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RED HILL VALLEY PARKWAY

Performance Review after Six Years in Service

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Golder Associates

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by the City of Hamilton (City) to evaluate the performance of the Red Hill Valley Parkway (RHVP) five years after construction. The RHVP is a divided highway, approximately 7.5 kilometer long, connecting the Lincoln M. Alexander Parkway and Queen Elizabeth Way in Hamilton, Ontario. The RHVP was constructed in 2007.

2.0 FIELD INVESTIGATION

Golder completed a field investigation to assess the current condition of the RHVP in the Spring and Summer of 2013. The field investigation involved the following:

- Visual condition inspection;
- Limited coring of the asphalt;
- Surface longitudinal profile; and
- Falling Weight Deflectometer (FWD) testing.

3.0 RESULTS

3.1 Visual Condition Inspection

The visual condition inspection was completed by members of Golder's Pavement and Materials Engineering Group in the spring of 2013. The pavement was generally in good condition with limited surface distresses being observed. Pavement edge cracking was present in the shoulder in numerous locations and was slight to moderate in severity. Figure 1 shows an example of the pavement edge cracking. There was also frequent cracking observed in the paved shoulder along the edge of the driving lanes.

Slight to moderate distortions were observed in a few locations. It is anticipated that the distortions are a result of the significant flooding that occurred in the past on the highway. No cracking was present in the distorted areas.

Slight to moderate generally longitudinal cracking was observed in portions of the north and south bound lanes of the pavement. The cracking was primarily in the outside lane (Lane 2). An example of moderate cracking location is shown in Figure 2. The cracking is anticipated to be of top down nature.

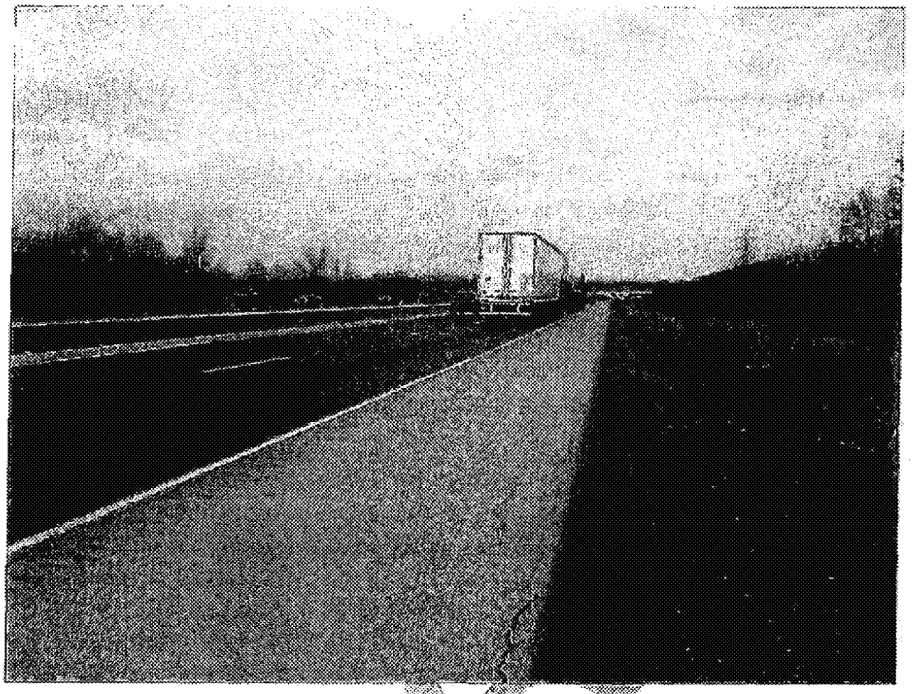


Figure 1: Pavement edge cracking in shoulder

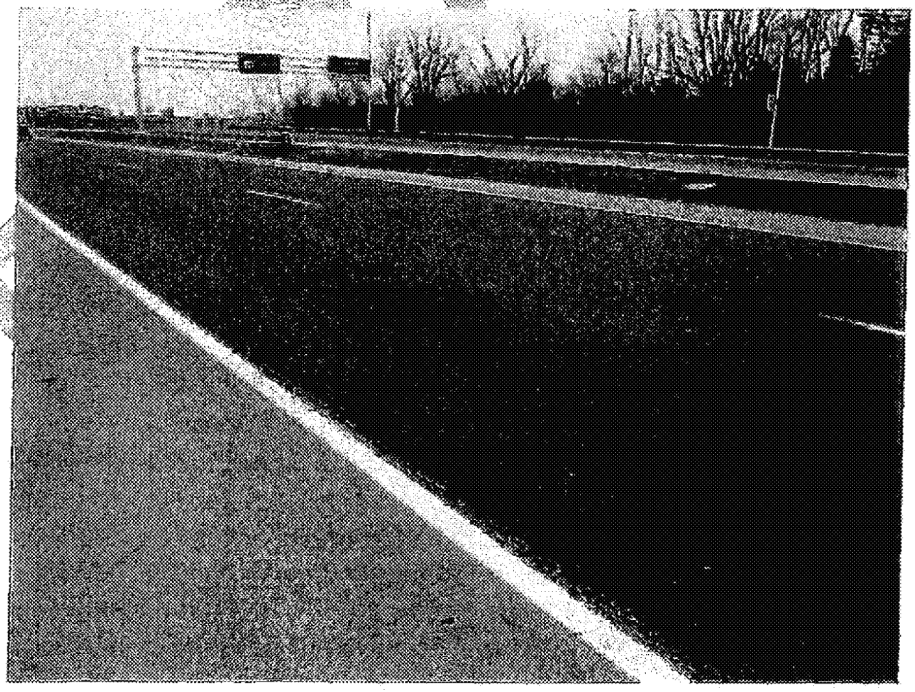


Figure 2: Longitudinal top down cracking on RHVP

The longitudinal construction joints were opening in a few locations. These locations were particularly where the highway widened to three lanes in one direction. Additional photos from the visual pavement condition inspection are provided in Appendix A. No other cracking was observed in the pavement.

3.2 Asphalt Coring

Four asphalt cores were drilled by representatives of Golder on August 6, 2013. Asphalt cores were taken to further investigate the longitudinal cracking that was observed on the pavement surface during the visual condition inspection. Fours cores were taken from the left wheel path of the southbound outside lane (Lane 2) between Barton Street and Queenston Road. The cores were taken at locations where longitudinal cracks were visible on the surface. A description of each of the four cores is provided in Table 1. Photos of the cores are provided in Appendix B.

Table 1: Asphalt Core Descriptions

Core	Core Thickness (mm)	Crack Depth from Surface (mm)	Comments
1	39 mm	39 mm	Top lift of asphalt (SMA) debonded from second lift. Only top lift was extracted. The crack was throughout the thickness of the top lift and was not observed to be in the second lift.
2	248 mm	92 mm	The core was the entire thickness of asphalt in the pavement structure. The top two lifts of asphalt had debonded from the remainder of the core. The cracking was throughout the thickness of the top two lifts of asphalt.
3	250 mm	46 mm	The core was the entire thickness of asphalt in the pavement structure. The top two lifts of asphalt had debonded from the remainder of the core. The cracking was throughout the thickness of the top lift of asphalt and partially through the second lift of asphalt.
4	40 mm	40 mm	Top lift of asphalt (SMA) debonded from second lift. Only top lift was extracted. The crack was throughout the thickness of the top lift and was not observed to be in the second lift. While the core was being drilled, water was coming out of voids in the surrounding pavement surface.

As shown in Table 1, the cracks were found to be within the top of maximum top two layers of asphalt. The top asphalt layer and second layer were often debonded from the deeper layers of asphalt. While Core 4 was being drilled, water from the drilling activity was coming out of the pavement surface through surrounding voids.

3.3 Surface Profile

The longitudinal profile of the RHVP was measured in Lanes 1 and 2 in both the northbound and southbound directions. The profile was measured at highway speed. Stationing started at 0+000 at approximately the south limit of the RHVP and increased until the north limit of the testing (7+600). The International Roughness Index (IRI) was calculated every 100 m in each lane. Complete results of the profile testing are presented in Appendix C. Table 2 shows a summary of the profile testing.

Table 2: RHVP IRI

Lane	Average IRI (m/km)	Maximum IRI (m/km)	Minimum IRI (m/km)
Lane 1 Southbound	0.92	2.25	0.52
Lane 2 Southbound	1.05	2.18	0.62
Lane 1 Northbound	0.99	2.29	0.48
Lane 2 Northbound	1.14	2.22	0.73

4.0 FALLING WEIGHT DEFLECTOMETER DATA ANALYSIS

The Falling Weight Deflectometer (FWD) load/deflection testing was carried out in both directions of the RHVP in Hamilton, Ontario. Testing was completed throughout the entire length of Lane 1 (inside lane) in both the northbound and southbound directions from the Queen Elizabeth Way to the Lincoln M. Alexander Parkway. FWD testing in Lane 2 (outside lane) in both directions was limited because of the presence of numerous ramps and the traffic pattern on the RHVP. Limited testing was carried out in Lane 2 (outside lane) in the southbound direction from Barton Street to Queenston Road and from King Street to Greenhill Avenue, where longitudinal top down cracking was the most frequent. In both directions the testing in the inside lane was carried out at 100 m intervals with the test points in the adjacent lanes being staggered by 50 m. The testing in the southbound Lane 2 was carried out at a 50 m spacing

The FWD load/deflection testing was carried out on the above mentioned pavement section on May 9, 2013. Testing was performed by an FWD unit owned by Golder. During the FWD testing an impulse load similar in magnitude and duration to a moving truck wheel load was applied to a loading plate sitting on the pavement surface. The response of the pavement (resulting pavement deflection) to the applied load was measured using eight (8) seismic transducers (geophones) spaced at predetermined intervals from the centre of the loading plate (0, 200, 300, 500, 600, 900, 1200 and 1500 mm). From these deflection readings the deflection basin at a particular location was determined. At each test location three selected load impulses of about 30, 40 and 50 kN were applied to the pavement and deflections were measured for each load pulse.

4.1 Analysis and Results

4.1.1 Normalized Deflection and Pavement Surface Modulus

The measured deflections were normalized to represent a standard wheel load of 40 kN and a standard temperature of 21°C. In addition to normalizing the measured deflections, the analysis of the FWD data also involved determination of the pavement surface modulus. Pavement surface modulus is determined using the normalized deflection measured by the geophone located at the centre of the loading plate. Pavement surface modulus is an indication of the overall load bearing/support characteristics of the entire pavement structure.

Table 3 shows a summary of the normalized deflections and pavement surface modulus for the tested section. Typically the pavement surface modulus for a conventional asphalt pavement ranges between 300 to 500 MPa and for a deep strength asphalt pavement between 500 and 800 MPa. From the table shown below it can be seen that all the tested lanes are somewhat above the anticipated range for a deep strength asphalt pavement indicating that even after being in place for 6 years, the pavement has adequate structural bearing capacity to support the anticipated future traffic loading. However, it should be noted that the perpetual pavement on the

RHVP was designed for a 50 year life while conventional deep strength asphalt pavements are design for a 20 year life.

Table 3: Summary of Normalized Deflection and Pavement Surface Modulus

Section Name	Direction	Lane	Normalized Deflection (mm)		Pavement Surface Modulus (MPa)	
			Mean	Standard Deviation	Mean	Standard Deviation
QEW to Linc	Northbound	1	0.16	0.03	981	206
QEW to Linc	Southbound	1	0.17	0.03	917	187
Barton Street to Queenston Road	Southbound	2	0.16	0.05	980	211
King Street to Greenhill Avenue	Southbound	2	0.16	0.03	938	131

The Asphalt Institute Manual Series No. 17 (AI MS-17) was used to determine the design rebound deflection required to accommodate approximately 80,000,000 ESALs, which was estimated to be the remaining ESALs that the pavement on RHVP would be required to accommodate over its design life. The design rebound deflection to accommodate this traffic was approximately 0.35 mm. The design rebound deflection determined form AI MS-17 refers to a static deflection as compared to the dynamic deflection measured by the FWD. The dynamic deflection reported in Table 3 was converted to an equivalent static deflection for each section as shown in Table 4. This spring correction factor is typically applied to the measured deflection in order to account for the fact that the pavement is considered to be structurally the weakest during the spring months. Since the testing was carried out in the spring (May 9, 2013), an additional spring correction factor was not applied to the static deflection shown in Table 4, since it can be considered that the pavement on the RHVP was at its weakest at the time of testing.

Table 4: Static Deflection

Section Name	Direction	Lane	Static Deflection (mm)
QEW to Linc	Northbound	1	0.34
QEW to Linc	Southbound	1	0.36
Barton Street to Queenston Road	Southbound	2	0.40
King Street to Greenhill Avenue	Southbound	2	0.34

Table 4 above shows that the measured deflection for each of the sections was either slightly below or only slightly above the design rebound deflection required for the remaining 80,000,000 ESAL required to be accommodated by the RHVP. The section in Southbound Lane 2 from Barton Street to Queenston Road likely has a higher calculated static deflection as compared to the other sections because it had the fewest test points with one test points having a higher deflection, as shown in the detailed analysis results in Appendix D, which in turn resulted in a higher standard deviation. The higher standard deviation for this section increased the calculated static deflection which is a function of both the mean and standard deviation of the measured dynamic deflection.

4.1.2 Layer Moduli

If the layer thicknesses are known, the deflection basins that are determined during the FWD testing, can be subsequently used to backcalculate the modulus of each of the pavement layers at each test point. For the purpose of the analysis, all the asphalt layers of the pavement structure were combined. Additionally, the base and subbase layers were also combined for the backcalculation and a combined modulus for the granular material was obtained.

For the backcalculation analysis the design pavement layer thicknesses were utilized; however, it should be noted that the as constructed pavement layer thickness may somewhat vary from the design thicknesses. Backcalculation of layer moduli is very sensitive to the input layer thickness and if the layer thickness at a particular test location are not representative of the actual thicknesses at that location the backcalculated moduli can be inaccurate. Very low modulus value for the asphalt concrete layers could indicate that the asphalt is either cracked and/or delaminated in that location, although this can be verified during visual condition inspection, and/or that the layer thickness is questionable. Similarly, very high modulus values could indicate that the asphalt thickness input for the backcalculation is questionable.

Table 5 shows a summary of the layer moduli for the for all the test sections on the RHVP. Typically the modulus of hot-mix asphalt (HMA) in good condition is between 3,000 and 6,000 MPa. The asphalt modulus values were within the specified range indicating that the asphalt is generally in good structural condition. Typical granular layer modulus values are between 300 and 700 MPa. The granular layer modulus values shown in the table below are within the specified range and therefore have good load bearing capacity. The table also shows that the subgrade modulus values are relatively high indicating that the soil has good support characteristics.

Table 5: Summary of Layer Moduli

Section Name	Direction	Lane	Asphalt Modulus (MPa)		Base/Subbase Modulus (MPa)		Subgrade Modulus (MPa)	
			Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
QEW to Linc	Northbound	1	4498	720	417	132	217	76
QEW to Linc	Southbound	1	3798	580	373	83	218	84
Barton Street to Queenston Road	Southbound	2	5457	1582	381	99	233	54
King Street to Greenhill Avenue	Southbound	2	5154	607	396	123	197	57

As noted previously, the backcalculation analysis was carried out using the design layer thicknesses; however, the results shown in Table 5 can be used as estimates of the pavement layer moduli on the RHVP. Therefore, the results indicate that there is no significant deterioration of the load bearing capacity of the pavement layers on the RHVP.

5.0 FRICTION TESTING

[redacted]

Table 6: Friction Testing Results

Section	Average Friction Number
Lane 1 Southbound	34
Lane 2 Southbound	35
Lane 1 Northbound	39
Lane 2 Northbound	36

Although the Friction Number (FN) values are higher than when measured in 2007 immediately after construction (between 30 and 34), they are considered to be relatively low. Typically the FN values should be at least equal to or higher than 40 to be considered adequate. In the United Kingdom, for example, the FN values should be at least 48 for a motorway pavement.

6.0 ANALYSIS AND RECOMMENDATIONS

The pavement on the RHVP was originally design to accommodate traffic volumes of 30,000 Average Annual Daily Traffic (AADT) in year one, growing to about 90,000 AADT in year 50. However, following construction of the RHVP, the traffic patterns in the City of Hamilton were significantly altered resulting in a dramatic increase in the amount of traffic on the RHVP as compared to the traffic volumes assumed during the design. Additionally, shortly after construction of the pavement, two separate flooding events occurred that inundated the roadway and likely worsened the subgrade conditions and resulted in a few areas of localized depressions.

In the perpetual pavement design for the RHVP and the life cycle cost analysis it was anticipated that some cracking, mainly longitudinal top-down, will occur and will have to be addressed. This top down cracking would typically be expected to start occurring between years 5 to 12 after the pavement is opened to traffic. In the life cycle costs analysis, carried out as part of the pavement design process, it was assumed that about 740 m2 of 40 mm milling and patching would be required per kilometre, 4 lane width, in Year 9 and then 3000 m2 in Year 15 and again in Year 19. It was assumed that the entire pavement would require resurfacing in Year 21.

It was also anticipated that the pavement would require routing and sealing over time: 240 m per kilometer in each lane in year 3; 640 m per kilometer in each lane in year 9; 1200 m per kilometer in each lane in year 15; and 1200 m kilometer in each lane in year 19. Table 7 shows the cumulative Equivalent Single Axle Loads (ESALs) that the pavement of the RHVP parkway was assumed, during the original pavement design, to have during various stages following its opening to traffic.

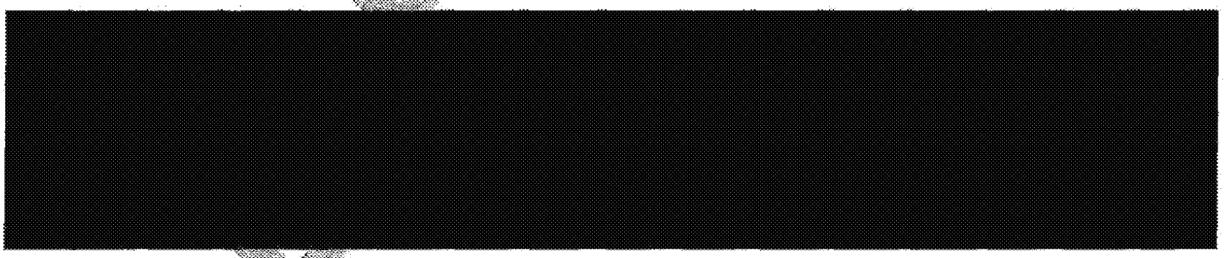
Table 7: Cumulative ESALs Assumed to have Been Accommodated, at Original Design Stage, Following Specified Years of Service

Years After Opening to Traffic	Cumulative ESALs Assumed to have been Accomodated
9	11,000,000
15	19,000,000
19	26,000,000
21	29,000,000

In reality, the traffic loading on the RHVP was much higher than the values assumed during the original design as shown in Table 7. Our initial analysis indicates that the pavement on the RHVP has taken approximately 16,000,000 ESALs following 6 years in service. Based on the table above it can be seen that during the original design and life cycle cost analysis it was anticipated that this traffic volume would be accumulated between 9 and 15 years after the pavement was opened to traffic.

The top down longitudinal cracking is most visible at the end of the RHVP that is closest to the QEW. The FWD testing clearly indicates that the subgrade is the softest along this section of the RHVP.

In order to remedy the longitudinal top down cracking, it is recommended that the surface course SMA be milled and a new surface course mix be placed at selected locations. At a minimum the milling and overlaying should be carried out on sections where the most frequent top down cracking is observed. Based on our pavement visual condition inspection, the minimum total length of the sections where mill and overlay is required would be about 2.5 km. The exact locations for the milling and overlaying should be determined on site. It is also recommended that if there is any debonding of the underlying SP 19.0 layer observed during the milling and overlaying operation, the debonded SP 19.0 layer should also be removed.



The cracks in the paved shoulder along the edge of the driving lanes should also be routed and sealed to stop the ingress of water.

