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Track Gage Strength Distribution Based on FAST Data

Anna M. Rakoczy and Yin Gao

Key Findings:

- The distribution of track gage strength can be compared to the lateral load distribution to evaluate any overload on tracks.
- The analyzed data show that as the million gross ton (MGT) loads increase, DTG increases indicating reduced track gage strength. Track with elastic fasteners generally has higher track gage strength than track with American Railway Engineering and Maintenance-of-Way Association (AREMA) tie plates and cut spikes.

Transportation Technology Center, Inc. (TTCI) is investigating the lateral wheel/rail force caused by longitudinal in-train forces. The study, part of the Association of American Railroads (AAR) Strategic Research Initiatives Program, is being conducted at the Facility for Accelerated Service Testing (FAST), at the Transportation Technology Center near Pueblo, Colorado.

In the assessment of track gage strength, the first step is to obtain the track gage strength distribution by converting gage strength test results in terms of delta track gage (DTG) to a distribution of gage strength in terms of allowable gage spreading load. The next step in the analysis is to obtain the lateral load distribution exerted on the track and compare it with the gage strength distribution. If the available gage strength is less than the applied lateral load, the affected portion of track is likely to be prone to rapid degradation. The lateral load distribution can be determined from either a truck performance detection (TPD) site or instrumented wheelset testing.

In this issue of *Technology Digest*, data from track gage strength tests FAST show how track gage strength distribution can be obtained and how it can be used to identify potential risk of accelerated degradation.

BACKGROUND

Track resistance is one of the most important influences on track performance and safety. Geometry retention and buckling prevention are primarily provided by the lateral, longitudinal, and torsional resistance of the track structure. The lateral track strength can be defined in terms of lateral track stability, rail roll resistance, and gage-restraining capacity. Several methods can be used to measure the gage-restraining capacity including a track loading vehicle (TLV) or a gage restraint measurement system (GRMS). Previous research[1] documented a methodology that converts gage strength test results in terms of DTG measured by TLV to a distribution of gage strength in terms of allowable gage spreading load. This publication uses similar methodology to analyze the TLV data for FAST.

After gage strength distribution in terms of an allowable gage spreading load is determined over a segment of track, it can be compared to a lateral load distribution for demand versus capacity analysis. There are two methods for determining the lateral load distribution that are applied on the track. The first method involves the use of instrumented wheelset data; this method is specific to the test vehicle type. The second method is to use loads recorded from TPD sites for the lateral load distributions of many vehicle types. These distributions are specific to the TPD site.

GAGE STRENGTH CALCULATIONS

The TLV data from FAST was used to determine the gage strength distribution. The TLV gage strength test was performed using 18-kip lateral and 33-kip vertical wheel loads that were applied to each rail of the track. The collected data provide unloaded track gage, loaded track gage and DTG information.

To translate the gage restraining strength at 18 kips to a wider range of lateral loads, the following equation derived from research by the Volpe National Transportation System Center[2] is used (assuming 33-kip vertical wheel loads):

$$LL_{new} = [DTG(@LL_{new})/DTG(@LL_{18}) + 0.652]/0.0918$$

where:

- $DTG(@LL_{new})$ = Delta gage at the desired lateral load
- $DTG\ (@LL_{18})$ = Delta gage at 18-kip lateral load (TLV test load)
- LL_{new} = Desired lateral load

The equation is intended to estimate gage spreading (DTG) over a range of lateral loads based on the TLV test results. In this study, gage spreading was estimated at four levels: 0.25, 0.5, 0.75 and 1.00 inch.

Gage strength distribution can be determined for various types of track based on this procedure. For this study, the gage strength distributions were obtained in terms of allowable lateral load for wood tie track at FAST, various fasteners and different tonnages.

The gage strength distribution generated from this procedure depends on the allowable DTG (0.25, 0.5, 0.75, and 1.00 inch). Determining the level of allowable DTG on a track may depend on the demand (required strength) that can be realized from the train forces that are present at a specific location. Choosing a lower value of allowable DTG will result in a gage strength probability distribution shifting to lower loads.

