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Initial Performance Evaluation of Partial Flange Bearing Frogs for Turnouts in Heavy Axle Load Service

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Summary

Partial flange bearing frogs for turnouts offer significant benefits in reduced maintenance and increased service life for applications where the great majority of traffic travels on the mainline route of the frog. As part of the program to improve the performance of special trackwork, Transportation Technology Center, Inc. conducted experiments using prototype frogs at the Facility for Accelerated Service Testing. These experiments help determine the operating envelope for this type of frog, as well as provide data on wear rates under known conditions.

Initial revenue service prototype test results indicate that partial flange bearing frogs offer performance benefits over conventional fixed point (i.e., rail bound manganese) or movable wing (i.e., spring) frogs for low volume turnouts in mainline track. The elimination of a flangeway gap in the mainline route is accomplished by raising the diverging route so that wheels travel over (not through) the mainline rail. The tests evaluated the dynamic performance and wear of flange bearing surfaces of two prototype frogs. This *Technology Digest* describes the results of the dynamic performance tests.

The following conclusions were drawn from the test results:

Mainline Route Performance:

- Test results conducted at FAST indicate that the dynamic impact loads are reduced by 70 percent at 40 mph under heavy axle loads.

Diverging Route Performance:

- Operation of loaded and empty freight cars over the diverging route of the prototype frogs can be accomplished safely at speeds up to and including 15 mph.
  - Load measuring wheelset results show that both loaded and empty car wheel lateral/ vertical (L/V) ratios, axle sum L/V ratios, and minimum vertical load ratios met Association of American Railroads' Chapter 11 criteria.
- Empty car wheel maximum L/V ratios and wheel back maximum L/V ratios were significantly higher than that of loaded car L/V ratios at 15 mph due to wheel unloading.
- Longer ramps will reduce vertical forces and wheel unloading. The ramps must accommodate a larger range of wheel flange heights to eliminate any impacts at transitions from tread bearing to flange bearing.
- A parallel ramp on the guard side will help equalize wheel loads within a wheelset or truck. This is most important for operation of equipment with rigid frames and less capable suspensions (i.e., work equipment).

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INTRODUCTION

Partial flange bearing turnout frogs function by lifting the diverging route wheels over the mainline running rail. This allows the mainline running rail to be continuous with no flangeway gap. The benefits for mainline traffic are significant in that the frog will perform like open track. Revenue service applications include mainline industrial sidings and bad order "set-out" tracks. These are locations where diverging traffic is less than 1 percent of the total mainline traffic. Transportation Technology Center, Inc. engineers are evaluating the performance of two prototype frogs for diverging traffic in heavy axle load service.

Figures 1 and 2 show the prototype frogs installed in test tracks at the FAST Facility in Pueblo, Colorado. Figure 1 shows the Lift Frog built by Progress Rail Services. It differs from the production version with longer ramps in the frog and a parallel ramp on the guardrail side opposite the frog. Figure 2 shows the Jump Frog built by VAE Nortrak. It is similar to those being purchased by railroads today.

Generally, partial flange bearing frogs function by providing ramps for diverging route wheels to climb over the mainline rail and descend back to nominal track level. Both test frogs do this with a combination of tread bearing and flange bearing ramps. Both frogs use a tread bearing ramp on the toe end of the frog (i.e., they raise the diverging running surface so that the wheel flange tip will be at the same elevation as the top of the mainline rail). Also, they both use a flange bearing ramp on the heel end of the frog (i.e., from the point of the frog and beyond).

Figure 1. Progress Rail Lift Frog in Test at FAST

Figure 2. VAE Nortrak Jump Frog in Test at FAST

Figures 1 and 2 show where the wheels make contact with the frog running surfaces. Each frog surface was painted before train operation. Note that both frogs have flange bearing contact on both ramps and the mainline running rails. The photographs do not show that both frogs carry some wheels across the mainline rail without making contact. These are wheels with shorter flanges and are tread bearing across the mainline rail.

The two frogs vary in specific details of the ramping and guarding of wheels through the frog. Table 1 gives more detail about each frog.

