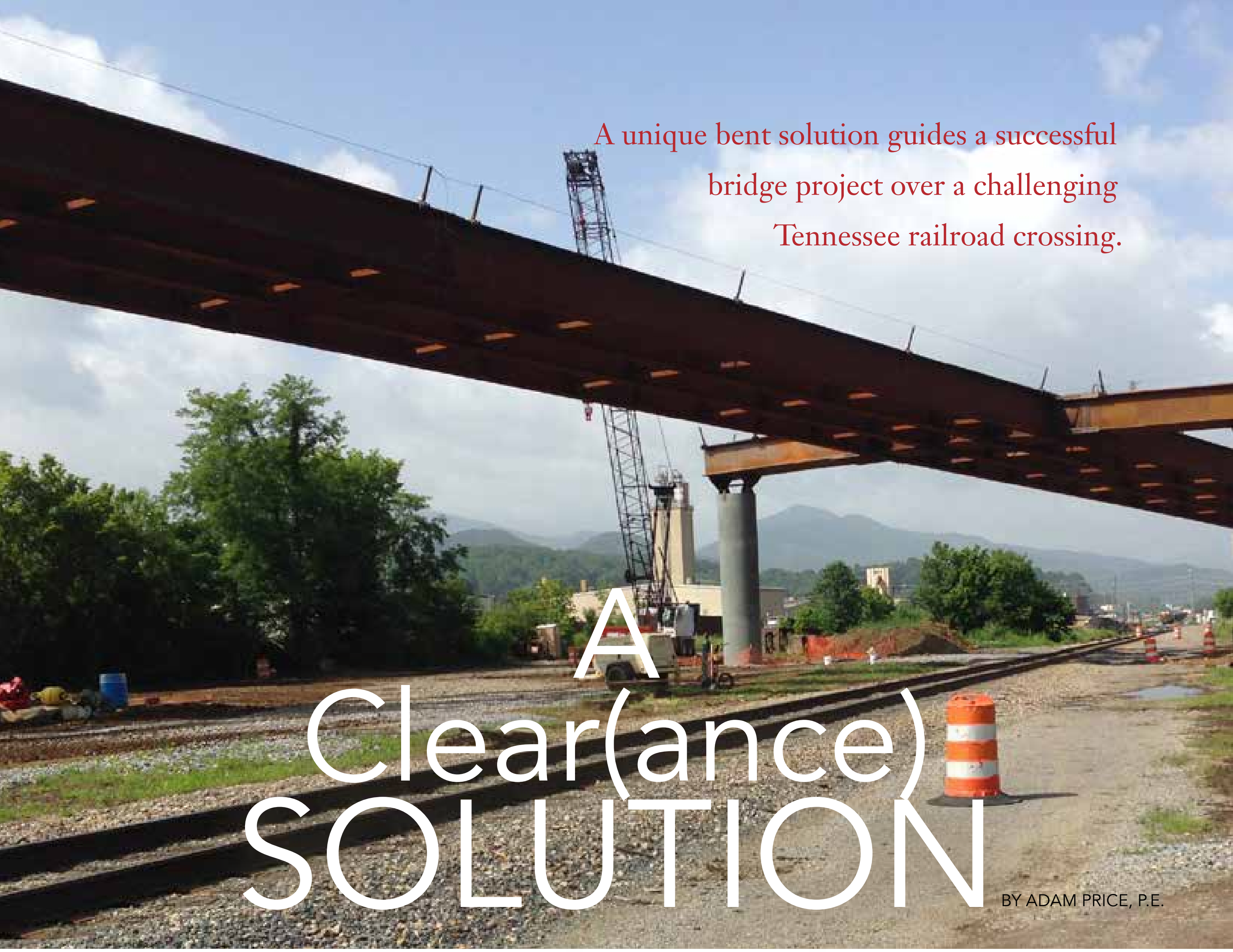


A unique bent solution guides a successful bridge project over a challenging Tennessee railroad crossing.

A Clear(ance) SOLUTION

BY ADAM PRICE, P.E.