STATISTICAL PARAMETERS OF TRACK STRENGTH

Using the FAST TLV data, the measured DTG was considered for the wood tie track sections that had accumulated 100 MGT and 1,300 MGT. The wood tie track was further grouped by the fastening system types. Figure 1 presents the comparison of the data for the four different wood tie sections.

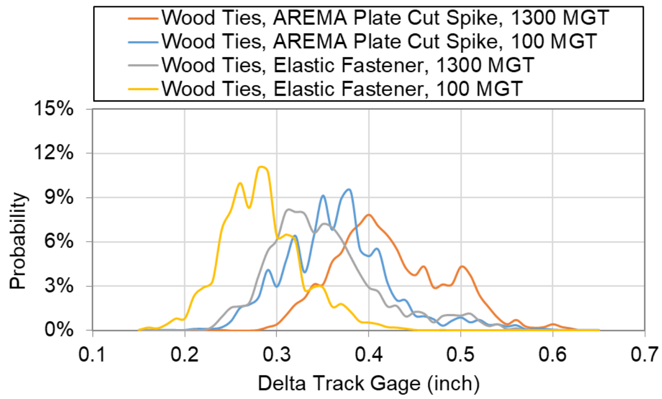

Figure 1. Probability of measured DTG from the data collected at FAST

The average DTG measured on the wood tie tracks with 1,300 MGT are 0.42 inch and 0.35 inch for cut spikes and elastic fasteners, respectively. The average DTG for wood tie tracks with 100 MGT are 0.36 inch and 0.28 inch for cut spikes and elastic fasteners, respectively. As can be seen from the plot, MGT and fastener type are two important factors that affect the track gage strength. As the MGT increases, the DTG increases indicating reduced track gage strength. The elastic fasteners generally have higher track gage strength than the AREMA plates with cut spikes.

TRACK GAGE STENGTH DISTRIBUTION

In the first step of analysis, histograms were created for wood tie tracks using four levels of allowable DTG (0.25, 0.5, 0.75, and 1.00 inch) calculated using the equation described in a previous section. Figures 2a and 2b show histogram plots based on the gage strength of wood tie track with AREMA tie plates and cut spikes at 1,300 MGT and wood tie track with elastic fasteners at 100 MGT as examples.

Both figures are presented with the number of occurrences of specific lateral load range. Each histogram column represents 1 kip. The generated histograms of data were analyzed and examined using the "distribution fitter" application available in MATLAB®. The data is presented in terms of probability distribution function (PDF).

