CONTINUOUS WELDED RAIL ON BRIDGES

Ken Bruestle

Senior Project Manager
HNTB

Introduction

I have been asked to talk about continuous welded rail, or CWR, on bridges today, but before we discuss the application to bridges, I am going to review some of the basics of welded rail.

Welded rail was introduced as a means of eliminating rail joints. A rail joint creates a weak spot in the track structure and an opening for wheels to pound. Removal of joints provides for a much stronger track structure and elimination of a wheel impact source. The familiar bolted joint is a simple way of splicing standard lengths of rail together in the field. For many years, the bolted joint was the only method used to join the pieces together.

The first installations of welded rail utilized standard lengths which were welded together in the field to create a continuous string. The weld procedures were slow and not very reliable, so the use of CWR was somewhat limited.

With the development of the modem rail welding plants which produced quality welds, and the special rail trains which could handle 1500' strings of rail, many railroads began to replace their worn bolted rail with continuous welded rail on the mainlines.

The 1500' pieces are joined in the field by a reliable weld procedure, so the track is virtually jointless, except at switches and other such locations. Today, most mainline rail is CWR.

CWR is placed in the roadbed in an unstressed state at so-called neutral temperature. Neutral temperature varies from location to location, ranging from about 90 degrees in the Northern latitudes to as high as the 120's in warmer climates.

Generally, auxiliary heat is required for the rail to reach neutral temperature, so the use of rail heaters is a common practice during installation.

I will now take a few minutes to discuss the mechanics of welded rail both in and out of the roadbed.

If rail is unrestrained, and is subjected to a temperature change, it will expand or contract at a rate proportional to the temperature change. The rail will always be in an unstressed state, if it is unrestrained.

When CWR is installed in the roadbed, it is no longer unrestrained. The rail is not allowed to move longitudinally. If the rail is now subjected to a change in temperature it will develop internal stresses. This stress is about 200 psi for each Fahrenheit degree of temperature difference.

The force that develops in CWR is dependent on the temperature change and the size of the rail. It is independent of the length.

At the discontinuous ends of CWR, the force in the rail must be resisted by the rail anchoring system. Between such locations, the forces in the rail are internally equalized, and the anchoring system will not be required to exert any restraining forces unless a rail failure or a sun kink occurs.

A sun kink is a lateral buckle of the track, which can occur in hot weather when the anchoring system and ballast in the roadbed do not provide adequate lateral restraint. Sun kinks are generally worse in tangent track than in curved track, since the track must buckle in a reverse curve in tangent alignment.

Often in the past, sun kinks would occur during the passage of a train and cause a derailment.

The railroad industry has researched the behavior of CWR in roadbed quite extensively over the years, and now experiences very few derailments due to sun kinks.

If the rail is allowed to creep longitudinally in the roadbed, higher stresses than predicted will occur. Therefore, it is important for the rail to maintain its location in the track.

And that's about all I know about CWR in roadbed.

Let's discuss CWR on bridges now.

CWR on Bridges

Twenty five years ago, when the use of CWR began to proliferate, most railroads were very cautious when using it near bridges. How the rail would perform was an unknown and there were few rules or guidelines governing its use on bridges.

The Chief Engineer of one railroad simplified the rules for welded rail on bridges for his company. He declared that CWR would not be placed on them.

Although this policy may have solved his anticipated problems with CWR, it created other problems. By making the rail discontinuous near the bridge ends, special attention had to be given to the anchoring system in those locations. In addition, this policy does not take advantage of the inherent benefits of CWR.

Today, when a CWR installation is done, it is generally placed continuously on all bridges within that relay length, also.

CWR installations on open deck bridges have experienced more problems than installations on ballasted deck bridges, apparently due to the anchoring systems used on open deck bridges.

Open deck bridges with bolted rail will generally experience damage to the ties under the rail joint because this is a weak spot in the rail. The higher impacts delivered to the rail joint are transmitted to the ties under the joint. Plate cut and splitting of the tie will occur at the joint first. After a joint tie has sustained damage, the adjacent ties begin to suffer, also.

As in roadbed, bad ties propagate bad ties.

Timber ties on open deck steel bridges are generally larger than track ties because they must perform more as a structural member than does a track tie. Bridge ties usually must be detailed and fabricated for a specific location. There are no standard bridge ties. Therefore, they are more expensive than track ties.

The installation of CWR on bridges greatly reduces the impacts that are delivered to the ties by the train wheels. CWR on bridges should promote longer tie life, if the installation is done properly. This longer tie life means savings for the owner.

