TECHNOLOGY DIGEST

TD-08-052
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TIMELY TECHNOLOGY TRANSFER

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Running Surface Profile Design for Intermediate Angle Diamond Crossing Frogs

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Summary

The Transportation Technology Center, Inc. has developed a running surface design for intermediate angle (i.e., 30-60 degrees) diamond crossing frogs. This design, which better accommodates worn wheel profile shapes, is a modification of the ramped corner concept that is currently used for high angle diamonds. The concept allows a transition from the traditional depressed point design used in turnout frogs to the successful ramped point designs used in high angle diamonds.

Ramped (i.e., raised) corner frogs are used extensively for most diamond crossings in North American freight and passenger service. The most significant benefit from the ramped corners is the reduction in the effective gap a wheel has to jump going across the flangeway. The widening of the flangeway gap from corner deformation over time results in higher dynamic loads. In addition, properly ramped running surfaces can further reduce dynamic loading over the traditional flat running surface in frogs. The ramp lifts the wheels over the flanging gaps so that they land on the top running surface instead of falling into the opposite curve.

Observations of ramped corner diamonds suggest they work well in extending high angle diamond crossing frog service life. Significant reductions in dynamic loading and resulting track structure degradation rates are seen. The benefits of the corner ramps for intermediate angle frogs are less clear. Analysis of the performance of the current designs produced the following findings:

- Reconfigured ramps with allowances for hollow tread profile wheels are recommended.
- Ramps can be detrimental, if the average train speed is lower than the ramp design speed.
- Ramping may increase dynamic forces on hollow tread profile wheels.
- Current designs are less effective if wheel/rail contact is not at the gage corner.
  – Current ramp designs assume a cone-shaped wheel tread.

The features of the reconfigured ramps include:

- A cross section profile with a 1:20 slope.
- A false flange channel cut in the running surface of all single route frogs.
- A false flange channel cut in the running surface of common corner frogs, where allowable.
- The false flange channel will not be needed for frogs with angles less than 35 degrees.
- For a high angle frog and 50-60 mph train speeds, the optimal ramp rate is 1:64 with a 6 inch length. For lower speeds and angles, flatter ramps with 4 inch length are suggested.

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INTRODUCTION

Over the past several years, Transportation Technology Center, Inc. has been developing improved performance frog running surfaces under the Association of American Railroads' Strategic Research Initiatives Program. Guidelines for high angle frogs have been implemented, and guidelines for low angle (turnout) frogs are being implemented.[1,2] Tests at the Facility for Accelerated Service Testing and in revenue service have shown that the designs and guidelines for high angle frogs and low angle (turnout) frogs work well in terms of reducing impact and wear on frogs. The design concept for high angle frogs, which adopts raised 1/4-inch cone-shaped ramp running surfaces centered on each frog point, was directly applied to intermediate angle frogs (20~60 degree) without extensive study. The ramps are used largely to provide for initial metal deformation during the work hardening process.

Field results show that the performance of the ramps for intermediate angle frogs was mixed. At some locations, they were effective at extending frog life. At others, they caused large dynamic forces and accelerated degradation.

The problem for lower angle frogs is related to the handling of hollow tread profile wheels. For this situation, the point of wheel/frog contact can shift from false flange to flange root and back while going over intermediate angle diamonds. When cone-shaped ramps are added, dynamic forces can increase as the hollow tread wheel can literally step over the "up" ramp, but collides with the "down" ramp. Figures 1 through 3 show how cone-shaped profiles and hollow tread profiles behave differently at frogs.