Report Signature Page

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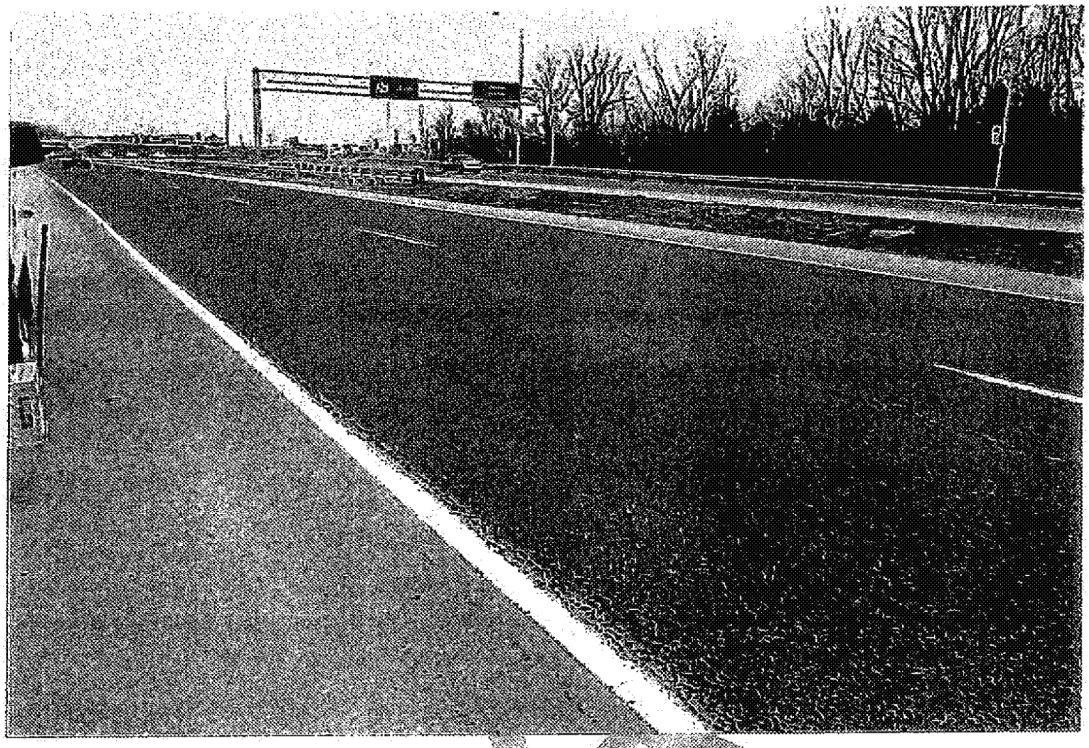
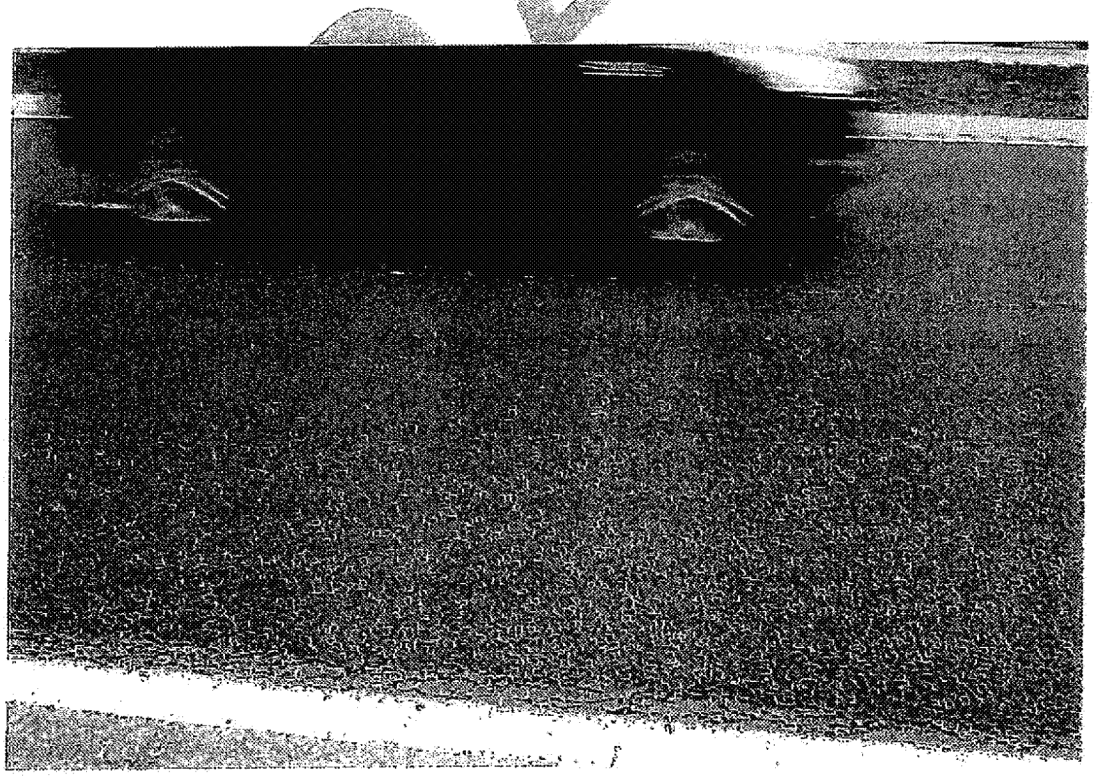
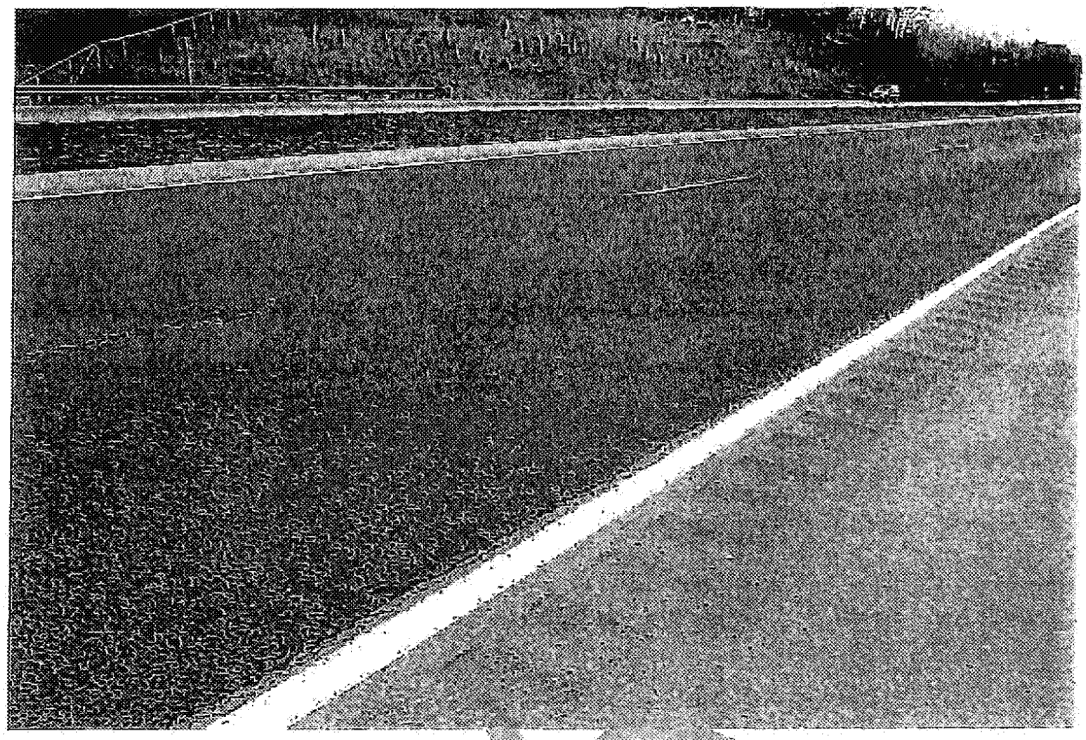
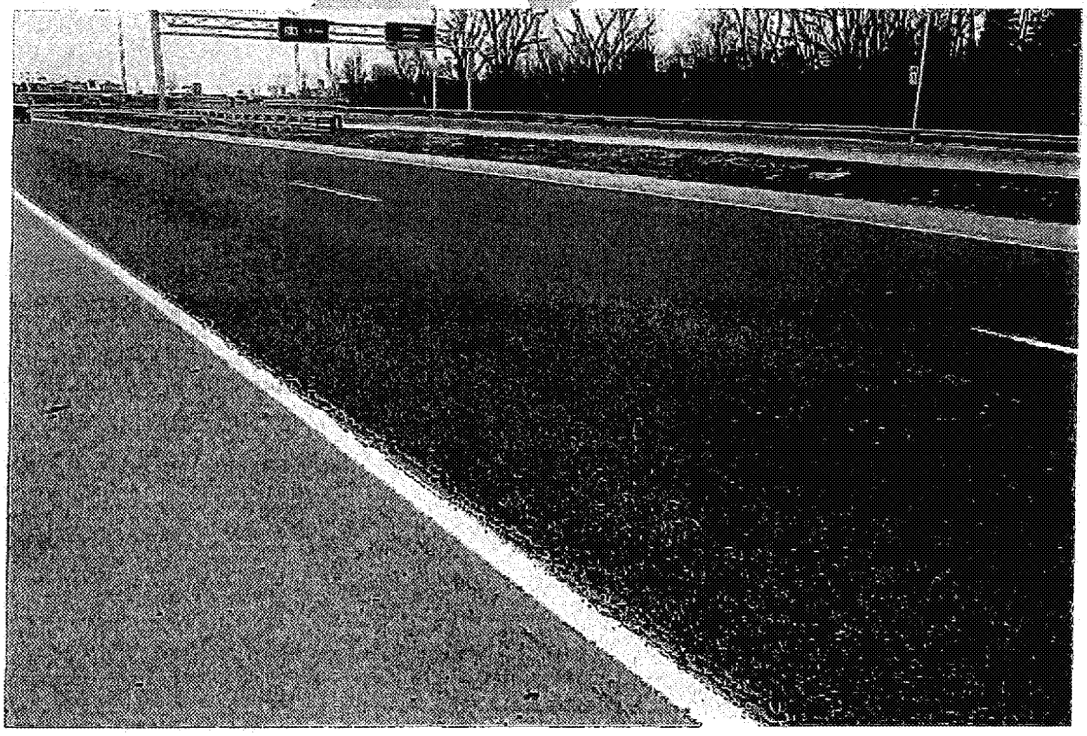
APPENDIX A