Table 1. Partial Flange Bearing Frog Dimensions

Frog	Toe End Ramp Rate	Heel End Ramp Rate	Running Rail Ramp	Guarding
Progress	1:30	1:30	Yes	Conventional guard rail, Toe ramp self guard
Nortrak	1:36	1:36	No	Conventional guard rail

Mainline Route Performance

The Lift Frog is installed in one of the High Tonnage Loop turnouts at FAST. As such, the mainline route carries 39-ton axle load traffic at 40 mph. Figure 3 shows a plot of maximum vertical wheel force versus train speed for the partial flange bearing frog and a previous rail bound manganese (RBM) frog. Note that the prototype frog has significantly reduced the dynamic forces at this location. With about 99 percent of the total traffic using the mainline route, this force reduction should result in a longer service life for the frog.

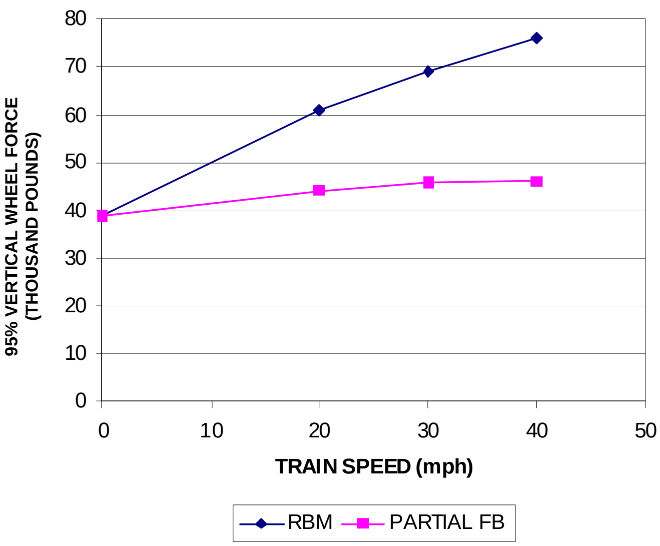

Figure 3. Maximum Vertical Wheel Forces versus Train Speed (main line route)

Diverging Route Performance

Similar measurements of wheel forces were made for diverging route traffic using both loaded and empty coal gondolas. Measurements were made during facing and trailing point moves over each frog at speeds ranging from 5 to 15 mph. Previous analysis of similar ramps built for One Way Low Speed flange bearing diamond crossings[1] suggested there might be an increased risk of wheel climb for empty cars at speeds above 5 mph. Flange bearing on one wheel while tread bearing on the other wheel of a wheelset will cause the wheelset to steer away from the flange bearing side. This situation can cause a high angle of attack for the wheelset and, possibly, higher lateral forces.

Figure 4 shows plots of axle sum L/V ratios for both loaded and empty cars going over each frog at speeds of 5 to 15 mph. Note that the empty car has a slightly higher L/V ratio at most speeds and that the ratio increases with speed. Careful examination of the data showed this caused by decreases in vertical load rather than increases in lateral load. Also, the plot shows the allowable limit for axle sum L/V ratio. In no case was the limit exceeded.

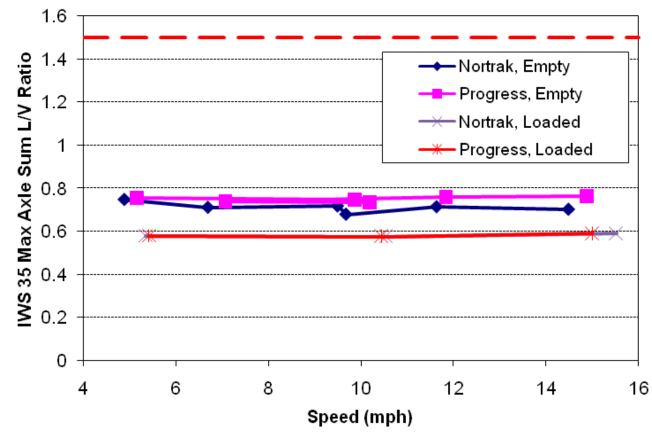

Figure 4. Axle Sum L/V Ratio versus Train Speed

Another potential concern is wheel unloading. The concern for partial flange bearing frogs is at the ramps, where wheels are raised to pass over, not through, the mainline running rail. Figure 5 shows the ratio of minimum vertical force to the static vertical force versus train speed. Again, there were no instances of wheel unloading below the minimum Chapter 11 limit. This indicates that the frogs are safe to operate in the intended speed range of 2 to 10 mph.

