ABSTRACT

To improve detection of railroad track defects that cause derailments, the Federal Railroad Administration Office of Research and Development with joint cooperation of the Railroad industry developed the Gage Restraint Measurement System (GRMS). This system measures and records the track's ability to support gage-wide forces and marks the locations at risk for derailment. The railroad industry has adopted this technology and is currently integrating it into regular maintenance activities. This paper describes the current practice on how the GRMS data is being applied by the railroads to improve safety and assist in maintenance planning.

Keywords: Railroad, Gage Restraint Measurement, Derailment Prevention

INTRODUCTION

The GRMS is a performance-based track strength evaluation system designed to improve railroad safety and maintenance efficiency. The system was developed under a joint effort by this federal government and the railroad industry. The agencies involved included the Federal Railroad Administration Office of Research and Development, The Volpe National Transportation Systems Center, with the help of the American Railway Engineering Association and supporting contractors. ENSCO Inc., the current FRA instrumentation contractor, operates
and maintains the FRA’s prototype system. The FRA’s GRMS has surveyed over 25,000 miles and is currently being used by several Class 1 and Short Line railroads to evaluate track gage strength. In addition, CSX Transportation has built and is utilizing two GRMS systems. AMTRAK and CP Rail have recently acquired GRMS capable systems and have used the FRA system in the past. BNSF is utilizing a high-rail version of GRMS technology. Combining the extensive experience utilizing all these systems, the industry as a whole has learned the benefits of using these systems and is developing ways to incorporate the data into regular maintenance activities. This paper discusses the details of what the industry has learned while using GRMS technology to improve safety and maintenance planning. This information was gathered through discussions with railroad personnel, FRA researchers, and personal experiences of the authors.

### Application of GRMS Technology

Many papers have been written that describes the function of GRMS technology and are shown in references (1) & (2). This paper will focus on the industry response after using a GRMS system. The railroads that participated in the development of this paper include: CP Rail, Bessemer & Lake Erie Railroad, CSXT, BNSF, Elgin Joliet and Eastern Railway, and the Maryland Midland Railway. A series of questions were developed and presented to representatives of each railroad to stimulate discussion on GRMS technology. The representatives were notified that the specific railroad contributions would not be identified to motivate a truly candid discussion. These railroads were selected because they have used the technology multiple times over a few years and in one case the GRMS has been used on the property for over ten years. A summary discussion of all the comments are combined and presented in the following paragraphs.
Common Locations for GRMS Defects

The railroads that utilize GRMS technology believe that the information provided by the GRMS is of great benefit to the maintenance programs of the railroad. It finds the isolated locations that are not visually apparent that have low gage widening strength and weak ties. A surprise was that a significant number of these weak locations exist on tangent track. This could be attributed to the focus of maintenance efforts on curves over tangents owing to higher wear rates on curves. Another interesting finding, but not unexpected, is that certain locations become common place for poor gage strength condition. These locations include; farm-crossings, road-crossings, bridge abutments, culverts, lubricator locations, and in one case defects arose consistently at milepost locations. This unique case was attributed to the start and stop locations of program tie maintenance. Stopping maintenance just prior to the actual milepost and starting maintenance, during the next year’s cycle, just after the milepost. This was a unique condition but interesting and informative for the track maintenance personnel.

Other than the milepost issue, these specific defect locations all have certain attributes. Materials covered the farm-crossings, road crossings, and lubricator locations so that a visual inspection was impossible. Also it was hypothesized that program maintenance may have skipped over these spots. The culverts and bridge abutment locations become defects by decreased vertical support. Settling of ballast around the abutment typically causes swing ties resulting in excessive lateral rail deflection caused by rail roll.

It was mentioned that running the GRMS the first time over the track was very enlightening for the maintenance personnel of whom many were very skeptical. In one case, the roadmaster was well aware of curves and track segments where problems were expected and marked these locations on the track chart prior to the GRMS survey. When the system triggered on maintenance or critical level
exceptions at the locations where the roadmaster had previously indicated, it confirmed that the system was measuring something he wanted to know and the GRMS car has been testing on the railroad every year since. A consensus of the railroads interviewed was that the GRMS reliably identifies both the location and the severity of weak tie conditions.