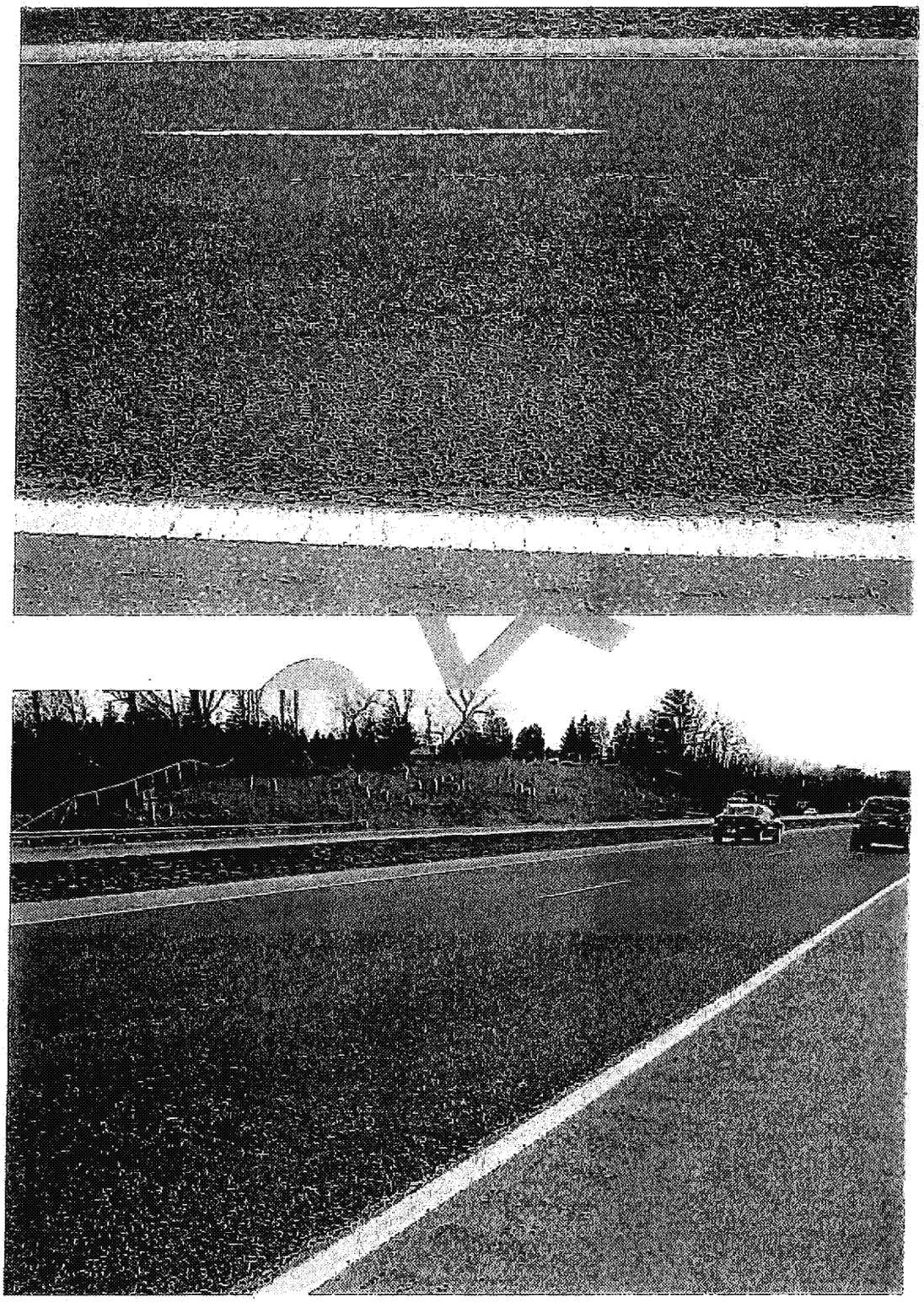
Pavement Condition Evaluation

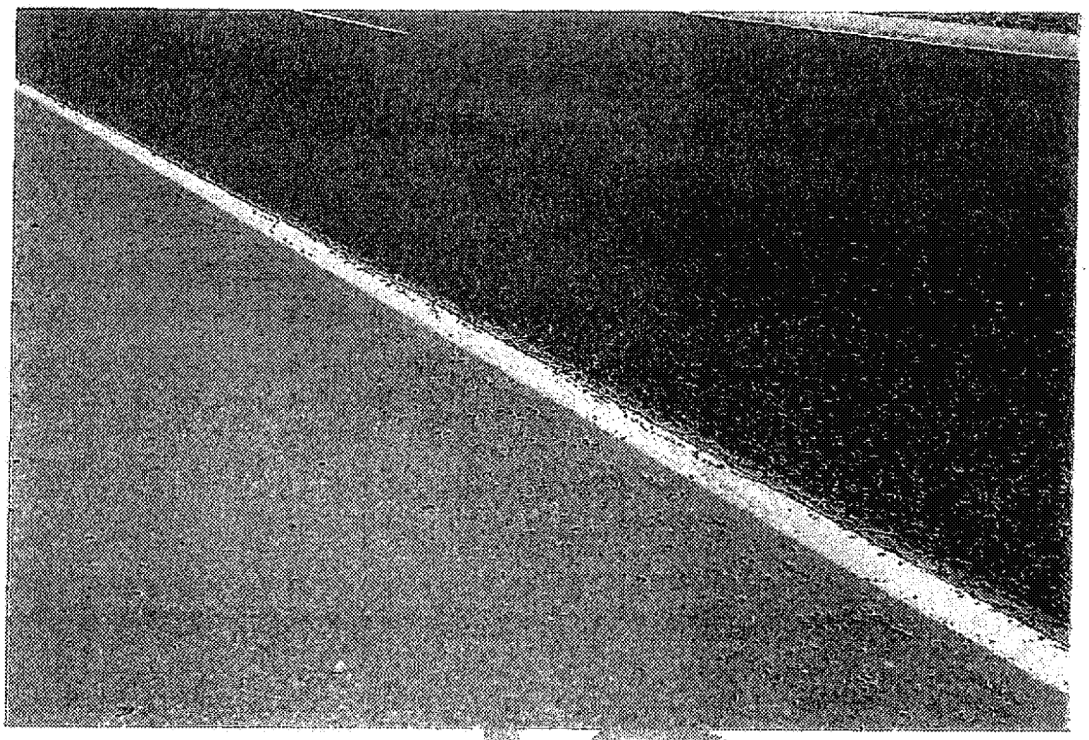


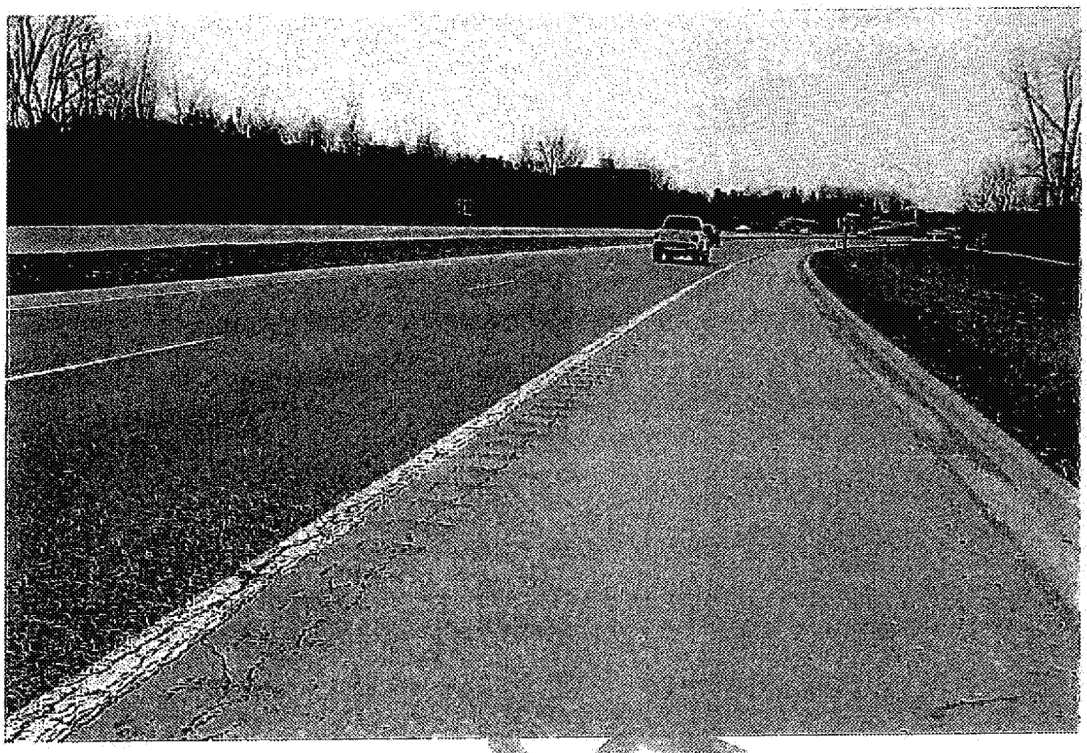


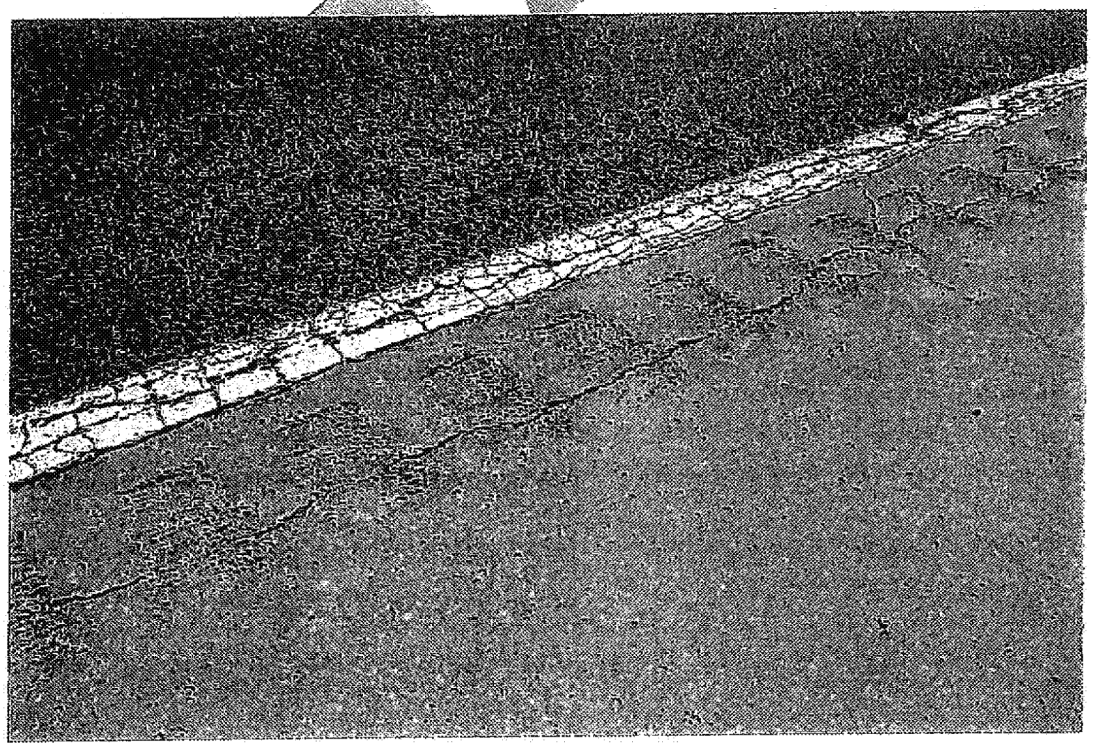


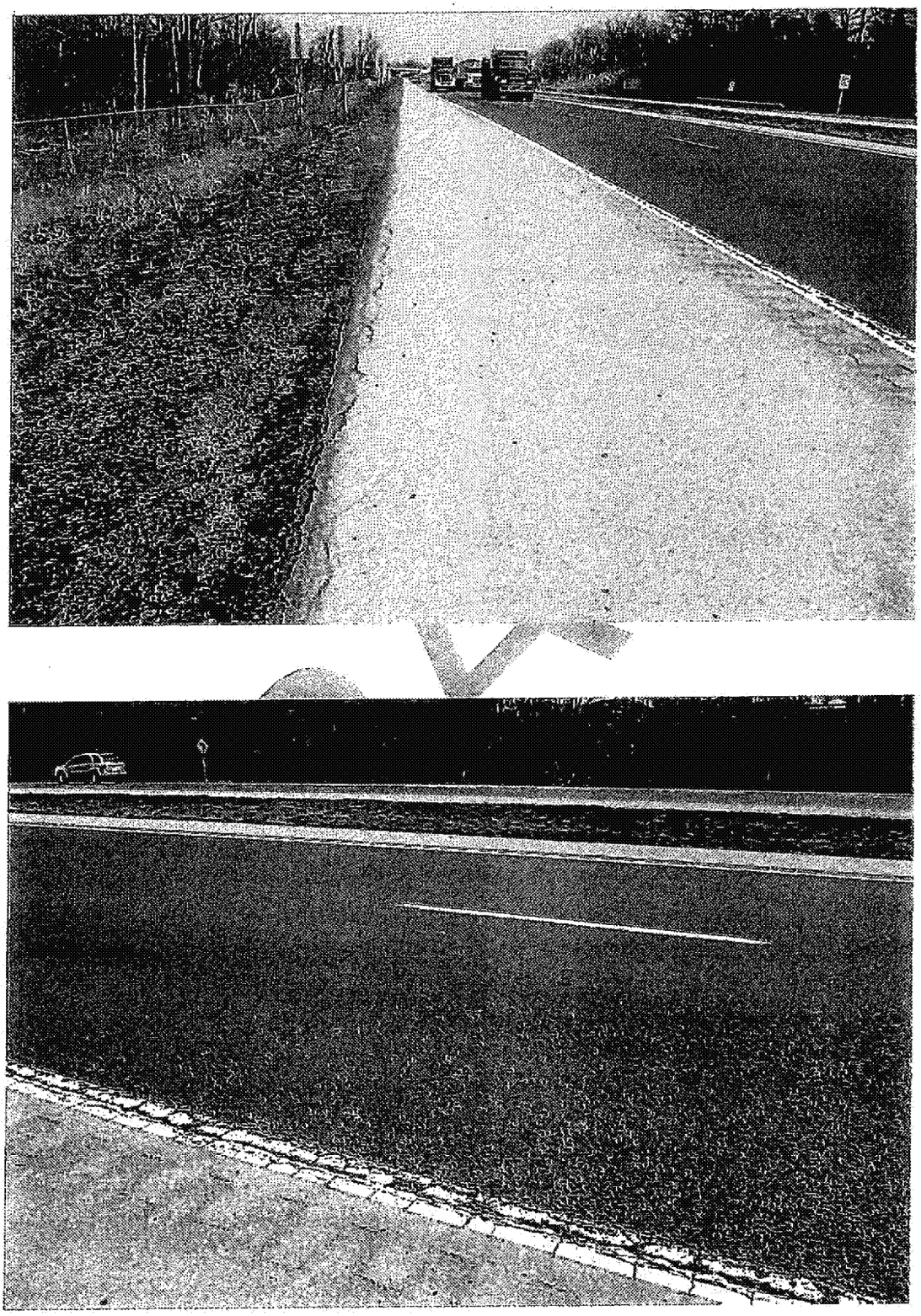


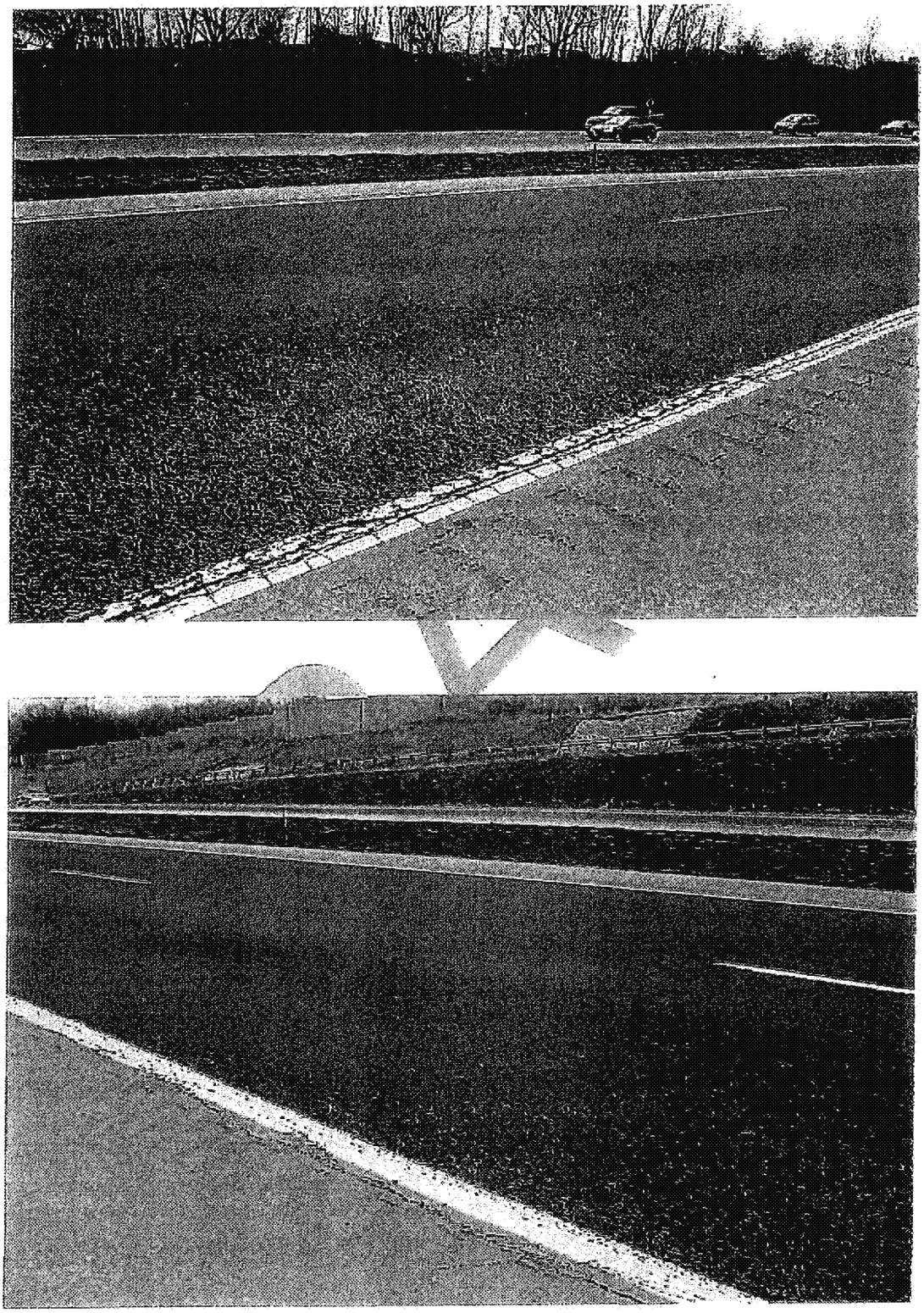


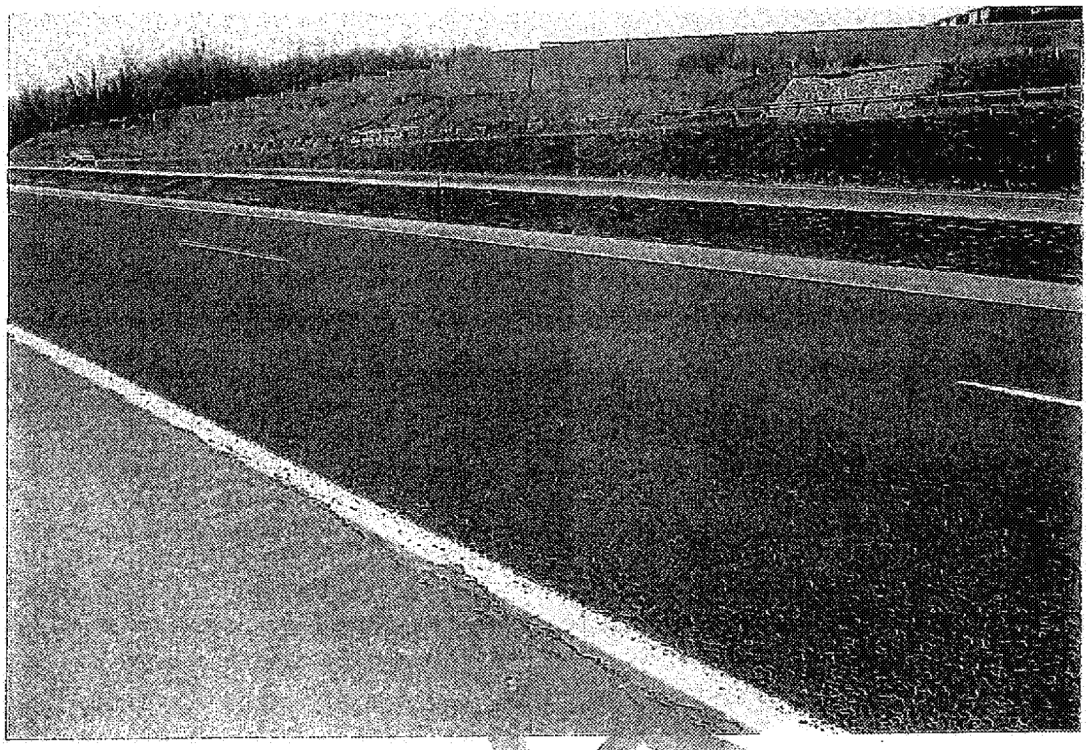


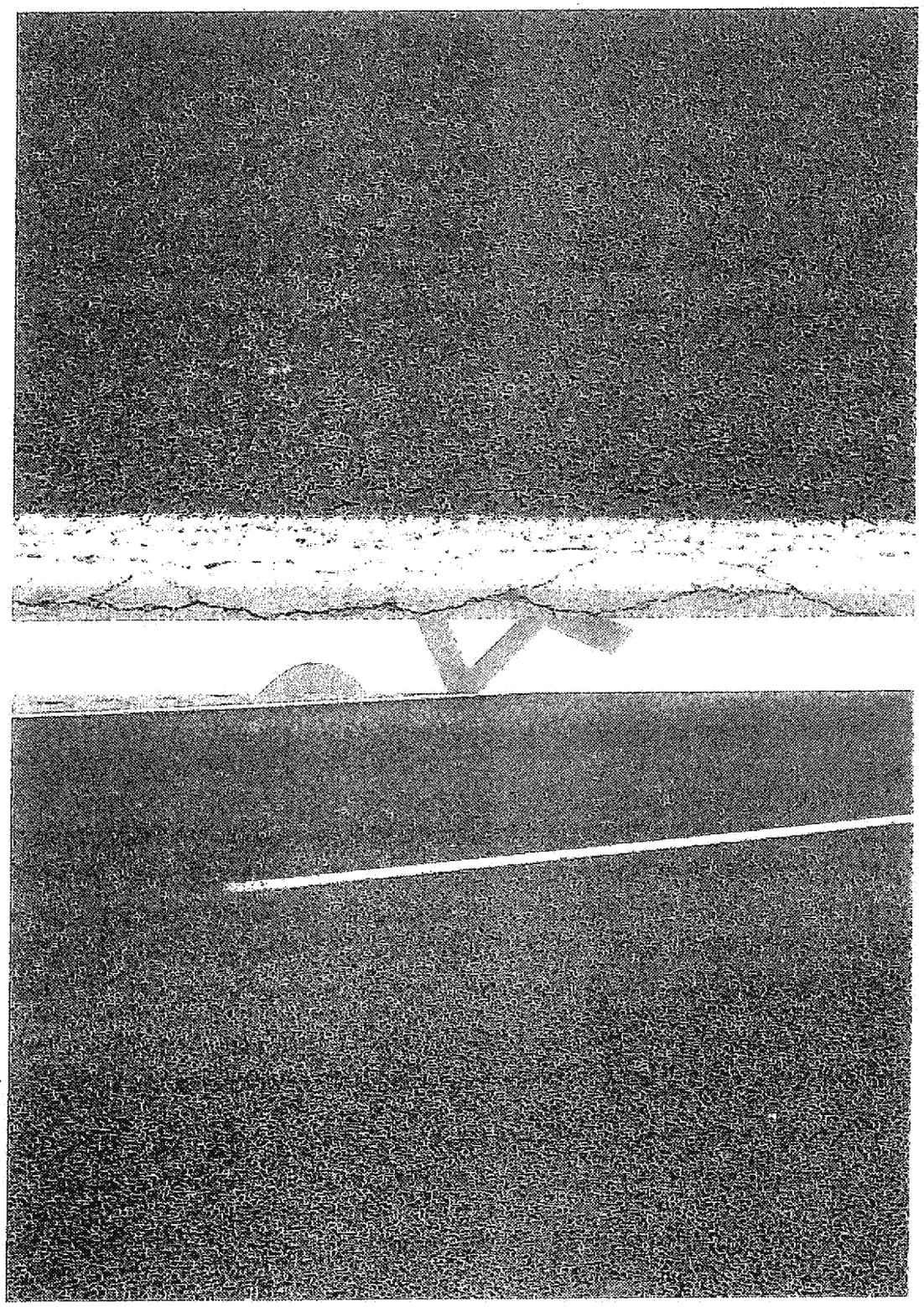


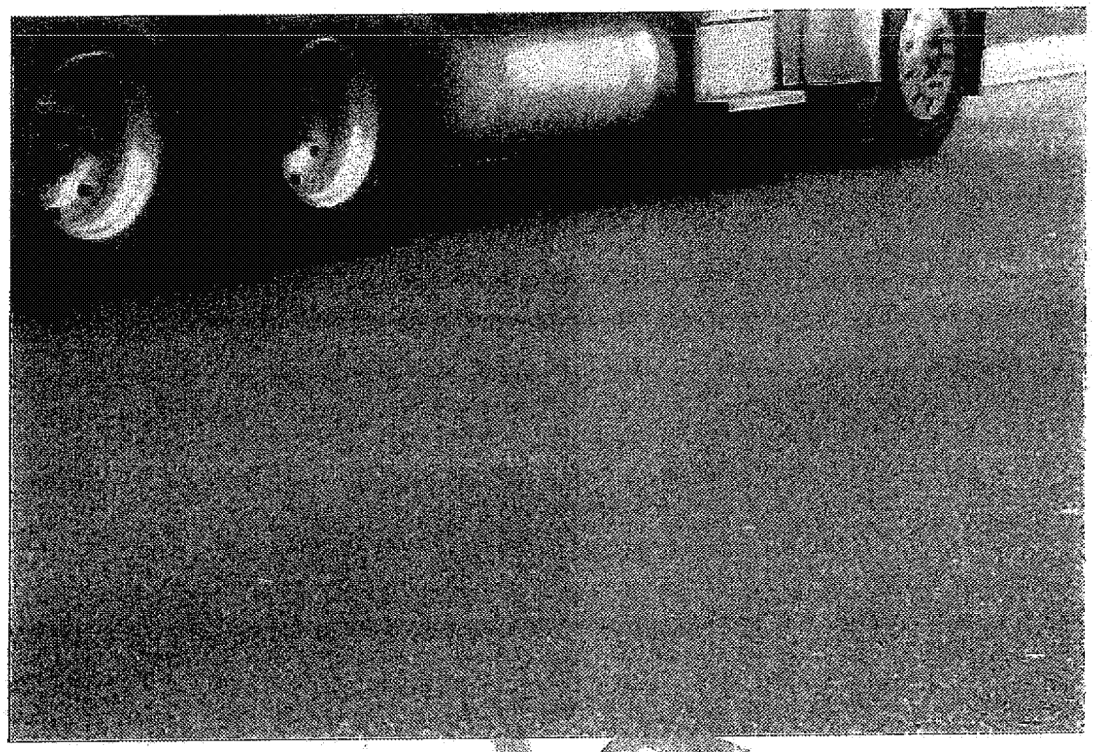


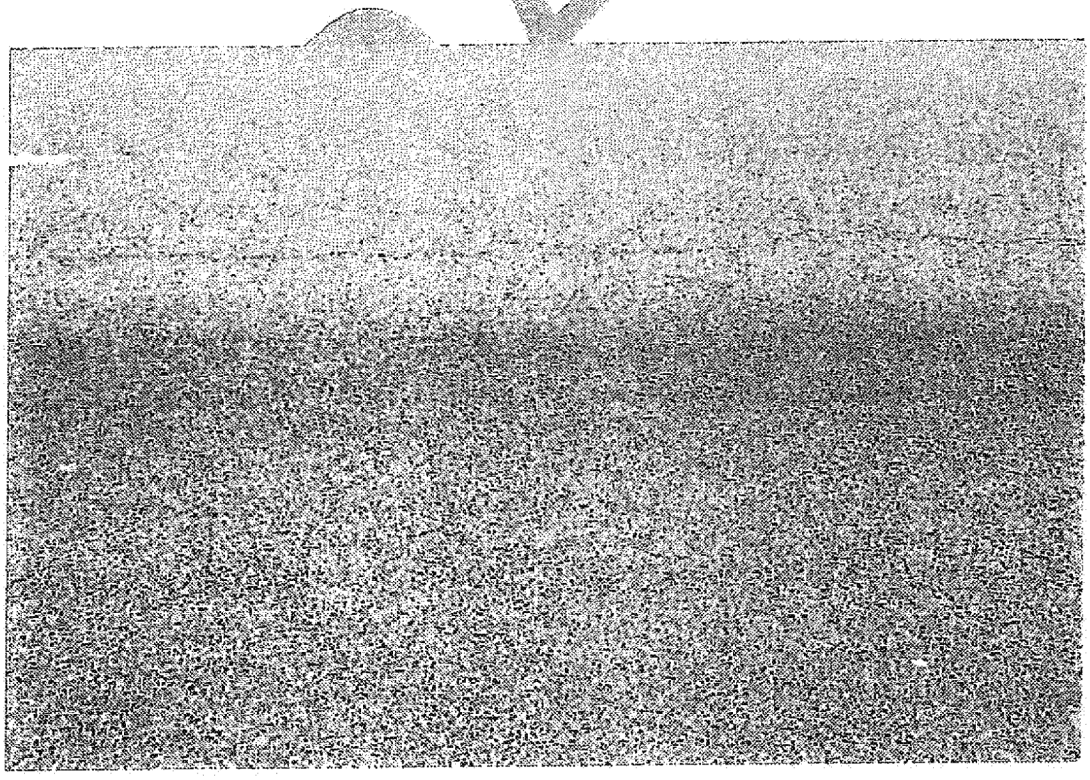


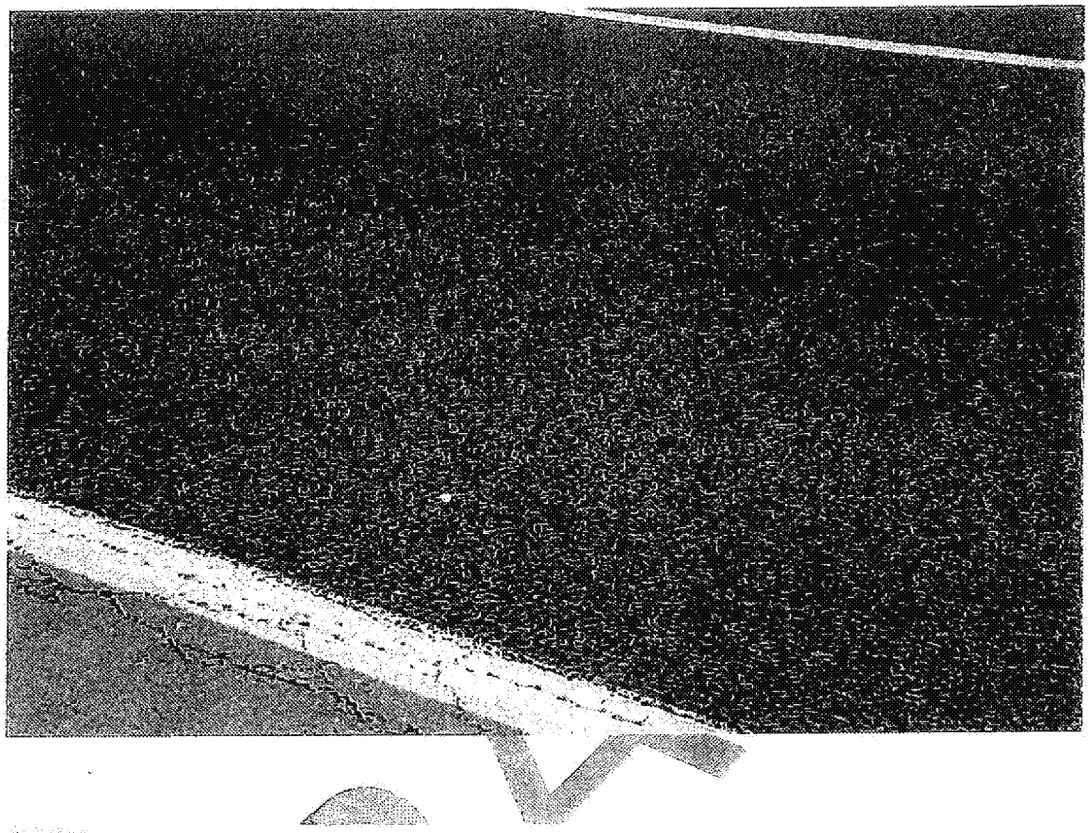


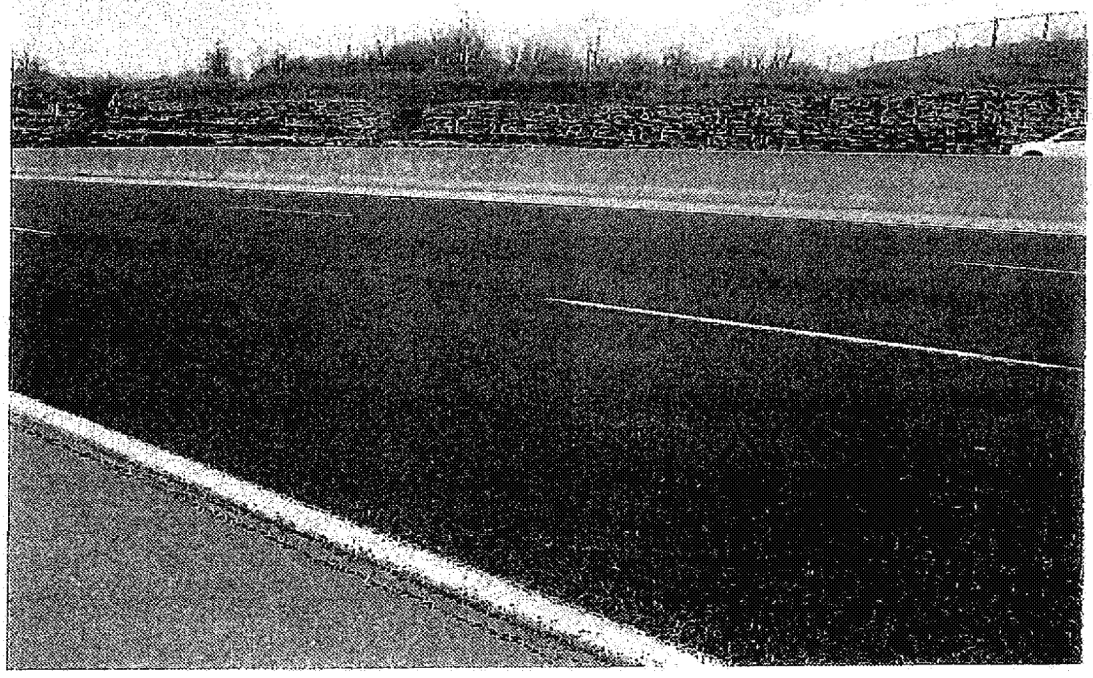


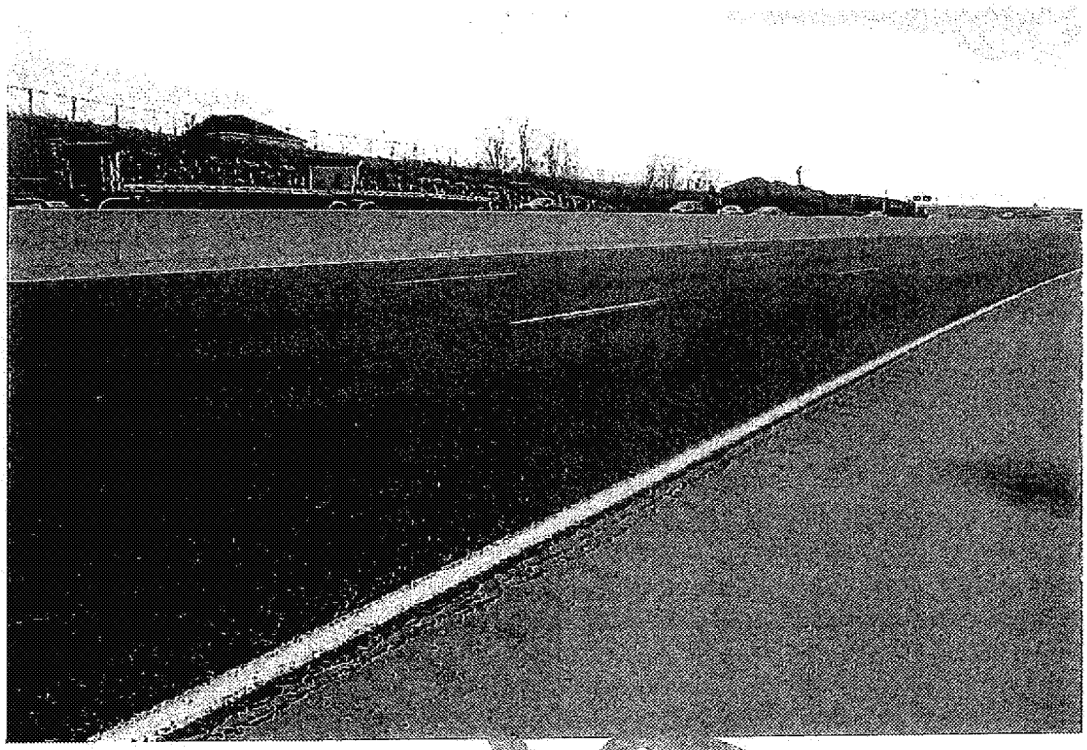


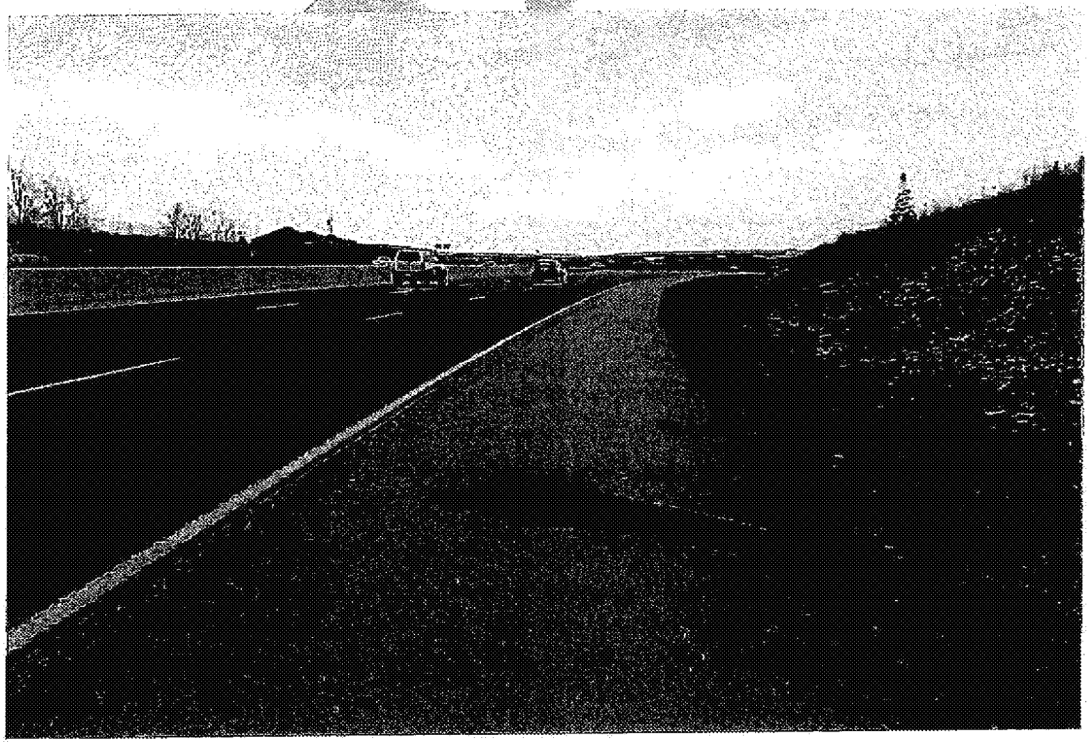


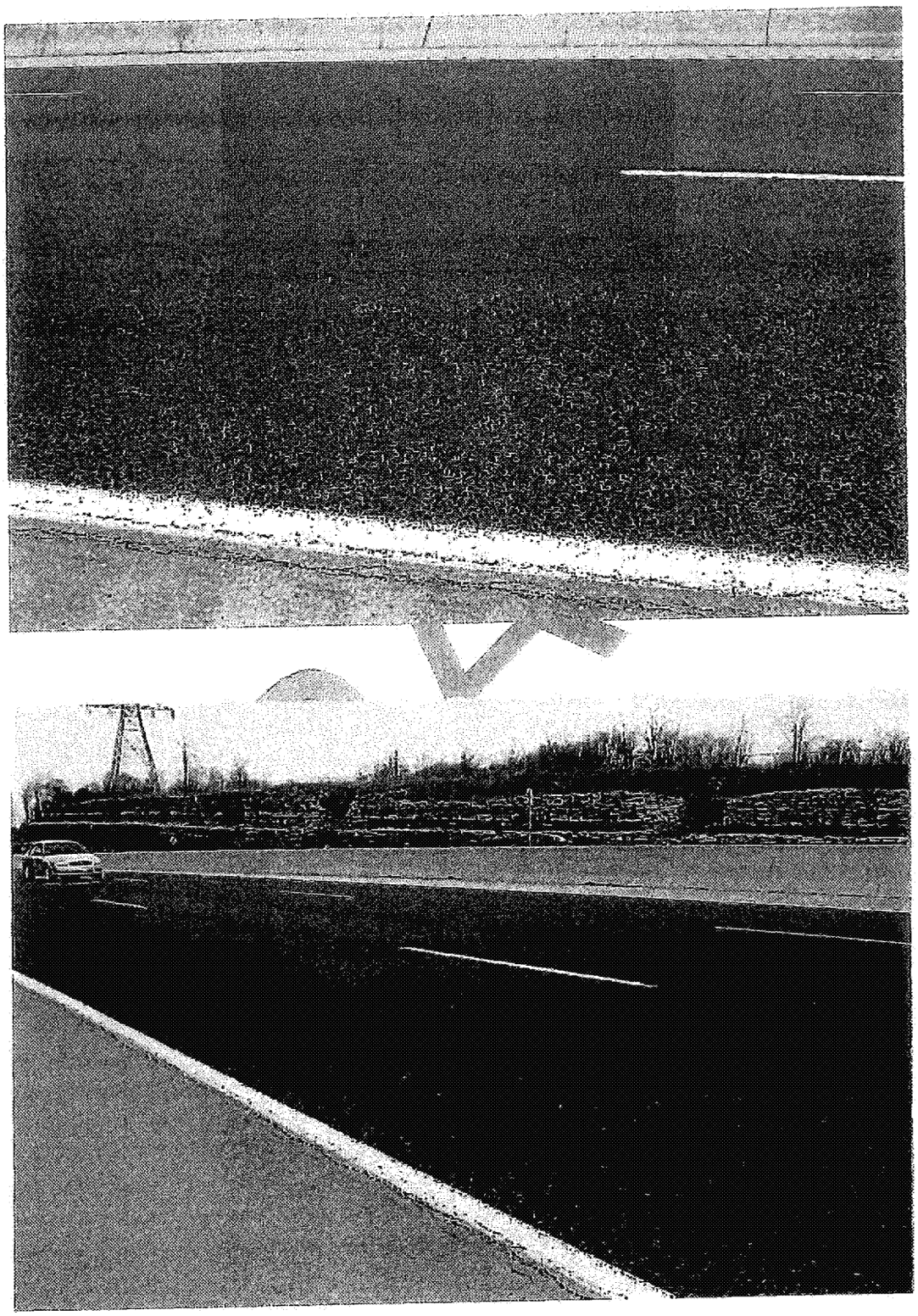


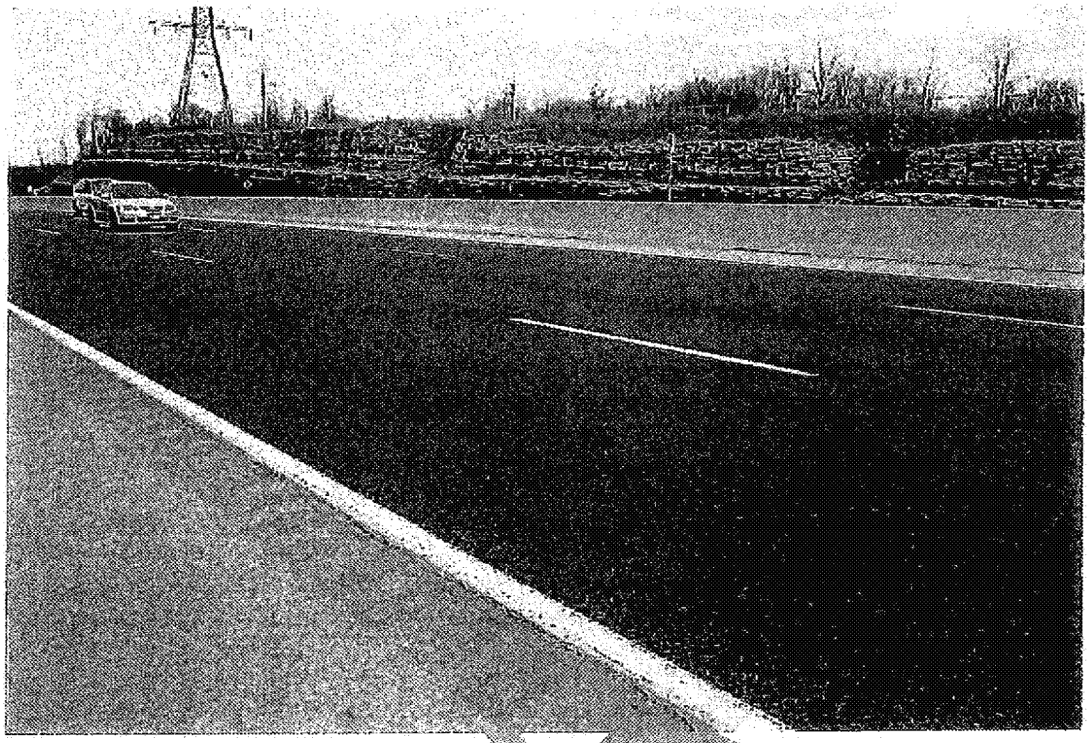


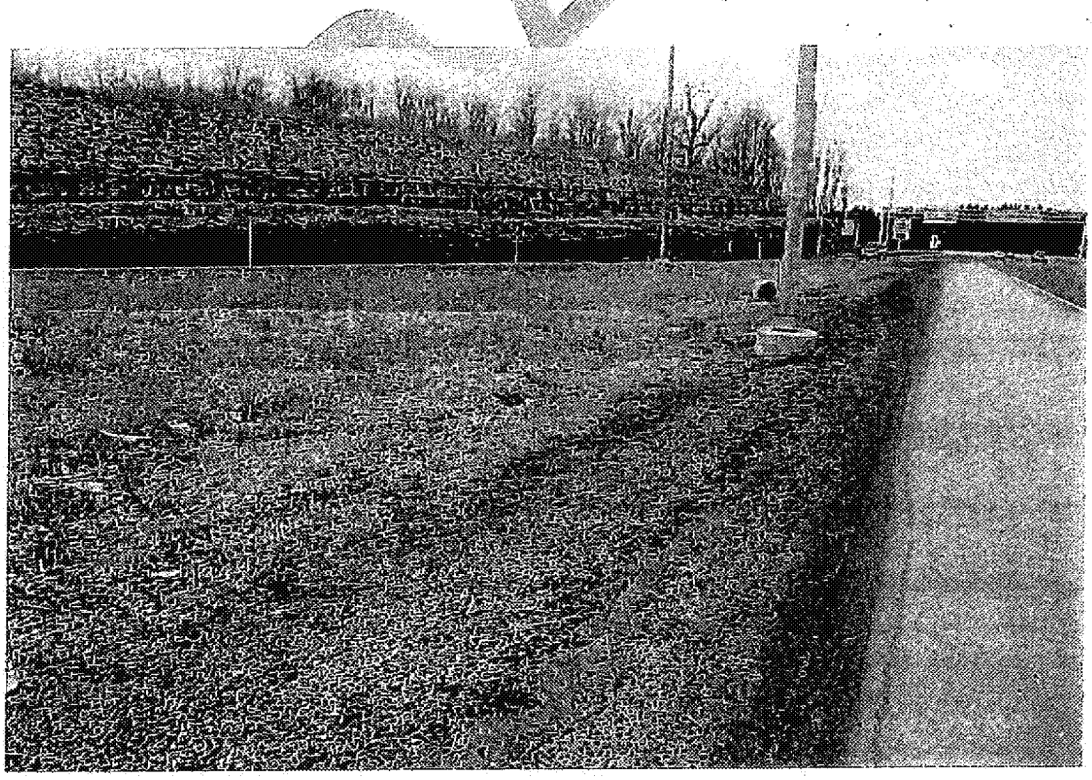


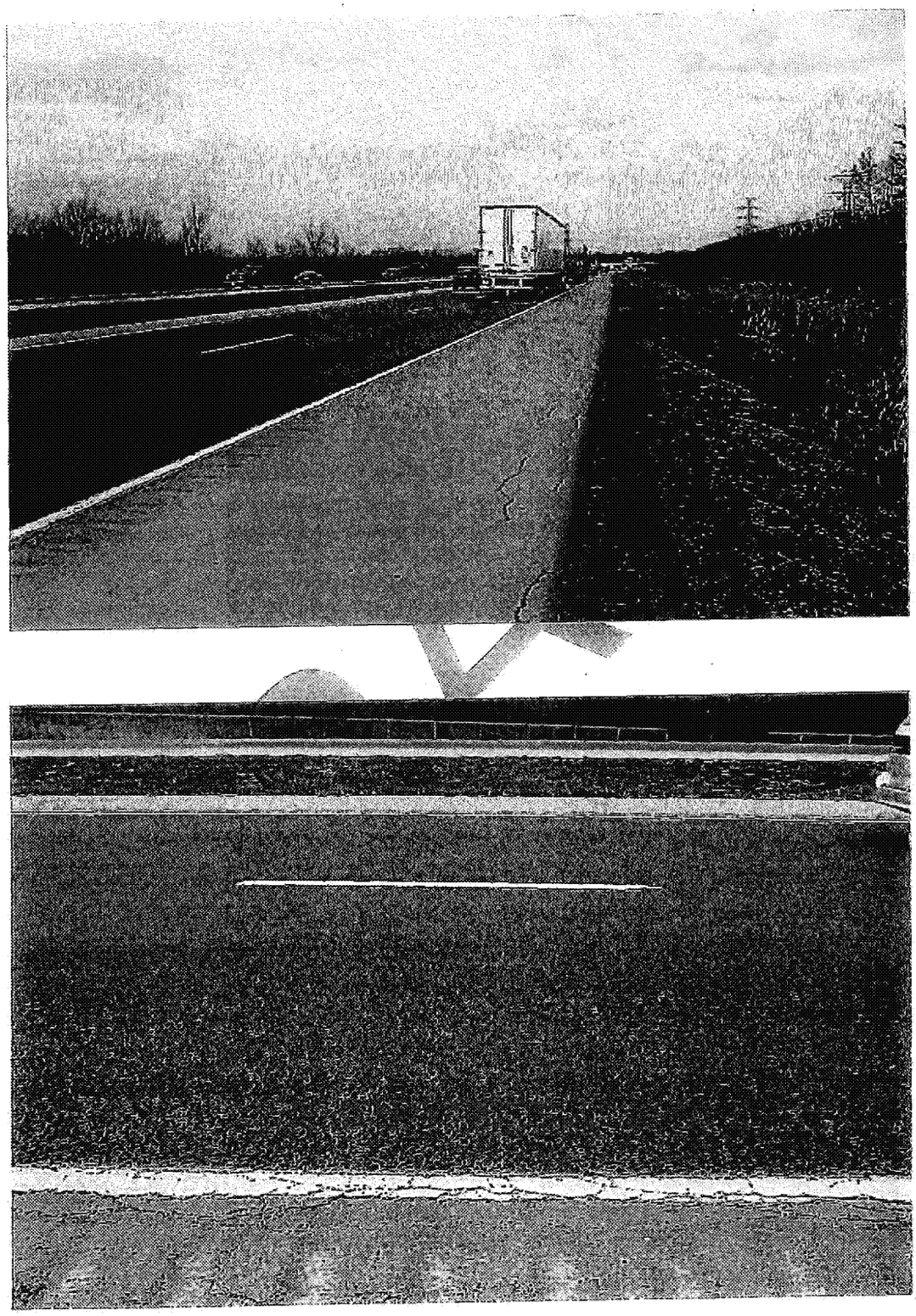


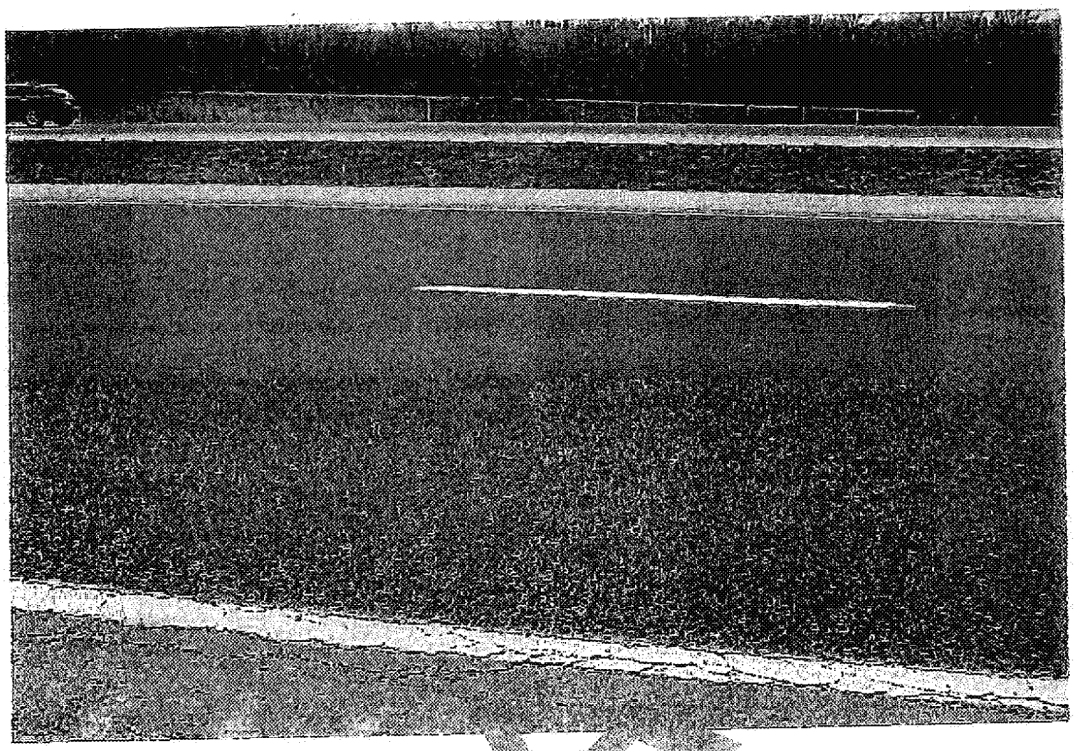


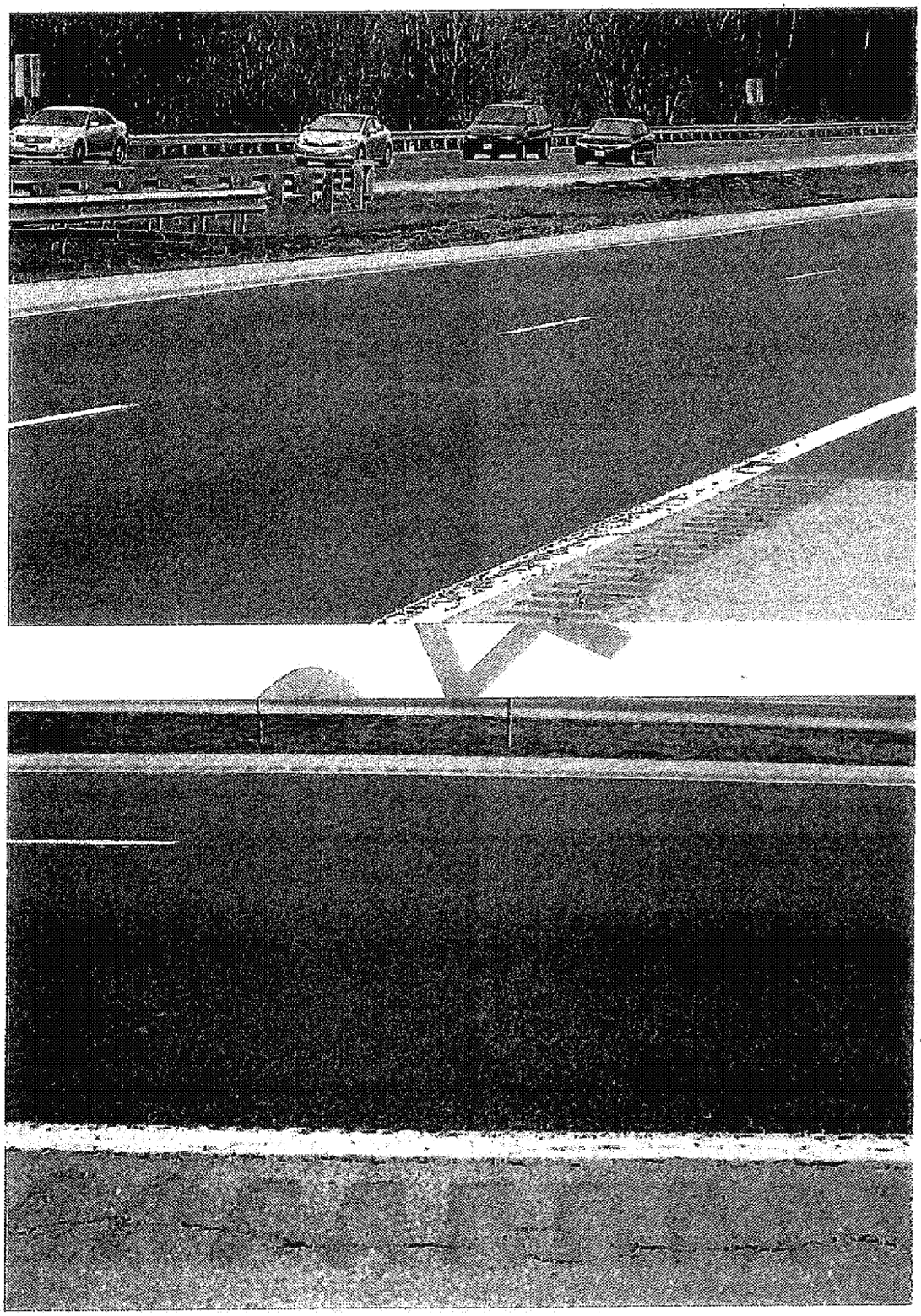


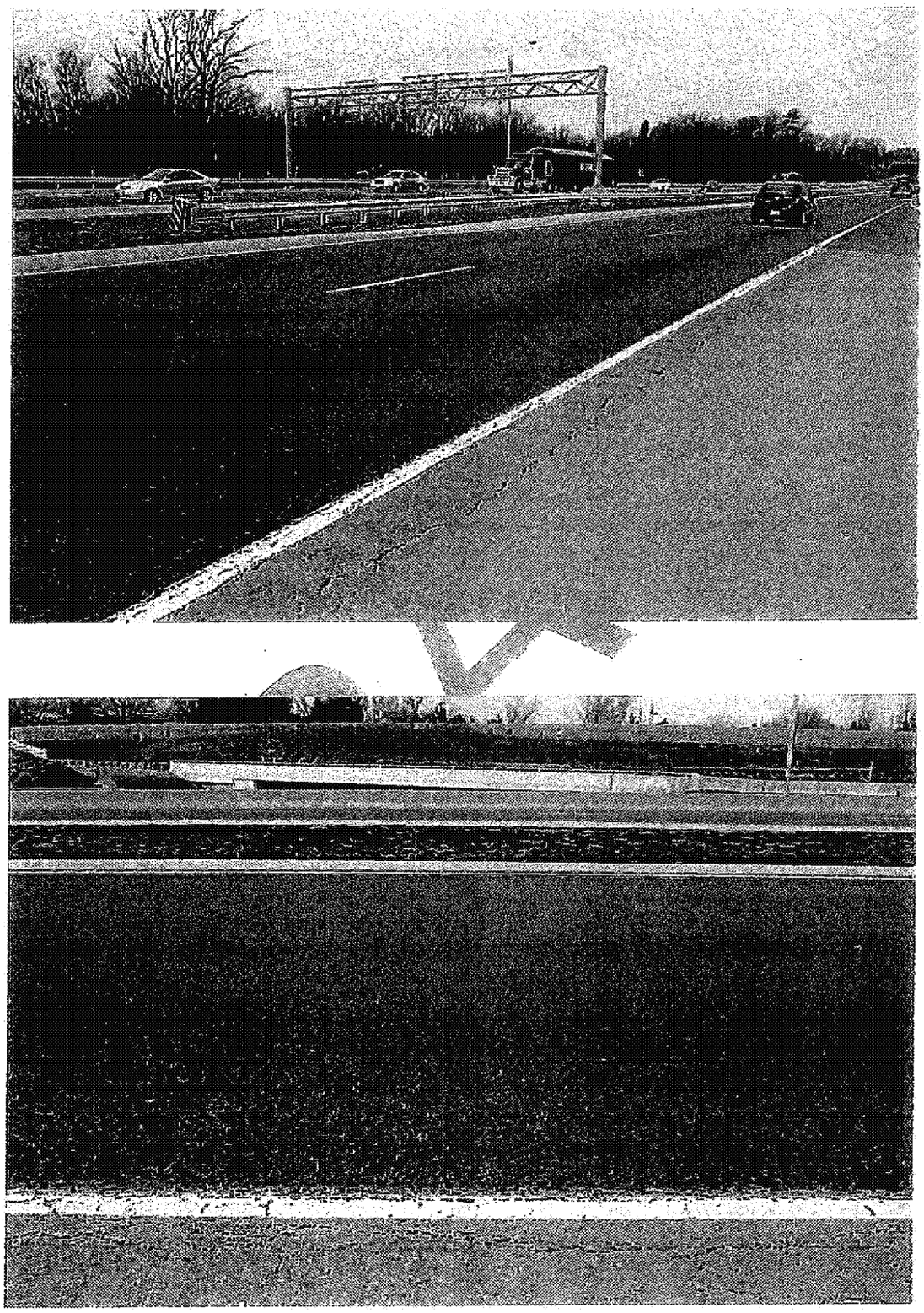


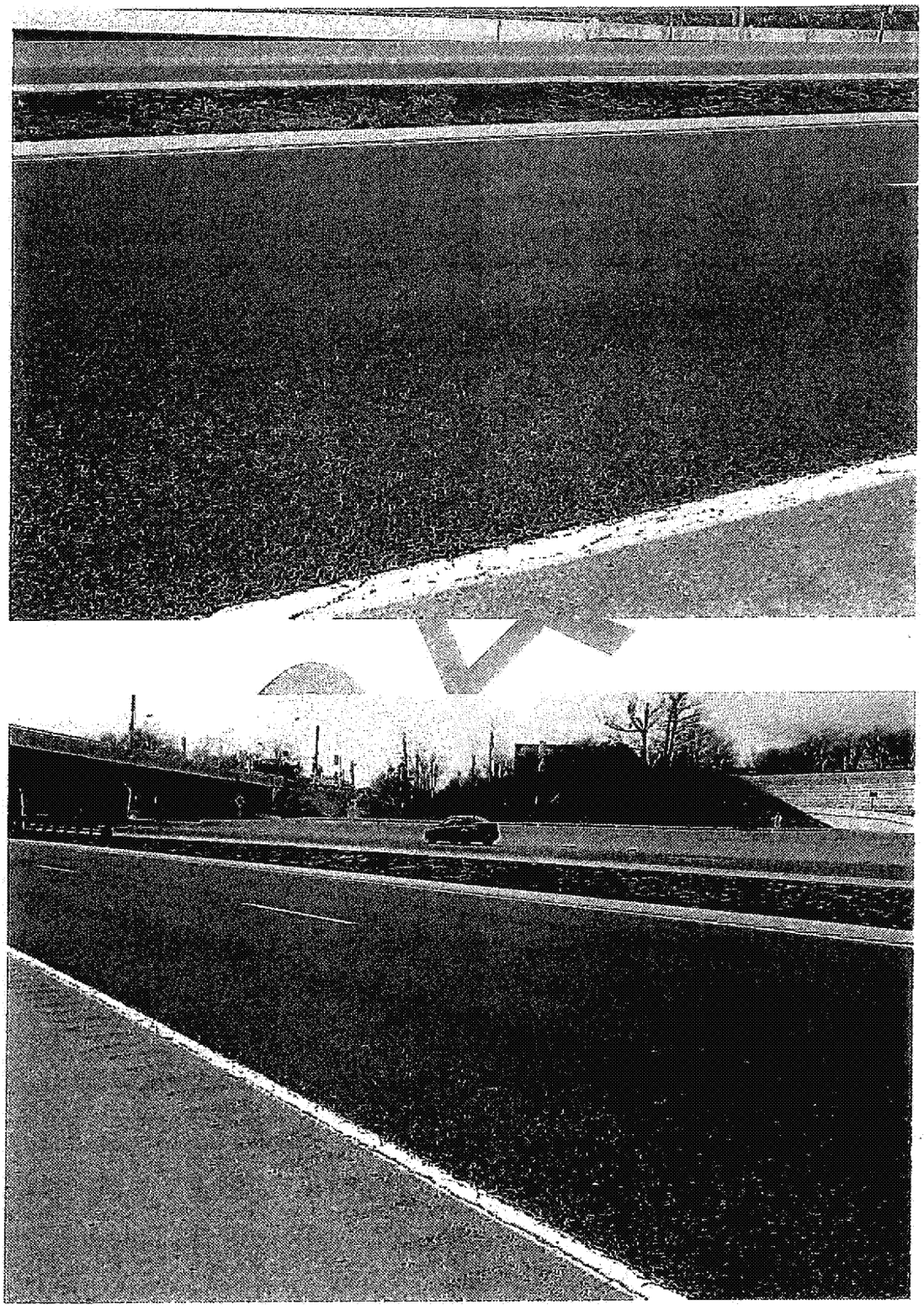


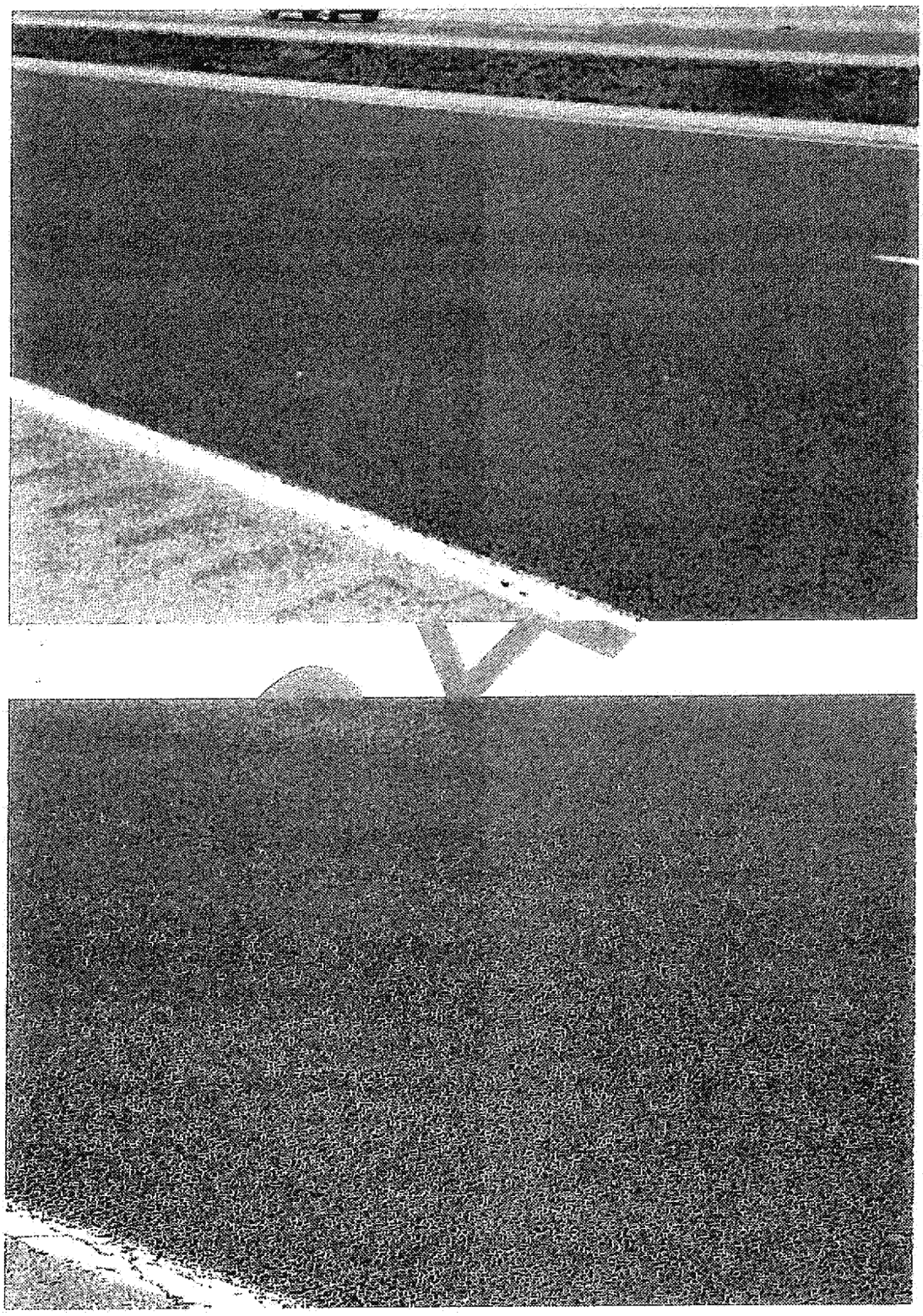


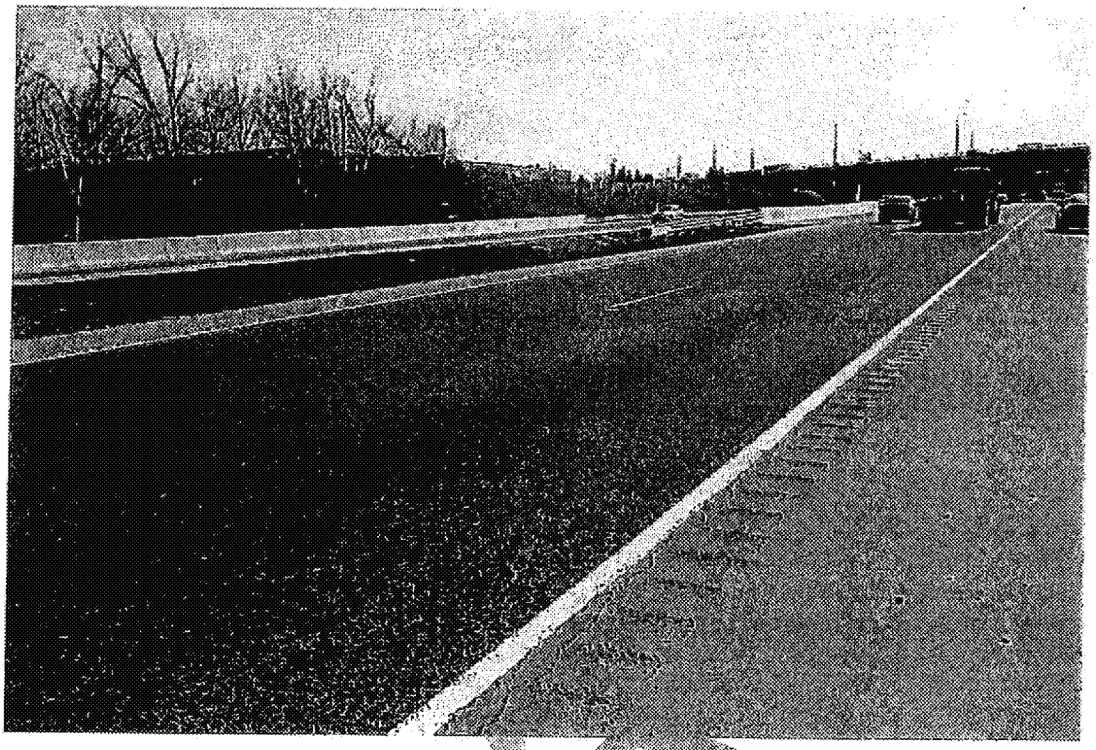


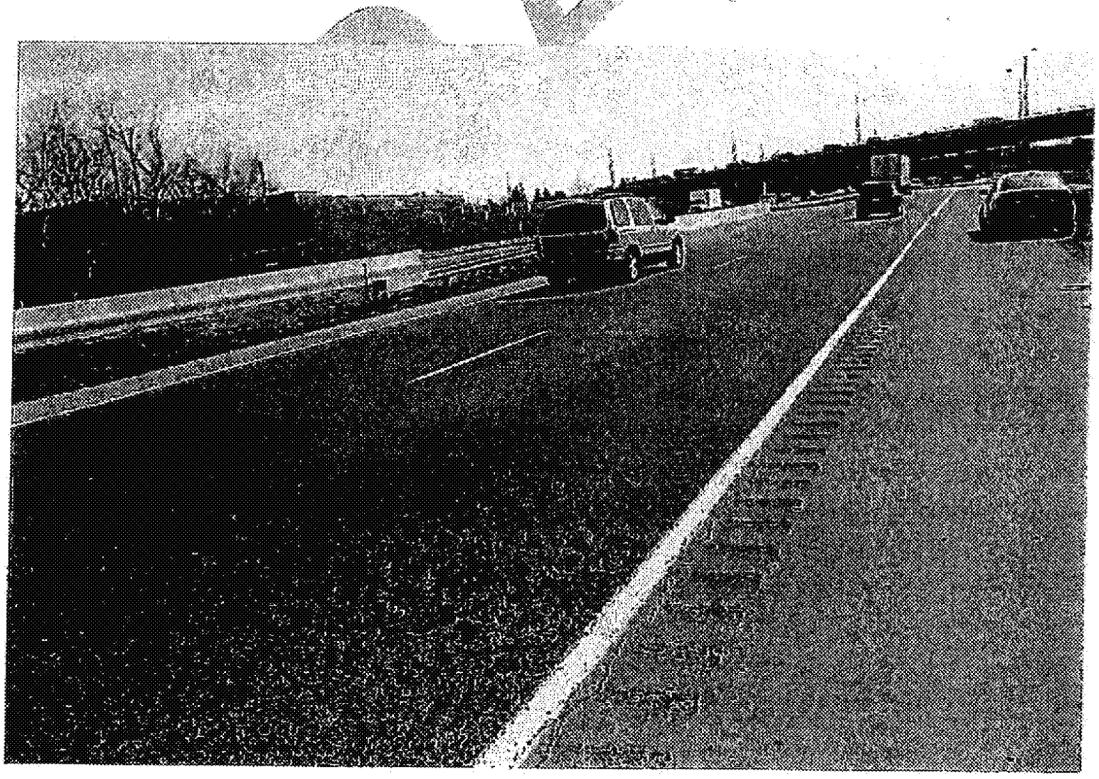


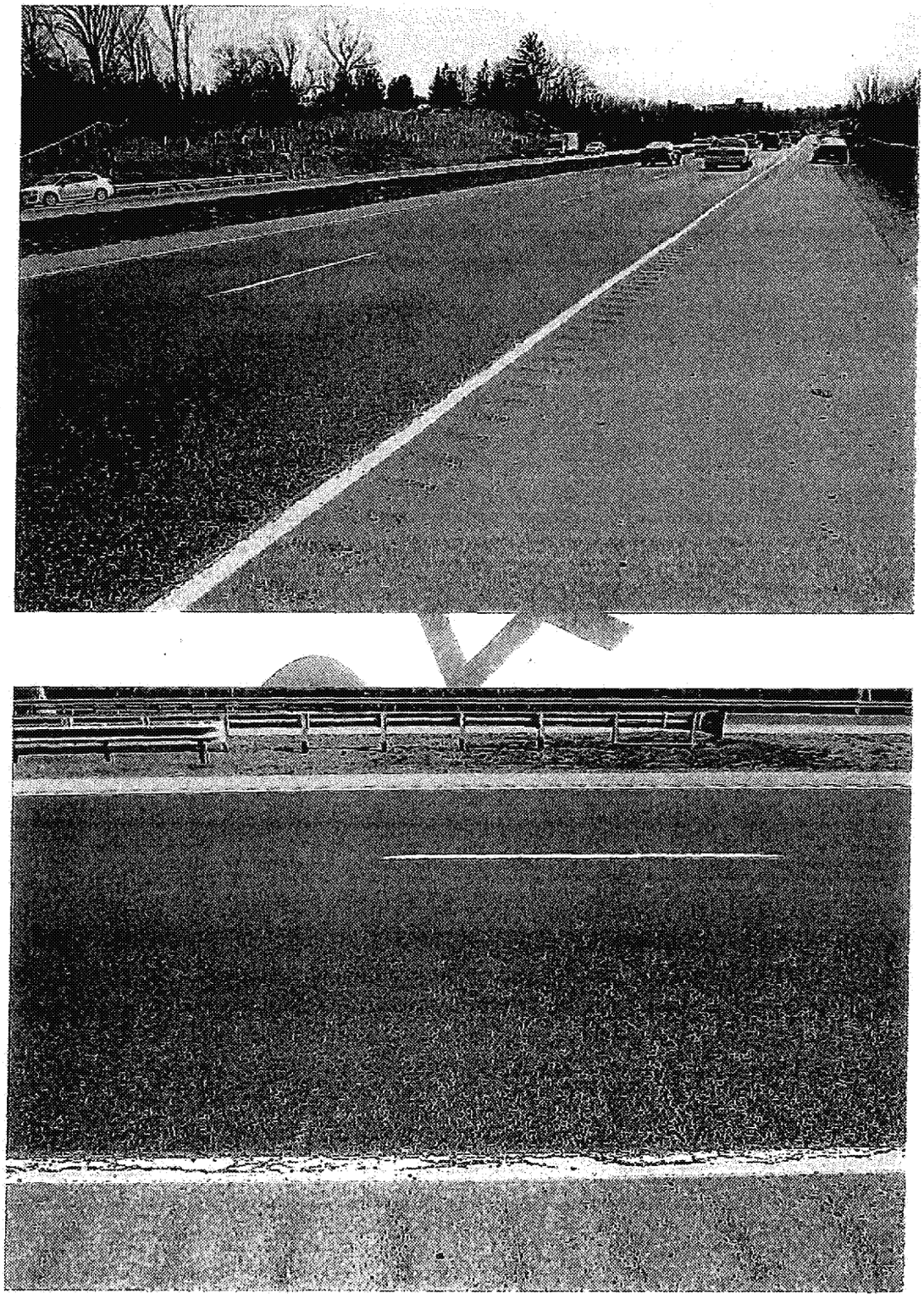


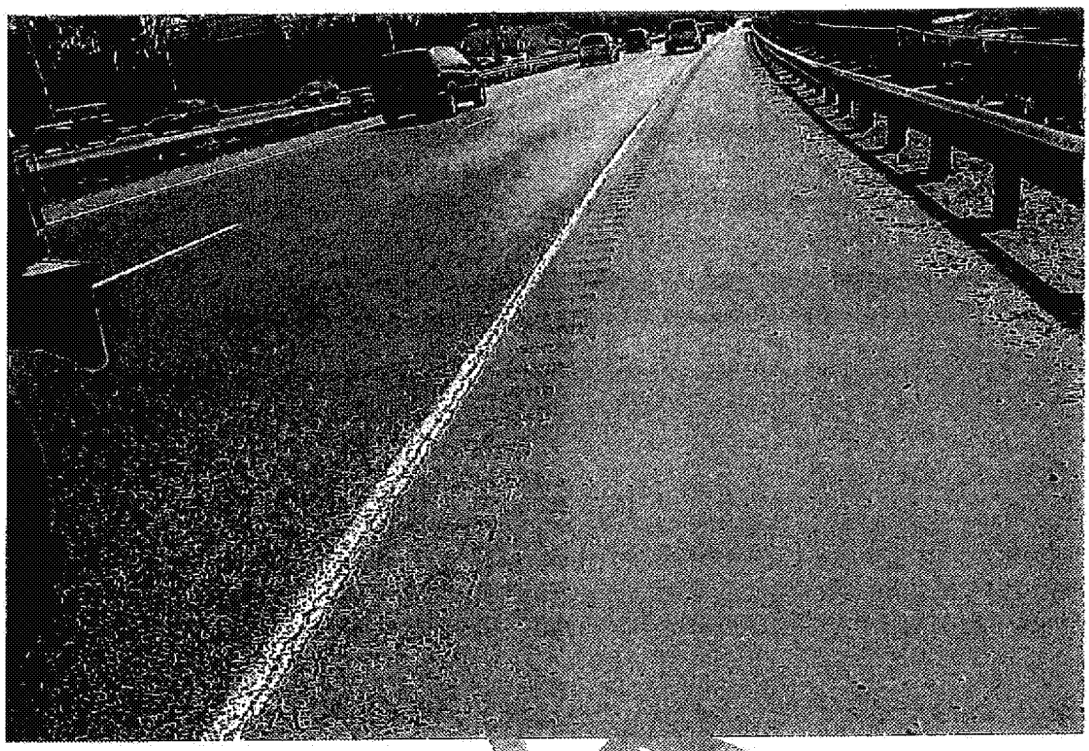


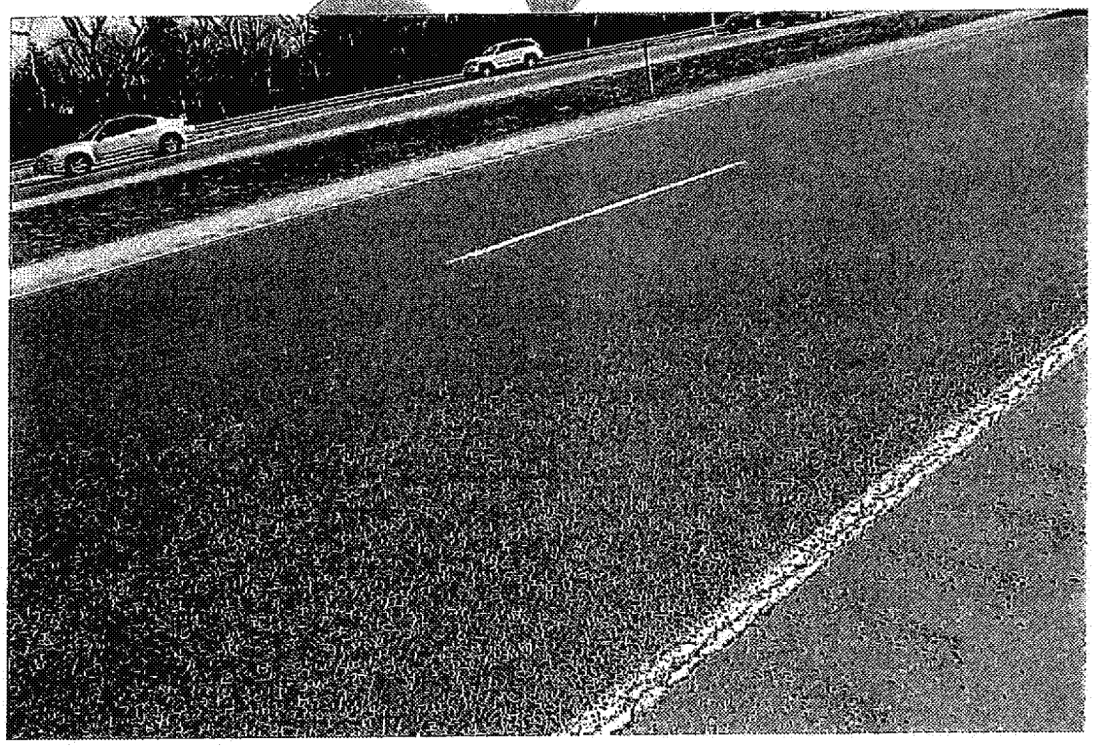


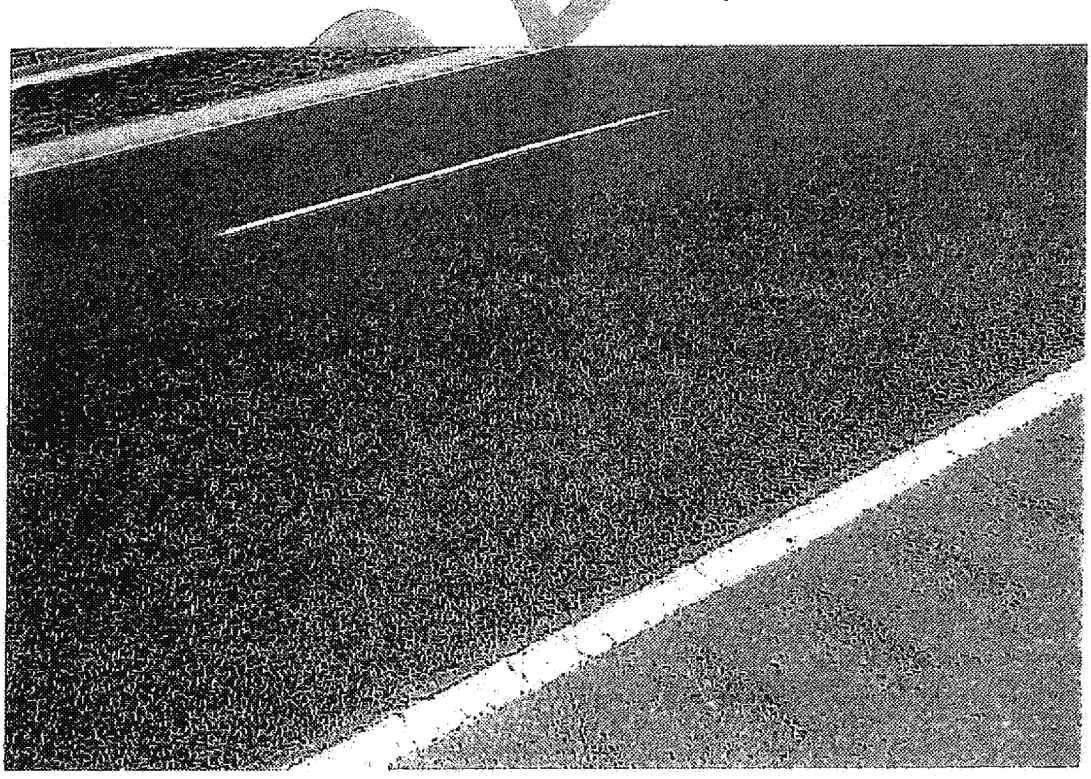


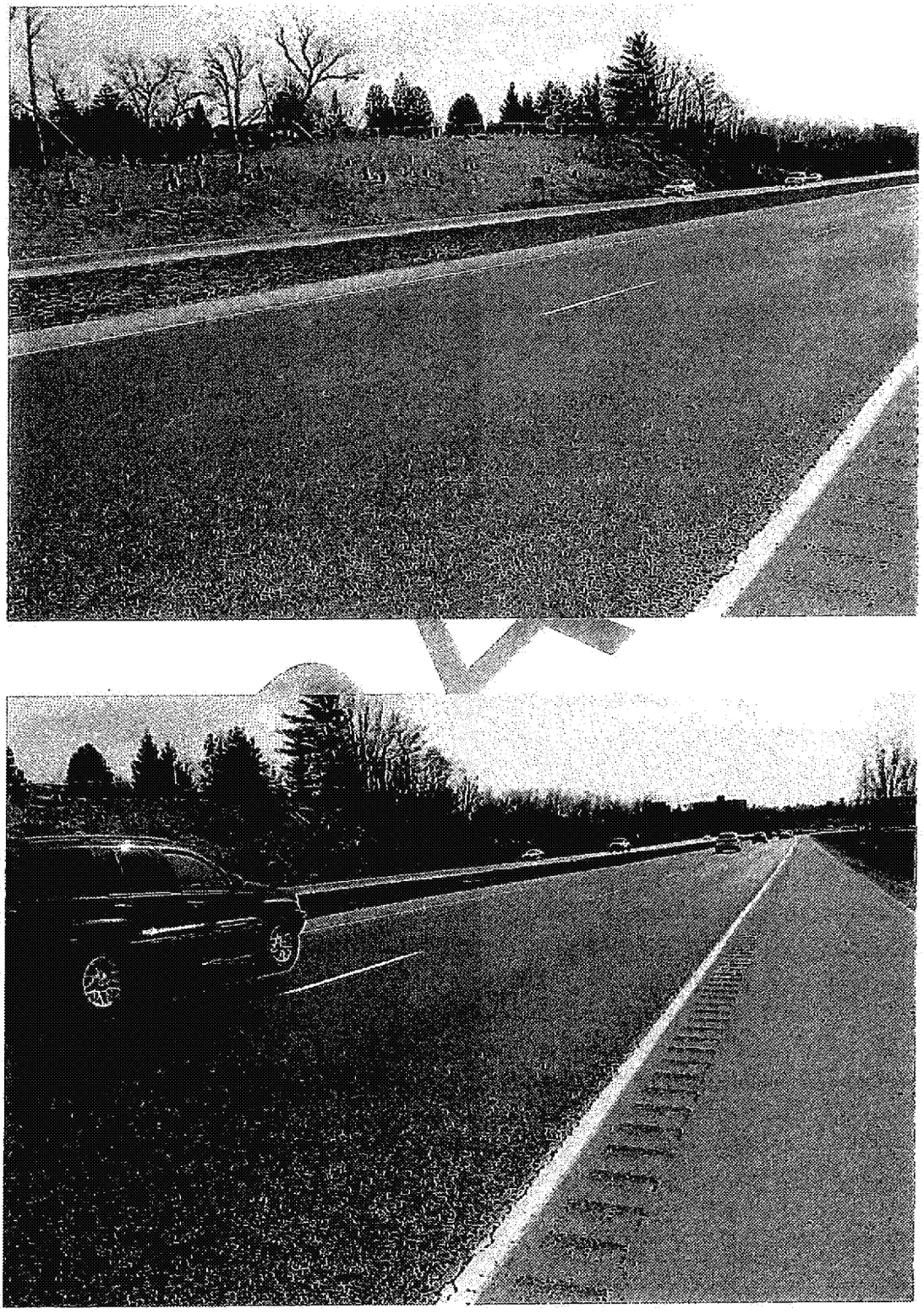


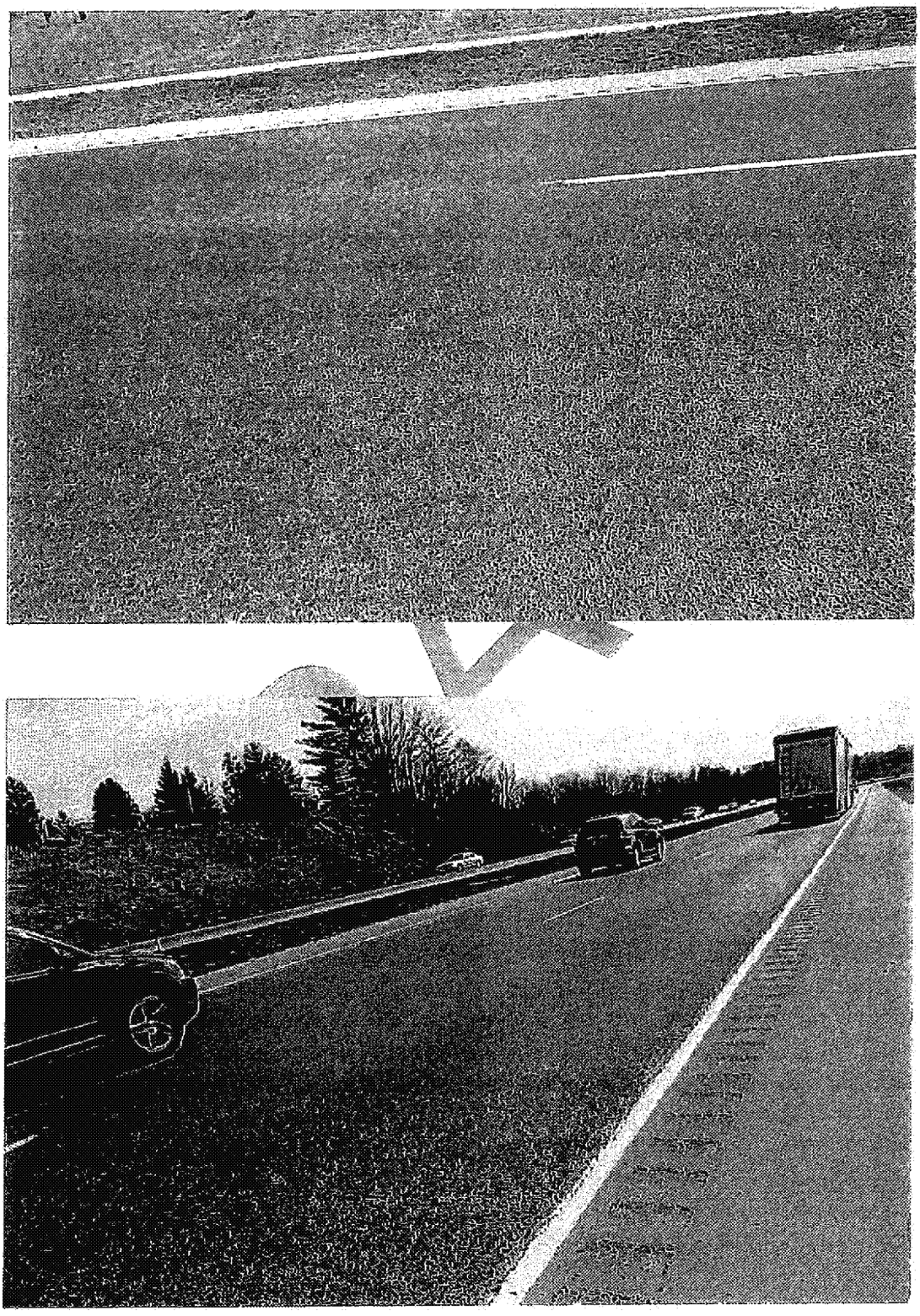


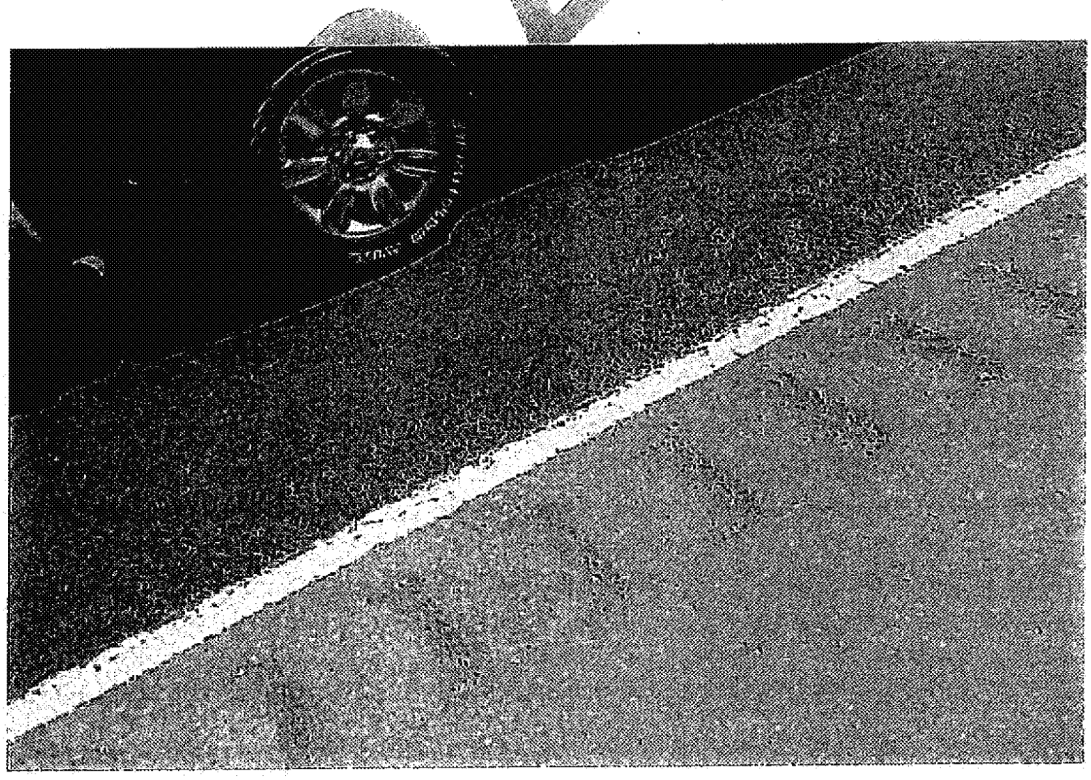


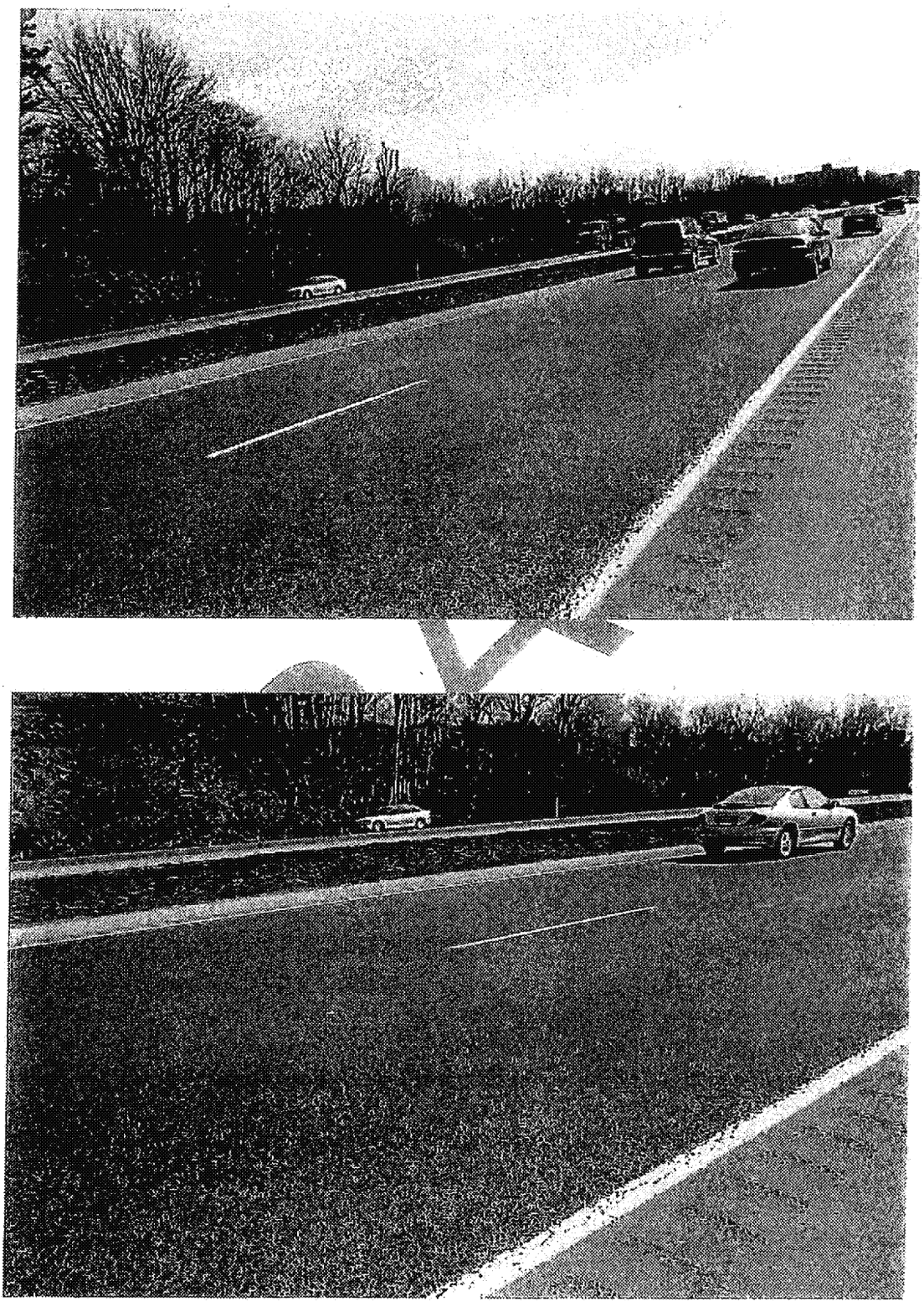


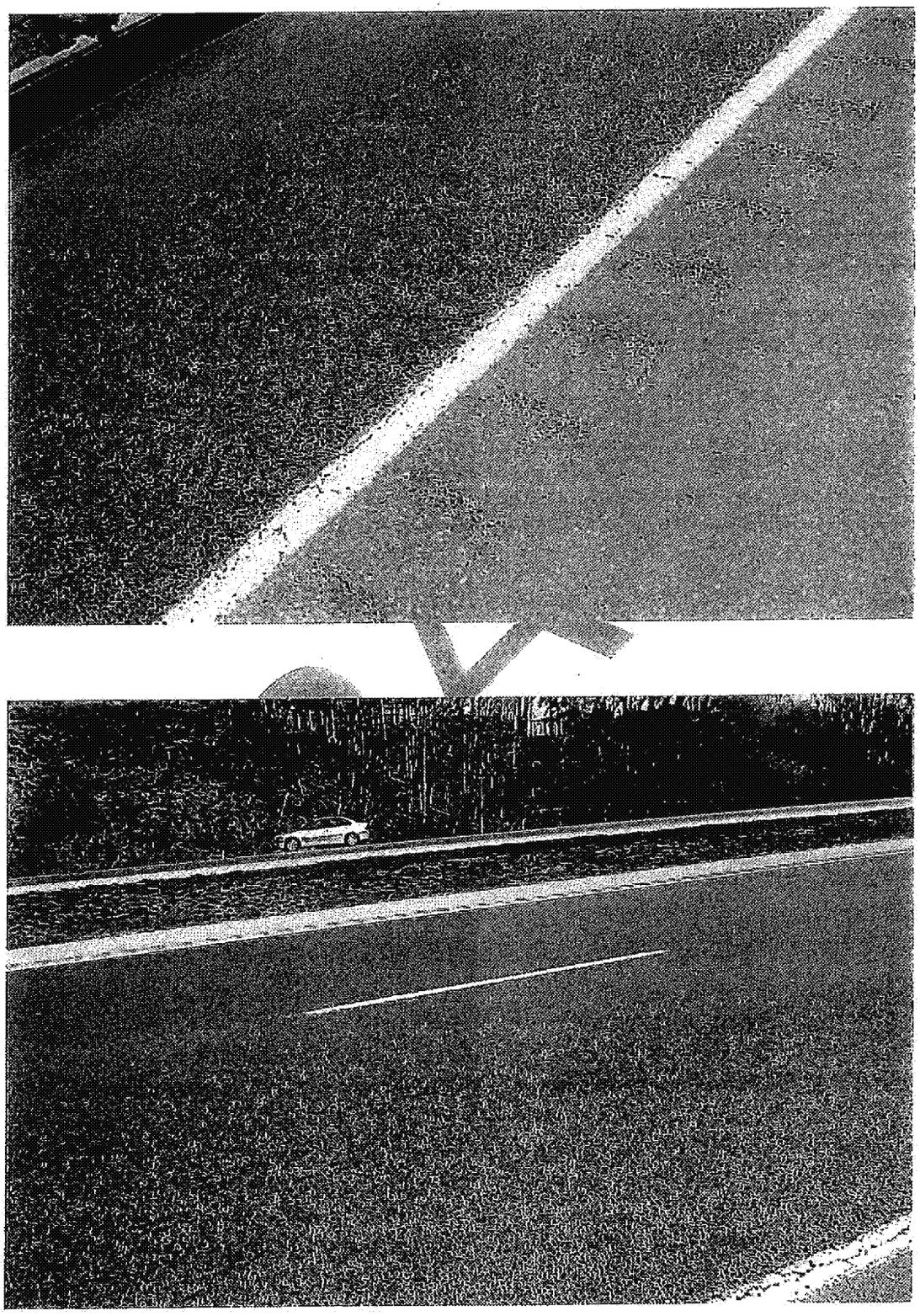


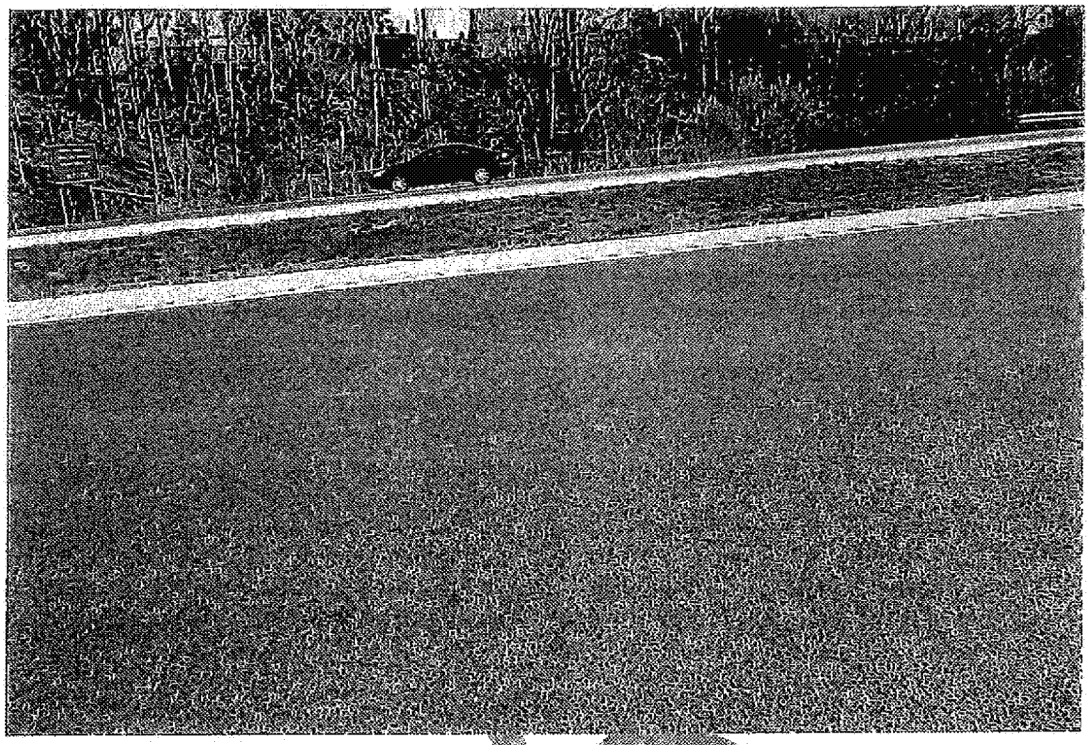


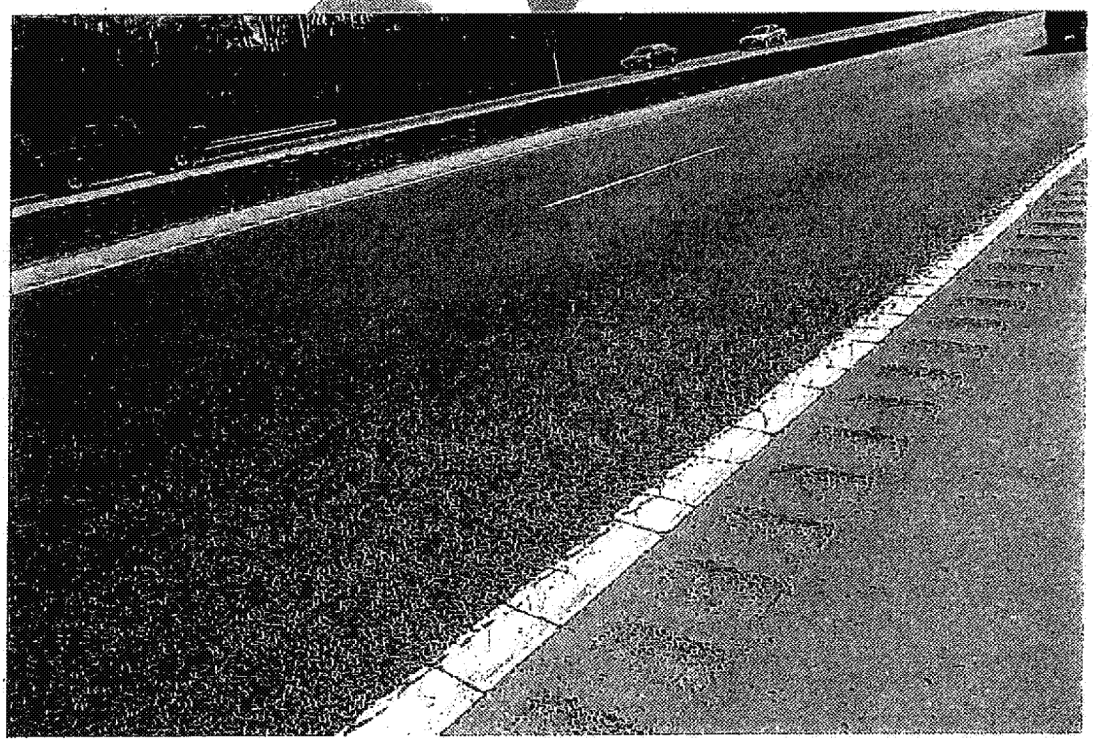


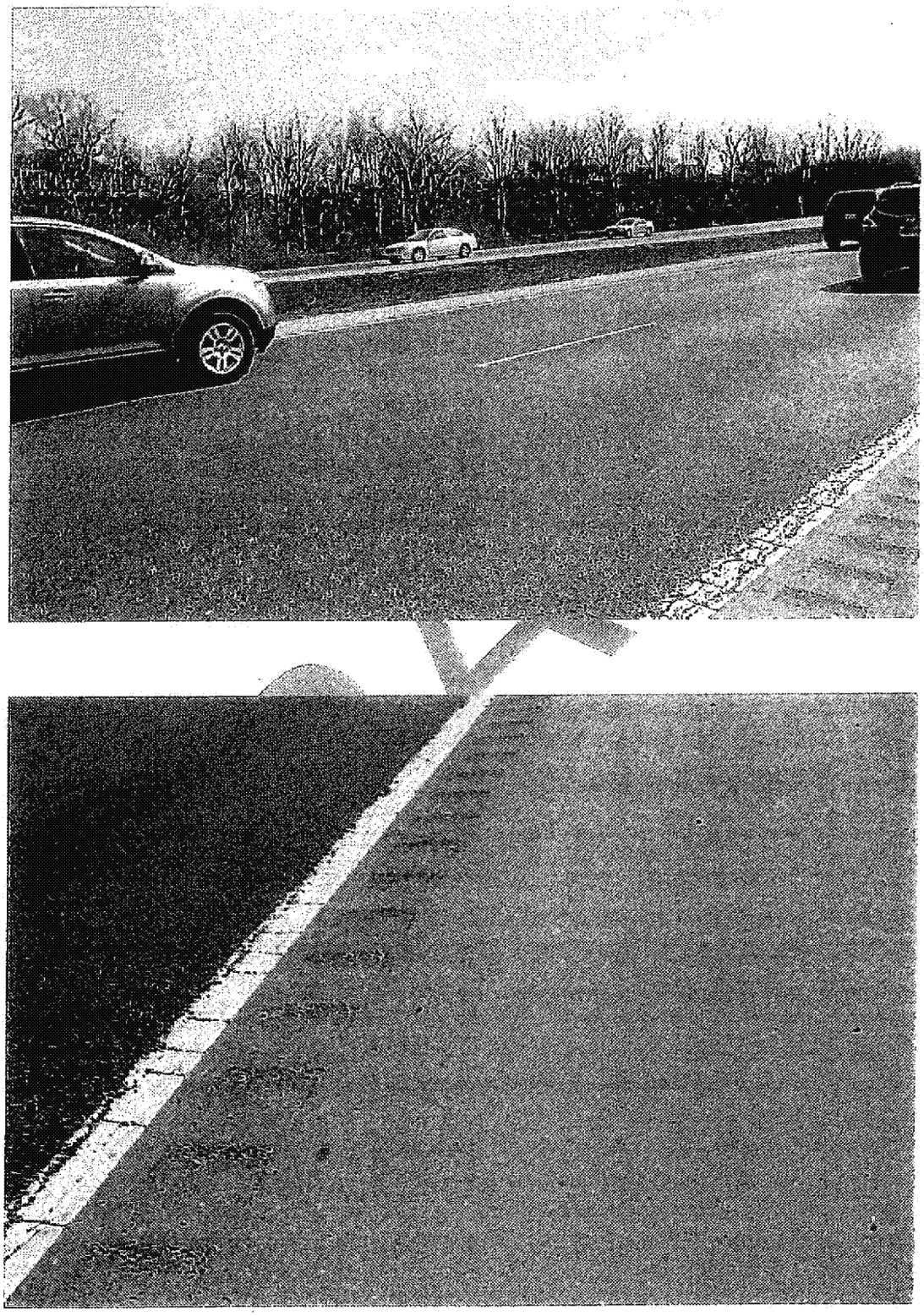


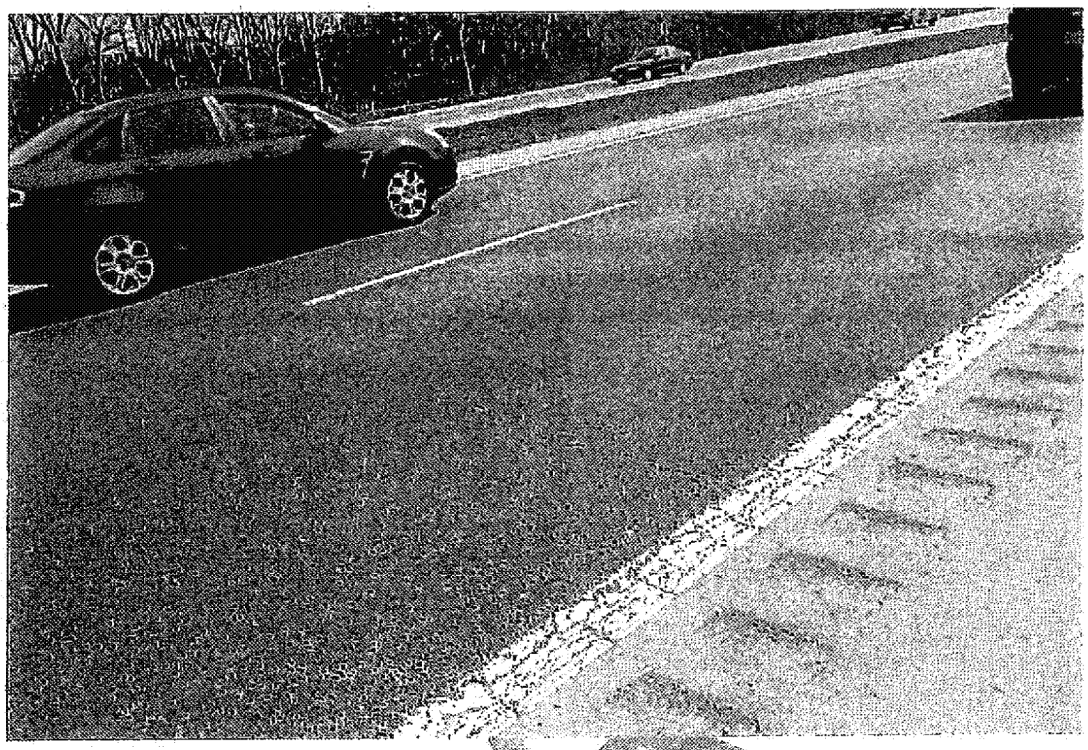


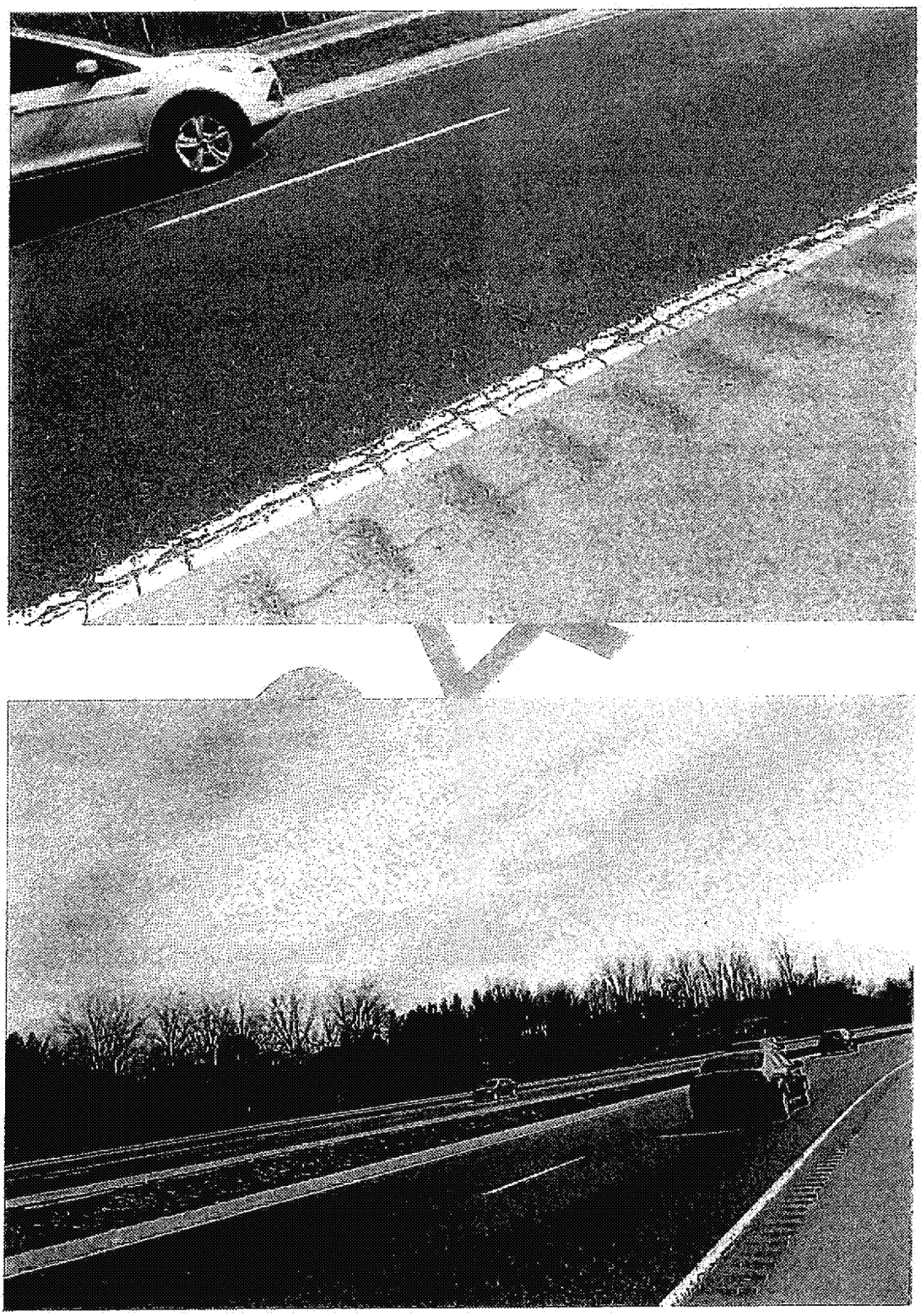


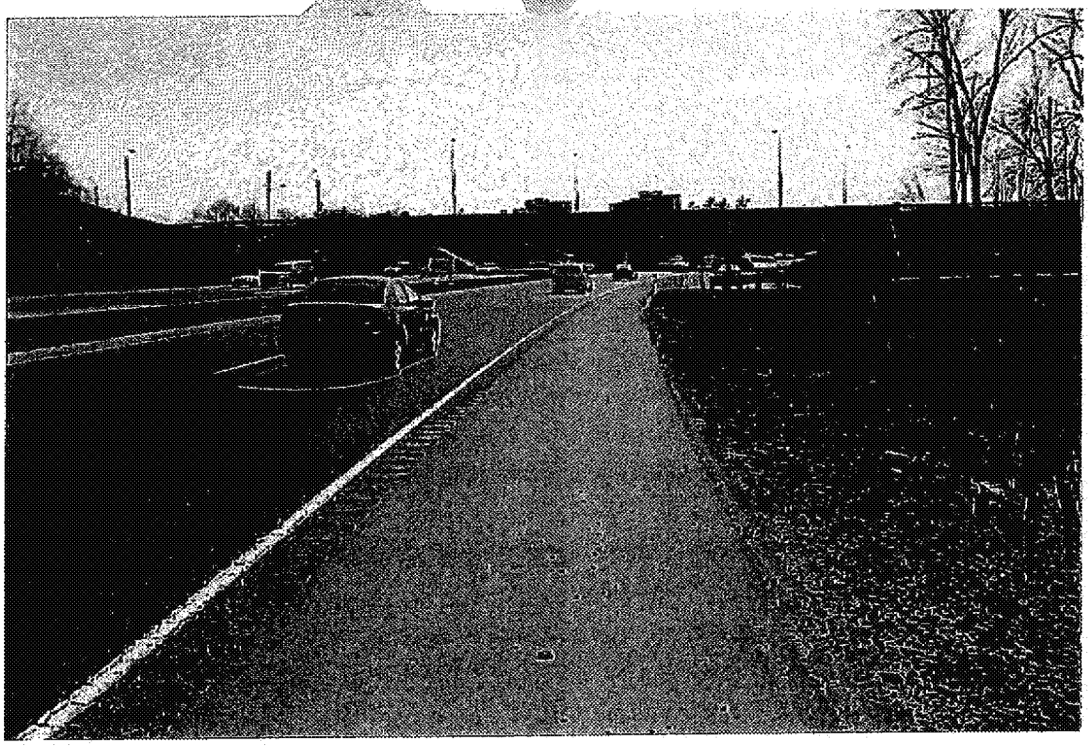


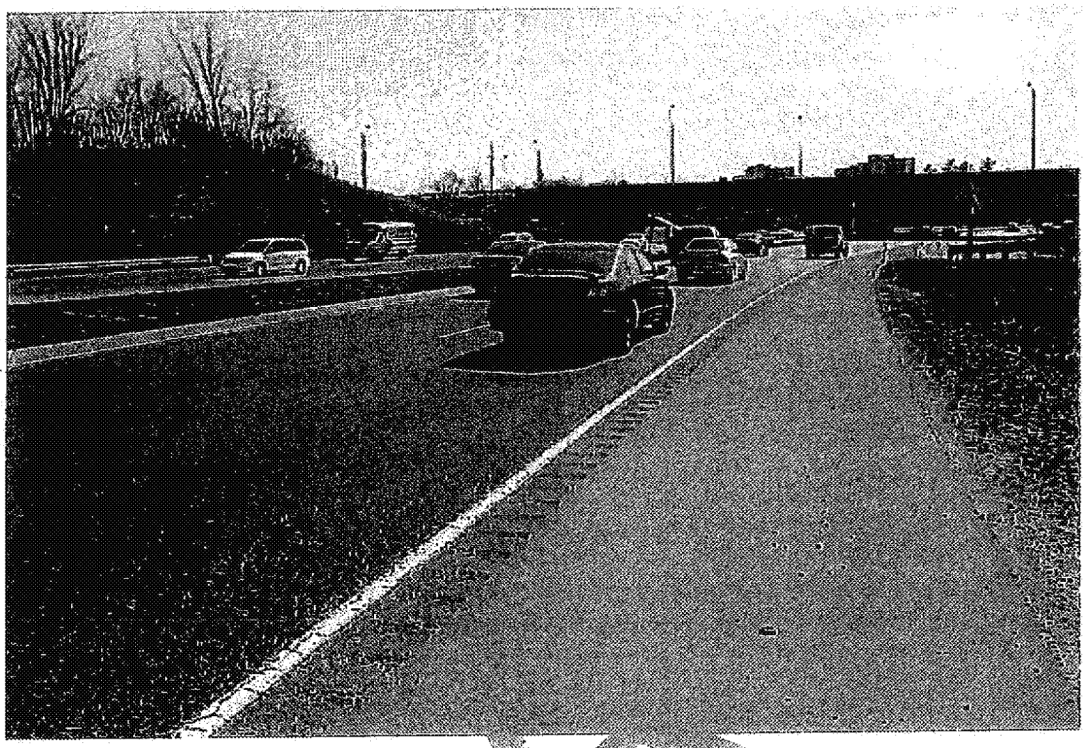












APPENDIX B

Core Photographs

APPENDIX B
CORE PHOTOGRAPHS

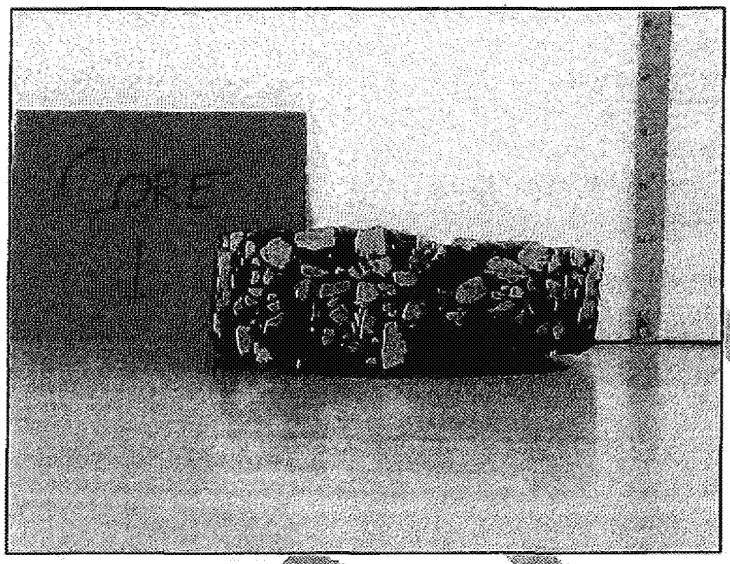


Photo 1: Side View of Core 1

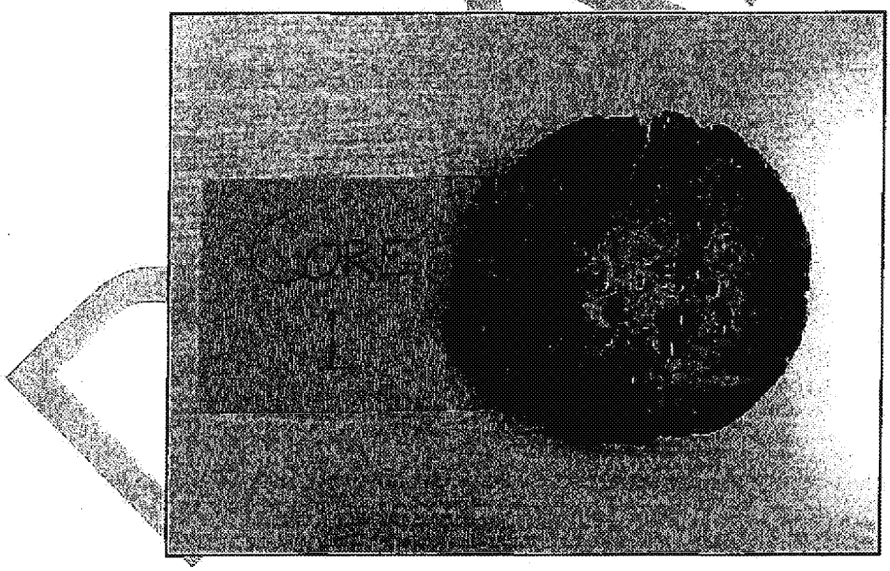


Photo 2: Top View of Core 1

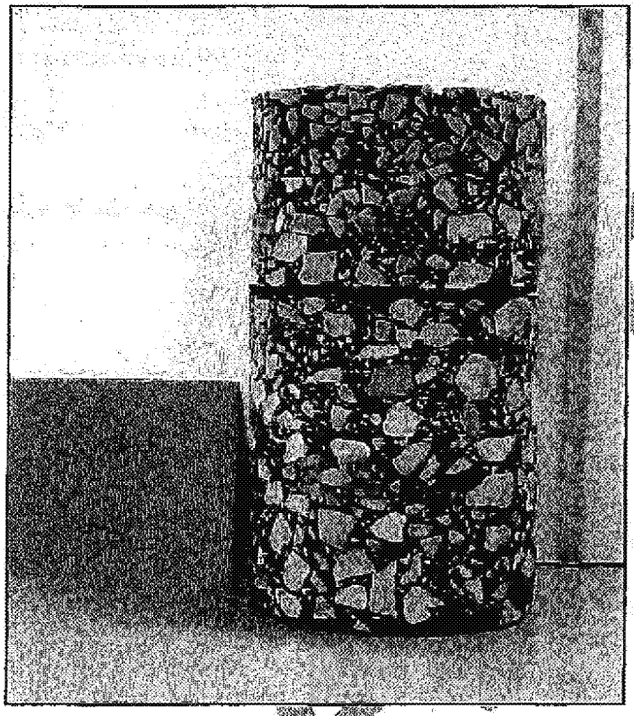


Photo 3: Side View of Core 2

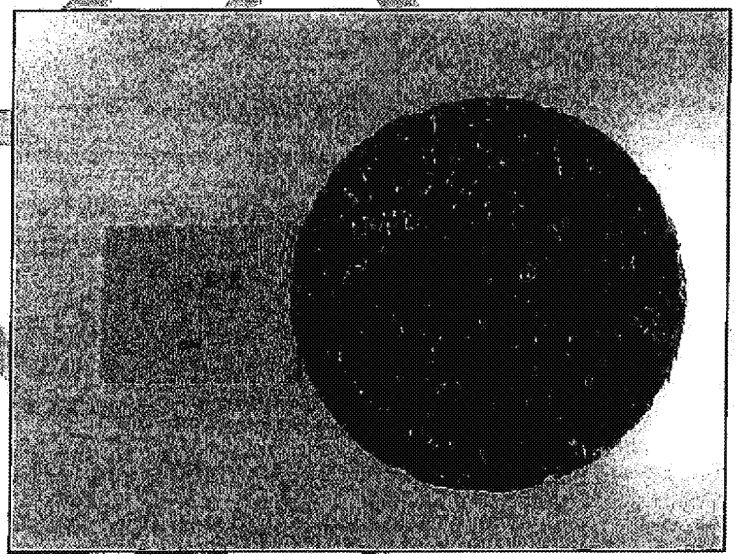


Photo 4: Top View of Core 2

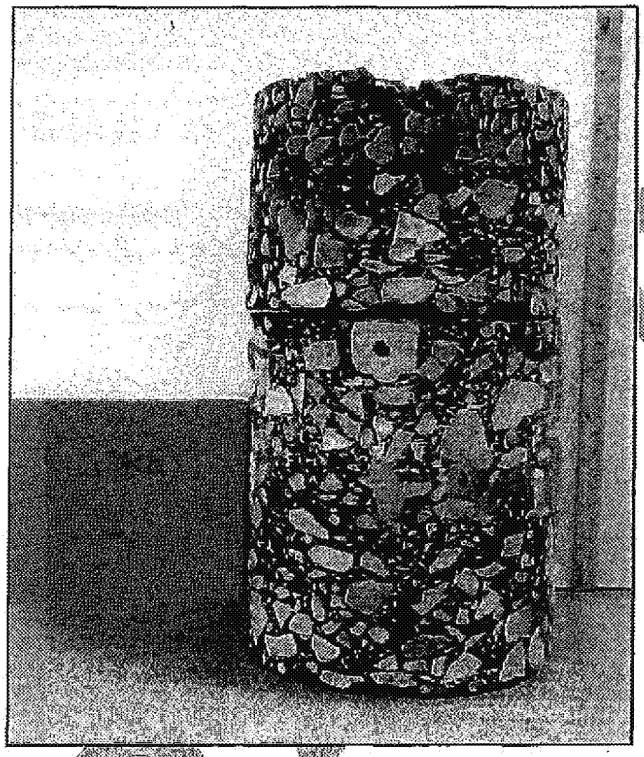


Photo 5: Side View of Core 3

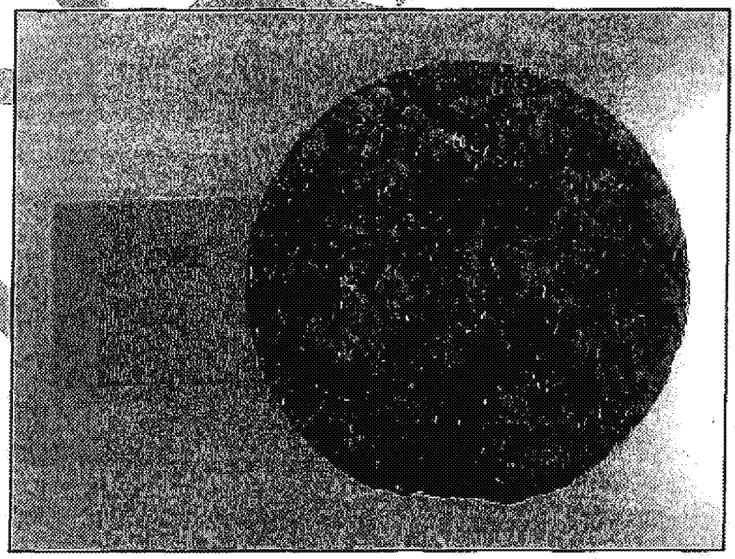


Photo 6: Top View of Core 3

APPENDIX B
CORE PHOTOGRAPHS

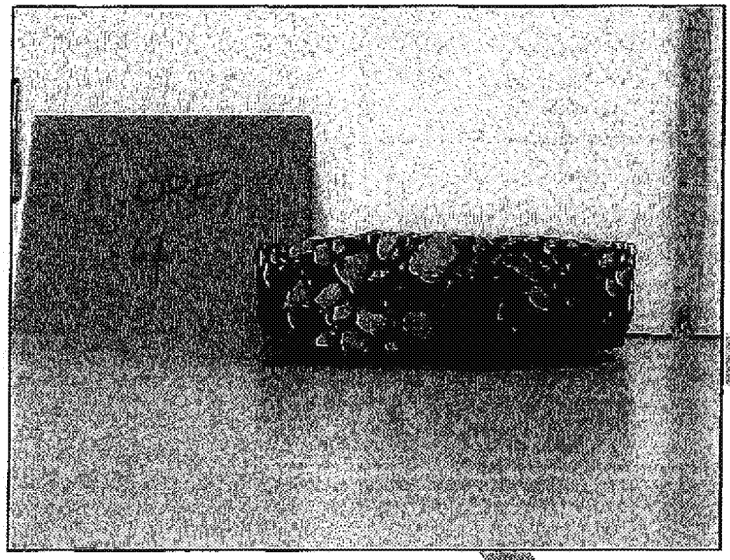


Photo 7: Side View of Core 4

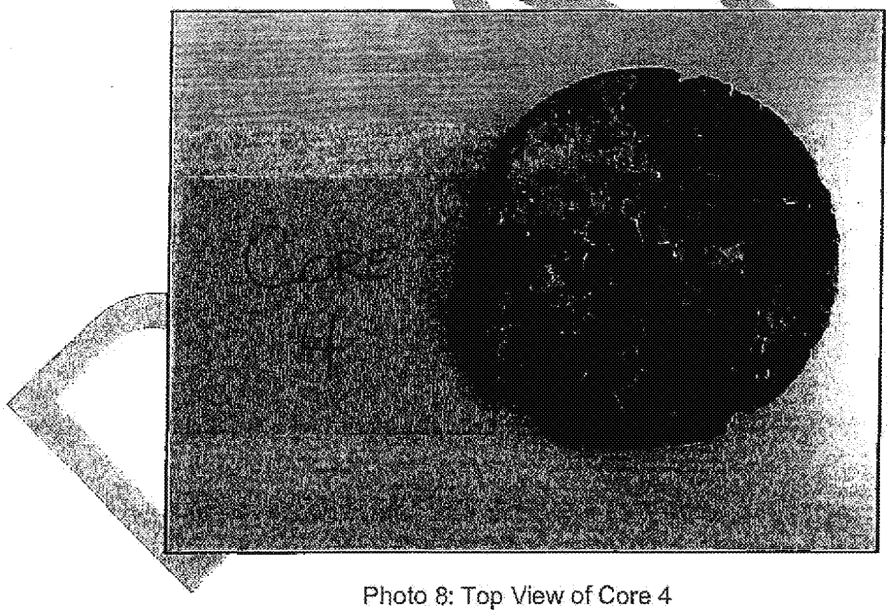


