Update on CWR on Open Deck Bridges

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ABSTRACT

This paper explains the recent changes to Part 8 of Chapter 15, Steel Bridges (1), concerning Continuous Welded Rail on Open Deck bridges that allow for seemingly conflicting solutions. The changes are based on an analytical model developed based on several tests conducted by the Transportation Technology Center, Inc. (TTCI) at the Federal Railroad Administration’s Facility for Accelerated Service Testing (FAST) and on several member railroads, data from tests done in China on rail and conclusions of tests done in Europe under the directions of Professor Fryba (2) for the European Rail Research Institute of the International Union of Railways (UIC).

The TTCI test results (3) indicate that full anchorage similar to that on open track is not appropriate on open deck bridges if the tie to structure interface is restrained by rivets or similar restraints. Test results also indicate that minimal restraint reduces considerably the stress in the rail that would cause the rail to break during cold weather.

Test results at high temperatures gave clear results but further testing will be required to fully understand cold weather behaviour.
INTRODUCTION

What is the best way to deal with the interaction of rail and bridge under varying temperature situations while at the same time dealing with potential rail creep and possible disastrous derailments due to rail fracture or rail buckling?

The question has been answered by different North American railways with a variety of policies varying between two extremes of:

- fully anchoring the rail across an open deck bridge,
- or let it float across unanchored.

For quite some time the AREMA Manual, Chapter 15 (1) recommended allowing the rail to float across short bridges and recommended expansion rails on longer bridges and longer spans similar to the recommendations used in Europe and Asia.

Over the past few years, the Transportation Technology Center Inc. (TTCI), a wholly owned subsidiary of the Association of American Railroads (AAR) has conducted tests and simulations to try and more definitively deal with this issue.

This paper presents an update on the findings so far. Further testing is in progress to evaluate the interaction between rail creep and temperature effects on open deck bridges with continuous welded rail (CWR) and the effect of extreme temperature ranges on behavior.

BEFORE THE IMPLEMENTATION OF THE CURRENT RESEARCH PROGRAM

The 2009 Manual, Chapter 15 (1) stated the following:

“a. In the absence of definitive data, there is no satisfactory way to predict behavior of rail on bridges under the influence of temperature changes, braking and traction of trains, and creep. Recommendations which follow are based on experience.

b. Effectiveness of deck and rail anchorage systems on bridges is dependent upon proper anchorage and
of track on the roadbed approaches.”

The recommendations at the time can be summed up as:

- For bridges without rail expansion joints to provide no anchors for bridges less than 300 feet long and for bridges longer than 300 feet to anchor only the first 100 feet of each span. Bridges less than 50 feet could be anchored.
- Expansion rail joints were recommended on individual spans 300 feet or greater, on moveable bridges, and bridges with curves over 2 degrees.
- Cautions were given to avoid buckling and to consider the effect of disturbing radial forces on curved track during maintenance operations.

**RESEARCH FINDINGS TO DATE**

Research was carried out by TTCI beginning in 2007 as part of the AAR Strategic Research Initiatives to reduce the stress state of railroad bridges. The Manual material has now progressed to the point where it can be stated that the recommendations are based on experience and research work done by TTCI and the UIC (International Union of Railways) as well as the Chinese CWR Institute.

The results of this investigation indicate that there are conflicting considerations regarding thermal effects of CWR on long open-deck bridges.

Rail expansion joints effectively accommodate rail thermal expansion and contraction; however, their use generates high impact loads and may accelerate bridge degradation. Also they are costly to install and require high maintenance.

Without rail expansion joints, longitudinal rail restraint must be incorporated to reduce longitudinal gap width and derailment risk should a rail break due to cold weather induced tension. However, rail restraint will introduce high rail longitudinal forces into the bridge in case of a broken rail.
Longitudinal restraint also causes longitudinal forces to develop in the rail during span expansion and contraction. These forces add to the rail force developed from heating and cooling of the CWR. Additional compressive forces in hot weather might increase the risk of track buckling at bridge approaches, particularly at abutments that support expansion bearings. Additional tensile forces in cold weather might accelerate rail defect and crack growth rates and increase the derailment risk in the case of a rail break.