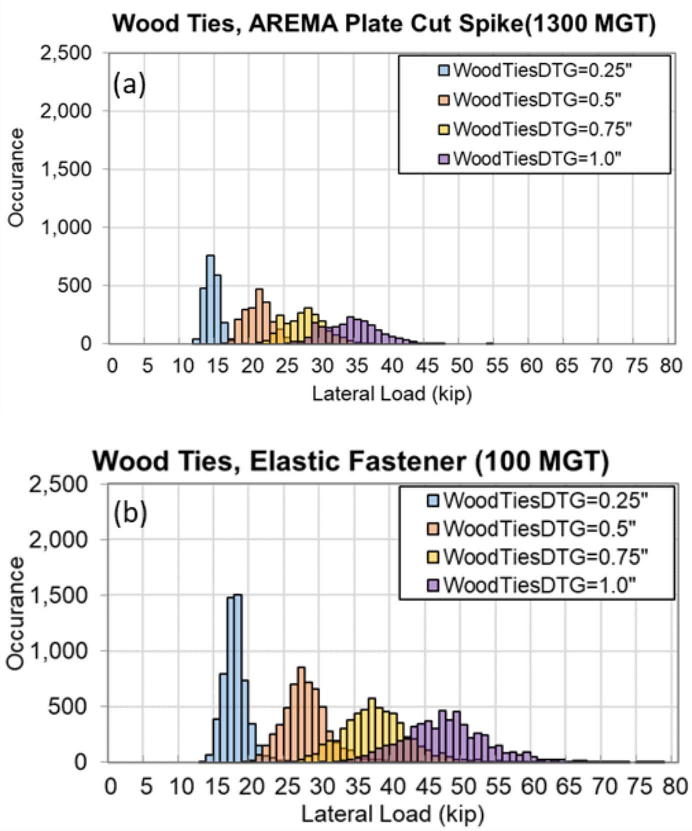

Figure 2. Histograms of gage-restraining capacity for: (a) wood tie track with AREMA tie plates and cut spikes (1,300 MGT); (b) wood tie track with elastic fasteners (100 MGT)

Figures 3(a-b) and 4 (a-b) present PDFs for wood tie track with elastic fasteners (100 MGT and 1,300 MGT) and wood tie track with AREMA tie plates and cut spikes (100 MGT and 1,300 MGT), respectively.

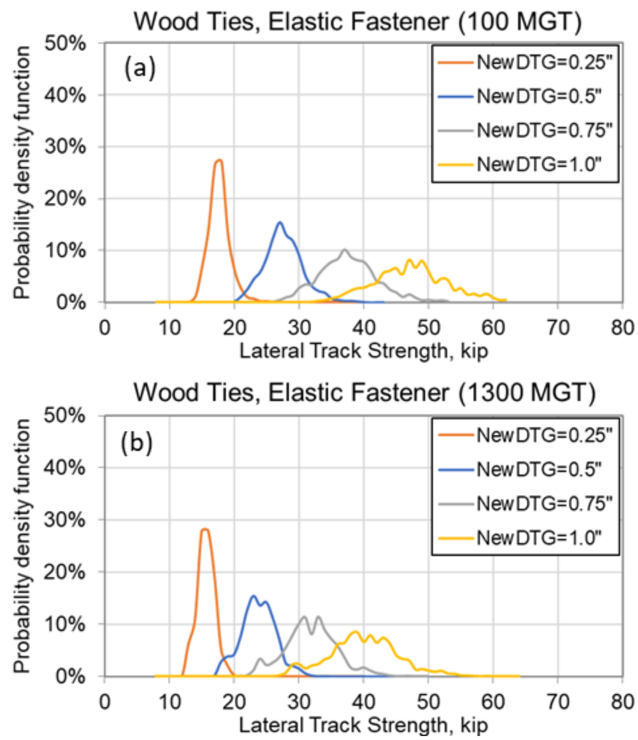

Figure 3. Summary of PDF of track gage strength for wood tie track with elastic fasteners: (a) 100 MGT; (b) 1,300 MGT

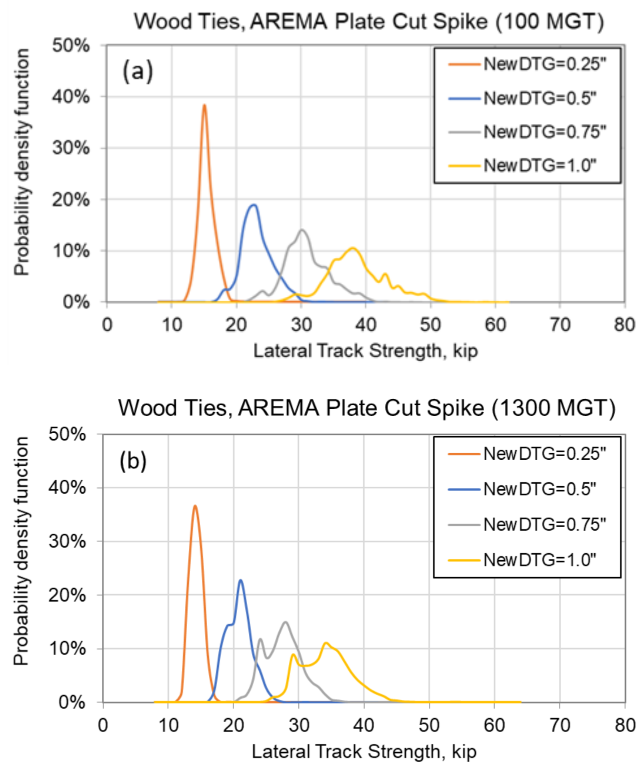

Figure 4. Summary of PDF of track gage strength for wood tie track with AREMA tie plates and cut spikes: (a) 100 MGT; (b) 1,300 MGT