Photo 8: Top View of Core 4

APPENDIX C

Surface Profile Results

Highway: Red Hill Valley Parkway
Date Tested: May 9, 2013
Direction: S **Lane:** 1 **Length(km):** 7.8±

From (m)	To (m)	Sublot Length (m)	Run 1		Run 2		Run 3		IRI Average
			IRI Left	IRI Right	IRI Left	IRI Right	IRI Left	IRI Right	
10000	9900	100	1.68	1.65	1.77	1.67	1.96	3.17	
9900	9800	100	0.82	0.90	0.97	0.83	1.00	0.88	0.90
9800	9700	100	0.82	0.91	0.76	0.66	0.74	0.70	
9700	9600	100	1.62	1.53	1.72	1.51	1.63	1.52	
9600	9500	100	2.09	1.74	1.86	1.52	1.70	1.42	
9500	9400	100	1.99	2.22	2.23	2.36	2.33	2.37	
9400	9300	100	1.01	1.06	1.01	1.13	1.03	1.15	1.06
9300	9200	100	0.99	1.17	0.99	1.07	1.02	1.11	1.06
9200	9100	100	1.96	2.26	2.11	2.43	2.02	2.31	
9100	9000	100	1.51	1.47	1.44	1.48	1.48	1.52	
9000	8900	100	0.73	0.75	0.79	0.81	0.78	0.80	
8900	8800	100	0.83	0.71	0.81	0.71	0.81	0.70	
8800	8700	100	1.18	1.46	1.23	1.41	1.20	1.45	1.32
8700	8600	100	1.00	0.87	1.01	0.86	1.03	0.88	0.94
8600	8500	100	0.55	0.56	0.52	0.56	0.54	0.58	
8500	8400	100	0.84	0.67	0.84	0.66	0.80	0.64	
8400	8300	100	0.82	0.69	0.85	0.74	0.87	0.75	
8300	8200	100	0.70	0.66	0.69	0.65	0.70	0.63	
8200	8100	100	0.53	0.60	0.53	0.64	0.51	0.66	
8100	8000	100	0.82	0.67	0.75	0.60	0.72	0.64	
8000	7900	100	0.91	0.79	0.92	0.82	0.93	0.78	0.85
7900	7800	100	0.62	0.56	0.64	0.57	0.67	0.62	
7800	7700	100	0.71	0.72	0.70	0.72	0.71	0.72	
7700	7600	100	0.56	0.61	0.55	0.63	0.54	0.64	
7600	7500	100	0.62	0.60	0.63	0.60	0.62	0.59	
7500	7400	100	0.97	0.93	0.96	0.89	0.90	0.88	0.92
7400	7300	100	1.48	1.49	1.56	1.49	1.54	1.48	
7300	7200	100	0.86	0.73	0.83	0.70	0.82	0.66	
7200	7100	100	0.69	0.67	0.69	0.69	0.72	0.71	
7100	7000	100	0.75	0.72	0.75	0.73	0.73	0.72	
7000	6900	100	0.74	0.62	0.74	0.58	0.78	0.61	
6900	6800	100	0.74	0.75	0.77	0.82	0.77	0.81	
6800	6700	100	0.78	0.68	0.74	0.69	0.74	0.71	
6700	6600	100	0.86	0.84	0.85	0.83	0.85	0.83	
6600	6500	100	0.96	1.01	0.93	0.94	0.93	0.93	
6500	6400	100	0.76	0.81	0.78	0.83	0.79	0.82	
6400	6300	100	1.21	1.35	1.13	1.23	1.04	1.13	
6300	6200	100	0.75	0.80	0.80	0.91	0.89	0.94	
6200	6100	100	1.06	1.15	1.02	1.13	1.03	1.15	1.09

Highway: Red Hill Valley Parkway
Date Tested: May 9, 2013
Direction: S Lane: 1 Length(km): 7.8±

From (m)	To (m)	Sublot Length (m)	Run 1		Run 2		Run 3		IRI Average
			IRI Left	IRI Right	IRI Left	IRI Right	IRI Left	IRI Right	
6100	6000	100	1.28	1.05	1.29	1.03	1.31	1.08	1.17
6000	5900	100	2.03	2.07	2.08	2.12	2.08	2.09	2.08
5900	5800	100	0.60	0.51	0.56	0.47	0.53	0.46	0.52