An alternative to rail expansion joints in CWR is to allow the rail to be unanchored on bridges under a certain length. The philosophy behind this approach is that the risk of rail break at cold temperatures, assuming there are no serious rail flaws, should be less as there is little or no transfer of forces between rail and bridge. A drawback is that, should a rail break, there may be little to constrain the resulting longitudinal rail gap.

Although not specifically simulated in this investigation, damage to decks and fasteners due to large thermal displacements between rail-tie and tie-deck interfaces has been reported in the field. This will likely be more evident on riveted or bolted top surfaces or where there are other methods of holding ties longitudinally on structures where ties do not easily slide on the top surface of the span. On long riveted or similarly constrained top surfaces of spans not protected by expansion joints, fasteners should be selected that are capable of accommodating the expected rail-tie displacement without damage to ties.

Figure 1. Example of Damage to Bridge Deck Ties due to Thermal Expansion (14” wide ties)
Results emphasize the need to maintain good track lateral resistance and proper rail neutral temperature on bridge approaches to minimize track buckling potential. On approaches near expansion bearings track lateral resistance is critical. Methods to provide additional lateral resistance should be considered – for example, additional width in the ballast shoulders, full height wing walls, sheet piling and use of ties with improved lateral restraint.

The main conclusion from European studies (2) for open deck bridges is that mutual displacements between rail and bridge structure must be compatible.

**Anecdotal Evidence**

There is considerable anecdotal evidence that has been used in writing the current (2011) requirements where conclusive test results do not clearly contradict that evidence. Much of the anecdotal evidence is seemingly contradictory. The only consistent anecdotal evidence is that long spans that have floor systems that incorporate floor system expansion experience serious distress unless rail expansion joints are appropriately used.

As more tests are completed the justification for seemingly contradictory policies produced by the anecdotal evidence will be replaced by recommendations based on test results.

**Chinese Data**

The Chinese have a rather large group researching the effects of CWR going back to the 1960s and some useful information has been published (4). Unfortunately this book is only available in Chinese.

The major concern on bridges is the rail longitudinal gap issue and interaction forces between bridge structures and track shall not exceed a certain specified allowable values. There also is concern about forces transferred to piers.

In Chinese specifications for spans less than 105 feet, K style fasteners are used to anchor the rail with anchorage limited to about half the anchorage on open track. This limit is expressed as a limit on torque of 44 to 59 ft-lb which equates roughly to 411 to 480 lbf/ft or 34.25 to 40 lbf/inch. This compares to the TTCI “Fully anchored track on
smooth top girder/floor system at 49 lb/in. The total permitted length of bridge depends on the temperature range varying from 721 feet at a temperature range of 126°F to 328 feet at a temperature range of 180°F (+140 to –40). Longer spans or bridges are dealt with on a case by case basis. Thermite welds are not permitted on bridges. The committee also reviewed Japanese policy.

**TTCI Results (3)**

TTCI used an analytical model based on several tests conducted at the Federal Railroad Administrations’ Facility for Accelerated Service Testing (FAST) and on several member railroads to conduct a parametric evaluation. Variations of temperature, anchoring conditions and bridge configuration were considered to evaluate buckling potential, rail break potential and the resulting rail gap from a potential cold-weather induced rail break.

*Temperature Assumptions*

The Manual Recommendations are based on the following:

- Rail neutral temperature assumed as 100°F
- Span installation temperature assumed as 70°F
- Hot weather buckling risk:
  - Maximum rail ΔT of 45°F above rail neutral temperature
  - Maximum span ΔT of 45°F above span installation temperature
- Cold weather rail break risk
  - Minimum ΔT of -100°F below rail neutral temperature
  - Minimum ΔT of -70°F below span installation temperature

Values were also investigated for smaller and larger temperature decreases but are not used in the Manual recommendations. These are discussed in the Manual Commentary and will not be covered in this paper.
The Manual (1) simply states that for more extreme temperature variations that might occur in Northern regions of the US or in Canada, site specific evaluations should be carried out. TTCI is proposing to do a test in a cold region in the near future.

