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TIMELY TECHNOLOGY TRANSFER

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Evaluation of a Compliant Switch Design

David Davis, Xinggao Shu, Rafael Jimenez and Duane Otter

Summary

Transportation Technology Center, Inc., (TTCI) conducted a study to investigate the effects of lateral support stiffness on switch dynamic performance. A flexible switch design was proposed based on simulation results with the NUCARS®* double rail model. Dynamic simulation suggested reducing lateral stiffness (below current values) will be beneficial for American Railway Engineering and Maintenance-of-Way Association (AREMA) style (large entry angle) turnouts. The potential benefits derive from lower peak lateral forces for facing point diverging route movements and moving the point of first wheel contact with the switch points further into the switch on facing point moves. The contact will occur where the switch point is thicker, promoting longer life and reduced maintenance.

As a first step in developing economical modification to improve the performance of existing AREMA style turnouts, a series of experiments to modify lateral switch stiffness were conducted at the Facility for Accelerated Service Testing (FAST), Pueblo, CO. These involved low-cost changes (i.e., changes that will add less than 1 percent to the cost of the turnout) to the lateral stops currently used on switch points. The effects on train lateral forces and switch point lateral deflections were measured.

Findings from these studies were:

- The effect of decreasing lateral stiffness 50 percent on wheel-rail forces was measured using a loaded freight car equipped with load measuring wheelsets. The measurements show approximately a 20-percent reduction in maximum lateral force in facing point diverging moves.
- The effect of using a full web contact switch point stop was to reduce switch point twist or roll by about 50 percent. This type of D-bar stop may reduce dynamic wheel-rail forces due to variations in the switch point orientation under load.
- The lateral stiffness of the diverging switch point was determined from measurements of deflection and wheel-rail loading. For this AREMA-style No. 20 turnout, the lateral stiffness was reduced by approximately 50 percent with the changes made.

The modeling results suggest that raising lateral stiffness will have little effect on forces and deflections. The effect of changing vertical support stiffness was simulated. The results showed little effect on location and magnitude of maximum vertical forces. This is likely due to the AREMA style switch point detail, where the switch point rests on the stock rail for a considerable distance between point of switch and switch heel. This study was performed under the Association of American Railroads' (AAR) Strategic Research Initiative (SRI) on special trackwork.

*NUCARS® is a registered trademark of Transportation Technology Center, Inc., Pueblo, CO.

Please contact **David Davis (719) 584-0754** with questions or concerns regarding this *Technology Digest.* E-mail: david_davis@aar.com.

INTRODUCTION

TTCI conducted a study to investigate the effects of lateral support stiffness on switch dynamic performance. Switch lateral stiffness always has been considered a fixed value that could not be easily changed. Of primary concern is that the switch must be strong enough to support the large lateral loading that results from turning a train in a flat curve that typically is not tangential and has no transition spirals. The capability to accurately simulate vehicle performance in turnouts and the advances in design and construction methods allow turnout designers to consider what properties are desirable for lateral and vertical turnout stiffness. Based on initial modeling and testing, a series of tests were conducted to determine the effects of varying lateral stiffness on vehicle performance.

Modeling the Effects of Lateral Support Stiffness

The first step in this effort was to model a turnout with varying degrees of lateral stiffness. The following parameters were used in the initial modeling:

- Loaded hopper car, with 65,744-pound axle load
- No. 10 straight split switch
- New AAR 1-B wheel (NW)
- Worn wheel with 3 mm hollow on tread (WW)
- New 136-pound/yard rail
- Dry rail (wheel/rail friction coefficient of 0.5)
- 20 mph running speed

A No. 10 switch initially was chosen because of its relatively high entry angle. Figures 1-5 show leading axle wheel lateral forces for facing point, diverging route movements through a No. 10 turnout. The point of switch of the turnout is at 30 feet in the plots.

Figures 1 and 2 show the leading axle lateral forces on the switch for the loaded car with both new and worn wheels was negligible with different lateral support stiffnesses; however, the wheel strikes the switch rail farther into the switch, where the point is thicker, as the lateral stiffness decreased.

Additionally, the effect of changing vertical support stiffness was simulated. The results showed little effect on location and magnitude of maximum vertical forces. This is likely due to the AREMA style switch point detail where the switch point rests on the stock rail for a considerable distance between point of switch and switch heel.