5800	5700	100	0.58	0.55	0.62	0.57	0.65	0.60	0.60
5700	5600	100	0.73	0.65	0.62	0.61	0.59	0.60	0.63
5600	5500	100	0.81	0.72	0.89	0.77	0.93	0.75	0.81
5500	5400	100	0.75	0.55	0.73	0.54	0.73	0.56	0.64
5400	5300	100	0.98	1.21	0.99	1.18	1.02	1.19	1.10
5300	5200	100	0.65	0.66	0.69	0.72	0.68	0.69	0.68
5200	5100	100	0.74	0.77	0.63	0.73	0.64	0.72	0.71
5100	5000	100	0.72	0.75	0.78	0.78	0.79	0.78	0.77
5000	4900	100	0.55	0.55	0.59	0.56	0.62	0.57	0.57
4900	4800	100	0.60	0.57	0.58	0.54	0.59	0.57	0.57
4800	4700	100	0.75	0.70	0.74	0.71	0.75	0.70	0.72
4700	4600	100	0.59	0.68	0.61	0.66	0.61	0.68	0.64
4600	4501	100	0.61	0.66	0.61	0.63	0.62	0.65	0.63
4501	4401	100	0.72	0.75	0.72	0.71	0.71	0.69	0.72
4401	4301	100	0.68	0.57	0.69	0.63	0.67	0.64	0.65
4301	4201	100	0.54	0.56	0.53	0.56	0.53	0.56	0.55
4201	4101	100	0.53	0.56	0.54	0.54	0.56	0.55	0.55
4101	4001	100	1.10	1.12	1.17	1.14	1.17	1.13	1.14
4001	3901	100	1.00	0.81	1.03	0.85	0.97	0.80	0.91
3901	3801	100	1.14	1.17	0.88	0.89	0.84	0.80	0.95
3801	3701	100	0.75	0.88	1.05	1.12	1.11	1.22	1.02
3701	3601	100	0.71	0.60	0.71	0.62	0.74	0.60	0.66
3601	3501	100	0.78	0.62	0.84	0.63	0.85	0.63	0.72
3501	3401	100	0.90	0.71	0.90	0.72	0.87	0.74	0.81
3401	3301	100	0.80	0.84	0.84	0.76	0.83	0.76	0.80
3301	3201	100	1.08	0.84	1.18	0.92	1.18	0.86	1.01
3201	3101	100	1.16	1.11	1.21	1.19	1.16	1.18	1.17
3101	3001	100	1.00	0.83	0.96	0.78	0.98	0.79	0.89
3001	2901	100	1.11	0.99	1.06	0.94	1.03	0.96	1.02
2901	2801	100	0.75	0.83	0.74	0.85	0.76	0.84	0.80
2801	2701	100	1.44	1.57	1.49	1.57	1.39	1.57	1.51
2701	2601	100	0.65	0.73	0.69	0.69	0.69	0.67	0.69
2601	2501	100	1.01	0.92	1.04	0.88	1.01	0.90	0.96
2501	2401	100	0.98	0.92	0.97	1.03	0.98	0.98	0.98
2401	2301	100	1.08	0.91	1.04	0.88	1.07	0.90	0.98
2301	2207	94	0.92	0.89	0.93	0.86	0.87	0.87	0.89

Highway: Red Hill Valley Parkway
Date Tested: May 9, 2013

Direction:	Lane:	Length(km):
S	2	7.8±

From (m)	To (m)	Sublot Length (m)	Run 1		Run 2		Run 2		IRI Average
			IRI Left	IRI Right	IRI Left	IRI Right	IRI Left	IRI Right	
10000	**9900**	**100**	**2.37**	**1.27**	**1.55**	**1.09**	**2.43**	**1.41**	[illegible]
9900	9800	100	0.82	0.67	2.08	1.26	0.99	0.64	1.08
9800	**9700**	**100**	**0.83**	**0.76**	**0.81**	**0.73**	**0.81**	**0.76**	[illegible]
9700	9600	100	1.67	1.42	0.71	0.74	1.35	1.07	1.16
9600	**9500**	**100**	**2.20**	**2.52**	**1.68**	**1.43**	**1.64**	**1.81**	[illegible]
9500	9400	100	1.52	1.83	2.26	2.72	1.96	2.57	[illegible]
9400	**9300**	**100**	**0.99**	**1.38**	**1.36**	**1.57**	**1.09**	**1.53**	1.32