**Anchoring Conditions**

For the purpose of the evaluation, four anchoring conditions were defined:

1. Fully anchored- riveted top girder: This condition assumes that the member has rivets or bolts or other devices protruding from the upper surface that restrain deck tie movement and that rail anchors or elastic fasteners are installed on every tie (see Figure 2).

   ![Figure 2. Example of Devices Protruding from Upper Surface to Restrain Deck Tie Movement](image)

2. Fully anchored-smooth top girder: Assumes that rail anchors or elastic fasteners are installed on every tie. Significant sliding takes place at the deck to girder interface.

3. AREMA anchoring

   AREMA Anchoring-riveted top girder: This condition assumes that rail anchors and the connection of the deck to the span occurs at a nominal spacing of 4’8.
Figure 3. Sliding of tie to span hook bolts shown every 4th tie

AREMA Anchoring-smooth top girder: Same assumption except smooth top- so sliding will occur.

4. No longitudinal anchoring of rail on span

**TABLE 1. Typical Anchorage (longitudinal restraint) Values**

<table>
<thead>
<tr>
<th>Anchoring Condition</th>
<th>Longitudinal Restraint (lbf/in)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Open Track</strong></td>
<td></td>
</tr>
<tr>
<td>Fully anchored</td>
<td>65</td>
</tr>
<tr>
<td>Fully anchored – frozen ballast</td>
<td>130</td>
</tr>
<tr>
<td><strong>Smooth top girder / floor system</strong></td>
<td></td>
</tr>
<tr>
<td>Unanchored track</td>
<td>4</td>
</tr>
<tr>
<td>AREMA Anchoring</td>
<td>13</td>
</tr>
<tr>
<td>Fully anchored</td>
<td>49</td>
</tr>
<tr>
<td><strong>Riveted top girder / floor system</strong></td>
<td></td>
</tr>
<tr>
<td>Fully anchored</td>
<td>360</td>
</tr>
<tr>
<td>AREMA Anchoring</td>
<td>93</td>
</tr>
</tbody>
</table>
Table 1 shows typical anchorage values (longitudinal restraint) of rail to bridge (rail to tie in open track) based on testing (3). These values are for low strain rates such as the forces exerted as a span expands and contracts thermally. After a sudden rail break, the longitudinal resistance is about half the above values in Table 1.

*Expansion Bearings Friction*

Coefficient of Friction was, where not included in the measurements, was assumed to be 0.06 which corresponds to the lowest value assumed in the Manual for expansion bearings and should provide a reasonable, yet conservative result.

*Hot Weather –Buckling*

*Hot Weather Results*

The critical location for hot weather buckling is the expansion bearing end of span at the approach (Figure 5). This is generally the weakest point in the track structure usually with no lateral support (Figure 4). Assuming a buckling risk at 60°F above neutral rail laying temperature (150 000 lb rail force), fully anchored rail on spans over 200 feet with temperature rise of 45°F Rail force is not acceptable.

Figure 4. The weakest point in the track structure.
Another critical location is where two spans share a pier with opposing expansion bearings. In this case, span expansion could impart high forces into the bridge deck. In addition undesirable forces maybe absorbed by span members. Fully anchored rail with a riveted deck to span interface approaches the equivalent of the AREMA Longitudinal Design traction and braking force for E 48 loading on spans of 300 feet.

*Cold Weather Results*

The forces are lowest with no rail anchorage.

As with the hot-weather case a critical location is where two spans with opposed expansion bearings share a pier. This is the case of fixed bearings on the abutments and expansion bearings on the pier. For a rail temperature drop of 100°F and span temperature drop of 70°F, there is an increased rail break potential on all span lengths greater than 100 feet for all anchoring patterns except the zero anchorage case. This is the case used in the 2011 Manual (1).