TRACK LOADING ENVIRONMENT ASSESSMENT BY STOCHASTIC ANALYSIS

The train-track interaction can be evaluated using the demand versus capacity approach used in the reliability method. The demand and capacity are variables that can be defined with statistical distributions. With this method, the amount that capacity exceeds demand can be determined with specific probability.

Figures 3 and 4 presented the distributions of track gage strength, which are the track capacity in this demand-capacity analysis. The demand in the analysis is the lateral load distribution. Typical methods to obtain the lateral load distribution are instrumented wheelset data and TPD. Once the lateral load distribution is measured and the probability distribution plotted, it will be compared with the distribution of track gage strength, as shown in Figure 5. The shaded region represents overloaded track. With 1.00-inch allowable DTG, the probability of overloaded track is minimal.

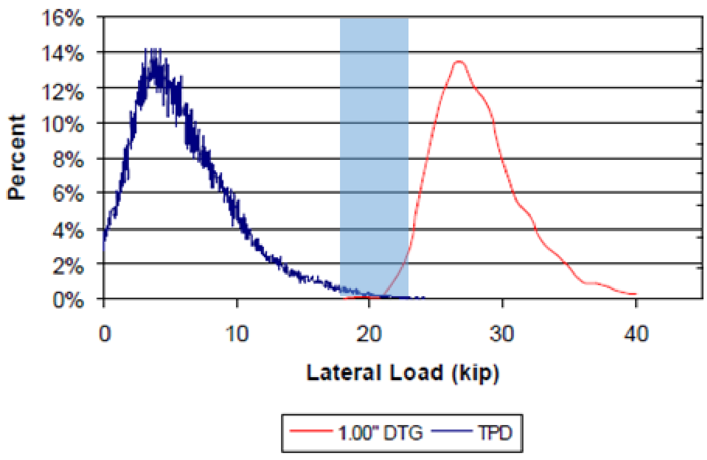

Figure 5. Track loading environment assessment using TPD load data[1]

CONCLUSION

The track gage strength at all four levels of allowable DTG was developed based on an equation developed by the Volpe National Transportation System Center. The original equation was intended to estimate gage spreading over a range of lateral forces loads based on the TLV test results. In this study, the equation was transformed to calculate the track gage strength distribution from TLV data collected at FAST.

The gage strength distribution generated from this procedure depends on the allowable DTG (0.25, 0.5, 0.75, and 1.00 inch). The level of allowable DTG on a track may depend on the train forces at the specific location. Selecting a lower value of allowable DTG will result in the gage strength probability distribution shifting lower. By comparing the gage strength distribution (capacity) to the lateral load distribution (demand), the probability of overloaded track can be obtained.

The analyzed data show that as the MGT increases, the DTG increases, indicating reduced track gage strength. Elastic fasteners generally have higher track gage strength than the AREMA plates with cut spikes.

References

1. Yoshino, D., D. Li, and R. Thompson. 2004. "Assessing Railroad Stress State through TLV Gage Strength Testing." *Technology Digest* TD04-009. AAR/TTCI Pueblo, CO.
2. Coltman, M., R. Dorer, and P. Boyd. "The Development of Automated Survey Techniques for Evaluating Tie and Rail Fastener Performance." Applied Mechanics Rail Transportation Symposium. ASME. 1988. AMD-Vol. 96, RTD-Vol.2.

For comments or questions about this publication, contact Yin_Gao@aar.com