MnROAD Mainline IRI Data and Lane Ride Quality
MnROAD Lessons Learned – December 2006

Derek Tompkins, John Tweet, Prof. Lev Khazanovich
University of Minnesota

MnDOT Contacts: Bernard Izevbekhai, Tim Clyne

1 Abstract

Since 1994, MnROAD engineers have regularly conducted ride quality assessments on both the low-volume road (LVR) and mainline test cells and collected the data from these assessments in the MnROAD database. While other facilities and DOTs have observed the ride quality of their roads, none have done so to the extent of the information in the MnROAD database. The data history includes several measurements for each of the 11 years, multiple measurements for particular days, and assessments of the left and right lanes (as opposed to an average assessment across both lanes). One simple analysis that can be accomplished using an extensive history of International Roughness Index (IRI) data is a comparison of the ride quality of the driving and passing lanes in a given pavement. Though even more analysis could be done (seasonal changes in IRI, for example), the lane ride comparison was recently addressed by two graduate researchers at the University of Minnesota. This brief details that analysis for the mainline IRI data and discusses the development of MnDOT's IRI specifications and the use of MnROAD test sections to calibrate IRI test equipment.

2 Background

From July 1994 to August 2005, engineers at the MnROAD facility conducted 60 individual assessments of the ride quality in the pavement test cells for both the mainline and low-volume road. These assessments, for both the driving and passing lanes, include the measurements given in Table 1.

Measurement	Description
IRI_LWP	IRI in the left wheelpath
IRI_RWP	IRI in the right wheelpath
RUT_AVG	Average rutting across both wheelpaths
FAULT_AVG	Average faulting across both wheelpaths
TEXTURE_AVG	Average texture
PSR_LWP	PSR in the left wheelpath

Table 1. Ride quality data collected by MnROAD

The ride quality observations in the MnROAD database also include lane length, data collection comments, and the time of day for an observation. It should be noted, however, that the comments and time of day fields are rarely completed for an observation. This technical brief will discuss an examination of the IRI measurements in the wheelpaths only to make the ride quality comparison between the two lanes.

MnROAD engineers collected the 60 assessments on the mainline and LVR test sections at irregular intervals. From July 1996 to July 1997, MnROAD conducted the ride quality assessments on a quarterly basis using a van (PaveTech) equipped with ultrasonic sensors. In July 1997, MnROAD acquired a new van (Pathways) with laser sensors, and MnROAD engineers continued to collect ride quality data on a quarterly basis using this laser sensor equipped van.

Figure 2. Laser sensor equipped Pathways van

In July 2001, MnROAD engineers began assessing their pavements on a more frequent interval. This interval varied, however, and was as small as one month and as large as two months, and these more frequent measurements continued until May 2002. From May 2002 to August 2005, the assessments occurred on highly irregular intervals, with as little as one month between some assessments and as many as eight months between others.

The analysis below does not always consider all 60 observations for a given cell. For example, due to rehabilitation and reconstruction on the AC cells and some of the PCC LVR cells, the data sets in each of these cases are selected to represent a period in which neither of the lanes has been altered.

Finally, the reader should note that the actual measurements for the IRI are those of the left and right wheelpaths of each lane. In analyzing the IRI data, however, the UM researchers typify the IRI data as an average of the values in the wheelpaths. Hence, the average IRI for the left lane of Cell 9 on 15 May 2001 will be average of the IRI measurements for the left and right wheelpaths of the left lane of Cell 9 in the data tables. These average IRI values for each lane then provide an easy, accessible basis for a lane comparison.

A final comment is on the units of the IRI measurements, which are in metric [m/km] form. While this is non-traditional for most pavement studies in the United States, the researchers preferred to leave the data in the form in which it was recorded. As the profilers at MnROAD record IRI data using metric units, these units were retained throughout the analysis. The conversion to English units is obtained through 1 m/km = 63.36 in/mi.

3 University of Minnesota Research and MnROAD Data

3.1 AC Mainline Lane Comparison

UM researchers examined the IRI data in eight of the mainline AC test cells in an effort to make a general lane ride quality comparison. For nearly every cell considered by the UM research team, a trend was present in the IRI data set for each lane, and this trend accounted for the existing data in a statistically significant manner.