**Using the GRMS as a Maintenance Planning Tool**

Finding safety defects helps to prevent derailments but is the GRMS capable of being used as a maintenance planning tool? Some users say, “absolutely” and others say, “we are working on it”. Most participating railroads have done comparisons between the tie counts of the inspectors and the tie counts generated by the GRMS. Often discrepancies are found when these two sources are compared. One railroad reported a difference of up to 20% of the ties. Figure 1 is one such comparison between a track inspector the GRMS data for a mile of track. Prior to the GRMS survey, the track inspector marked the ties that he planned on replacing. This required two passes, one pass to mark all the defective ties and a second pass to remove (black out) acceptable ties that could remain in the track to stay within the tie allotments for the segment. The GRMS surveyed the track and a Gage Widening threshold (GRMS output parameter) was chosen to keep the tie counts equal. This figure shows how the distribution is different between the inspector and the car. In this case, the inspector distributed the ties very evenly across the whole segment while the car distributed fewer in the tangents and more in the curves.
Some tie conditions like plate cutting can provide significant gage widening support and therefore, not a critical defect to the GRMS, while the tie is still failing in the vertical direction. Some of the discrepancies between the tie count from inspectors and the GRMS can partially be attributed to tie defects other than gage widening support. The consensus of most railroad users appears to be that the GRMS will never eliminate the need for visual tie inspection. However, the objective data it provides is a valuable input to planning tie programs.

Multiple railroads use the GEOEDIT™ software developed by ENSCO to import the data and process for tie counts. Others have developed their own software and techniques for data analysis. The procedures implemented by GEOEDIT™ are based on data processing analysis procedures developed under the FRA GRMS research. Railroad personnel typically vary the Gage Widening exception...
thresholds to develop the tie counts. Then they choose the threshold that closest represents the number of ties available for replacement and distributes them to the miles as indicated by the GRMS data. Figures 2, 3, & 4 are examples of tie counts and milepost distribution generated by GEOEDIT™, for a specific track segment, using Gage Widening limiting thresholds of .50, .40, and .30 respectively. This approach allows the allocation of the ties to the locations that need them the most. The result is a stronger and more uniform track.

Figure 2. Maintenance Planning Tie Analysis Data (GW 0.50)

Figure 3. Maintenance Planning Tie Analysis Data (GW 0.40)
The Effectiveness of GRMS Based Maintenance Planning

One of the railroads surveyed routinely uses the GRMS data from the FRA car to plan their annual tie program. The first year extensive and sometimes unfriendly discussions were held when the GRMS estimated a significantly different number of ties over a specific two-mile zone. Railroad management relied on the GRMS data and replaced the ties according to the car as an experiment. The railroad determined that the major discrepancy was related to visual tie surface degradation, like checking and cracking, but the gage holding capacity of the ties were acceptable. A repeat test showed significant improvement of the track segment gage strength and has convinced the railroad that GRMS data can successfully be used as a maintenance-planning tool and has used it for the last four years.

Another railroad also was concerned about the effectiveness of GRMS measurements on plate-cut ties and is thinking about methods for measuring the vertical track stiffness to address this issue.
Consistent GRMS Data for Comparisons

Some of the railroads have expressed interest in developing comparisons between consecutive GRMS surveys to develop trends of track degradation or the effectiveness of repair. This has been done and is demonstrated in references (3) and (4). These papers illustrate the issues related to GRMS data comparisons that have been used to determine track degradation trends. To accomplish this comparison, one must determine changes in track measurement at a specified location from one survey to the next. Two issues must be addressed to successfully develop these comparisons. The location along the track must be known within a single tie spacing and the calibration of both the loaded and unloaded gage measurements must be consistent. Automated and manual methods have been developed for aligning data year to year as shown in references (3) and (4). To address the gage calibration issue, a procedure was developed for the FRA system using multiple measurements at 50-mile intervals to assure consistent calibration for yearly comparisons.

Advancement of the Technology

When asked about what could be done to advance the GRMS technologies a few key issues were addressed. The main issue was related to retracting for switches. Recommendations were to either automate the retraction process or eliminate it and successfully test through switches. One railroad indicated that higher testing speeds would be a significant benefit to allow testing without interference with normal operations. Some of the railroads would also like to link the GRMS data with GPS for location comparisons.
CONCLUSION

It is clear from the discussions with the railroad personnel that utilize GRMS technology believe that the information provided is of great benefit to the maintenance programs of the railroad. It finds the locations that have low gage widening strength and weak ties that are not visually apparent. Many railroads are using the data to assist in tie maintenance planning and are expecting to use it on a yearly basis. These railroads use a combination of GRMS data and visual inspections to determine the tie count and placement. In conclusion, the railroads that use the GRMS are confident in its ability to locate weak track and are at varying stages of integrating the technology in to their tie planning programs.

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REFERENCES