In terms of effect on the span, the fully anchored rail with a riveted deck to span interface approaches the equivalent of the AREMA Longitudinal Design force for E 52 loading on spans of 200 feet. The other anchoring patterns are much less.
**Long Bridges – Short Spans** For long bridges of with 50 or 100 foot span, the anchored rail with a riveted deck to span interface approaches the equivalent of the AREMA Longitudinal Design force for E 80 loading on bridges of 100 feet or more when the rail breaks. The AREMA Riveted Anchoring case approaches the AREMA Longitudinal Design force for E 60 loading on bridges of 400 feet when the rails breaks. The other anchoring patterns are much less.

**Long Single Spans** For long single spans, the anchored rail with a riveted deck to span interface approaches the equivalent of the AREMA Longitudinal Design force for E 64 loading on bridges of 100 feet or more when the rail breaks and drops off for longer spans to a value of E45 at 300 feet. Other anchoring patterns are much less.

*Longitudinal Gap Widths If the Rail Breaks*

**Open Track** If a rail breaks a longitudinal gap of 5 ½ inches will occur on anchored track on ballast away from bridges. Longitudinal rail gaps of this magnitude are not acceptable in open track or on bridges. Most railroads perform frequent rail flaw detection in cold weather to find rails that have a high propensity for failure.

**Long Single Spans** For the case of unfrozen ballast on the approach, the best restraint came from the fully anchored riveted top girder condition with longitudinal gap widths at the expansion end controlled to 3 to 3.5 inches for all span lengths. For the fully anchored with smooth top flange interface the longitudinal gap width was controlled to 5 to 5.5 inches. Fully anchored open track away from a bridge would be able to control a longitudinal gap width to 5 ½ inches.

For the case of frozen ballast on the approach, again, the best restraint came from the fully anchored riveted top girder condition with longitudinal gap widths controlled to 2 to 2.5 inches for all span lengths. For the fully anchored smooth top flange interface, the longitudinal gap width was controlled to 3 to 4.5 inches. For unanchored rail, the reference open track longitudinal gap width value was exceeded at about 400 foot spans lengths.
For spans less than about 300 feet, all the anchoring conditions controlled the rail longitudinal gap width to less than the unfrozen ballast, open track rail longitudinal gap width value.

**Long Bridges with short spans 50 to 100 feet** For the case of unfrozen ballast on the approach, the best restraint came from the fully anchored riveted top girder condition with longitudinal gap widths at the expansion end controlled to 3 to 3.5 inches for all span lengths. For the fully anchored with smooth top flange interface the longitudinal gap width exceeded 5 inches for 100 foot bridges and above. AREMA Anchoring for riveted interface was less than the reference open track value for all bridge lengths to 1000 feet. Fully anchored open track away from a bridge would be able to control a longitudinal gap width to 5 inches. This was exceeded on the other anchoring patterns.

For the case of frozen ballast on the approach, again, the best restraint came from the fully anchored riveted top girder condition with longitudinal gap widths controlled to 2 inches for all span lengths. For the fully anchored smooth top flange interface, the longitudinal gap width was controlled to 5 inches up to 500 foot bridge lengths. For unanchored rail, the reference open track longitudinal gap width value was exceeded at about 300 foot spans lengths.

*Summary*

The key to CWR on open decks is compatibility of displacements between span and rail.

The Manual (1) requires rail expansion joint for spans of 300 feet or more. So discussing a 299.99 foot span, placing full anchoring of rail on such a span would potentially reduce the predicted cold weather broken rail longitudinal gap to about 3 inches for riveted top structures and to about 5 inches for smooth top structures, but the restraint would be such that the risk of track buckling on a bridge approach would be introduced where expansion bearings abut a bridge approach, and the risk of broken rail would be introduced where opposing expansion joints exist on a shared pier. This is the classical no-win situation, no matter which pattern the span expansion bearings are placed there is a problem.
The Manual (1) has reached a compromise that is valid within the temperature ranges considered on either:

- Allowing no restraint between deck and structure, or
- Allowing a reduced restraint of anchoring only every 4’ 8. Coincidently, this is very close to the restraint the Chinese specifications recommend.