As an example of the analysis that went into each cell, this brief presents the analysis of Cell 14, which is a 10-year design cell with a full-depth HMA course layer of 11 inches of 120/150 Pen-Graded asphalt concrete directly on a clay subgrade. A two-sample t-test of the average IRI values for this lane found a statistically significant difference ($\alpha = 0.05$) between the averages of the 28 observations for each lane. The 28 observations for this cell took place between July 1997 and July 2003.

The IRI data for Cell 14 is plotted against its time of observation in Figure 3. UM researchers believe the trend lines explaining the data for each lane are meaningful due to the strong r-squared values. These kinds of strong trends in the data for each lane were observed for nearly every single AC cell investigated. What is evident in Figure 3 and the plots of other cell data is that for both the driving and passing lanes in AC, the deterioration of ride was relatively similar over time.

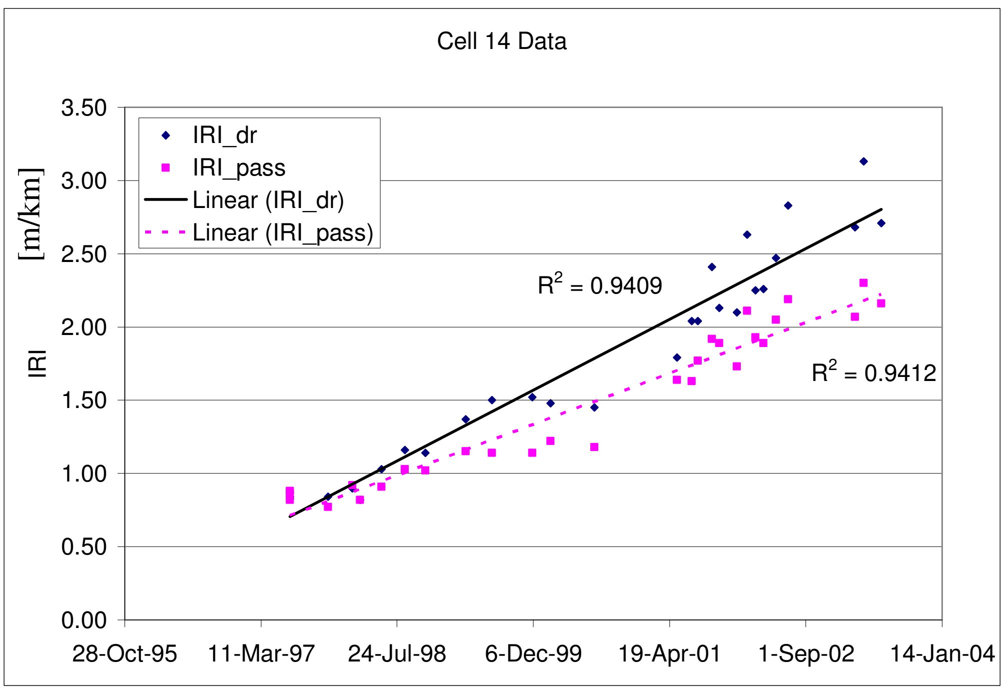

Figure 3. Ride quality trends in AC cell (14) vs. time

By plotting the average IRI for each lane versus the traffic (in ESALs) experienced in each lane, UM researchers developed a comparison of the ride quality trends in each lane due to traffic (Figure 4). The two lines indicated in Figure 4 are the least squares lines of best fit to indicate the trend of the data for each lane. The r-squared values are provided for each trend line in Figure 4.

