

STEEL CONNECTIONS

Engineers Slam Failed Joint Detail

Fear that slotted connection behind Pittsburgh collapse may be 'locked up' in other structures

In the realm of structural failures, the Feb. 5 collapse of a steel beam at the four-year-old David L. Lawrence Convention Center in Pittsburgh ranks among the most benign. No one was hurt, the damage was limited to a 60 x 30-ft bay in the second-floor loading dock; the fix is simple, and the facility is set to reopen for business this month. But the collapse, the

consequence of the locking up of a slotted, beam-to-girder connection along the facility's main expansion joint, has sounded the alarm about the pitfalls of the detail. Structural engineers say there could be other steel frames with sliding connections that have locked up, thanks to the popularity of the connection and its potential for misapplication. And they hope the failure will provide designers with ammunition to resist approving the detail for use under improper loading and weather conditions, similar to those that existed in Pittsburgh.

"It's good that this detail is brought to light because there is a cavalier attitude that it works for all loading situations," says Don Engler, vice president of international operations for BDS Steel Detailers, Tempe, Ariz. "The detail is problematic unless the loads are very, very light," says Engler, a licensed structural engineer with 38 years of experience in steel fabrication, detailing and erection. But

it is popular because it is "the cheapest," he says.

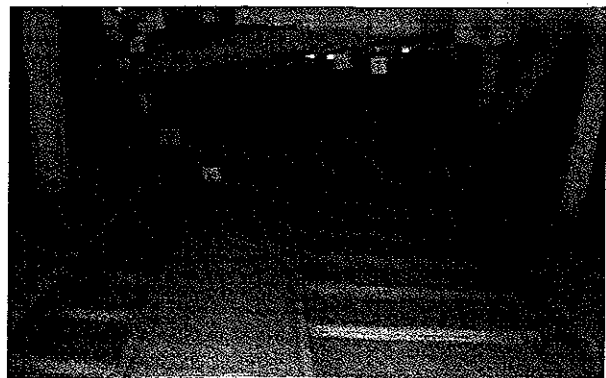
The failed beam is framed into a box girder that is the upper chord of one of the trusses that support the building's cable-stayed roof. The facility was designed by Rafael Viñoly Architects, New York City, to mimic nearby suspension bridges

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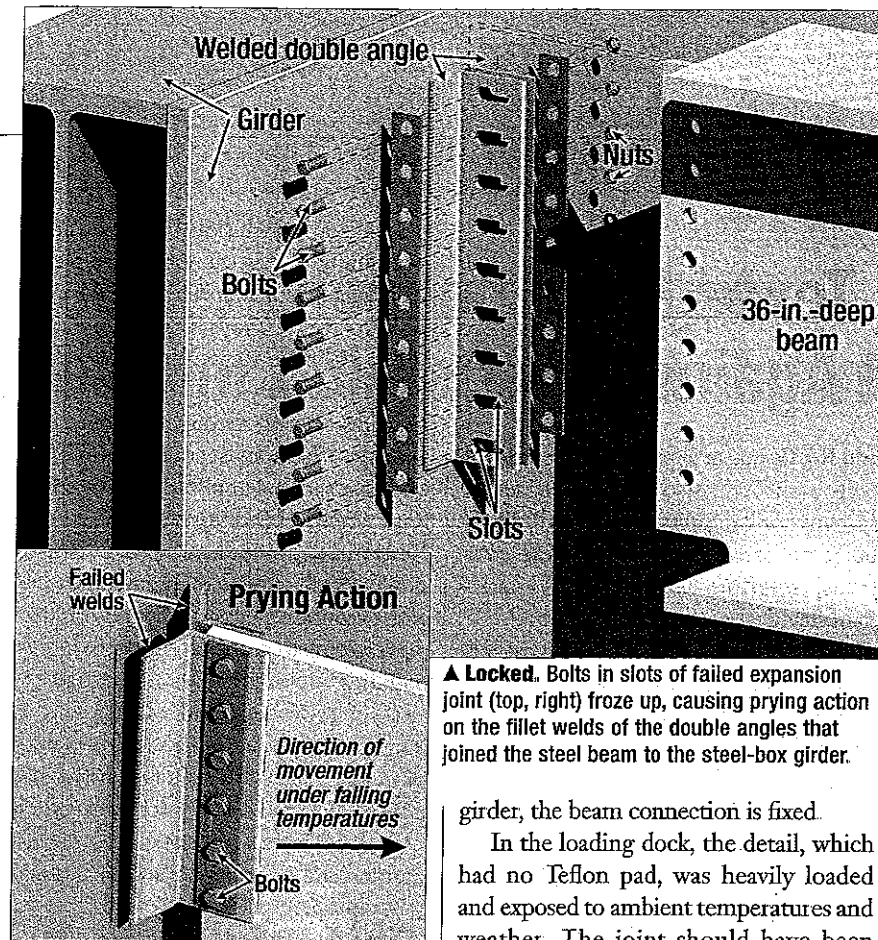
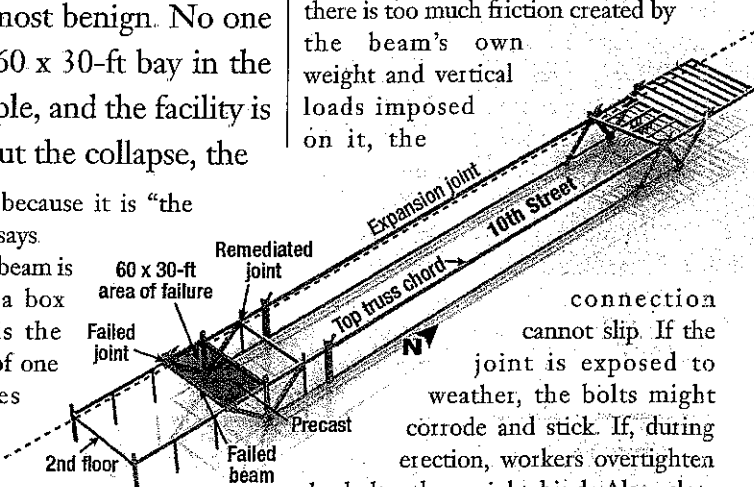
The connection, which relies on bolts sliding in slots, is vulnerable to slippage. If there is too much friction created by the beam's own weight and vertical loads imposed on it, the

