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AN ANALYSIS OF RIDE QUALITY OF THE ULTRA-THIN WHITETOPPING OVERLAYS AT THE FHWA ACCELERATED LOADING FACILITY

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ABSTRACT

In 1998, eight test lanes of ultra-thin whitetopping (UTW) were constructed over existing hot-mix asphalt pavements at the Federal Highway Administration's Accelerated Loading Facility (ALF) located at the Turner-Fairbank Highway Research Center. Various combinations of thickness, joint spacing, fiber reinforcement, and asphalt base type were used. As part of the experimental data collection effort, pavement profiles were obtained periodically during the ALF loading history. From this information, ride statistics were calculated including Ride Number (RN) and the International Roughness Index (IRI). This paper describes a comprehensive analysis of this information from a number of perspectives.

INTRODUCTION

Since the 1980's, the Federal Highway Administration (FHWA) has maintained several pavement test sections comprised of hot-mix asphalt (HMA) at its Accelerated Loading Facility (ALF). In 1998, eight lanes of ultra-thin whitetopping (UTW) overlays were placed over a portion of these HMA pavements. The test sections, located at the Turner-Fairbank Highway Research Center (TFHRC) in McLean, Virginia, presented an excellent opportunity for evaluation of a UTW pavement under controlled conditions. The experiment resembles a real-world application of UTW, since the underlying HMA pavements had been previously loaded. The new UTW overlays were placed at varying thickness, joint spacing, addition of fibers, and HMA base types (1).

Shortly after construction of the UTW pavements, a set of pavement profiles was taken by the FHWA using a Dipstick™ device. For purposes of this paper, these profiles are herein referred to as P_{98}. In the spring of 2000, two additional sets of profile readings were taken. The first was conducted by the FHWA (P_{00a}), and a second by the primary authors (P_{00b}). The final two sets of profile measurements were obtained after the ALF device had loaded each section at or beyond its scheduled number of load applications.

There are many methods by which to characterize the roughness of a pavement. Two commonly used methods, which are reported in this analysis, are the International Roughness Index (IRI) and the Ride Number (RN). Both of these statistics can be derived from a set of pavement profile data, filtered through a dynamic response model. The resulting values, IRI and RN, are indicators of the user's satisfaction with the roughness of the pavement. The IRI is a ride indicator that has quickly increased in popularity due to its portability. It is currently the ride indicator of choice of a number of highway departments and will most likely be the functional distress indicator used in the 2002 Guide for Design of Pavement Structures, currently under development (2). The RN is a second roughness performance indicator that is described as an estimate of the Present Serviceability Index (PSI), also commonly used in highway engineering (3). Since the IRI and RN statistics are sensitive to different wavelengths of roughness, it was decided to provide both for comparison purposes. More specifically, IRI has additional sensitivity over RN for wavelengths ranging from 20 to 50 feet (at highway speeds).

OBJECTIVES

Four objectives were established for the analysis and interpretation of the pavement profile data:

1. A comparative analysis of the change in roughness as affected by the number of **load applications**.
2. A comparative analysis of the change in roughness as influenced by the **load position** (loaded versus non-loaded slabs).
3. A comparative analysis of the change in roughness as affected by the **time of day**.
4. A comparative analysis of the change in roughness as a function of the pavement design, specifically the **HMA base type**.

DATA COLLECTION

All three sets of profile data were measured both in and out of the ALF's wheel path. This was done in order to observe the differences in roughness between loaded and non-loaded pavement areas. The non-loaded profile was taken on a "column" of slabs different than the column that was loaded by the ALF. The loaded profile was taken in the ALF wheel path column. Figure 1 shows the location of the P_{98} and P_{00a} profile sets with respect to the test section. Figure 2 shows the location of the P_{00b} profile readings. As can be observed from these figures, the previous two sets of profiles were taken at varying transverse distances from the edge of the slab, whereas the P_{00b} profiles were taken at the center of each column. In some cases, the two profile lines

overlap identically, while on some lanes, there may be a 0.3 to 0.6 m (1 to 2 ft.) offset between the two types of profile sets.

As mentioned previously, the P_{98} data set was collected at the beginning of the ALF loading (just after construction). The P_{00a} profiles were collected at the end of the ALF loading (after the loads had been applied). The P_{00b} profiles were also taken after all loading had been completed. However, in this case, profiles were taken both in the day and at night to help in the assessment of slab curling effects on roughness. The original two data sets (P_{98} and P_{00a}) were only collected during a single time of day.

DATA REDUCTION

In order to analyze profile data for IRI and RN, at least 23 m (75 ft.) of data is recommended for a proper analysis due to the boundary conditions in the solution of the differential equation as well as the proper definition of wavelengths (4). However, due to inherent geometric limitations at the site, the profiles measured at the ALF were a maximum of 15 m (48 ft.) in length. In addition, due to the loading characteristics of the ALF, an impact zone exists at one end of the lanes where the loading has been found to exceed the static load applied to the wheel assembly (5). At the other end of the lanes is a lift-off zone. As a result, the first 3.6 m (12 ft.) and the last 1.2 to 1.8 m (4 to 6 ft.) of data were discarded from the profile for purposes of this analysis. The final obstacle to the profile data collection, at least for the most recent measurements, was the ALF itself. At the time of the P_{00a} and P_{00b} measurements, the ALF was positioned on part of Lane 5, further shortening the profiles on that lane.

In order to overcome these limitations, two techniques were employed in the analysis of the profile data. The first technique (Method 1) involved analyzing the actual data set with the IRI and RN models as-is, ignoring the 23 m (75 ft.) minimum recommendation. For the second technique (Method 2), the profiles for each pass were appended, end to end, to obtain a length of at least 23 m (75 ft.). When appending the profiles, the beginning points of the additional "copies" were shifted to begin at the elevation of the ending point of the previous series. While neither method is truly "correct" as per the IRI/RN analysis specification, they do allow for a comparative analysis. Furthermore, as will be seen in the data analysis, both techniques yielded similar results. Table 1 contains a summary of the length of the profiles used for each lane and for each technique, as well as other statistics for each UTW lane.

DATA ANALYSIS

Table 2 shows the calculated results of the IRI and RN values for the P_{98} and P_{00a} profiles obtained by the FHWA. As mentioned previously, these profiles were taken along the same path both before and after the ALF loading cycles. In this table, the column labeled *Traffic* indicates whether the profile was taken in or out of the column of slabs coinciding with the ALF wheel path. The table column labeled *Number of Load Apps* indicates the cumulative number of load applications applied prior to the profile being taken – note that the P_{98} profiles have values of zero, signifying that they were taken prior to ALF loading. The remaining table columns contain

the IRI and RN values predicted using both techniques described previously as well as their average and difference (shown as a % of the average).

From Table 2, it can be observed that (with the exception of lane 5, where the profiles were very short) the difference in the ride statistics calculated using the two analysis methods is generally within ten percent. The ride statistics calculated using the second method (with the profiles appended end-to-end) were generally slightly "worse" than those calculated using the first method (with the profile as-is).

As can be seen in Figures 1 and 2, the actual profile lines measured in Lane 5 differed. During the most recent measurement, the ALF was occupying a portion of Lane 5, preventing the line to be extended further. In order to make a more accurate comparison of these two lines, the "zero applications" profiles from Lane 5 were analyzed a second time with a shorter line. These statistics are shown with a double asterisk notation in Table 2.

Table 3 shows a data summary for the P_{00b} profiles. These profiles, like the P_{00a} profile data, were taken only after the sections had been loaded. However, the P_{00b} data contained profiles taken both in the day and at night. Note that due to scheduling constraints during the data collection, a profile line was not taken in Lane 5 during the day.

