
western end, the east tower fell westward into the river along
with the center span. Finally, the west tower collapsed toward
Point Pleasant and into the Ohio River.”

The “double duty” of some of those eyebars—serving as
both part of the top chord of the stiffening truss and as suspen-
sion members—probably didn’t help matters. “If there had
been a separate top chord for the stiffening truss,” says Brown,
it might have been possible that the stiffening truss could have
prevented, at least temporarily, a total collapse of the bridge.”

But what had caused the crack? According to Petroski,
John Bement of the National Bureau of Standards, one of the
inspectors, concluded that the rust-encrusted crack “had grown
over a long period of time from some much smaller manufac-
turing imperfection. The mechanism by which it grew from
an imperfection to a flaw was a combination of repeated concen-
trated forces and corrosion that assisted in the resultants’
extension into the metal.” Cars and trucks by 1967 had also
grown significantly heavier than the vehicles the bridge was
designed for in 1929.

Petroski continued that once the crack grew large
enough, the load on the chain grew too strong for the link.

“Spontaneous brittle fracture occurred on the side of the
eye containing the crack. This shifted the entire load that
the eyebar had carried to the oth-
er (unbroken) side of the eye and
caused it to tear apart in a non-
breakable way.”

The task force’s final report, three years after the collapse, as-
signed no blame to the bridge de-
signers; it noted that “stress cor-
orrosion and corrosion fatigue were
not known to occur in the classes
of bridge material used under con-
ditions of exposure normally en-
countered in rural areas.”

But Petroski pointed out that the
design did have a flaw. “The
failure was rooted in a design that
inevitably made inspection all
but impossible and failure all but
inevitable,” he wrote. (And, as Bul-
lard et al. noted, similar corrosion
crews were found on other eyebars.)

While the community grieved and
inspectors investigated the collapse,
the towns around the bridge had to
determine how to get traffic moving again. The close-
est bridges were miles away. Ferries were
launched by February 1968, but they
were only a temporary fix. The bridge
collapse was costing the town and
month.

President Johnson had vowed that the federal government
would replace the bridge within two years, and on December
13, 1969, the 1,950 ft Silver Memorial Bridge, built with a
conventional cantilever design, opened 1.5 mi south of its
predecessor. The old approaches to the Silver Bridge were
eventually demolished in the 1970s, and a brickwork memo-
rial was placed in downtown Point Pleasant.

While the Silver Memorial Bridge still stands, the more
important legacy of the Silver Bridge collapse was the cre-
ation of the National Bridge Inspection Program, which
modernized a previously scattered approach to bridge in-
spection in which states had essentially been on their own
to establish standards. A series of laws, beginning with the Fed-
eral-Aid Highway Act of 1968, which required an inventory
of the federal highway system, began to put in place Ameri-
cas’s contemporary bridge inspection program.

Brown says that over the years the federal inspection pro-
gram has allowed bridge inspectors in West Virginia to
identify problems with some bridges that, left uninspected,
might otherwise have collapsed.

“This was tremendous, and ev-
everybody realizes that, but they didn’t
pish in vain,” says Brown. “Hope-
fully [people] get a little bit of solace in
the fact that some good came out of it.”

T.R. Witcher
T.R. Witcher is a contributing editor to Civil Engineering.