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Evaluation of Under-tie Pads for Flange Bearing Frog Crossing Diamonds

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Summary

Flange bearing frog (FBF) crossing diamonds reduce impacts due to removal of unsupported flangeway gaps from the running surfaces. But dynamic loads remain due to track stiffness changes. Transportation Technology Center, Inc. (TTCI) evaluated the potential effects of under-tie pads to reduce track stiffness changes and their resultant dynamic loads and differential settlement in crossing diamonds.

A flange bearing track panel was built for evaluating potential frog steels, flange bearing ramp shapes and foundations for FBFs. The panel and its approaches were fitted with under-tie pads. Results from the first 80 million gross tons (MGT) of testing include:

- Under-tie pads reduced the vertical stiffness of the flange bearing track panel to the same level as the surrounding open track. This is significant due to the extra rails and larger crossties.
  - The approaches to the panel were less stiff than the panel; suggesting the pads reduced stiffness more than needed in these areas.
- Permanent settlement on the flange bearing panel has been less than the approaches and open track. Thus, the track panel has not become a low spot.
  - The rates of settlement of all three locations has been similar after the initial 10 MGT. This suggests the track can be maintained on one schedule for most of its life.

This *Technology Digest* is one of a series on research, development, and evaluation of potential improvements to FBF crossing diamonds. The series will include frog steels, foundation designs, and transverse running surface profiles. TTCI conducted this project under the AAR Strategic Research Initiatives Program.

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INTRODUCTION

Flange bearing frog (FBF) crossing diamonds and turnout frogs have proven to be feasible for heavy axle load freight operations. The improved dynamic performance of these designs is significant in reducing required track surface and frog bolt maintenance. Slow orders related to crossing diamond condition have also been significantly reduced in locations where full FBF crossing diamonds have been implemented.

The industry is still in the early stages of learning how to maximize the efficiency of flange bearing ramp, frog, and crossing diamond system designs. This is evident in the high initial wear rates of flange bearing ramps and frogs. Also evident is the uneven wear and dynamic loading seen on some crossing diamonds.

This *Technology Digest*, one of a series on the current flange bearing research and development work, describes some of these issues and the design improvements developed in response.

FBF DIAMOND PERFORMANCE ISSUES

While FBF crossing diamonds perform well dynamically as compared to conventional tread bearing frog crossing diamonds, there are still some areas for improvement. These can include relatively rapid changes in wheel/rail contact conditions, running surface grade, track stiffness, and track alignment. Mitigating the potential deleterious effects of these necessary transitions is the goal of this project.

FBF crossing diamonds are less likely than their tread bearing frog counterparts to be low spots in the track. This is mostly due to the great reduction in dynamic loading at the frogs. Since the wheels are supported going across the frogs, there is no impact and much lower dynamic loading throughout the crossing diamond.

However, changes in track stiffness remain due to significant changes in track structure. These changes can result in differential deflections, settlement, and resultant dynamic loads. Figure 1 shows the typical low spots that can develop in the approaches to a FBF crossing diamond. Additionally, the transition of wheels from tread to flange bearing can result in dynamic loading due to the potential change in elevation of the vehicle. These dynamic loads occur, away from the frogs, in the approaches and the ramps of the diamond.

The train and track form a complex dynamic system that is subject to changes in the static and dynamic properties of each. Variations in dynamic performance are manifested as uneven wear and deformation of track and running surfaces. Figure 1 shows the resultant humps and dips in the flange bearing and tread bearing running surfaces. The shiny spots on the field side of the conventional running rail correspond to low spots on the flange bearing running surface.

Figure 1. Low Approach (far side of crossing diamond) Due to Track Stiffness Changes and Dynamic Loads at FBF Diamond

Development of a Uniform Track Foundation for Crossing Diamonds

A challenge for designers is determining how to make track stiffness and dynamic deflection more uniform across special trackwork. For high angle crossing diamonds, the track structure, in terms of crosstie configurations, platework, and frog running rails, changes significantly in a short distance. This is of necessity to carry the dynamic loading of trains crossing another track.