9300	9200	100	1.57	1.88	1.06	1.43	1.19	1.68	[illegible]
9200	**9100**	**100**	**2.29**	**2.25**	**1.55**	**1.90**	**2.54**	**2.55**	[illegible]
9100	9000	100	1.63	1.43	2.29	2.29	1.84	1.65	[illegible]
9000	**8900**	**100**	**1.06**	**1.11**	**1.62**	**1.34**	**1.05**	**1.16**	1.22
8900	8800	100	1.04	1.43	1.03	1.26	1.06	1.39	1.20
8800	**8700**	**100**	**2.07**	**2.20**	**1.10**	**1.49**	**2.10**	**2.28**	[illegible]
8700	8600	100	1.05	1.37	2.03	2.16	1.13	1.51	[illegible]
8600	**8500**	**100**	**0.79**	**0.75**	**1.03**	**1.25**	**0.78**	**0.74**	0.89
8500	8400	100	0.90	0.80	0.82	0.78	0.86	0.81	0.83
8400	**8300**	**100**	**0.93**	**0.85**	**0.88**	**0.86**	**0.92**	**0.80**	0.87
8300	8200	100	0.83	1.06	0.93	0.87	0.83	0.98	0.92
8200	**8100**	**100**	**0.77**	**0.77**	**0.83**	**1.05**	**0.79**	**0.75**	0.83
8100	8000	100	0.91	0.88	0.75	0.81	0.89	0.92	0.86
8000	**7900**	**100**	**0.88**	**0.96**	**0.88**	**0.82**	**0.91**	**0.95**	0.90
7900	7800	100	0.99	0.99	0.89	0.87	1.06	0.98	0.96
7800	**7700**	**100**	**0.83**	**0.78**	**0.98**	**1.06**	**0.80**	**0.85**	0.88
7700	7600	100	0.66	0.76	0.83	0.75	0.74	0.69	0.74
7600	**7500**	**100**	**0.83**	**0.81**	**0.73**	**0.86**	**0.71**	**0.80**	0.79
7500	7400	100	1.06	1.03	0.85	0.80	0.96	0.89	0.93
7400	**7300**	**100**	**1.26**	**1.01**	**1.10**	**1.13**	**1.38**	**1.18**	1.18
7300	7200	100	0.80	0.76	1.09	0.94	0.77	0.84	0.87

Highway: Red Hill Valley Parkway
Date Tested: May 9, 2013

Direction:	Lane:	Length(km):
S	2	7.8±

From (m)	To (m)	Sublot Length (m)	Run 1		Run 2		Run 2		IRI Average
			IRI Left	IRI Right	IRI Left	IRI Right	IRI Left	IRI Right	
7200	**7100**	**100**	**0.79**	**0.74**	**0.78**	**0.75**	**0.73**	**0.61**	0.74
7100	7000	100	0.99	1.27	0.72	0.72	0.81	0.75	0.88
7000	**6900**	**100**	**0.86**	**0.77**	**0.98**	**1.19**	**0.99**	**1.17**	0.99
6900	6800	100	0.87	0.72	0.90	0.70	0.85	0.62	0.77
6800	**6700**	**100**	**1.14**	**1.23**	**0.91**	**0.77**	**0.96**	**0.89**	0.98
6700	6600	100	1.18	1.03	1.10	1.27	1.07	1.21	1.14
6600	**6500**	**100**	**1.03**	**0.94**	**1.24**	**1.03**	**1.25**	**1.07**	1.09
6500	6400	100	1.03	0.81	1.03	0.94	1.01	0.92	0.96
6400	**6300**	**100**	**1.35**	**1.17**	**1.00**	**0.79**	**1.32**	**1.15**	1.13
6300	6200	100	1.10	0.88	1.31	1.14	1.06	0.76	1.04
6200	**6100**	**100**	**1.49**	**1.44**	**1.16**	**0.96**	**1.51**	**1.47**	1.34
6100	6000	100	1.21	1.30	1.57	1.47	1.34	1.33	1.37
