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PORTABLE TRACK LOADING FIXTURE IMPROVEMENT

BACKGROUND

The portable track loading fixture (PTLF) has been used in the field as a nondestructive means of testing track strength, as per the Federal Railroad Administration's (FRA) Track Safety Standards (TSS) 49 CFR §213.110 (m). The PTLF operates by placing a 4,000-pound-force (lbf) lateral load as close to the shear center of the rails as possible, while the deflection at the gage point is measured. Gage is measured as the lateral distance between the 5/8" points on the two rails below a plane formed by the top of the rails. If measurement is conducted at the web of the rails, it is known as web gage. Although it is widely accepted that rail deflection caused by the PTLF loading has a strong correlation with track strength, repeatability of measurements has been a concern. It has been observed that some locations, which exceed the displacement criteria on initial loadings, are within the limits on subsequent loadings. As a result of these variations, the reliability of the PTLF test has been questioned in the past.

Through repeated testing, it has been determined that variability in rail deflection is largely because of "set of the rail" or the difference between the initial unloaded gage and the unloaded gage following a load application and release. Upon unloading, as a result of friction in the ties and tie plates, the rail does not return to its initial position. During testing, the

rail set was observed to lead to significant cycle-to-cycle variability in head gage deflection.

It has been found that recent track excitation can have a significant impact on the rail set during a PTLF test. These excitations can be caused by external loadings such as trains or hi-rail vehicles passing the location or internal forces caused by factors such as temperature. It is believed that continued vibrations after a train passes a given location, allow the rails to overcome the friction, leaving them in a position of optimal set, whereas other forms of excitation result in more set. This means that recent excitation of the track can change the initial conditions for the PTLF test. With the exact initial conditions for the PTLF test unknown, variability is introduced into the measurements.

OBJECTIVES AND APPROACH

The purpose of this analysis is to find a data processing method or measurement approach that will achieve the best correlation with track strength, while reducing variability of repeated tests at the same track location. This process needs to remain simple enough so that extensive training for railroad industry personnel is not required, while the size and weight of the new PTLF remain similar to the current unit.



Figure 1. The Portable Track Loading Fixture (PTLF) in Use for Testing



METHODS

Several different methods were investigated in this analysis to determine a more replicable measure for the PTLF. PTLF data used for this analysis was collected between 2007 and 2009. Data was collected from Norfolk Southern Railway (NS) as well as Maryland Midland Railroad (MMID). Most of the data used during this analysis was compiled from the tests performed with NS in November 2009, with two data sets from MMID tests used for validation purposes. One MMID data set from July 2009, which was collected in the same manner as the NS data, was used to validate the various methods being evaluated. The selected method was the Exercise Gage Method (EGM), and the data from a specific track location was analyzed using the return portion of the force deflection curve when the load is dropped from 4,000 lbf back down to a 0 lbf load. This method can be used for both head and web gage measurements.

TESTING

Testing for analysis of PTLF data was performed with NS in November 2009, with 15 locations selected to cover track conditions ranging from lower to higher lateral restraint. Of these 15 locations, 14 produced results that were usable. At each location, two tests consisting of loading the track to 4,000 lbf and then releasing the load back down to 0 lbf were conducted using the PTLF. The track was then returned to its initial state by pulling the track inward to match the original measured gage. Last, a third loading was applied. During each of these loadings, head gage, web gage, and pressure data were collected continuously. For this analysis, only the first two loadings are being used because they produce the most variability. The MMID data, which was used as a validation, was collected in the same manner.

ANALYSIS AND RESULTS

The first analysis was to determine the variability of the current method as a baseline. Using the NS test data, it was found that the standard deviation between consecutive tests of the current method was 8.28 percent. Figure 2 shows data for the current method from the NS tests. All plots of measurement data for this

report use the first loading's delta head gage at that particular location to serve as the baseline. In the plot below, if the data falls above and left of the diagonal line, there was less displacement than the baseline measurement, and if the data falls below and right of the diagonal line, there was more displacement during than the baseline measurement. This data was collected on track that had been recently exercised by the gage restraint measurement system (GRMS) vehicle. The data from the MMID test, which was on unexercised track, produced a standard deviation of 23.31 percent, which was significantly higher than for the NS tests. The difference in the standard deviation between the two data sets illustrates the effect of set of the rail.

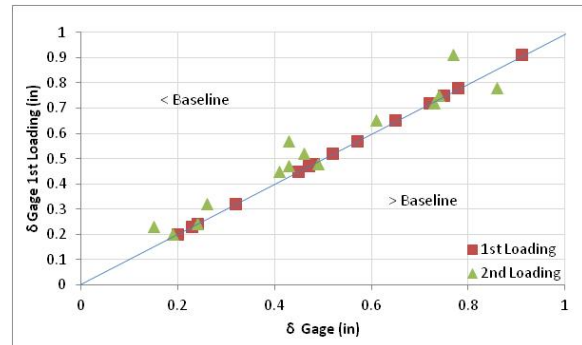


Figure 2. Current method First and Second Loadings NS Test Data

With a baseline established from the NS data, the other method's correlation and standard deviation were analyzed and compared with the current method. Figure 3 shows the results of this analysis, with the current method highlighted using a dashed box. In this plot, the ideal method would be near the top for both parameters.