Use of under-tie pads has been shown to provide good results for conventional track and for turnouts under heavy axle load service.[1,2] Testing of mainline turnouts under controlled conditions has shown that a 70 percent reduction in track stiffness variation, a 30 percent reduction in average settlement, and a 70 percent reduction in settlement variation were achieved. This has resulted in lower dynamic train forces and longer surfacing cycles for the turnout.

As part of a multiple-purpose experiment at the Facility for Accelerated Service Testing (FAST), a track panel was built to evaluate several design issues with FBF applications. Figure 2 shows the track panel test configuration.

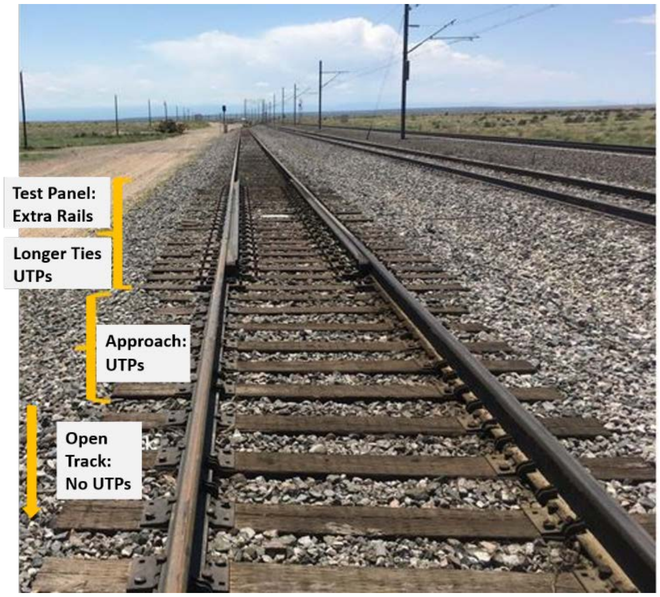

Figure 2. Flange Bearing Track Foundation Test Layout (Note: UTP = under-tie pad)

The track panel superstructure is considerably stronger than open track, with the addition of flange bearing bars and guardrails. Ten-foot long crossties also make the track stiffer. To compensate, under-tie pads made by Pandrol were installed under the track panel and the approaches. The approaches consisted of six 8.5-foot ties with the same under-tie pads.

TEST RESULTS

Measurements of track stiffness and settlement were made during the first 50 MGT period of operations at FAST. Figure 3 shows the average track stiffness for three zones of the track: (1) flange bearing test panel, (2) the approaches (i.e., the first few ties in front of the test panel), and (3) open track surrounding the test panel and approaches.

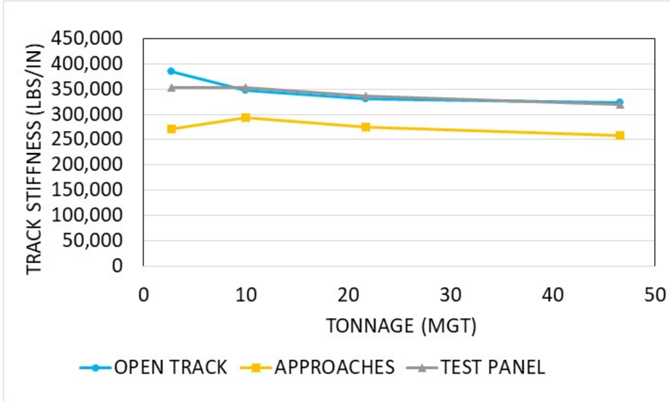

Figure 3. Profile View of Candidate Flange Bearing Ramp Designs

The objective is to have uniform track stiffness throughout the track panel. This will produce uniform deflections under load, and thus, reduce dynamic loading. From Figure 3, the panel and open track do have similar track stiffness, which suggests the under-tie pads are a good match for the panel superstructure. The softer approaches suggest the same under-tie pad reduces track stiffness too much here. Note that the difference between track stiffness in the approach and open track is due to the under-tie pads. This suggests that with properly engineered pads for the panel, pads might not be necessary on the approach.