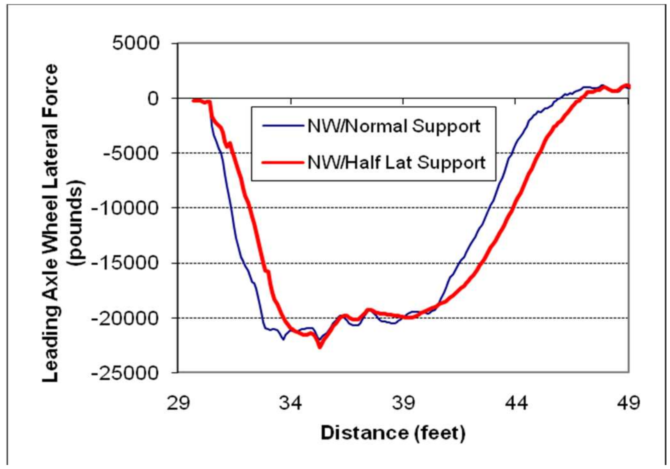

Figure 1. Effect of switch point lateral support stiffness on wheel lateral force (loaded car, new wheel, No.10, 20 mph)

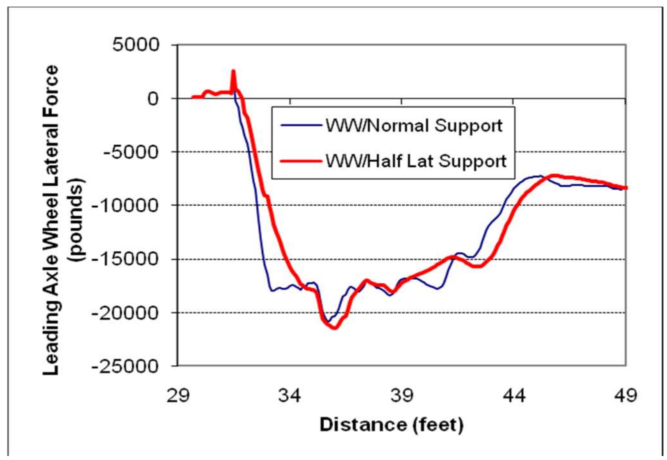

Figure 2. Effect of switch point lateral support stiffness on wheel lateral force (loaded car, worn wheel, No. 10, 20 mph)

The modeling results were confirmed with a test at FAST using a No. 20 turnout. The test involved two cases: 1) stock rail braces on each crosstie in the switch and 2) stock rail braces on every other crosstie. The result was a 20 percent reduction in maximum lateral forces for loaded car facing point moves.[1]

This initial success led to the current testing, which involved another low-cost change to the stops between the switch points and stock rails. These stops occur further back in the switch past where the switch point head is full width and no longer contacts the stock rail head. The lateral stop provides the lateral stiffness and rotation resistance for the switch point in this area.

Field Measurements of Switch Performance for Varying Lateral Stiffness

A No. 20 turnout in the FAST High Tonnage Loop (HTL) was modified with various lateral stops intended to provide a range of lateral stiffness and/or gaps between switch point and stock rail. In total, the six test cases shown in Table 1 were tested along the diverging route to measure wheel-rail forces using instrumented wheelsets (IWS) under a loaded 315k (GRL) coal hopper. Each of the stop types described in Table 1 was used at the three switch point stop locations.

Figure 3 illustrates the various stops used in the test. For the sixth test case (Figure 3f.), a lightly spring-loaded D-bar fastened to the switch point was designed and fabricated at TTCI's machine shop to interface with the stock rail.

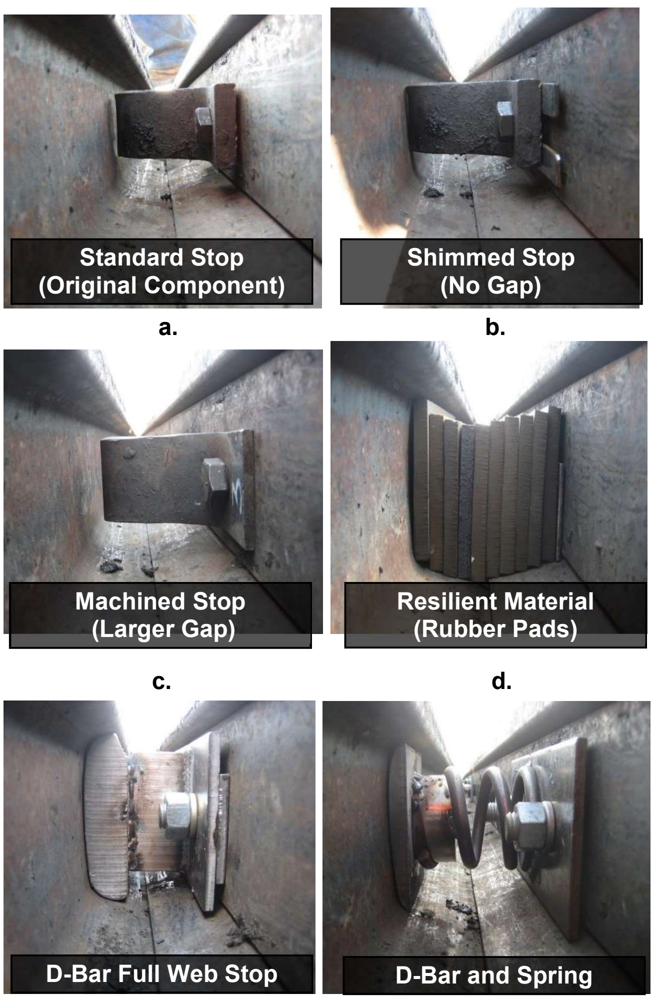

Figure 3. Various stops used in the test

Table 1. Test cases and switch point stop configurations.