connection cannot slip. If the joint is exposed to weather, the bolts might corrode and stick. If, during erection, workers over-tightened the bolts, they might bind. Also, slots could be too short to allow adequate movement under a wide range of temperatures. Further, the connection depends on precision fabrication and erection: If beam-to-beam slots do not line up exactly or if beams are not aligned, an uneven loading condition could cause failure.

The American Institute of Steel Construction Inc., Chicago, recommends a double line of framing so there is no load transfer across an expansion joint, says Charles J. Carter, AISC's chief structural engineer. "When load must be trans-



▲ Drop. Collapse at Pittsburgh convention center caught by security cameras in the 10th Street entrance that slices under the facility.



▲ Locked. Bolts in slots of failed expansion joint (top, right) froze up, causing prying action on the fillet welds of the double angles that joined the steel beam to the steel-box girder.

ferred, our design guide shows several details with a sliding mechanism that usually incorporates a low-friction element, such as a Teflon-like pad," says Carter. None show bolts transferring shear and sliding at once, he adds.

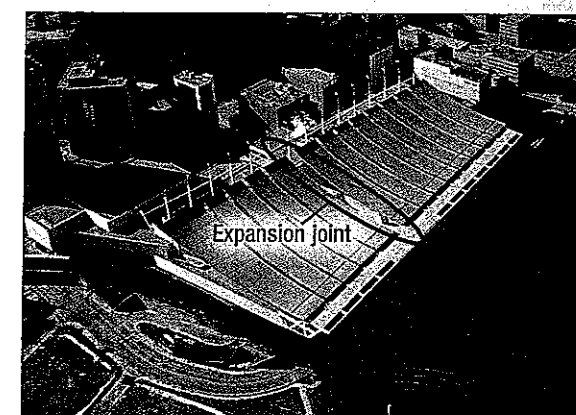
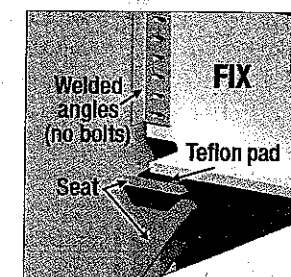
The 1,000-ft-long facility has expansion joints on floors two, three and four. The 575-ft-long joint runs in the short direction, over 10th Street, which slices the facility at grade and provides vehicular access. At the failure location, 70 ft from the south perimeter in the east section, 36-in.-deep wide flange beams with side plates frame into the box girder, also with side plates. The failed joint had back-to-back angles with slotted holes, fillet-welded to the box girder.

"The expansion joint is the line through the nine, 2-in.-wide slots," says Gary F. Panariello, principal of New York City-based structural consultant Thornton Tomasetti, which designed the connection repair for Viñoly and the steel fabricator, ADF Group, Montreal. It is the only thing designed to move, he adds. On the west side of the

girder, the beam connection is fixed.

In the loading dock, the detail, which had no Teflon pad, was heavily loaded and exposed to ambient temperatures and weather. The joint should have been welded to the box girder in line with the beam, but geometry prevented access, says a source familiar with the structure. As a result, the 20-in.-long fillet weld was more vulnerable to prying action, which is given as the failure mechanism.

In the damaged bay, precast concrete double-Ts spanned between beams to create the floors. If the precast had been parallel to the failed beam, as it is in other areas, the damage would have been greater, say sources.



▲ Riverside. A seat (top) is replacing the failed detail and is being added at 25 other locations along the expansion joint.

As temperatures dropped to 4° F, each building half wanted to shrink toward its own center, causing the halves to move away from each other. But the joint locked.

Thornton Tomasetti found four other joints that needed immediate attention. The fix, including for the failed joint, is similar to a suggestion on the structural drawings: It calls for the addition of a 1-ft-square steel seat, about 1.5 ft tall, fillet-welded under the double angle. The beam slides on a 10 x 5-in. Teflon pad on the seat. The bolts are out, says Panariello.

ADF, which designed the detail, and the structural engineer, Dewhurst Macfarlane & Partners in association with Goldreich Engineering, both in New York City, were not available for comment on why that detail was used.

Often, the structural engineer shows conceptual connection details with certain conditions on the drawings. After the fabricator's detailer designs the connections and stamps the drawings, the engineer of record reviews and approves them. As far as responsibility goes, "the fabricator will say the engineer approved the detail; the engineer will say the fabricator sealed the shop drawings," says one source.

The New York City office of Wiss Janney Elstner, working for the Allegheny County-Pittsburgh Sports & Exhibition Authority, has a similar fix for 21 connections that have shear tabs, not double angles.

All remedial work should be done by March 9, when the building is set to reopen. SEA, after holding a Feb. 20 press conference on the mechanism of the collapse, declined comment on the causes until metallurgical tests are complete in a week or so. ■

By Nadine M. Post