Table 4 further illustrates the P_{00b} data by comparing the ride statistics calculated from the daytime and nighttime traces. Although the RN values did not demonstrate a clear trend, the IRI values calculated using the daytime traces demonstrated a 3% increase (rougher) than the nighttime traces. Differences in curled-up or curled-down shape could account for some of this ride difference, although the scatter in the data may be too significant to draw such a conclusion at this time.

Since the P_{00b} data was taken after the pavement loading, a comparison can be made to the P_{00a} data taken at about the same time. Table 5 contains a summary of the statistics for the P_{00a} and P_{00b} profiles. Since the P_{00b} data was taken both at night and in the day, and since the differences between the night and day measured statistics averaged less than 3%, the day and night ride statistics were averaged in this table.

In order to better visualize the pavement profile data, examples of the measured profiles are shown in Figures 3 through 6, representing Lanes 5, 7, 9, and 12, respectively. Some lateral and vertical translations of the profiles were made in order to adjust the data to fit together as well as possible. This translation and rotation process was found to have no impact on the calculated ride statistics for the profiles.

The next step in the analysis was to compare the change in ride quality with respect to traffic. Table 6 summarizes some statistics that were derived from the P_{98} and P_{00a} data. Since the P_{00b} data was collected on a slightly different alignment, and since it was only collected at the end of the loading period, it was not used in this aspect of the analysis. As expected, each lane performed differently under load. In comparing the calculated ride statistics before and after loading, some interesting results surfaced. The average increase in roughness for all of the lanes was manifested in an increase of 25% in the IRI and a decrease of 7% in the RN. The reader

must keep in mind that each lane was loaded to a different number of applications, has a different HMA base, and that two different concrete mixes were used. Lane 5 performed the poorest, with the IRI more than doubling, and the RN decreasing by a third in the loaded area. Lanes 7, 8, and 11 performed the best with no significant change in the ride.

The change in the IRI for the loaded slabs from the time of construction to the completion of the ALF loading is plotted in Figure 7. The change in ride was then divided by the number of load applications applied in order to generate a rough indicator of distress rate. These values are tabulated in Table 6 as well as illustrated in Figure 8.

CONCLUSIONS

The limitations of the analysis technique described in this section should be considered when evaluating the resulting IRI values from this analysis. They are not absolute, and should not be compared with IRI values from other facilities. However, some observations can be made from the data with respect to the objectives of this analysis. With respect to the number of load applications, Table 6 indicates that an average increase in IRI of 25% occurred due to the loads applied by the ALF. The range of the IRI increase, however, is rather large, from –5% to 117%. Overall, most of the sections incurred a 0% to 33% increase.

The load position was found to have an impact on the increase in IRI. For the profiles taken in the wheel path, the average increase in IRI was 25%, as mentioned in the previous paragraph. The ride statistics from the profiles taken outside of the wheel path, however, had changed negligibly due to loading, with an average decrease of 4% in IRI (see Table 6). The IRI calculated from the P_{00a} and P_{00b} profile data (which include differences in the location of the profiles) have been shown to vary by about 10% and by as much as 49% in one case. A 4% difference in IRI, then, is within the variability produced between the two sets of profiles.

Data shown in Table 4 indicates the average IRI values for the P_{00b} profiles both at night and in the day. To compare the difference in IRI between day and night, accounting for differences in slab curling, the IRI was calculated both in and out of the wheel path, and in the day and night for each location. Out of the wheel path, the average IRI in the day was 3.93 m/km (249 in./mi.) and the average at night was 3.83 m/km (243 in./mi.). In the wheel path, the average IRI in the day was 3.61 m/km (229 in./mi.) and 3.53 m/km (224 in./mi.) at night. The conclusion from this is that slab curling does not seem to have a major effect on UTW ride quality. This seems reasonable due to the short slab length, thin concrete section, and the bond between the concrete and the HMA layers.

One final, but important observation was made with respect to the ride quality as a function of the HMA base type. When the measured rutting potential of the HMA layer prior to UTW construction is compared to the IRI, a good trend is observed. The data, shown in Figures 9 and 10, compare the number of passes of the ALF required to produce a 20-mm (0.8-in) rut depth (6) to the percent increase in IRI. Figure 10 shows the same data as Figure 9, but without the effect of Lane 5. A clearer trend can be distinguished in Figure 10. A greater number of loads required to produce a 20-mm (0.8-in) HMA rut indicates greater resistance to rutting, and less rutting

throughout the life of the pavement. For increasing number of passes to produce a 20-mm (0.8-in) rut, there is a corresponding lower increase in IRI per million loads on the UTW.

In summary, the following observations were made throughout the analysis of this data:

- IRI increased on almost all sections after being loaded by the ALF,
- IRI did not significantly increase in the slabs adjacent to those that were loaded,
- The time of day did not significantly influence the IRI of the UTW at the ALF facility, and
- The rutting potential of the HMA pavement beneath an ultrathin whitetopping overlay has an influence on the change in IRI under repeated loading.

Further investigation should be conducted using data from other UTW overlays to determine if the trends and conclusions identified in this analysis can be verified. In addition, as structural distress history data becomes available, a correlative investigation should be made between this and the observed change in ride quality.

It is recognized that the sections at the ALF facility are short in length, and were not subjected to the same type of loading that a "real" UTW may encounter. However, a number of key observations can be made from this data set with regards to the relative impact of traffic loading on the ride quality of UTW pavements.

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TABLES

Table 1. Summary of Profile Measurements.

Lane	Design Thick. mm (in.)	Joint Spacing m (ft.)	Fibers?	HMA Type	Profile Length Used, m (ft.) P_{98} & P_{00a} Method 1	P_{98} & P_{00a} Method 2	P_{00b} Method 1	P_{00b} Method 2
5	64 (2.5)	1.2 (4)	YES	AC-10 (surface mix)	9.4 (31)/ 3.4 (11)*	23 (77)	4.0 (13)*	28 (93)
6	64 (2.5)	1.2 (4)	NO	AC-20 (surface mix)	9.4 (31)	28 (93)	9.4 (31)	28 (93)
7	64 (2.5)	0.9 (3)	YES	Styrelf (surface mix)	9.1 (30)	27 (90)	9.1 (30)	27 (90)
8	64 (2.5)	0.9 (3)	NO	Novophalt (surface mix)	7.0 (23)	28 (92)	7.0 (23)	28 (92)
9	89 (3.5)	1.8 (6)	YES	AC-5 (surface mix)	8.8 (29)	27 (87)	8.8 (29)	27 (87)
10	89 (3.5)	1.8 (6)	NO	AC-20 (surface mix)	8.8 (29)	27 (87)	8.8 (29)	27 (87)
11	89 (3.5)	1.2 (4)	YES	AC-5 (base mix)	9.4 (31)	28 (93)	9.4 (31)	28 (93)
12	89 (3.5)	1.2 (4)	NO	AC-20 (base mix)	9.4 (31)	28 (93)	9.4 (31)	28 (93)

** Note: The P_{00a} and P_{00b} profiles were limited due to the ALF equipment on the section at the time.*

Table 2. IRI and RN Values for P_{98} and P_{00a} Profile Data.