**Rail Expansion Joints** The alternative is to use rail expansion joints that would effectively eliminate any cold weather broken rail longitudinal gap condition without introducing the risk of track buckling or broken rails. The negative is that these are costly, difficult to maintain and are likely to increase impact loads to the bridge.

**CHAPTER 15 2011 - RECOMMENDATIONS**

Due to the fundamental conflicts noted above, it is unlikely that all of the design goals will be completely addressed. But the Manual attempts to balance these important considerations. For open deck bridges without expansion rails there are two options:

- Rail not longitudinally anchored
  - Unanchored length up to 400 feet of bridge on tangent and up to 1 degree of curvature
  - But not recommended on spans of 300 feet or greater
  - Requires rail flaw management program.

- Rail longitudinally anchored
  - Rail anchors applied only to the first 100 feet of each span
  - Anchorages applied at a spacing of 4’8 on riveted or other spans where the ties are fixed in longitudinal position

For open deck bridges rail expansion joints are recommended for:

- Moveable bridges
- Spans 300 feet or longer
- On curves greater than 2 degrees.
- One pair of joints for each 1500 feet of bridge.

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REFERENCES


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CWR on Open Deck Bridges

North American railways’ policies varying between two extremes:

- fully anchoring the rail across an open deck bridge,

- no anchorage to let it float across unanchored.
The main conclusion for open deck bridges is that mutual displacements between rail and bridge structure must be compatible.

Tend to avoid open decks
TTCI test results

- full anchorage similar to open track not appropriate on open deck bridges if the tie to structure interface is restrained by rivets or similar restraints.

- minimal restraint reduces considerably the thermal stress in the rail that would cause the rail to break during cold weather.
Test results at high temperatures gave clear results

but further testing will be required to fully understand cold weather behaviour.

Interaction with traction and breaking forces is currently under test
Rail Expansion Joints

- Rail expansion joints effectively accommodate rail thermal expansion and contraction;
- But, high impact loads and may accelerate bridge degradation.
- Costly to install and require high maintenance.
Without rail expansion joints

- Bridge moves with temperature - unlike open track

- Can provide longitudinal rail restraint to reduce longitudinal gap width and derailment risk should a rail break due to cold weather induced tension.

- But, high rail restraint will introduce high rail longitudinal forces into the bridge in case of a broken rail and increases stress in the rail.
Consequences of High Longitudinal Restraint

- causes longitudinal forces to develop in the rail during span expansion and contraction. These forces add to the rail force developed from heating and cooling of the CWR.

- Additional compressive forces in hot weather might increase the risk of track buckling at bridge approaches, particularly at abutments that support expansion bearings.

- Additional tensile forces in cold weather might accelerate rail defect and crack growth rates and increase the derailment risk in the case of a rail break.
allow the rail to be unanchored on bridges under a certain length.

The risk of rail break at cold temperature, assuming there are no serious rail flaws, should be less as there is little or no transfer of forces between rail and bridge.

Should a rail break, there may be little to constrain the resulting longitudinal rail gap.
Considerable anecdotal evidence has been used in writing the current (2011) requirements where conclusive test results do not clearly contradict that evidence.

Much of the anecdotal evidence is seemingly contradictory.
**Anecdotal Evidence 2**
The only consistent anecdotal evidence is that long spans that have floor systems that incorporate floor system expansion experience serious distress unless rail expansion joints are appropriately used.
Chinese Studies

The Chinese have a large group researching the effects of CWR going back to the 1960s and some useful information has been published in Chinese

Their major concerns on bridges:
- the rail longitudinal gap issue
- interaction forces between bridge structures and track shall not exceed certain specified allowable values.
- Also concern about forces transferred to piers.