Track settlement was determined from a series of top of rail elevation surveys. Figure 4 shows the average top of rail elevation change for each zone of the track with tonnage. Note that the track panel itself has settled less than the surrounding approaches and open track. However, the approaches have settled in a similar manner to the surrounding open track. This is very encouraging in that the approaches are typically low spots on conventional diamonds today.

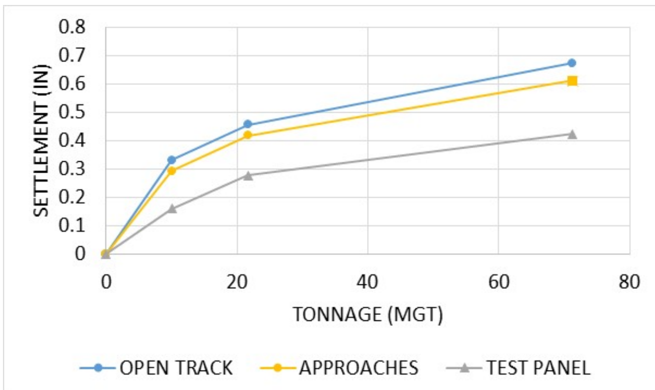

Figure 4. Average Track Settlement by Test Zone versus Tonnage

In revenue service applications, it is likely the crossing diamond would have more settlement due to the contribution of crossing track traffic. That effect is not present for the current test panel. Additionally, note that the rates of settlement for all three zones are similar after the initial 10 MGT of traffic. This suggests the entire track may be maintained to nearly level over the majority of the crossing diamond's life.

Figure 5 shows the relative elevation of the test panel and surrounding track after 21 MGT of traffic. One end of the panel was disturbed due to replacement of a ramp. Thus, the elevation of the panel is not comparable in subsequent measurements.

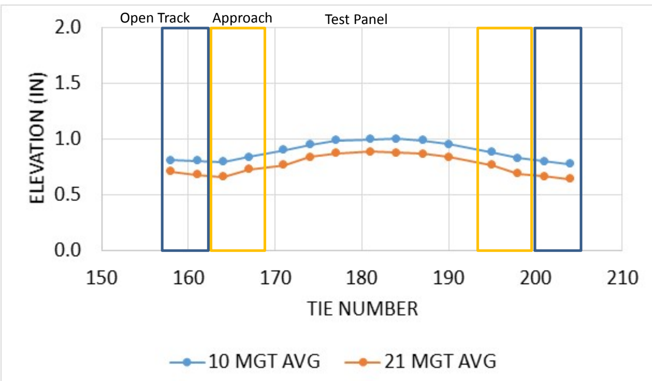

Figure 5. Track Panel Top of Rail Elevation versus Tonnage. Note the plot shows the panel, approaches, and open track that were monitored.

The panel remains higher than the surrounding track. It was built with a slight crown, which it has maintained over time. As the panel is settling less than the approaches and the surrounding track, an adjustment may be needed as the test continues.

Under-tie Pads

The under-tie pads used in the test were epoxied and nailed into place at the test site prior to assembly of the test panel. The pads cover the entire length of each tie. Figure 6 shows the under-tie pads being nailed to the test panel timbers.

CONCLUSIONS

- Under-tie pads reduced the vertical stiffness of the flange bearing track panel to the same level as the surrounding open track. This is significant due to the extra rails and larger crossties.
- Permanent settlement on the flange bearing panel has been less than on the approaches and open track. Thus, the track panel has not become a low spot.

Figure 6. Under-tie Pads Being Attached to the Test Panel Timbers

ACKNOWLEDGEMENTS

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References

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