Lane	Traffic	Number of Load Apps	IRI - m/km (in/mile) Method 1	Method 2	Average	Difference	RN Method 1	Method 2	Average	Difference
5	No	0 (P_{98})	3.19 (202)	3.08 (195)	3.13 (198)	4%	2.70	2.72	2.71	-1%
		0** (P_{98})	1.56 (99)	1.22 (77)	1.39 (88)	25%	3.29	3.26	3.28	1%
		194,500 (P_{00a})	0.99 (63)	0.87 (55)	0.93 (59)	13%	3.05	3.08	3.07	-1%
	Yes	0 (P_{98})	2.91 (185)	2.92 (185)	2.92 (185)	0%	2.43	2.36	2.39	3%
		0** (P_{98})	3.19 (202)	3.85 (244)	3.52 (223)	-19%	2.13	1.92	2.03	10%
		194,500 (P_{00a})	7.61 (482)	7.67 (486)	7.64 (484)	-1%	1.43	1.20	1.32	18%
6	No	0 (P_{98})	4.52 (286)	4.88 (309)	4.70 (298)	-8%	2.13	2.08	2.10	2%
		359,000 (P_{00a})	3.07 (194)	3.30 (209)	3.18 (202)	-7%	2.79	2.65	2.72	5%
	Yes	0 (P_{98})	3.28 (208)	3.50 (222)	3.39 (215)	-7%	2.79	2.73	2.76	2%
		359,000 (P_{00a})	3.81 (241)	4.10 (260)	3.96 (251)	-7%	2.60	2.55	2.58	2%
7	No	0 (P_{98})	3.71 (235)	3.82 (242)	3.76 (238)	-3%	2.68	2.67	2.67	0%
		283,942 (P_{00a})	3.71 (235)	3.76 (238)	3.73 (237)	-1%	2.69	2.67	2.68	1%
	Yes	0 (P_{98})	2.36 (150)	2.53 (160)	2.44 (155)	-7%	3.01	3.03	3.02	-1%
		283,942 (P_{00a})	2.25 (142)	2.38 (151)	2.31 (147)	-6%	3.10	3.11	3.10	0%
8	No	0 (P_{98})	2.71 (172)	2.71 (172)	2.71 (172)	0%	2.94	2.85	2.89	3%
		625,838 (P_{00a})	2.72 (173)	2.71 (172)	2.72 (172)	0%	2.95	2.88	2.92	2%
	Yes	0 (P_{98})	3.05 (193)	3.16 (200)	3.10 (197)	-3%	3.00	2.94	2.97	2%
		625,838 (P_{00a})	3.10 (196)	3.13 (198)	3.11 (197)	-1%	2.90	2.88	2.89	1%
9	No	0 (P_{98})	4.59 (291)	4.72 (299)	4.65 (295)	-3%	2.13	2.13	2.13	0%
		265,913 (P_{00a})	4.67 (296)	4.80 (304)	4.73 (300)	-3%	2.23	2.23	2.23	0%
	Yes	0 (P_{98})	5.16 (327)	5.33 (338)	5.25 (332)	-3%	1.73	1.68	1.70	3%
		265,913 (P_{00a})	6.20 (393)	6.49 (411)	6.35 (402)	-4%	1.46	1.42	1.44	3%
10	No	0 (P_{98})	3.47 (220)	3.63 (230)	3.55 (225)	-4%	2.55	2.54	2.54	0%
		441,000 (P_{00a})	3.77 (239)	4.04 (256)	3.91 (248)	-7%	2.51	2.50	2.51	0%
	Yes	0 (P_{98})	2.33 (148)	2.35 (149)	2.34 (148)	-1%	2.99	2.97	2.98	1%
		441,000 (P_{00a})	2.78 (176)	2.94 (186)	2.86 (181)	-5%	2.82	2.81	2.82	1%
11	No	0 (P_{98})	2.97 (188)	2.90 (184)	2.94 (186)	2%	2.74	2.76	2.75	-1%
		1,071,302 (P_{00a})	3.31 (210)	3.31 (210)	3.31 (210)	0%	2.65	2.67	2.66	-1%
	Yes	0 (P_{98})	5.31 (337)	5.35 (339)	5.33 (338)	-1%	1.88	1.90	1.89	-1%
		1,071,302 (P_{00a})	5.29 (335)	5.38 (341)	5.34 (338)	-2%	1.83	1.86	1.85	-2%
12	No	0 (P_{98})	2.28 (145)	2.45 (155)	2.36 (150)	-7%	2.98	2.98	2.98	0%
		1,071,302 (P_{00a})	2.49 (157)	2.65 (168)	2.57 (163)	-6%	3.00	3.01	3.01	0%
	Yes	0 (P_{98})	1.31 (83)	1.33 (84)	1.32 (83)	-1%	3.50	3.50	3.50	0%
		1,071,302 (P_{00a})	1.70 (108)	1.80 (114)	1.75 (111)	-6%	3.45	3.46	3.46	0%

*** Note: In Lane 5, a second analysis was performed for the Zero Load Apps case with a reduced profile length*

Table 3. IRI and RN Values for P_{00b} Profile Data.

			IRI - m/km (in/mile)				RN			
Lane	Traffic	Time	Method 1	Method 2	Average	Difference	Method 1	Method 2	Average	Difference
5	No	Night	1.58 (100)	1.48 (94)	1.53 (97)	7%	2.71	2.72	2.72	-1%
	Yes	Night	6.65 (421)	6.89 (437)	6.77 (429)	-4%	1.29	1.20	1.25	7%
6	No	Day	4.28 (271)	4.57 (289)	4.43 (280)	-6%	2.18	2.09	2.14	4%
		Night	3.83 (243)	4.11 (260)	3.97 (252)	-7%	2.24	2.15	2.20	4%
	Yes	Day	3.60 (228)	3.79 (240)	3.69 (234)	-5%	2.51	2.43	2.47	3%
		Night	3.55 (225)	3.78 (240)	3.66 (232)	-6%	2.61	2.52	2.56	4%
7	Yes	Day	2.41 (152)	2.40 (152)	2.40 (152)	0%	3.06	3.04	3.05	1%
		Night	2.45 (155)	2.42 (153)	2.43 (154)	1%	3.11	3.08	3.10	1%
	No	Day	3.94 (250)	3.88 (246)	3.91 (248)	2%	2.50	2.50	2.50	0%
		Night	3.80 (240)	3.78 (239)	3.79 (240)	1%	2.48	2.47	2.47	0%
8	Yes	Day	2.88 (183)	2.80 (177)	2.84 (180)	3%	3.00	3.00	3.00	0%
		Night	2.84 (180)	2.85 (180)	2.84 (180)	0%	2.86	2.86	2.86	0%
	No	Day	3.16 (200)	3.65 (231)	3.41 (216)	-15%	2.64	2.46	2.55	7%
		Night	3.13 (198)	3.62 (230)	3.38 (214)	-15%	2.56	2.39	2.48	7%
9	Yes	Day	6.27 (397)	6.46 (410)	6.37 (404)	-3%	1.63	1.58	1.61	3%
		Night	6.15 (390)	6.33 (401)	6.24 (396)	-3%	1.65	1.59	1.62	3%
	No	Day	4.56 (289)	4.46 (283)	4.51 (286)	2%	2.25	2.26	2.26	-1%
		Night	4.64 (294)	4.46 (283)	4.55 (289)	4%	2.30	2.31	2.31	0%
10	Yes	Day	2.60 (164)	2.69 (170)	2.64 (167)	-3%	2.86	2.87	2.87	0%
		Night	2.47 (157)	2.51 (159)	2.49 (158)	-1%	2.79	2.80	2.80	0%
	No	Day	3.80 (241)	4.18 (265)	3.99 (253)	-10%	2.56	2.55	2.56	0%
		Night	3.73 (237)	4.07 (258)	3.90 (247)	-9%	2.62	2.61	2.62	1%
11	No	Day	5.81 (368)	5.97 (378)	5.89 (373)	-3%	1.81	1.73	1.77	5%
		Night	5.91 (375)	6.10 (387)	6.01 (381)	-3%	1.81	1.72	1.76	5%
	Yes	Day	5.29 (335)	5.48 (347)	5.38 (341)	-4%	1.84	1.84	1.84	0%
		Night	5.21 (330)	5.36 (340)	5.29 (335)	-3%	1.82	1.82	1.82	0%
12	No	Day	1.38 (88)	1.42 (90)	1.40 (89)	-3%	3.62	3.61	3.62	0%
		Night	1.20 (76)	1.25 (79)	1.23 (78)	-4%	3.51	3.51	3.51	0%
	Yes	Day	1.90 (120)	2.10 (133)	2.00 (127)	-10%	3.46	3.43	3.44	1%
		Night	1.77 (112)	1.88 (119)	1.82 (115)	-6%	3.48	3.47	3.47	0%

Table 4. Comparison of Daytime and Nighttime Statistics using P_{00b} Data.