6000	**5900**	**100**	**2.14**	**2.05**	**1.05**	**1.24**	**2.23**	**2.21**	1.90
5900	5800	100	0.74	0.66	2.09	1.99	0.65	0.50	1.11
5800	**5700**	**100**	**0.92**	**0.67**	**0.73**	**0.71**	**0.83**	**0.80**	0.78
5700	5600	100	0.85	0.92	0.90	0.63	0.82	0.79	0.82
5600	**5500**	**100**	**0.95**	**0.85**	**0.91**	**0.98**	**0.99**	**0.98**	0.94
5500	5400	100	0.84	1.04	0.91	0.83	0.82	0.98	0.90
5400	**5300**	**100**	**1.43**	**1.63**	**0.84**	**1.11**	**1.50**	**1.66**	1.36
5300	5200	100	0.62	0.62	1.47	1.64	0.69	0.76	0.97
5200	**5100**	**100**	**0.96**	**1.12**	**0.63**	**0.60**	**0.69**	**0.75**	0.79
5100	5000	100	0.88	0.80	0.99	1.16	1.07	1.10	1.00
5000	**4900**	**100**	**0.65**	**0.61**	**0.87**	**0.82**	**0.76**	**0.69**	0.73
4900	4800	100	0.71	0.64	0.60	0.55	0.62	0.58	0.62
4800	**4700**	**100**	**0.68**	**0.82**	**0.72**	**0.66**	**0.70**	**0.80**	0.73
4700	4600	100	0.73	0.81	0.68	0.90	0.74	0.80	0.78
4600	**4501**	**100**	**0.81**	**0.76**	**0.77**	**0.77**	**0.83**	**0.73**	0.78
4501	4401	100	0.78	0.90	0.76	0.73	0.74	0.90	0.80

Highway: Red Hill Valley Parkway
Date Tested: May 9, 2013

Direction:	Lane:	Length(km):
S	2	7.8±

From (m)	To (m)	Sublot Length (m)	Run 1		Run 2		Run 2		IRI Average
			IRI Left	IRI Right	IRI Left	IRI Right	IRI Left	IRI Right	
4401	**4301**	**100**	**0.74**	**0.59**	**0.70**	**0.86**	**0.77**	**0.66**	0.72
4301	4201	100	0.69	0.59	0.72	0.56	0.68	0.54	0.63
4201	**4101**	**100**	**0.71**	**0.70**	**0.68**	**0.69**	**0.67**	**0.72**	0.70
4101	4001	100	1.32	1.37	0.72	0.62	1.34	1.30	1.11
4001	**3901**	**100**	**0.85**	**0.84**	**1.35**	**1.38**	**0.82**	**0.81**	1.01
3901	3801	100	1.18	1.28	0.86	0.85	0.79	0.82	0.96
3801	**3701**	**100**	**0.80**	**0.75**	**1.13**	**1.30**	**1.18**	**1.31**	1.08
3701	3601	100	0.80	0.74	0.84	0.75	0.85	0.76	0.79
3601	**3501**	**100**	**0.73**	**0.63**	**0.76**	**0.73**	**0.65**	**0.57**	0.68
3501	3401	100	0.96	0.90	0.79	0.67	0.88	0.78	0.83
3401	**3301**	**100**	**0.90**	**0.99**	**0.94**	**0.87**	**0.95**	**0.98**	0.94
3301	3201	100	1.05	0.95	0.92	1.06	1.11	1.13	1.04
3201	**3101**	**100**	**0.96**	**1.03**	**1.05**	**0.88**	**0.97**	**0.92**	0.97
3101	3001	100	1.30	1.04	1.00	1.00	1.12	1.08	1.09
3001	**2901**	**100**	**1.03**	**1.10**	**1.33**	**1.11**	**1.03**	**1.02**	1.10
2901	2801	100	0.77	0.92	0.96	1.01	0.86	0.94	0.91
2801	**2701**	**100**	**1.70**	**1.92**	**0.83**	**0.97**	**1.73**	**1.94**	1.67
2701	2601	100	0.73	0.84	1.71	1.82	0.73	0.83	1.11
2601	**2501**	**100**	**0.83**	**1.07**	**0.72**	**0.86**	**0.78**	**0.84**	0.85