THERE WAS TOO MUCH HAPPENING in too short of a stretch of State Route 107 in Erwin, Tenn.

The highway intersected with the CSX Railroad at a main line and a spur line that were only 500 ft apart. These at-grade intersections caused serious traffic delays in this community in the Appalachians of eastern Tennessee, not only for the motoring public but also for emergency vehicles. As motorists figured out other routes to avoid the congestion, the result was a downturn in business for many local businesses. In order to solve these problems, the Tennessee Department of Transportation (TDOT) decided to change the alignment of State Route 107 and install a bridge over both tracks. The alignment shift allowed the bridge to be built without phased construction, which would have created even more traffic congestion during construction.

At each of the two tracks spanned by the new bridge, CSX Railroad needed 50 ft of horizontal clearance for a future track adjacent to the current one; normally, TDOT provides at least 25 ft of horizontal clearance from the centerline of the track to the closest substructure. The skew angle between the main line and State Route 107 is 45°18'34" to the roadway centerline while the skew angle between the spur line and State Route 107 is only 21°52'1" to the roadway centerline—and this very acute skew angle at the spur line made the horizontal clearance requirements more difficult to meet.

Straddle Solution

When it came to vertical clearance, the bridge has six piers and piers 1 and 3 were placed as close together as reasonably possible. However, supporting the span between them became a puzzle. Due to the load, a girder would need to be very deep (over 8 ft deep) but this would violate the vertical clearance requirements. And placing a traditional pier between these two would encroach on the required horizontal clearances.

The decision was made to straddle the railroad by using a bent with two columns placed outside the required clearances to support the cap and superstructure. (TDOT considers substructures with a single column to be piers and multiple columns to be bents, hence the designation as a "straddle bent.") The width of the bridge is 38 ft, 5 in., but the cap length for the straddle bent is 96 ft. Due to vertical clearance requirements, a steel integral box cap was the most viable option, and ASTM A709 Grade HPS50W steel was used for the flanges and webs. Grade HPS50W was used in lieu of Grade HPS70W because the stiffness of the heavier section would help reduce live load deflections. And since the bottom flange and webs are fracture critical, Grade HPS50W steel was used in lieu of Grade 50W due to its higher Charpy V-notch toughness and better weldability. All other piers are reinforced concrete single-column hammerhead piers.

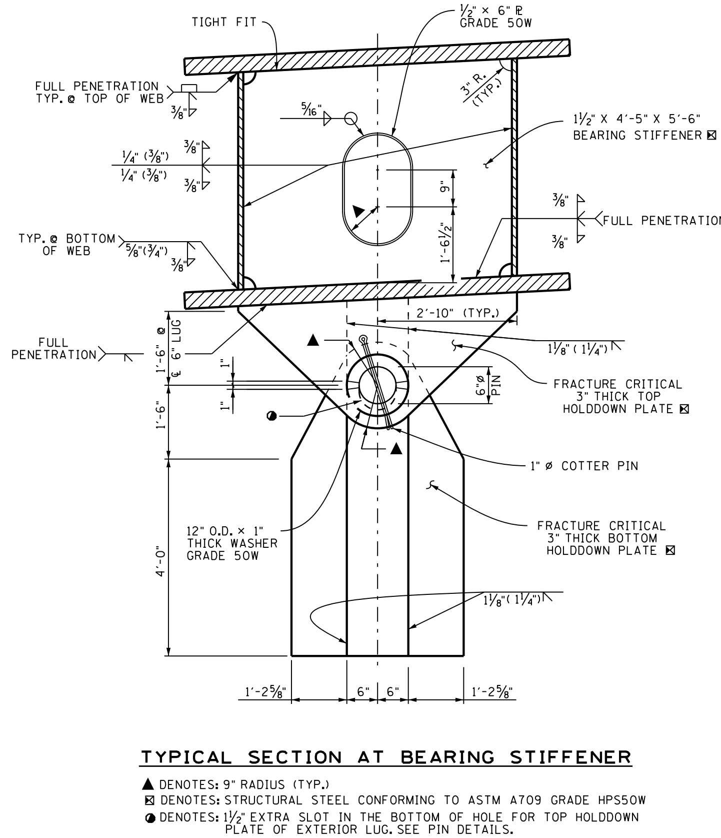
The bridge used 1,218 tons of weathering steel in all.