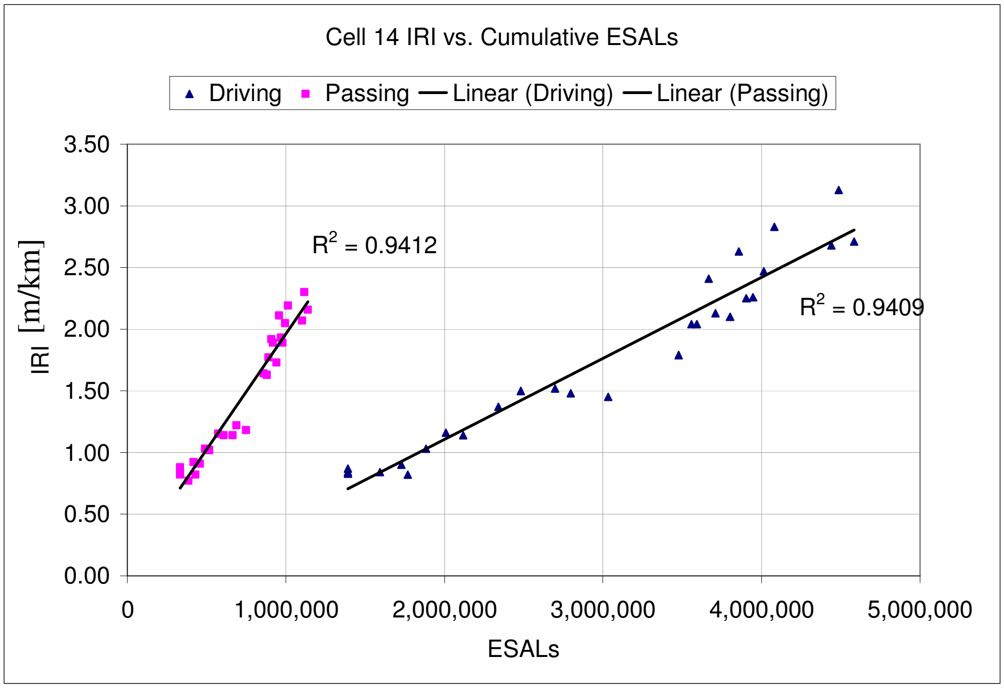

Figure 4. Ride quality trends in AC cell (14) vs. traffic

In Figure 4, it is evident that the notable difference in ESALs between the two lanes did not influence the ride deterioration in those lanes to a significant extent. The main observation of the UM research team, then, is that for AC pavements the deterioration of ride is influenced more by time (i.e. environment) than traffic.

The trends observed here for each lane of Cell 14 are similar to those of every cell except Cell 50, which has a 4-inch thick Superpave overlay on 9 inches of full-depth HMA on a clay subgrade. Cell 50 has a reputation among MnROAD engineers and researchers as being an "odd duck" for its strange response to traffic. It is suspected that the abnormality of this cell is mostly due to construction problems.

3.2 PCC Mainline Lane Comparison

UM researchers examined the IRI data in the nine mainline PCC cells from the original construction of MnROAD in October 1992. The ride quality data examined for the mainline PCC cells describes the 11 years of "ride quality history" between July 1994 and August 2005. In stark contrast to the similar trends found for each of the mainline AC cells examined, the mainline PCC cells showed no consistent significant differences in lane ride quality among the nine cells.

One easy process to determine the lack of consistent differences in lane ride quality is to conduct a two-sample t-test for the average IRI values of each lane for each of the cells. Hence, for the nine cells, UM researchers conducted a two-sample t significance test of the null hypothesis that the mean of the 60 IRI averages for the left lane is equivalent to the mean of the 61 IRI averages for the right lane, with $\alpha=0.05$ for a t distribution with 119 degrees of freedom for each test. These t-tests suggest a statistically significant difference in the average IRI of the two lanes in only five of the nine cells.

The 60 or 61 observations for these cells took place between July 1994 and August 2005, and the values observed during these dates were plotted versus the date of observation (Figure 7). One of the five cells that exhibited a difference in ride quality between the lanes (Cell 7) has its IRI data plotted versus time in Figure 7. Though we have included trend lines for the IRI data in Figure 7, the r-squared values are low and the trend lines do not meaningfully explain the data. Whereas the data points were easily distinguished for the AC in Figure 3, the data points have been connected in Figure 7 to make the data corresponding to a given lane easier to distinguish.