Test Cases	Stop Type/ Modification
a.	Original Component
b.	Shimmed (no gap between point and stock rail)
c.	Large Gap (allowing more displacement)
d.	Resilient Material (rubber pads)
e.	D-Bar full-web contact no gap
f.	D-Bar & Spring (full web contact and spring resistance)

Displacement of the switch point high on the web and at the base was measured during the IWS runs using instrumented bending beams shown in Figure 4. Each test case consisted of a three-speed sweep (one run each at 20 and 30 mph, and two runs at 40-mph).

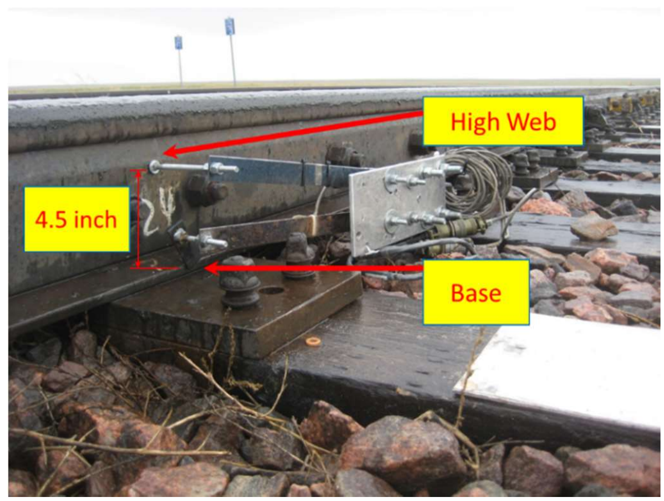

Figure 4. Instrumented bending beams to measure lateral displacement of the switch point

Figure 5 shows the relationship between maximum lateral wheel force (99th percentile) and lateral switch point stiffness in the area of the stops for facing point diverging moves. Note that halving the switch point lateral stiffness, and assuring there are no point to stock rail gaps (the spring stop case), reduced the maximum lateral force by about 20 percent under loaded traffic.

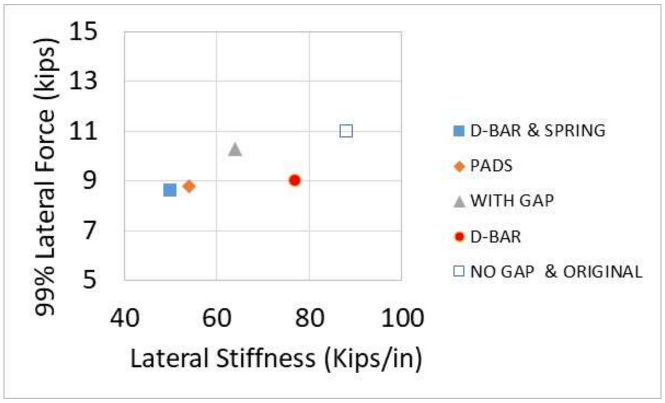

Figure 5. Maximum (99th percentile) lateral forces in the facing point direction at 40 mph versus switch point lateral stiffness.

CONCLUSIONS

The concept of a lower lateral stiffness switch that will reduce maximum lateral forces was evaluated and shown to be technically and economically possible. The simulations conducted suggest that the benefits will come from delayed wheel flanging with the switch point until further into the turnout in facing point moves. At this point, the switch point is thicker and better able to withstand the lateral impact forces. Additionally, from testing results, a small benefit in lower maximum lateral forces was measured under heavy axle load operations. These two factors should result in longer service lives for switch components.

FUTURE WORK

The next steps will be to develop a practical prototype for service life testing. This will involve documenting the actual distribution of lateral stiffness of current switches. Using this information, the project team will develop a consistent optimized lateral stiffness for the entire switch while assuring that the track gage is controlled within maintenance limits. The prototype is envisioned to have a lateral stiffness that is similar to a bilinear spring: it will have low initial stiffness up to a certain displacement. Beyond this displacement limit, the lateral stiffness will be much higher.

Reference

1. David Davis, Xinggao Shu, Rafael Jimenez, and Beatrice Rael, “Evaluation of the Effects of Switch Lateral Stiffness on Heavy Axle Load Performance,” *Technology Digest* TD14-023, November 2014, AAR/TTCI, Pueblo, CO.