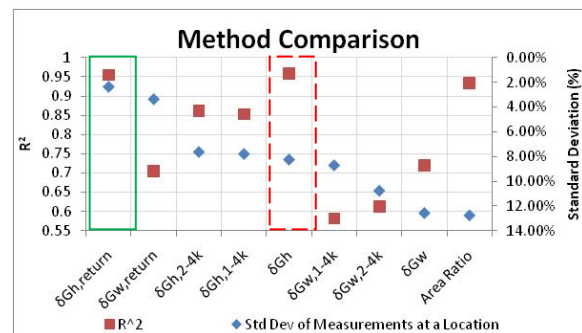


Figure 3. Comparison of Data Analysis Methods



As Figure 3 shows, several methods were able to reduce the measurement variability, but most came with a significant reduction in correlation to track strength. The most promising results were seen in the EGM (the solid box of Figure 3) using head gage measurements. This method reduced the standard deviation from 8.28 percent for the current method to 2.39 percent, with an R^2 value that only fell from 0.96 for the current method to 0.95. The EGM will be the focus of the remainder of this *Research Results*.

EXERCISE GAGE METHOD RESULTS

While examining the load deflection curves from the various locations, it was noted that although the initial gage varied from one loading to the next, the loaded gage and exercised gage remained very repeatable (as shown in Figure 4). On the basis of this observation, use of the exercise gage data was determined to be a viable method of reducing variability, while retaining a strong correlation to track strength. Exercise gage deflection is measured as the difference in gage with the 4,000 pound-force applied and after the load has been removed. As Figure 4 shows, generally the load is increased slightly above 4,000 lbf during testing. For this analysis, the displacement at the time when the load crosses 4,000 lbf while increasing is considered the full load.

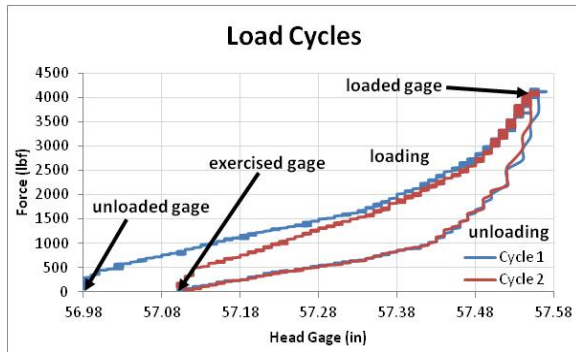


Figure 4. Plot of Load First and Second Loadings

Using the data from the NS test, which was performed on track exercised by the GRMS vehicle, we saw a reduction in variability from 8.28 to 2.39 percent. Figure 5 shows the NS exercise gage method results, in which the data points at each location are very close for different loadings. With the MMID test data, which was on unexercised track, we found the variability was reduced from 23.31 to 1.89 percent. These two data sets show that regardless of the track condition, the exercise gage method is capable of delivering highly repeatable numbers.

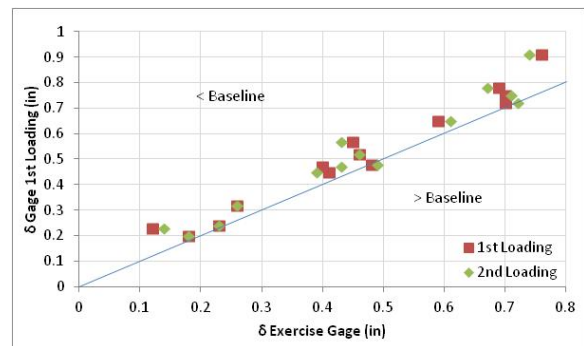


Figure 5. Exercise Gage Method First and Second Loading

Measurements of web gage were also analyzed for both the NS and MMID data. With the exercise gage web results from the NS tests, a standard deviation of 3.4 percent was found. This is a significant improvement over the current method but not as repeatable as the head gage exercise gage method. Also, the correlation between the web gage exercise gage method and the track strength was significantly weaker than that of the head gage exercise gage method, which is shown by the weaker linear relationship in the data of Figure 6 (next page).

Similar results were found with the MMID data in which the web gage exercise method standard deviation was 4.82 percent. Although the variability improvement was significant compared to the current method, it was lower than the head gage exercise results.

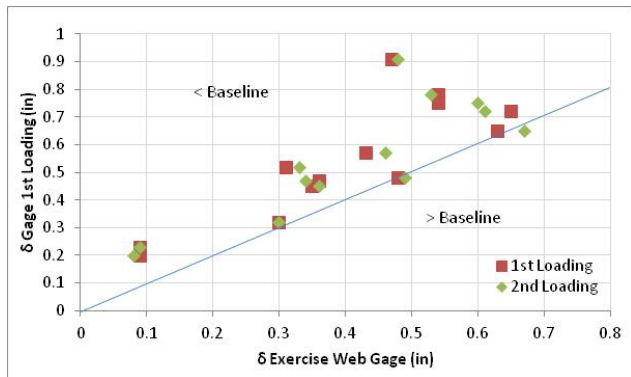


Figure 6. Exercise Gage Method Web Deflection First and Second Loading

CONCLUSION

Through analysis of data collected during multiple tests using an instrumented PTLF, it was found that the best combination of repeatable measurements and a strong correlation to track strength is the EGM. Although many of the methods investigated could also reduce variability, no other method was able to retain the strong correlation while doing so. The EGM also has an advantage over many of the other methods in that it requires no additional equipment or complicated calculations. Through this method, the simplicity of the current method can be retained, while addressing the repeatability concerns that have been raised. A more detailed analysis and discussion on the EGM as well as the data analysis conducted will be presented as a forthcoming FRA report.

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KEYWORDS

Portable track loading fixture (PTLF), gage restraint measurement system (GRMS), track strength.

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