			IRI - m/km (in/mile)		RN	
Lane	Traffic	Time	Average	Difference	Average	Difference
6	No	Day	4.43 (280)	11%	2.14	-3%
		Night	3.97 (252)		2.20	
	Yes	Day	3.69 (234)	1%	2.47	-4%
		Night	3.66 (232)		2.56	
7	Yes	Day	2.40 (152)	-1%	3.05	-1%
		Night	2.43 (154)		3.10	
	No	Day	3.91 (248)	3%	2.50	1%
		Night	3.79 (240)		2.47	
8	Yes	Day	2.84 (180)	0%	3.00	5%
		Night	2.84 (180)		2.86	
	No	Day	3.41 (216)	1%	2.55	3%
		Night	3.38 (214)		2.48	
9	Yes	Day	6.37 (404)	2%	1.61	-1%
		Night	6.24 (396)		1.62	
	No	Day	4.51 (286)	-1%	2.26	-2%
		Night	4.55 (289)		2.31	
10	Yes	Day	2.64 (167)	6%	2.87	2%
		Night	2.49 (158)		2.80	
	No	Day	3.99 (253)	2%	2.56	-2%
		Night	3.90 (247)		2.62	
11	No	Day	5.89 (373)	-2%	1.77	0%
		Night	6.01 (381)		1.76	
	Yes	Day	5.38 (341)	2%	1.84	1%
		Night	5.29 (335)		1.82	
12	No	Day	1.40 (89)	14%	3.62	3%
		Night	1.23 (78)		3.51	
	Yes	Day	2.00 (127)	9%	3.44	-1%
		Night	1.82 (115)		3.47	
			Average	*3%*		*0%*

Table 5. P_{00a} and P_{00b} Combined IRI and RN Values.

			IRI - m/km (in/mile)				RN			
Lane	Traffic	Source	Method 1	Method 2	Average	Difference	Method 1	Method 2	Average	Difference
5	No	P_{00b}	1.58 (100)	1.48 (94)	1.53 (97)	-49%	2.71	2.72	2.72	12%
		P_{00a}	0.99 (63)	0.87 (55)	0.93 (59)		3.05	3.08	3.07	
	Yes	P_{00b}	6.65 (421)	6.89 (437)	6.77 (429)	12%	1.29	1.20	1.25	5%
		P_{00a}	7.61 (482)	7.67 (486)	7.64 (484)		1.43	1.20	1.32	
6	No	P_{00b}	4.06 (257)	4.34 (275)	4.20 (266)	-27%	2.21	2.12	2.17	23%
		P_{00a}	3.07 (194)	3.30 (209)	3.18 (202)		2.79	2.65	2.72	
	Yes	P_{00b}	3.57 (226)	3.79 (240)	3.68 (233)	7%	2.56	2.47	2.52	2%
		P_{00a}	3.81 (241)	4.10 (260)	3.96 (251)		2.60	2.55	2.58	
7**	Yes	P_{00b}	2.43 (154)	2.41 (152)	2.42 (153)	-4%	3.09	3.06	3.07	1%
		P_{00a}	2.25 (142)	2.38 (151)	2.31 (147)		3.10	3.11	3.10	
8**	Yes	P_{00b}	2.86 (181)	2.82 (179)	2.84 (180)	9%	2.93	2.93	2.93	-1%
		P_{00a}	3.10 (196)	3.13 (198)	3.11 (197)		2.90	2.88	2.89	
9	No	P_{00b}	4.60 (291)	4.46 (283)	4.53 (287)	4%	2.27	2.29	2.28	-2%
		P_{00a}	4.67 (296)	4.80 (304)	4.73 (300)		2.23	2.23	2.23	
	Yes	P_{00b}	6.21 (394)	6.40 (405)	6.31 (400)	1%	1.64	1.59	1.61	-11%
		P_{00a}	6.20 (393)	6.49 (411)	6.35 (402)		1.46	1.42	1.44	
10	No	P_{00b}	3.77 (239)	4.13 (262)	3.95 (250)	-1%	2.59	2.58	2.59	-3%
		P_{00a}	3.77 (239)	4.04 (256)	3.91 (248)		2.51	2.50	2.51	
	Yes	P_{00b}	2.54 (161)	2.60 (165)	2.57 (163)	11%	2.83	2.84	2.83	-1%
		P_{00a}	2.78 (176)	2.94 (186)	2.86 (181)		2.82	2.81	2.82	
11**	Yes	P_{00b}	5.25 (332)	5.42 (343)	5.33 (338)	0%	1.83	1.83	1.83	1%
		P_{00a}	5.29 (335)	5.38 (341)	5.34 (338)		1.83	1.86	1.85	
12**	Yes	P_{00b}	1.83 (116)	1.99 (126)	1.91 (121)	-9%	3.47	3.45	3.46	0%
		P_{00a}	1.70 (108)	1.80 (114)	1.75 (111)		3.45	3.46	3.46	

*** Note: In Lanes 7-8 and 11-12, the P_{00b} and P_{00a} profiles were performed on different panel columns for the "No" Loaded case*

Table 6. Impact of Traffic Loading on IRI and RN.

			IRI - m/km (in/mile)					RN				
Lane	Traffic	Number of Load Apps	Average Value	Difference	Difference per 10^6 Apps	% Change	% Change per 10^6 Apps	Average Value	Difference	Difference per 10^6 Apps	% Change	% Change per 10^6 Apps
5	No	0 (Adj)	1.39 (88)	-0.46 (-29)	-2.37 (-150)	-33%	-171%	3.28	-0.21	-1.08	-6%	-33%
		194,500	0.93 (59)					3.07				
	Yes	0 (Adj)	3.52 (223)	4.12 (261)	21.18 (1342)	117%	602%	2.03	-0.71	-3.65	-35%	-180%
		194,500	7.64 (484)					1.32				
6	No	0	4.70 (298)	-1.51 (-96)	-4.21 (-267)	-32%	-90%	2.10	0.61	1.71	29%	81%
		359,000	3.18 (202)					2.72				
	Yes	0	3.39 (215)	0.56 (36)	1.57 (99)	17%	46%	2.76	-0.19	-0.52	-7%	-19%
		359,000	3.96 (251)					2.58				
7	No	0	3.76 (238)	-0.03 (-2)	-0.10 (-7)	-1%	-3%	2.67	0.01	0.02	0%	1%
		283,492	3.73 (237)					2.68				
	Yes	0	2.44 (155)	-0.13 (-8)	-0.45 (-29)	-5%	-19%	3.02	0.08	0.29	3%	10%
		283,492	2.31 (147)					3.10				
8	No	0	2.71 (172)	0.01 (0)	0.01 (1)	0%	0%	2.89	0.02	0.04	1%	1%
		625,838	2.72 (172)					2.92				
	Yes	0	3.10 (197)	0.01 (1)	0.02 (1)	0%	1%	2.97	-0.08	-0.13	-3%	-4%
		625,838	3.11 (197)					2.89				
9	No	0	4.65 (295)	0.08 (5)	0.31 (19)	2%	7%	2.13	0.10	0.38	5%	18%
		265,913	4.73 (300)					2.23				
	Yes	0	5.25 (332)	1.10 (70)	4.13 (262)	21%	79%	1.70	-0.26	-0.98	-15%	-58%
		265,913	6.35 (402)					1.44				
10	No	0	3.55 (225)	0.36 (23)	0.81 (51)	10%	23%	2.54	-0.04	-0.09	-2%	-3%
		441,000	3.91 (248)					2.51				
	Yes	0	2.34 (148)	0.52 (33)	1.18 (75)	22%	50%	2.98	-0.16	-0.37	-5%	-12%
		441,000	2.86 (181)					2.82				
11	No	0	2.94 (186)	0.37 (24)	0.35 (22)	13%	12%	2.75	-0.09	-0.09	-3%	-3%
		1,071,302	3.31 (210)					2.66				
	Yes	0	5.33 (338)	0.01 (0)	0.00 (0)	0%	0%	1.89	-0.05	-0.04	-2%	-2%
		1,071,302	5.34 (338)					1.85				
12	No	0	2.36 (150)	0.20 (13)	0.19 (12)	9%	8%	2.98	0.03	0.02	1%	1%
		1,071,302	2.57 (163)					3.01				
	Yes	0	1.32 (83)	0.43 (27)	0.40 (26)	33%	31%	3.50	-0.04	-0.04	-1%	-1%
		1,071,302	1.75 (111)					3.46				
Average "Trafficked Slabs Before Loading"			3.34 (211)	0.83 (52)		25%		*2.61*	-0.18		-7%	
Average "Trafficked Slabs After Loading"			4.16 (264)					*2.43*				

