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Correlation of Rut Depths Measured by the Profilers of LTRC and DOTD PMS

INTRODUCTION

The Louisiana Transportation Research Center (LTRC) currently owns a road profiler, which uses a 5-point rut bar system for pavement rut depth measurements. DOTD is currently contracting with Fugro to collect pavement rut depth data for its PMS. Fugro uses an automatic road analyzer (ARAN) equipped with a Pave3D system for the pavement profile data collection. Because of the difference in rut model and algorithm, it is obvious that the two systems will result in some differences of calculated rut depths. Pavement management system section of DOTD often requests LTRC to collect rutting data for the pavement management control sites and compare them with the data in DOTD PMS. The correlation of calculated rut depths between these two systems should be established for us to better understand the rutting data collected by LTRC and the rutting data in the DOTD PMS. It is also believed that, in the long run, LTRC is going to move towards the latest scanning laser technology. To ensure that the historical data can be kept for future referencing and have a smooth transition, a good correlation is also necessary.

OBJECTIVE

The objective of this research was to develop a correlation of rut depths measured with LTRC's profiler with a 5-point laser system and DOTD PMS's profiler with a scanning laser system. A standard operating procedure (SOP) of pavement rutting data collection, compilation, and delivery by LTRC was developed so that DOTD pavement engineers can use LTRC data together with PMS data to evaluate the pavement performance and conduct/support pavement management activities.

SCOPE

Three repeat runs of LTRC's 5-point rut bar system have been made at 6 control sites and 4 selected sites. The repeatability of LTRC's 5-point rut bar system was evaluated for all 6 control sites and 4 selected sites using the cross-correlation of calculated rut depths.

The transverse profile data collected in 2020 and 2021 at the 8 pavement management control sites with flexible and composite pavement by both LTRC and Fugro profilers were analyzed to obtain individual rut depth, average rut depth over 0.004 mile and average rut depth over 0.1 mile. Additional 25 sites were selected to represent the typical pavement conditions and characteristics of the Louisiana highway network: roads with varying rut depths; roads with varying lane widths; roads with varying quantity needed to fill ruts; and roads with varying standard deviation for rutting. Average rut depth over 0.004 mile and 0.1 mile were obtained from both LTRC and Fugro transverse profile data.

Correlations were examined by constructing scatter plots of the rut depths from the profile data collected by LTRC's profiler versus the rut depths estimated from the profile data collected by Fugro's profiler. T-test or paired t-test were conducted to determine if there was a statically significant difference between the rut depth measured by LTRC's profiler and the rut depth measured by Fugro's profiler. The strength of the relationship between the rut depths measured by LTRC's profiler and Fugro's profiler were evaluated using the correlation coefficients and R square values.

At the end, an SOP was developed to standardize the process of collecting and compiling rutting data by LTRC and delivering them to DOTD engineers for subsequent actions, such as evaluating pavement performance and conduct/support pavement management activities.

METHODOLOGY

Repeatability of LTRC's 5-point rut bar system was evaluated with 3 repeat runs at 10 sites. Both 2020 and 2021 rutting data from 8 calibration control sites with flexible or composite pavement were used for the comparison of rut depths measured by the profilers of LTRC and DOTD PMS. Twenty-five homogeneous pavement sections, which represent the typical pavement conditions and characteristics of the Louisiana highway network, were selected to collect additional rutting data for the comparison.

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CONCLUSIONS

- Averaging rut depths over 0.004-mile and 0.1-mile increments show noticeable improvement of repeatability of LTRC's 5-point rut bar system, especially for average rut depths over 0.1 mile, which achieved an overall correlation value of 0.90 and above.
- The current algorithm of Roadware Vision, causes incorrect measurements that include measurements in cracks, measurements outside wheel path, failure of locating the point of maximum rut depth.
- LTRC's 5-point rut bar system cannot always capture the maximum rut depth for transverse profiles (missing the peak and valley). It can also be significantly affected by the edge drop off and grass for RWP rut depth
- The correlations of average rut depths were higher than those for the LWP and RWP. Averaging rut depths over the 0.1-mile increment showed noticeable improvement of correlation between LTRC and Fugro road profiler.
- The results of t-tests showed that mean values of LTRC's 5-point rut depth and Fugro's full profile rut depth were statistically different at all scales (individual rut depth, 0.004 mile average rut depth and 0.1 mile average rut depth).
- The t-tests indicated that the mean values of LTRC's and Fugro's 5-point rut depth was statistically different at individual and 0.004 mile average level, but with careful planning, the difference between the mean value of LTRC's 5-point rut depth and Fugro's 5-point rut depths at the 0.1 mile average level could be statistically insignificant.
- For pavement sections that cracks are prevalent, the cracks have significant effect on computed Fugro full profile rut depths with the current algorithm of Roadware Vision. In this case, including rut index in pavement condition index computation can possibly create double penalty issue for cracks.

RECOMMENDATIONS

The following SOP is recommended for using LTRC's 5-point rut bar system to collect rutting data to support pavement management activities:

1. Site Selections:
1.1. The control site selected for rutting verification should be at least 11 ft. wide.
1.2. The control site that cracks are prevalent should be excluded from rut depth comparison

2. Preparation:
2.1 The accuracy of DMI should be checked at least at one section with at least 1000 ft. in length.
2.1.1 This test should be performed before the LTRC's 5-point rut bar system obtains rutting data at the control sites.
2.1.2. A section of at least 1000 ft. in length shall be selected on N. Line Rd near LTRC's pavement research facility. Clearly marking the starting and ending points of the test section. Measure the distance between the starting and ending points with a measurement tape.
2.1.3. At least three auto-triggered runs at the low (30 mph) and high test speeds (50 mph) shall be conducted.
2.1.4. Compute the absolute difference between the DMI readings and the distance of the section tested. The average of the absolute difference for both the high-speed and low-speed runs must be less than 0.15 percent.
2.2 LTRC's 5-point rut bar system repeatability should be checked at least at six control sites.
2.2.1 Three repeat runs of the LTRC system shall be made at each selected control sites. Data collection shall be automatically triggered at the starting location of the section.
2.2.2 Evaluate repeatability using the cross-correlation of the rut depth. Calculate the cross-correlation value of each site. On each site, cross-correlate each of the three rut depth profiles to each of the remaining two. The cross-correlation for each site is the average of three values. The repeatability cross-correlation is the average of cross-correlation value of each site. A repeatability cross-correlation of 0.40, 0.6, and 0.85 or greater is required for individual rut depth, 0.004-mile average rut depth, and 0.1-mile average rut depth, respectively. A lower repeatability cross-correlation may be acceptable for the individual site.

3. Data Collection and Report
3.1 Since control sites are short sections (0.5 mile), it would be better to make sure start and end points are triggered with a cone or some other means of ensuring the start/end locations are accurate.
3.2 Care shall be taken to ensure the center of the rut bar is as close to the centerline of the lane as possible during data collection.
3.2 Data shall be collected at a 1 ft. interval.
3.2 The rut depth data shall be reported in tenth of a mile and sent to pavement management engineer.
3.3 It is recommended that LTRC's 5-point rut depth data be compared to Fugro's 5-point rut depth data.