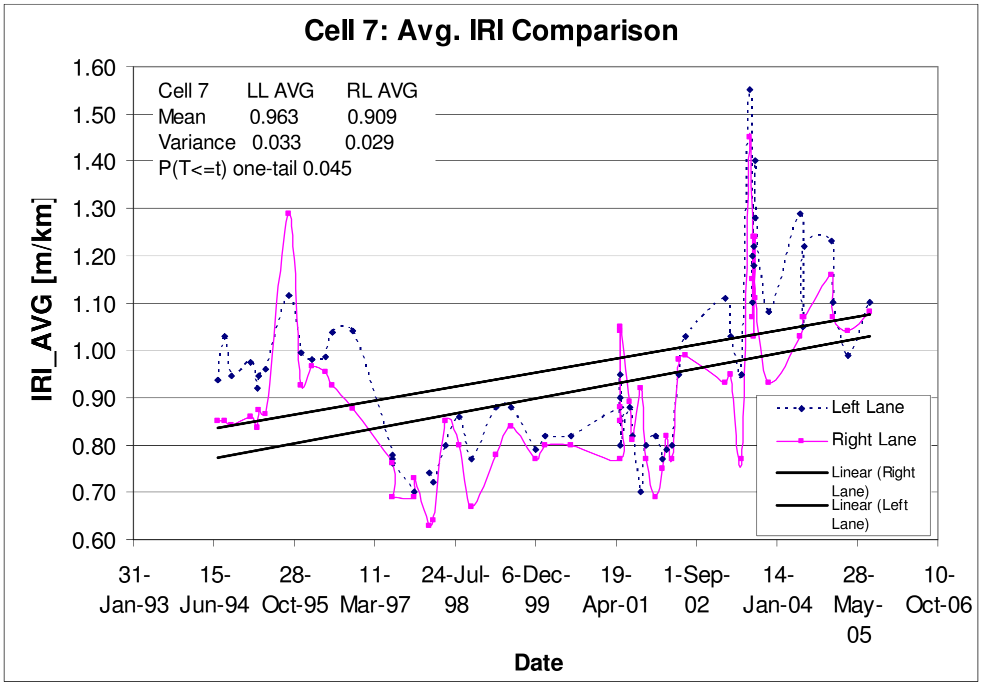

Figure 7. Ride quality trends in PCC cell (7) vs. time

Figure 7 provides an example of the difficulty of spotting trends in the mainline PCC IRI data--the two trend lines for the IRI in each lane have essentially the same slope, the only difference being the y-intercept. UM researchers observed this kind of trending in all nine mainline PCC cells.

As for the AC analysis, the IRI data for the two lanes of each cell (in this case Cell 7) was also plotted against the traffic experienced in each lane. This plot is Figure 8 below.

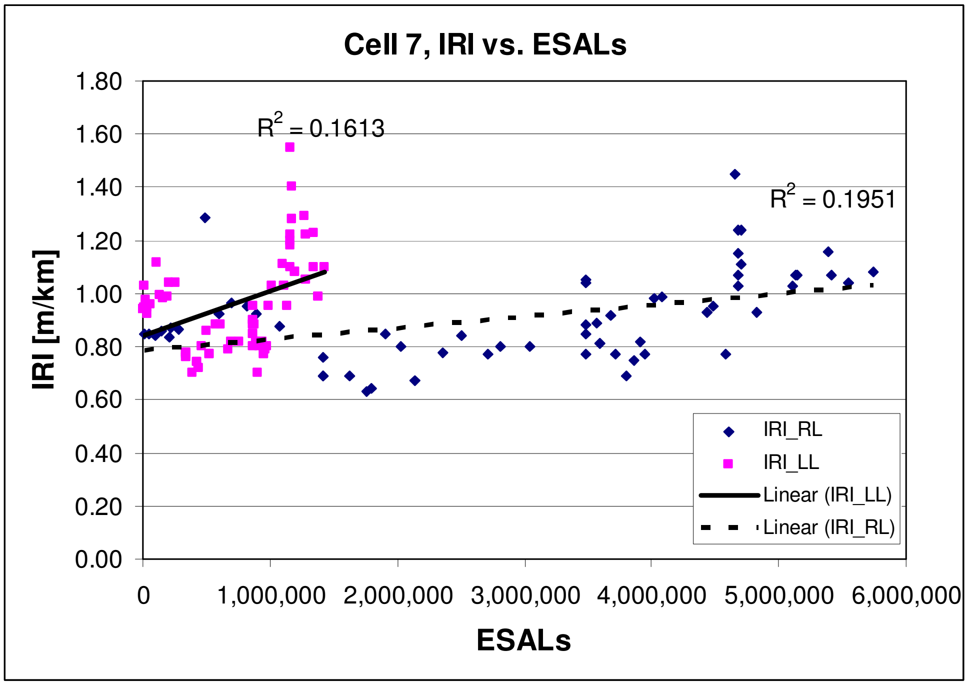

Figure 8. Ride quality trends in PCC cell (7) vs. traffic

Given the large amount of observations, the very low r-square values for each trend line in Figure 8 leads the research team to reject attempts to correlate traffic and IRI ride quality. The main conclusion is that in PCC pavements, as in AC pavements, time (or environment) contributes more to ride deterioration than traffic.