1 Mr. Lu "Research and Application of Continuous Welded Rail Track", Chapter 5, CWR on Bridges, China Railway Press in 2004
Under 105 feet K style fasteners are used to anchor the rail (TTCI 100 feet)
anchorage limited to about half the anchorage on open track.
expressed as a limit on torque of 44 to 59 ft-lb which equates roughly 34 to 40 lbf/inch.
compares to the TTCI “Fully anchored track on smooth top girder/floor system at 49 lb/in.
AREMA Manual Recommendations are based on the following:

- Rail neutral temperature = 100°F
- Span installation temperature = 70°F

**Hot weather buckling risk:**
- Maximum rail $\Delta T$ of 45°F above rail neutral temperature
- Maximum span $\Delta T$ of 45°F above span installation temperature

**Cold weather rail break risk**
- Minimum $\Delta T$ of -100°F below rail neutral temperature
- Minimum $\Delta T$ of -70°F below span installation temperature
Without expansion rails anchoring condition 1 of 4

Fully anchored- riveted top girder with rail anchors or elastic fasteners installed on every tie.
Without expansion rails
Anchoring Condition 2 of 4

- Fully anchored-smooth top girder: Assumes that rail anchors or elastic fastenners are installed on every tie.
- Sliding
- Photo every 4th tie
Without expansion rail
Anchoring Conditions 3 of 4

AREMA anchoring-riveted top girder:
- rail anchors and the connection of the deck to the span occurs at a nominal spacing of 4’8.

AREMA anchoring-smooth top girder:
- Same
- sliding
will occur.
Without expansion rails, ANCHORING CONDITION 4 of 4

No longitudinal anchoring of rail on span
## Typical longitudinal restraint Values

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<td>93</td>
</tr>
</tbody>
</table>
1. Weakest point in track structure

Most Critical with expansion bearings at abutment, Rail fully fixed: problem with spans over 100 ft
Hot Weather

- where two spans share a pier with opposing expansion bearings also a problem

- Fully anchored rail with a riveted deck to span interface approaches the equivalent of the AREMA Longitudinal Design traction and braking force for E 48 loading on spans of 300 feet.
Cold Weather Results

rail $\Delta = 100^\circ F$, span $\Delta = 70^\circ F$

- The thermal forces are lowest with no rail anchorage.

- where two spans with opposed expansion bearings share a pier.

- increased rail break potential on all span lengths greater than 100 feet for fully anchored rail with a riveted deck to span interface.
Long Bridges – Short Spans

- anchored rail with a riveted deck to span interface approaches the equivalent of the AREMA Longitudinal Design force for E 80 + loading on bridges of 100 feet or more when the rail breaks.

- The AREMA Riveted Anchoring case approaches the AREMA Longitudinal Design force for E 48 loading on bridges of 400 feet when the rails breaks.

- The other anchoring patterns are much less.
ANCHORED RAIL with a riveted deck to span interface approaches the equivalent of the AREMA Longitudinal Design force for E 64 loading on bridges of 100 feet when the rail breaks and drops off for longer spans to a value of E45 at 300 feet.

Other anchoring patterns are much less.
Longitudinal Gap Widths If the Rail Breaks

Open Track  If a rail breaks a longitudinal gap of 5 ½ inches will occur on anchored track on ballast away from bridges. (Rail $\Delta T$ of -100° F)

gaps of this magnitude are not acceptable in open track or on bridges.

Most railroads perform frequent rail flaw detection in cold weather to find rails that have a high propensity for failure.
Longitudinal Gap Widths If the Rail Breaks, LONG SINGLE SPANS

- unfrozen approach ballast
  - fully anchored riveted top girder: 3 to 3.5 inches for all span lengths.
  - fully anchored with smooth top flange: 5 to 5.5 inches.

- Compare to Fully anchored open track gap width 5 ½ ".
Longitudinal Gap Widths If the Rail Breaks, LONG SINGLE SPANS

- **Frozen approach** ballast
  - fully anchored riveted top girder: 2 to 2.5 inches for all span lengths.
  - fully anchored smooth top flange: 3 to 4.5 inches.