Figure 1. Running Bands on a New Frog Flat Rail Surface

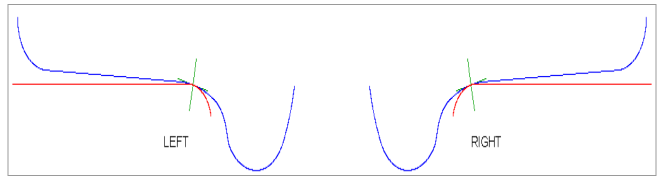

Figure 2. New Wheel Contacts on the Rail Flange Corner

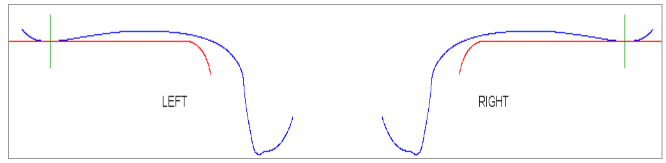

Figure 3. Hollow Wheel Contacts on the Running Rail Surface

Ramp Design

Previous work discussed the optimal longitudinal ramp rate for high angle diamonds.[3] For a high angle diamond, the optimal ramp is 6 inches long, with a 1:64 slope. Because the initial deformation until first flow grinding in Austenitic Manganese Steel is about 3/16 inch, railroads have adopted a 4-inch long, 1/4-inch high ramp. This will leave a residual ramp close to the proper height after flow grinding. The optimal residual ramp rate is a function of frog angle and desired train speed. For a high angle frog and 50-60 mph train speeds, the optimal ramp rate is 1:64 with a 6 inch length. For lower speeds and angles, flatter ramps with 4 inch length are suggested.

Figure 4 shows the effects of frog running surface ramps on maximum dynamic load at the frog points for cone-shaped and hollow tread wheels. The figure shows how ramps can decrease dynamic loads at mainline freight train speeds, as compared to the flat frog case. Note also that the ramps are sensitive to train speeds. Application of ramps designed for speeds above typical train operating speeds can actually worsen the dynamic load environment.

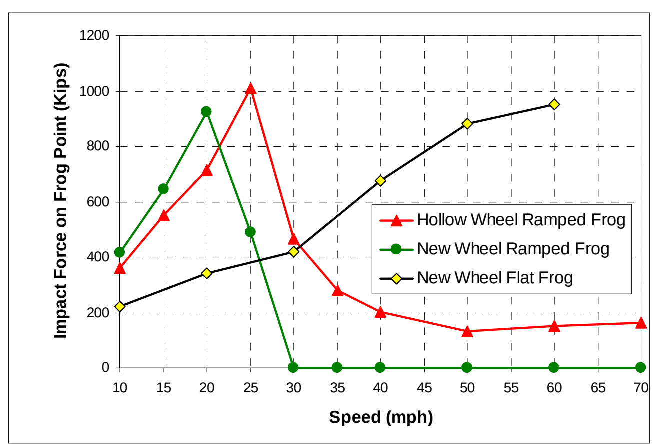

Figure 4. Effects of Ramps and Wheel Shape on Dynamic Loads at Frog Point

Ramp Shapes

Additionally, the ramps should have a cross-section shape that increases the likelihood of contact near the wheel flange root. This will allow the wheels to be in contact with the frog closer to the point of frog. It will also allow all wheels to have the same ramp rate, regardless of tread surface shape. The desired shape is a 1:20 slope with a 5/8-inch radius gage corner. Additionally, a false flange allowance is preferred where the frog running surface width exceeds 3 inches.

Obviously the common corner, where wheels from both routes run, is the most difficult to configure. For ramps to be successful, both routes must have similar track speeds. In addition, the ramps for each route must not adversely affect the performance of trains on the other route. With these compromises in mind, the ramps should be shaped like a pyramid, with a "roof ridge" running radial from the point of frog.

A further refinement is to provide for false flange relief, where required, on the ramps. This will be required for all frog points with running surface widths greater than about 3 inches. This includes the obtuse corners of all frogs and the acute corners of frogs with angles above about 35 degrees.

A false flange channel is often used on the mainline route of spring frog castings to provide an impact free running surface. However, the false flange channel must end prior to disrupting the path of crossing track wheels.

Figure 5 shows a plan view of a frog point with these features. Figures 6 and 7 show a cross section profile with new and hollow worn wheel contacts at the location marked A-A in Figure 5.