4 MnROAD Contributions to Pavements in IRI Assessments

MnROAD's work in the ride quality assessment of pavements (or profilometer as it as known within MnDOT) has greatly influenced how MnDOT assesses its in-field pavements. MnDOT recently switched from the Pavement Serviceability Index (PSI) to IRI in its specification for assessing the ride quality in the delivery of its bituminous pavements. Furthermore, MnDOT is currently performing a research implementation project toward the use of IRI in construction projects.

Since 2001, MnDOT has also certified contractors in the use of the profilometer, and the MnROAD facility has been a staging area for the certification procedure. Certification takes place for concrete on Cells 39 and 40 and for asphalt on Cells 34 and 35. During these extensive tests, MnDOT, through MnROAD, has learned more about operator error in using the profilometer and has increased the level of sophistication applied to a ride quality assessment of Minnesota pavements.

5 Conclusions and Recommendations

The main conclusion and recommendation from the research done by UM students using MnROAD IRI data is that time—i.e. environment—has a huge influence on ride quality. Furthermore, we feel the data (exemplified in the figures above) supports the conclusion that for both AC and PCC pavements environment is much more important than traffic when considering ride deterioration. The main recommendation is for MnDOT to continue to take advantage of MnROAD's abilities as the premier cold-regions pavement research facility and invest more effort into studying the effects of climate on ride deterioration.

As far as the lane ride comparison component of the research, one conclusion is that for the AC test cells, the data analysis performed by UM researchers suggests that the right lane performed worse than the left lane in terms of IRI. This conclusion agrees with observations in the field, as the AC sections have shown traffic related distresses, and a majority of those distresses have been in the driving lane. Furthermore, both lanes have experienced thermal cracks, and as the thermal cracks in the driving lane are subjected to traffic beyond that of the passing lane, it seems reasonable that these thermal cracks would deteriorate faster and contribute to a faster increase in IRI in the driving lane.

In the PCC test cells, however, the UM research team does not feel confident in making any conclusions about which lane performed better due to the lack of statistically significant differences between the data for each lane of each cell. In other words, at this time the only reasonable conclusion for the PCC cells is that there is no difference between the ride qualities of the two lanes after 11 years of traffic. In contrast to the AC cells, the PCC cells have not shown significant distresses in either lane. While we observe that over time, for every PCC cell, the IRI of both lanes increases above its initial value at construction, this deterioration in ride quality takes place without accompanying observed distresses in the test cells. In the end, the PCC test cells suggest that this lane comparison in ride deterioration may not be easily accomplished using the IRI index.

Finally, the examples of MnROAD's contributions to pavements in Section 4 illustrate the necessity of MnROAD in MnDOT's adoption of IRI ride assessments as a new standard. MnROAD's use of the profilometer and the MnROAD facility itself provided MnDOT with a significant knowledge base in pavement assessment. This expertise allowed MnDOT the ability to both certify contractors for the profilometer and explore and implement a new ride assessment in the MnDOT specifications for the delivery of pavements.

6 Acknowledgements

The authors of this brief would like to thank Benjamin Worel, Operations Engineer at MnROAD, for his assistance in the analysis of MnROAD data and Bernard Izevbekhai, Research Operations Engineer at MnROAD, for overseeing this brief on behalf of MnDOT and providing suggestions for revision and additions in content.

7 References

1. Worel, B. *Guide to the MnROAD Database.* Unpublished technical brief. Minnesota Department of Transportation, 2006.
2. MnROAD Test Cell Diagram. Office of Materials and Road Research, Minnesota Department of Transportation. Accessed August 2005. http://www.mrr.dot.state.mn.us/research/cell_info/trackml_lv.asp.
3. Van Deusen, David. *MnROAD Ride Quality Observations*. Unpublished report. Minnesota Department of Transportation, 2001.
4. MnDOT Standard Specifications for Construction, Minnesota Department of Transportation. http://www.dot.state.mn.us/tecsup/spec/. Accessed on 31 July 2006.