The width of the bridge is 38 ft, 5 in., but the cap length for the straddle bent is 96 ft.

To accommodate the span lengths dictated by the railroad crossing, welded plate weathering steel girders (ASTM A709 Grade 50W) with a web depth of 66 in. were used, and the resulting seven-span bridge has a total length of 1,101 ft. Expansion joints were provided at both abutments to accommodate thermal contraction and expansion, and all abutments, bents and piers are founded on end bearing HP12×53 steel piles. The columns are reinforced concrete with ASTM A709 Grade HPS50W steel casings. The bearing assemblies consist of lugs welded to the cap and column casings in bearing around a steel pin—a much stronger bearing style than the traditional pin shear style.

Uplift Challenge

A key design challenge came in the form of the large uplift forces encountered at the outer top hold-down plates under full dead and live load. This was a result of the large couple generated due to the bearing lugs for each column being only 5 ft, 5 in. apart. In order to avoid the formation of this couple, only the exterior lugs were welded to the column casings when the cap was



As a design contingency, each lug was designed to carry the entire reaction acting alone, and bearing stiffeners were placed inside the cap over each lug.

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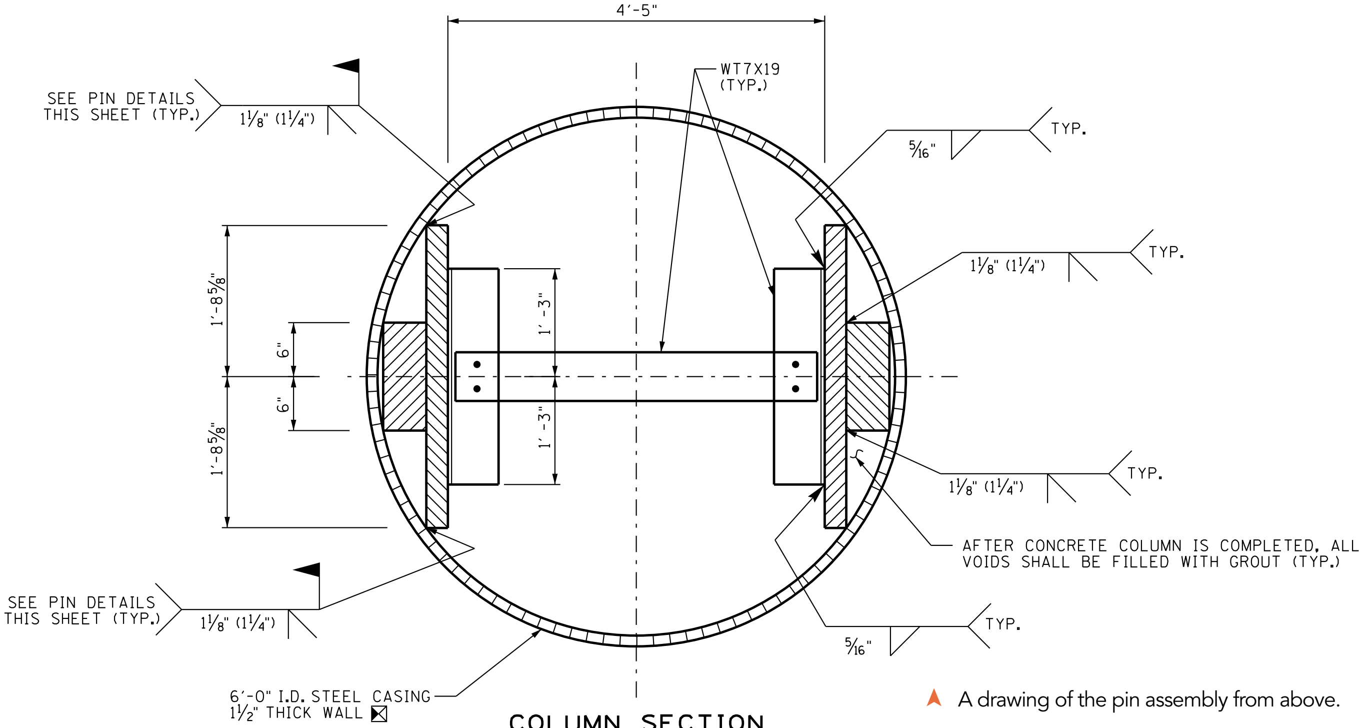
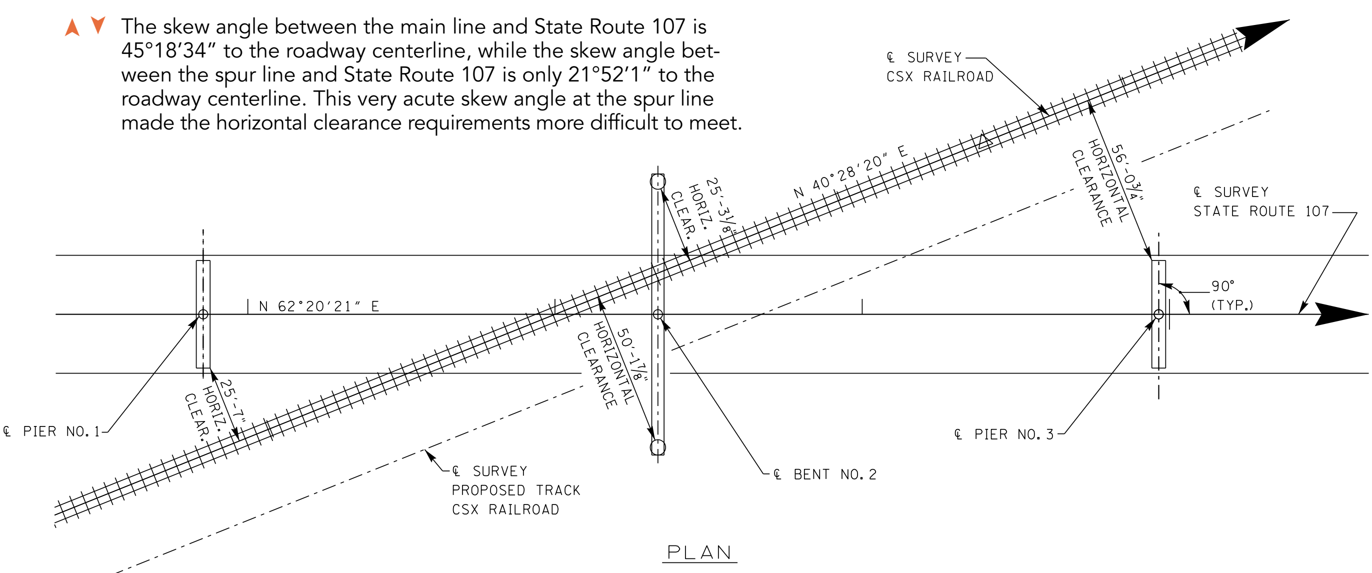