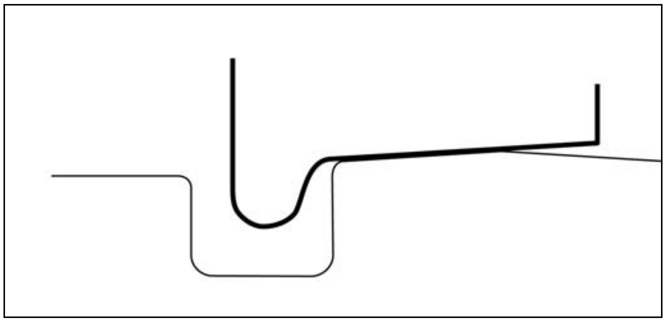

Figure 6. New Wheel Contact on the Wing Ramp

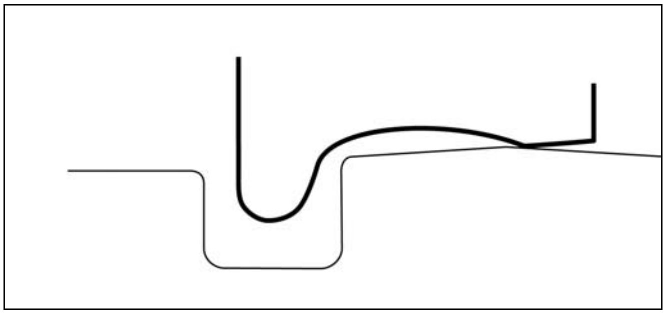

Figure7. Hollow Wheel Contact on the Wing Ramp

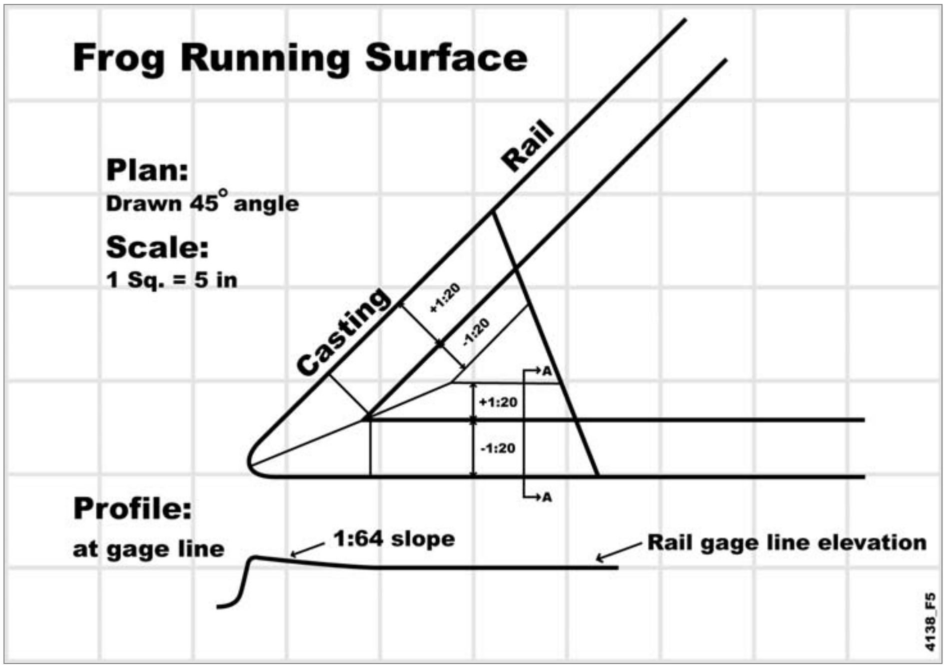

Figure 5. Conceptual Plan and Profile Views of Frog Point with Ramps

OBSERVATIONS

Observations of ramped corner diamonds suggest they work well in extending high angle diamond crossing frog service life. Significant reductions in dynamic loading and resulting track structure degradation rates are seen. The benefits of the raised corner ramps for intermediate angle frogs are less clear. Analysis of the performance of the current designs produced the following findings:

- Current ramp designs assume a cone-shaped wheel tread. This implies wheel/rail contact on the gage corner of the flat frog running surface.
- Current designs are less effective if wheel/rail contact is not at the gage corner. A wheel with 1/4-inch tread hollowing may not make contact with a corner ramp at all.
- Ramping may increase dynamic forces on hollow tread profile wheels. This happens on lower angle frogs because the wheel misses the up ramp (at the gage corner) but bluntly hits the down ramp on the other side of the flangeway.
- Ramps can be detrimental, if the average train speed is lower than the ramp design speed.
- Reconfigured ramps with allowances for hollow tread profile wheels are recommended.

The features of the reconfigured ramps include:

- A cross section profile with a 1:20 slope. This will provide wheel to ramp contact over a wider range of wheel profiles.
- A false flange channel cut in the running surface of all single route frogs. This will help assure that wheels with a wide range of tread profiles will encounter the ramps in the same way.
- A false flange channel cut in the running surface of common corner frogs, where allowable. This will also help assure that a wide range of wheel tread profiles is accommodated. These channels will not disrupt the crossing track running surface.

References

1. Singh, Satya P., Don Guillen and David D. Davis. July 1999. “Proof Tests of Crossing Diamond Surface Ramps in Heavy Axle Load Service.” *Technology Digest* TD-99-024, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colo.

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3. Singh, Satya P. and David D. Davis. July 1998. “Reduced Impact Forces on High-Angle Crossing Diamonds.” *Technology Digest* TD-98-021, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colo.