FIGURES

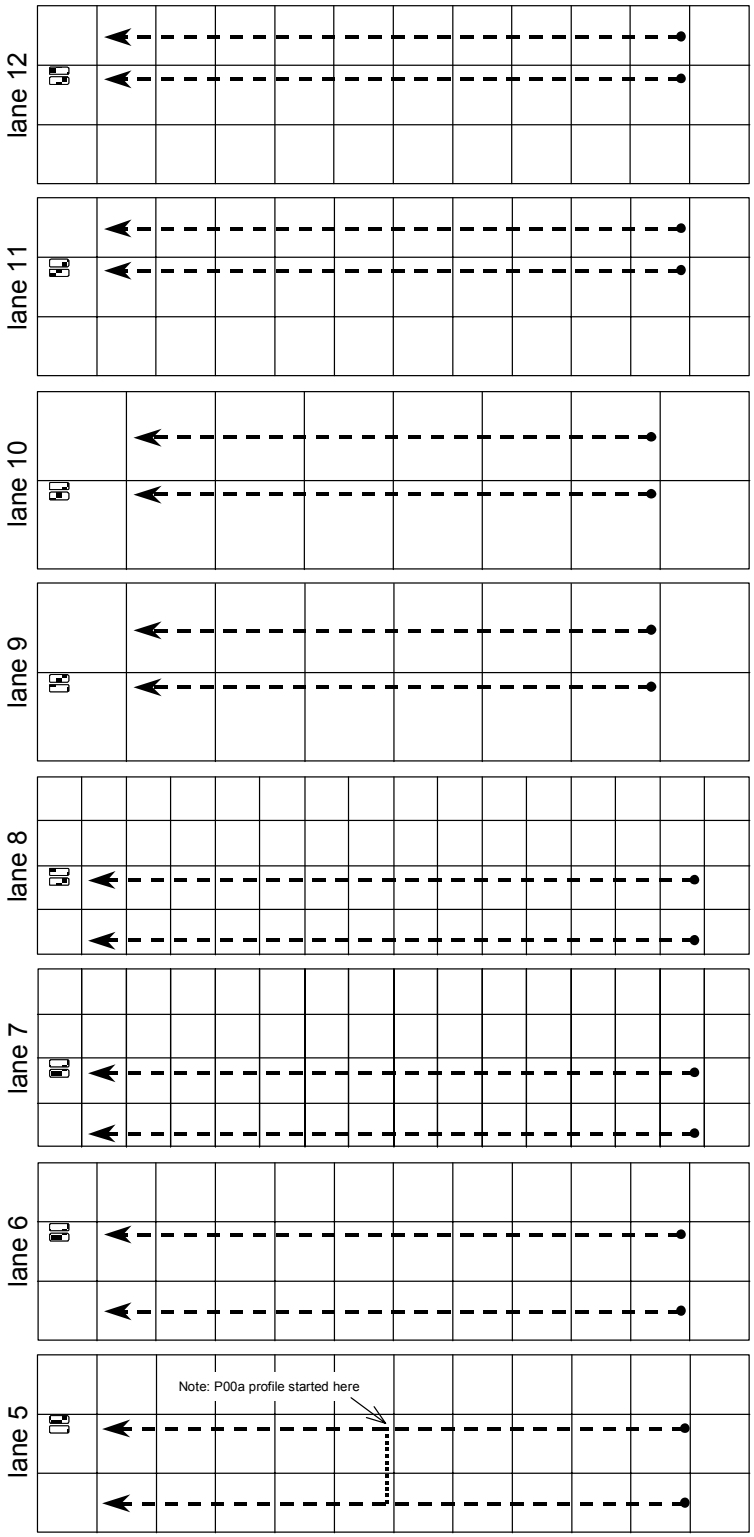


Figure 1. P_{98} and P_{00a} Pavement Profile Locations.

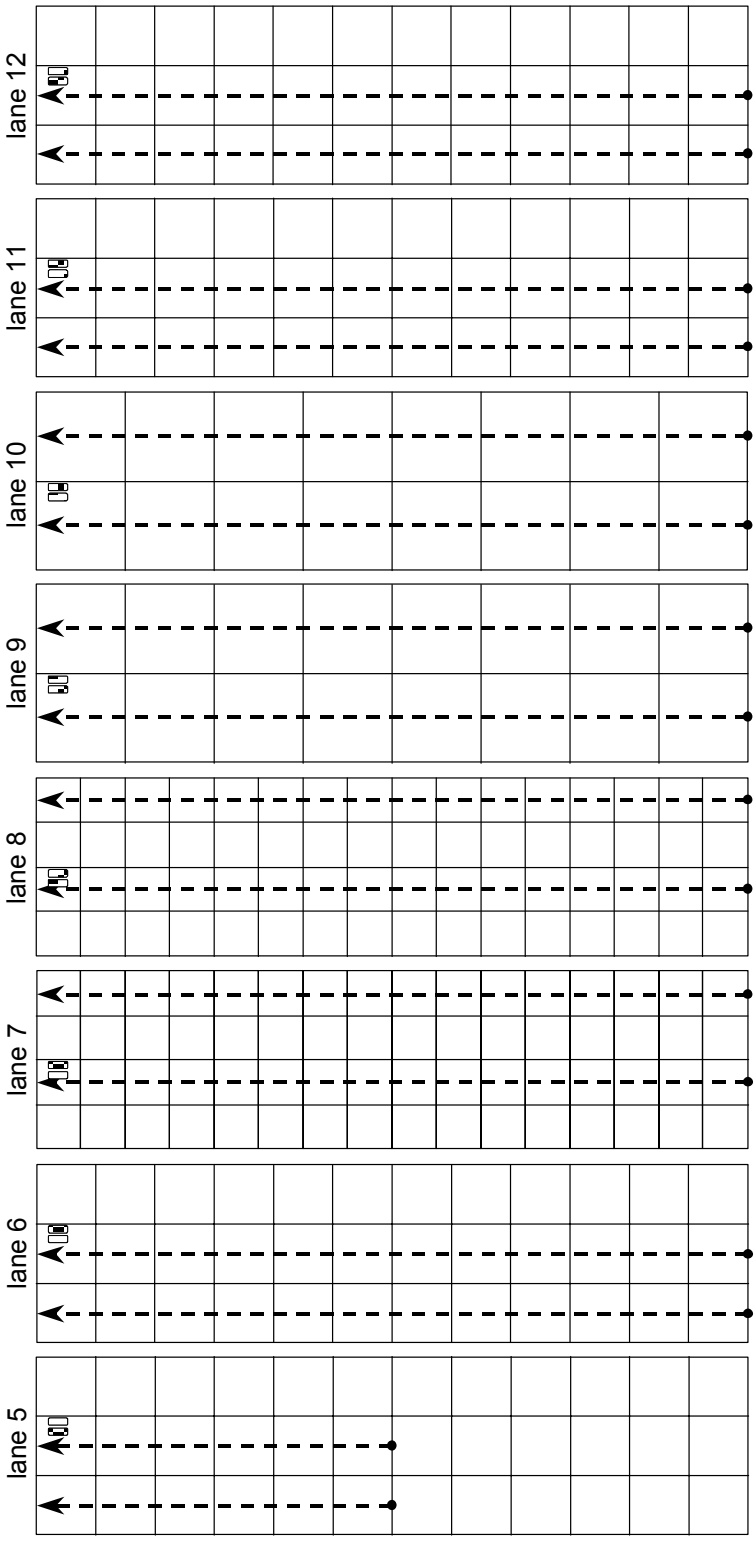


Figure 2. P_{00b} Pavement Profile Locations.