- For unanchored rail, the reference open track longitudinal gap width value was exceeded at about 400 foot spans lengths.
Long Bridges, short spans 50 - 100 feet, Gap if Rail breaks

- **unfrozen approach** ballast
  - fully anchored riveted top girder: 3 to 3.5 inches for all span lengths.
  - fully anchored with smooth top flange: 5 inches for 100 foot bridges and above.
  - AREMA Anchoring for riveted interface was less than the reference open track value for all bridge lengths to 1000 feet.
Long Bridges, short spans 50 - 100 feet, Gap if Rail breaks

- **Frozen approach ballast**
  - fully anchored riveted top girder: 2 inches for all span lengths.
  - fully anchored smooth top flange: 5 inches at 500 foot bridge lengths.
  - For unanchored rail, the reference open track longitudinal gap width value was exceeded at about 300 foot spans lengths.
SUMMARY

key to CWR on open decks is compatibility of displacements between span and rail.

- Rail Area typ. 12-13 Sq-in
  - 2 rails, say 26 sq-in
- Single Girder Area typ. > 100 Sq.-in
  - 2 girders, say > 200 sq-in
For a 299.99 foot span

- full anchoring rail would reduce the predicted cold weather broken rail longitudinal gap to:
  - about 3 inches for riveted top structures and to about 5 inches for smooth top structures,
- but the restraint would be such that the risk of track buckling on a bridge approach would be introduced where expansion bearings abut a bridge approach,
- and the risk of broken rail would be increased where opposing expansion joints exist on a shared pier.
- Classical no-win situation, no matter which pattern the span expansion bearings are placed there is a problem with fully anchored rail.
Manual Compromise

- valid within the temperature ranges considered on either:
- Allowing no restraint between deck and structure, or
- Allowing a reduced restraint of anchoring only every 4’ 8. (very close to the restraint in the Chinese specifications).

- Or Rail Expansion Joints
Rail Expansion Joints

Rail expansion joints effectively eliminate any cold weather broken rail longitudinal gap condition without introducing the risk of track buckling or broken rails.

The negative: costly, difficult to maintain and are likely to increase impact loads to the bridge.
Open deck bridges **without expansion rails**, two options:

**Rail not longitudinally anchored**
- Unanchored length up to **400 feet of bridge** on tangent and up to **1 degree of curvature**
- Not recommended on **spans of 300 feet** or greater
- Requires rail flaw management program.

**Rail longitudinally anchored**
- Rail anchors applied only to the **first 100 feet** of each span
- Anchorages applied at a **spacing of 4’ - 8** on riveted or other spans where the ties are fixed in longitudinal position
CHAPTER 15 2011 – RECOMMENDATIONS (2)

- For open deck bridges rail expansion joints recommended for:
  - Moveable bridges
  - Spans 300 feet or longer
  - On curves greater than 2 degrees.
More to Come

- Testing in progress to better understand interaction with traction and braking forces.

- Test plan in preparation to test bridge under large temperature range ($\Delta T = -100^\circ F$).

- Hopefully will explain more of the inconsistencies in anecdotal evidence.
Thanks to

Ed Zhou, PHD, P.E.
for Chinese Data
Without rail expansion joints:
- no anchors for bridges < 300 feet,
- for bridges longer than 300 feet to anchor only the first 100 feet of each span.
- Bridges less than 50 feet could be anchored.

Expansion rail joints recommended:
- spans 300 feet or greater,
- moveable bridges, and
- bridges with curves over 2 degrees

Avoid buckling and to consider the effect of disturbing radial forces on curved track during maintenance operations.
Cold Weather Results

rail $\Delta = 100^\circ F$, span $\Delta = 70^\circ F$

Example, fully anchored rail with a riveted deck to span interface approaches the equivalent of the AREMA Longitudinal Design force for E 52 loading on spans of 200 feet.

The other anchoring patterns are much less.
Tie Damage due to rail restraint

14” wide tie after 1 month