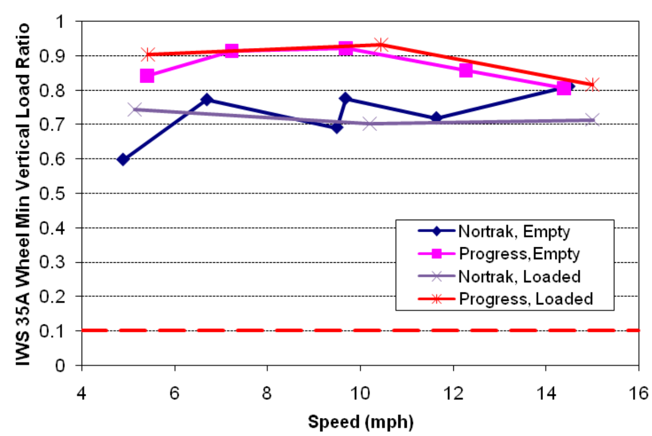

Figure 5. Wheel Minimum Vertical Load Ratio versus Train Speed

Recommendations for Improvement

For mainline traffic, the prototype frogs provide a significant improvement over conventional fixed point (rail bound manganese) frogs and spring frogs. But the designs can be further improved for the diverging route with the following changes:

- Longer ramps will reduce vertical forces and wheel unloading. The ramps must accommodate a larger range of wheel flange heights to eliminate any impacts at transitions from tread bearing to flange bearing. This is done with a chamfer of the tread bearing surface near the point of frog. The Nortrak frog has a larger capacity chamfer. Figure 6 shows the higher maximum forces on the shorter ramped frog.

- A parallel ramp on the guard side will help equalize wheel loads within a wheelset or truck, which is most important for operation of equipment with rigid frames and less capable suspensions (i.e., work equipment). Figure 7 shows how vertical forces are better equalized on the frog with the adjacent parallel ramp.

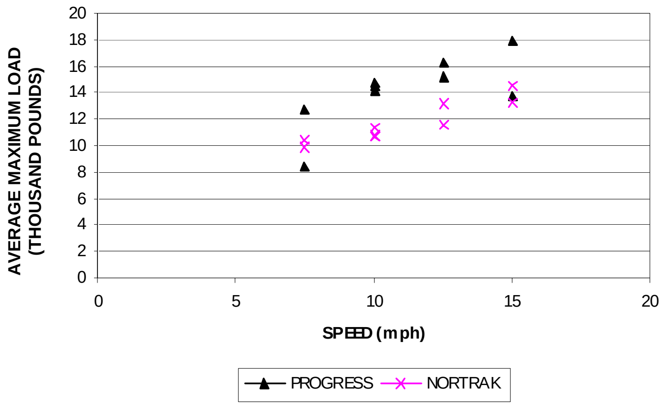

Figure 6. Maximum Vertical Wheel Load versus Train Speed

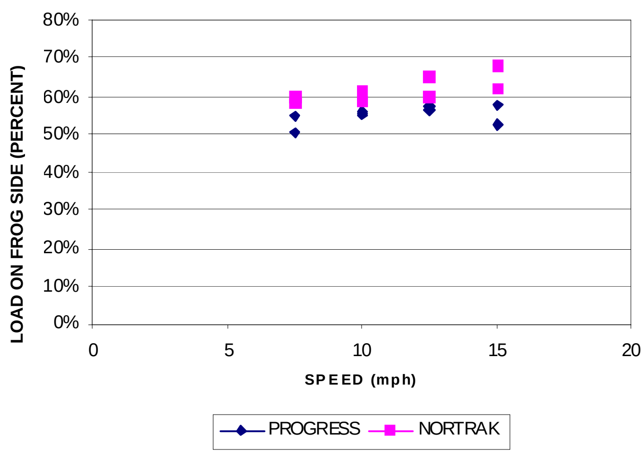

Figure 7. Portion of Load Carried on Frog Side Wheel versus Train Speed

FUTURE WORK

TTCI is working with the railroad and supplier counterparts to implement the above recommendations for improvements. The performance of the improved designs will be monitored.

References

1. Davis, D.D., X. Shu, and T. O'Connor. October 2008. "Evaluation of Flange Bearing Frogs for Turnouts," *Technology Digest* TD-08-044, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colorado.