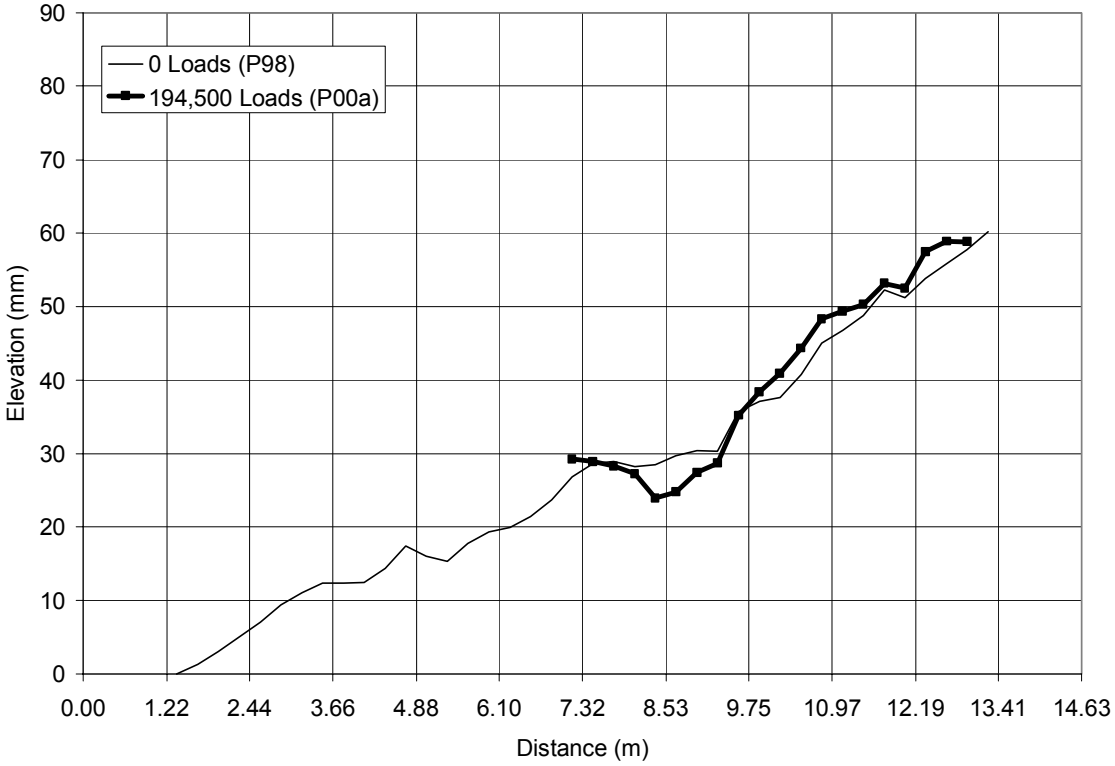


Figure 3. Lane 5 Profile Comparison – P_{98} versus P_{00a}.

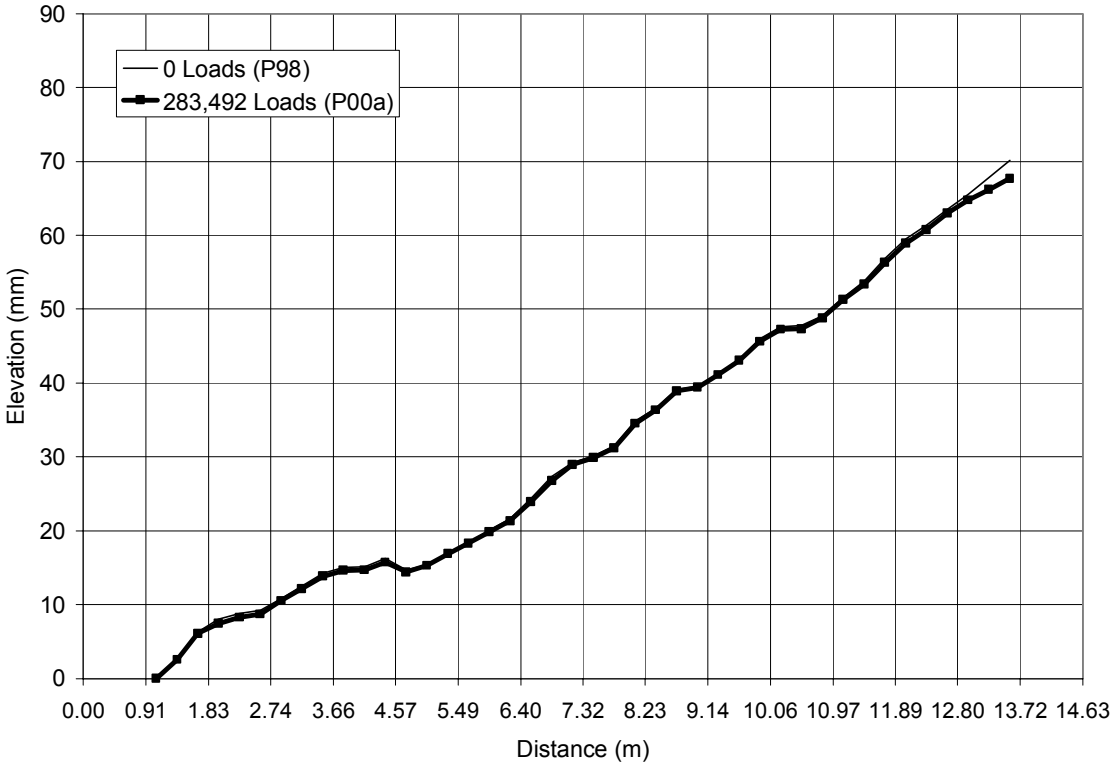


Figure 4. Lane 7 Profile Comparison – P_{98} versus P_{00a}.