But, what constitutes a proper installation of CWR on a bridge'?

We might ask seven different railroad bridge engineers and get seven different answers. If we ask the roadmaster, we may get another opinion.

Chapter 15 of A.R.E.A. has recommendations for installing welded rail on bridges. Recommendations are made for open deck bridges and for ballasted deck. Short span installations and long spans are discussed. There are guidelines for tangent and curved track.

If A.R.E.A. has covered this topic so thoroughly, then why should there be any controversy? The controversial area is the treatment of CWR on long spans. What appears in the A.R.E.A. Manual for long spans is a field-tested installation procedure, that has worked well in many cases. But, at times, the prescribed procedures do not work right for a particular installation and other techniques have been utilized.

The reason that long spans can experience difficulties with CWR is that all railroad bridge spans change length with temperature and long spans move more than short ones.

If CWR is anchored continuously to a long steel span, the rail must either move with the span, and experience increased internal stresses, or the anchoring system must slip, or the bridge ties and tie spacers will split from the movement of the track.

We certainly don't want to increase the internal stresses in the rail and risk a track buckle just off the bridge.

And, on the other hand, if the rail anchoring system slips or damages the ties, we are using the wrong anchoring system.

So we conclude that the rail must be unanchored on long spans, or a special anchoring system must be employed.

Another solution is to introduce a rail expansion joint near the end of the span. This allows the rail to move with the span without inducing stresses in the rail. Rail expansion joints have worked well in many installations, and I would venture a guess that all major roads have one, or more, of these installations.

They are also used with all movable spans.

One method of anchoring rail on open deck bridges is to place rail anchors, such as Channellock or others, tightly on either side of all ties that are bolted to the span.

A fairly new anchoring system for bridges involves so-called elastic fasteners, as those developed by Pandrol. This system eliminates the need for conventional rail anchors. A steel clip provides the restraint to keep the rail from moving relative to the tie.

A variation on this system is the zero longitudinal restraint fastener. This fastener restrains the rail vertically and laterally, but allows the span to move longitudinally under the rail in response to temperature changes.

This system has been employed by several railroads recently with very favorable results. One road has used this system in order to eliminate rail expansion joints on one of their bridges.

This double track structure had six rail expansion joints which were removed when the new 136 lb rail and anchoring system were installed.

You may recall that earlier in this presentation, I suggested interviewing seven different railroad bridge engineers. Well, in fact, I did that several years ago, with the results shown in this table. You will notice that there is very little agreement between the various roads.

I would like now, to present a couple of case histories. This bridge has only one long span, but there are long approaches with numerous short spans.

The ties are moving and skewing, as though one rail is running north and the other one south.

Some of the ties have split.

Tie spacers have broken, as well.

This movement is occurring in spite of the fact that some of the ties are secured by an angle welded to the top flange of the span.

What is the solution? Perhaps a different rail anchoring system and continuous tie spacers would improve the situation.

In this case, approach embankment grades and direction of heavy traffic may be contributors to this phenomenon.

Another case history takes place near a small community that claims to be the home of Superman, Metropolis, Illinois.

A major bridge over the Ohio River had been experiencing movement in the CWR, in spite of having several rail expansion joints strategically placed.

This installation was with standard tie plates and spikes, and conventional rail anchors. This system was not able to restrain the rail from moving.

At one floorbeam, the ties had skewed and bunched badly.

At other locations, the ties were skewed and split.

The owner is presently experimenting with different anchoring systems and rail expansion joint configurations, and appears to be realizing some degree of success.

Conclusions and Recommendations

Ballasted deck bridges are usually less troublesome than open deck bridges with CWR.

Short spans and short bridges generally fare better than longer spans and bridges.

The rail anchoring system is very important. Rail expansion joints may be eliminated with the proper anchoring system.

Every bridge is unique.

Topics for Further Study

With the introduction of the new A/C traction locomotives, what will the effects of the increased traction forces be on CWR on open deck structures? Foutch and Tobias have done some work on this subject and reported their findings at the Workshop on Bridge Research in Progress, in July.

What contribution to resistance to seismic forces does CWR provide? The A.A.R. has conducted a full-size field test in California and has reported the results. In addition, the topic is currently an assignment for A.R.E.A.

Mr. Clark: Thank you, Ken. Our next feature is Amtrak's Track Alignment and will be presented by Paul Mertens, director of track geometry maintenance with Amtrak.