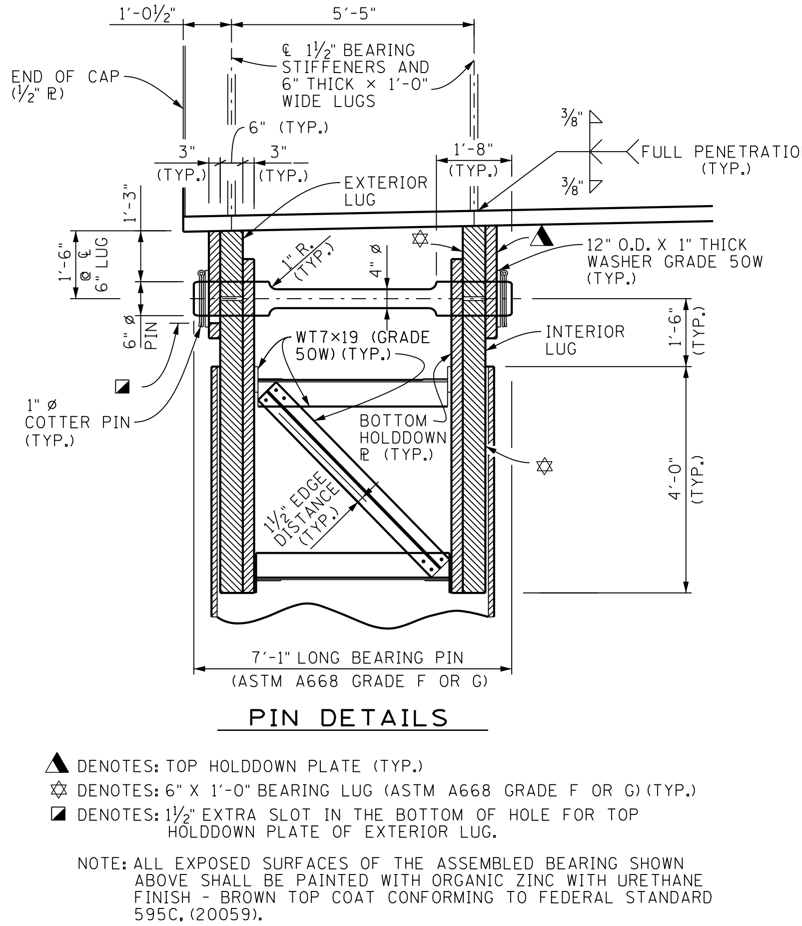
▲ A drawing of the pin assembly from above.

▼ To accommodate the span lengths dictated by the railroad crossing, welded plate weathering steel girders with a web depth of 66 in. were used.

▲ ▼ The skew angle between the main line and State Route 107 is 45°18′34″ to the roadway centerline, while the skew angle between the spur line and State Route 107 is only 21°52′1″ to the roadway centerline. This very acute skew angle at the spur line made the horizontal clearance requirements more difficult to meet.



The bearing assemblies consist of lugs welded to the cap and column casings in bearing around a steel pin.



A detail of the pin assembly.

first erected, guaranteeing no load on the interior lugs. After half of the total non-composite dead load deflection at the interior lugs was achieved during the bridge deck pouring operations, the inner lugs were then welded to the column casings. Thereafter, all subsequent dead and live load bears on the inner lugs.

To eliminate the large uplift forces at the outer top hold-down plates under full dead and live load, an extra 1½-in. slot was fabricated in the bearing pinhole of the hold-down plate to release it in uplift and prevent the couple from forming. As a design contingency, each lug was designed to carry the entire reaction acting alone, and bearing stiffeners were placed inside the cap over each lug. Also, stiffener plates were placed inside the cap in alignment with the girder webs, and the height and width of these plates matched the interior dimensions of the cap. Manholes were provided at each end of the cap and in all internal stiffener plates to allow access for inspection.

Biaxial bending was not desirable for the cap. The resulting biaxial stresses would require flange plates rolled in both directions, which is not practical, so a special detail was used to effectively eliminate cap flange transverse stresses. Instead of bolting the girders directly to the cap flanges, the girders were bolted to filler plates extending over and under the cap. Thin neoprene pads were placed on both sides of the filler plates and between the inner splice plates and the bevel plate. The bevel plates were required since the girders were plumb while the cap was sloped to match the roadway cross-slope. This sandwich detail effectively allowed the longitudinal forces in the girder top and bottom flanges to pass over and under the cap without introducing stresses in the cap flanges. Using this detail, the cap was then designed for moments and shears due to the girder reactions and cap self-weight, greatly simplifying the design. In addition, bolted field splices were provided to reduce the weight required to lift the cap in the fabrication shop.

Altogether, the bridge used 1,218 tons of weathering steel and opened to traffic in May. The integral steel straddle bent achieves CSX Railroad's targeted horizontal and vertical clearances needed for a future railroad track, while allowing TDOT to build the bridge needed to eliminate the traffic congestion problems at the crossing. ■

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