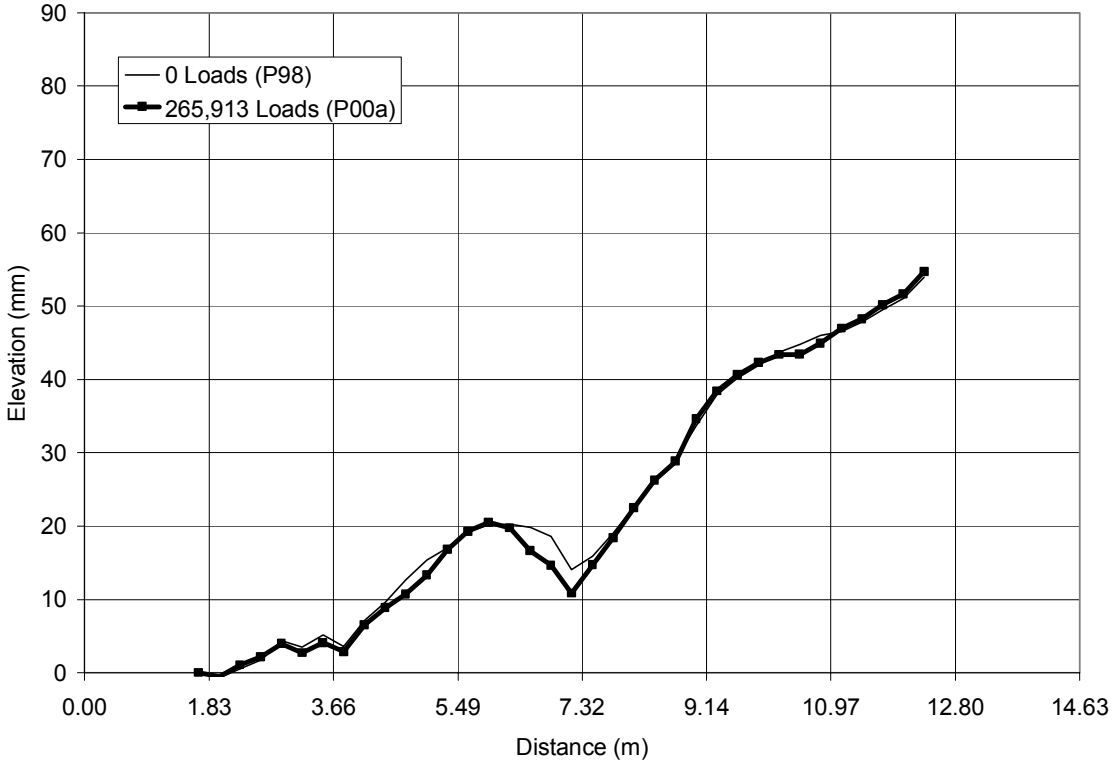


Figure 5. Lane 9 Profile Comparison – P_{98} versus P_{00a}.

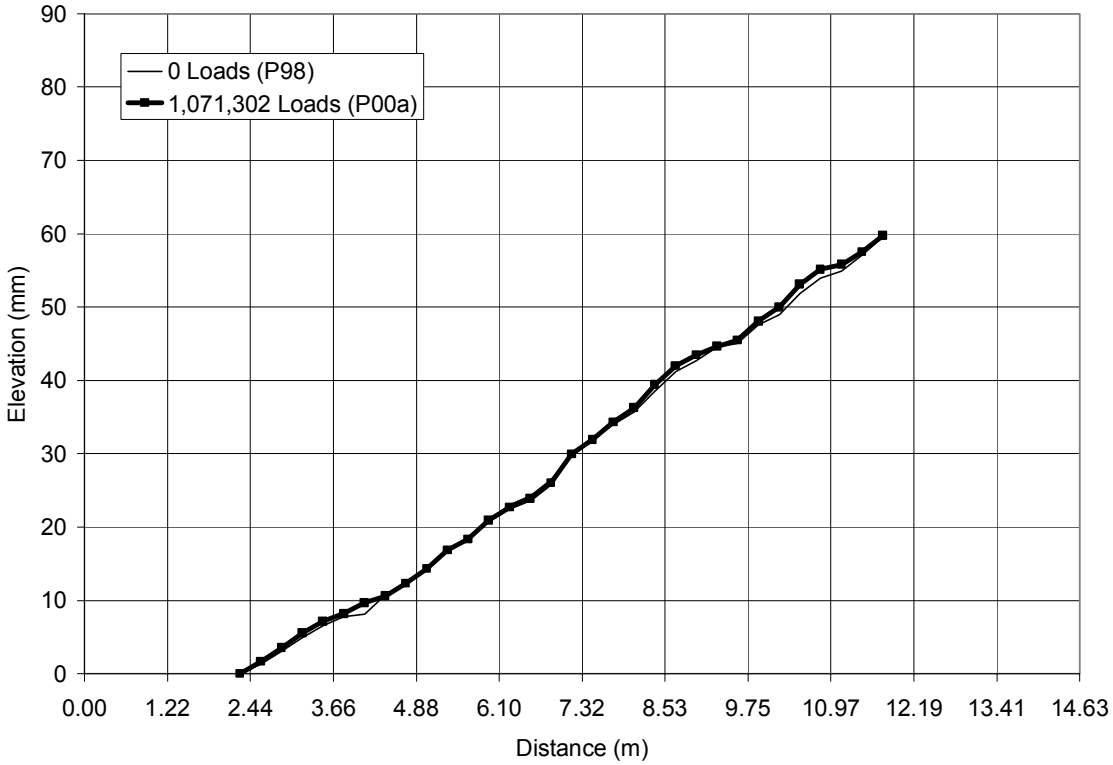


Figure 6. Lane 12 Profile Comparison – P_{98} versus P_{00a}.

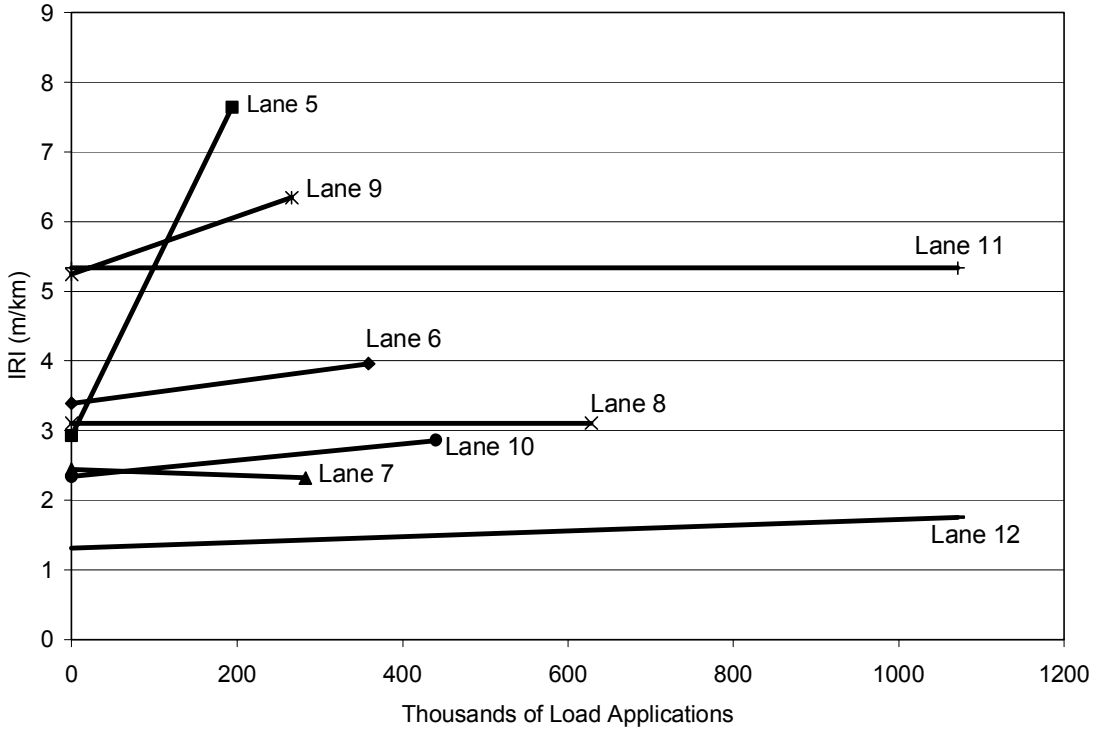


Figure 7. IRI Values for Before and After ALF Loading.

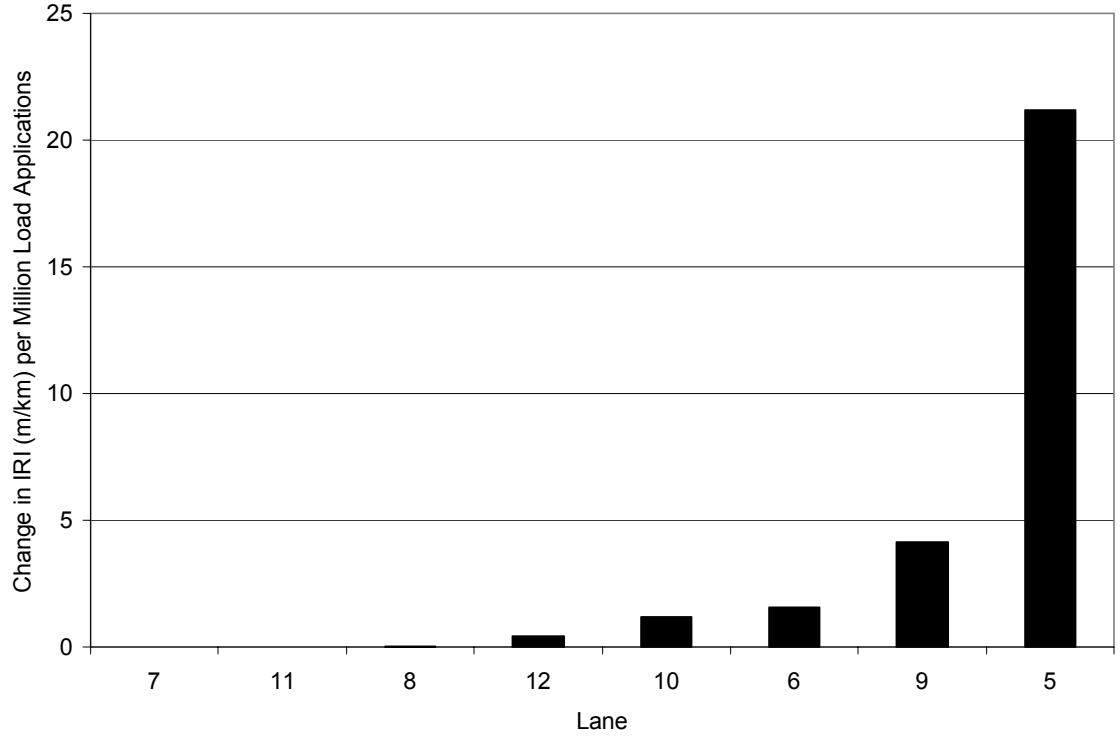


Figure 8. Change in IRI with Respect to ALF Load Applications.

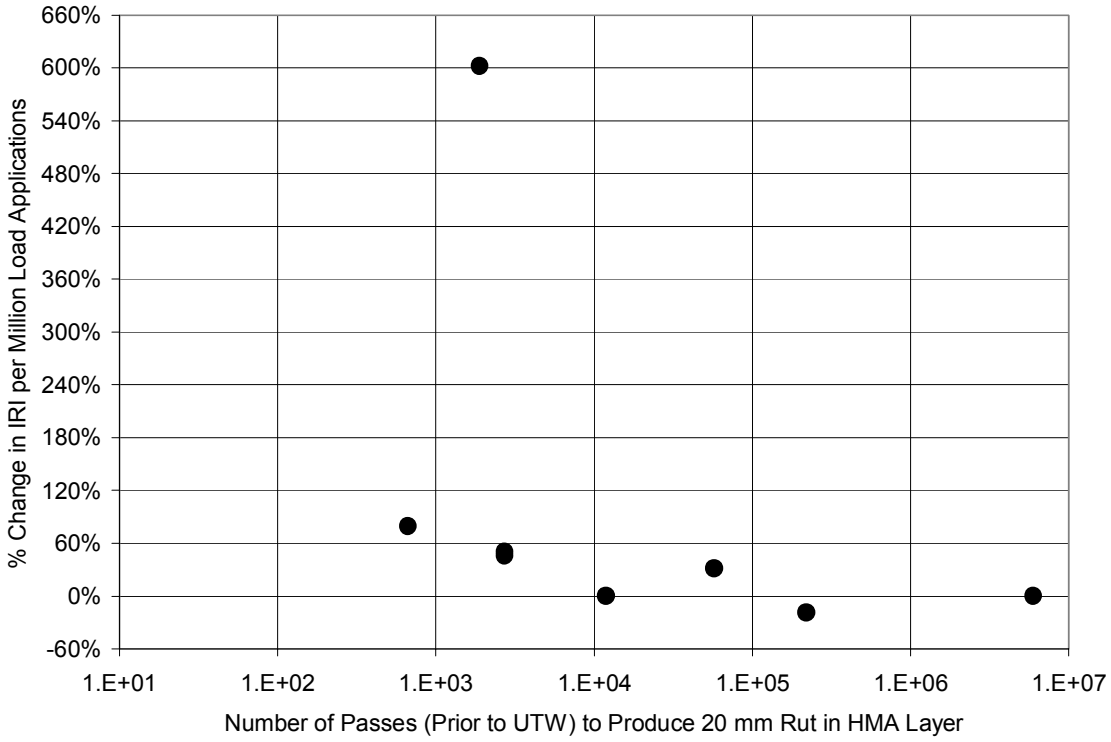


Figure 9. Change in IRI with Respect to the Rutting in the HMA Layer.

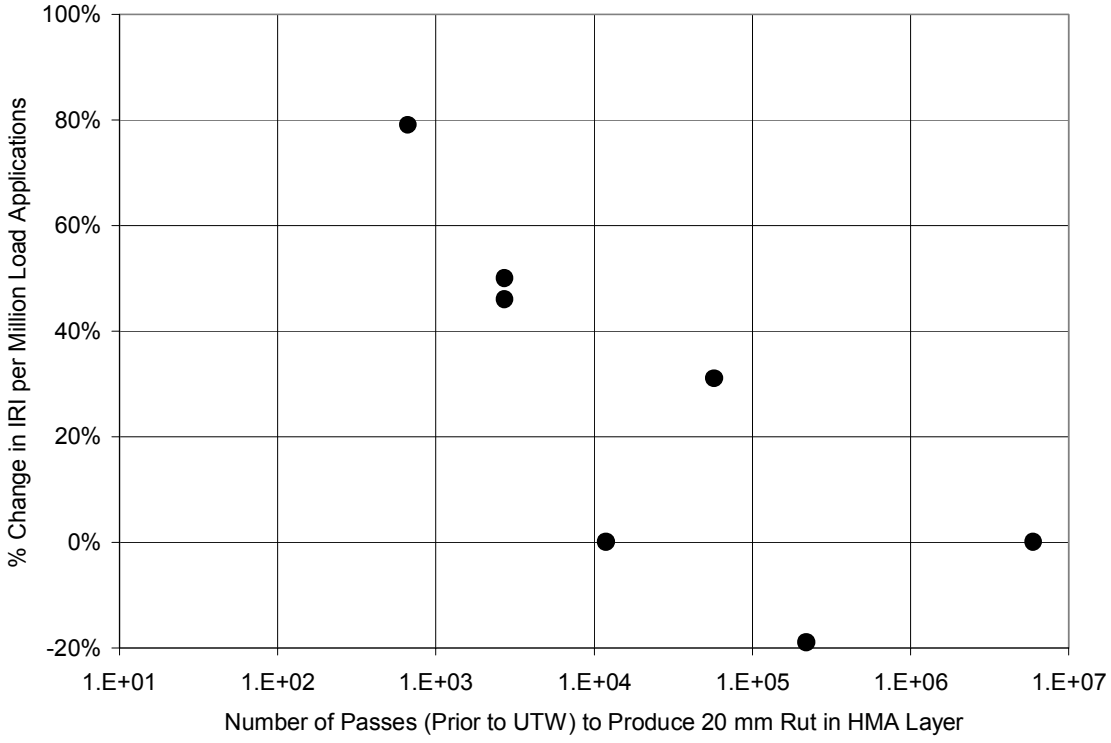


Figure 10. Change in IRI with Respect to the Rutting in the HMA Layer (omitting Lane 5).