2501	2470	31	0.81	0.78	0.82	1.02	0.83	1.07	0.89

Highway: Red Hill Valley Parkway
Date Tested: May 9, 2013
Direction: N **Lane:** 1 **Length(km):** 7.8±

From (m)	To (m)	Sublot Length (m)	Run 1		Run 2		Run 2		IRI Average
			IRI Left	IRI Right	IRI Left	IRI Right	IRI Left	IRI Right	
2300	**2400**	**100**	**1.19**	**1.30**	**1.16**	**1.42**	**1.29**	**1.40**	1.29
2400	2500	100	1.24	1.18	1.29	1.20	1.21	1.16	1.21
2500	**2600**	**100**	**1.48**	**1.06**	**1.49**	**1.10**	**1.52**	**1.11**	1.30
2600	2700	100	1.00	1.05	1.01	1.09	1.06	1.04	1.04
2700	**2800**	**100**	**1.25**	**1.31**	**1.27**	**1.32**	**1.29**	**1.29**	1.29
2800	2900	100	1.66	1.60	1.79	1.62	1.55	1.63	1.64
2900	**3000**	**100**	**0.86**	**1.31**	**0.98**	**1.28**	**0.89**	**1.26**	1.10
3000	3100	100	1.12	0.98	1.14	0.96	1.05	0.94	1.03
3100	**3200**	**100**	**1.11**	**1.07**	**1.10**	**1.07**	**1.10**	**1.11**	1.09
3200	3300	100	1.30	1.02	1.23	1.03	1.32	1.03	1.16
3300	**3400**	**100**	**1.15**	**0.94**	**1.17**	**0.95**	**1.11**	**0.95**	1.04
3400	3500	100	0.88	0.64	0.87	0.66	0.85	0.66	0.76
3500	**3600**	**100**	**0.88**	**0.80**	**0.89**	**0.80**	**0.93**	**0.75**	0.84
3600	3700	100	0.91	0.80	0.93	0.79	0.90	0.78	0.85
3700	**3800**	**100**	**1.83**	**1.28**	**1.76**	**1.36**	**1.73**	**1.24**	1.53
3800	3900	100	1.10	0.79	1.06	0.72	1.19	0.80	0.94
3900	**4000**	**100**	**0.69**	**0.64**	**0.68**	**0.65**	**0.65**	**0.62**	0.66
4000	4100	100	1.74	1.16	1.77	1.15	1.74	1.17	1.45
4100	**4200**	**100**	**0.49**	**0.46**	**0.52**	**0.46**	**0.51**	**0.46**	0.48
4200	4300	100	0.53	0.45	0.53	0.45	0.56	0.47	0.50
4300	**4400**	**100**	**0.78**	**0.58**	**0.79**	**0.61**	**0.79**	**0.63**	0.70
4400	4500	100	0.72	0.65	0.81	0.66	0.71	0.61	0.69
4500	**4600**	**100**	**1.29**	**0.68**	**1.34**	**0.71**	**1.40**	**0.72**	1.02
4600	4700	100	1.11	0.70	1.17	0.73	1.10	0.68	0.92
4700	**4800**	**100**	**0.90**	**0.63**	**0.90**	**0.68**	**0.88**	**0.68**	0.76
4800	4900	100	0.78	0.70	0.76	0.67	0.77	0.65	0.72
4900	**5000**	**100**	**0.61**	**0.64**	**0.65**	**0.61**	**0.66**	**0.62**	0.63
5000	5100	100	0.51	0.55	0.51	0.55	0.52	0.54	0.53

Highway: Red Hill Valley Parkway
Date Tested: May 9, 2013
Direction: N **Lane:** 1 **Length(km):** 7.8±

From (m)	To (m)	Sublot Length (m)	Run 1		Run 2		Run 2		IRI Average
			IRI Left	IRI Right	IRI Left	IRI Right	IRI Left	IRI Right	
5100	**5200**	**100**	**0.51**	**0.53**	**0.55**	**0.53**	**0.56**	**0.53**	0.54
5200	5300	100	1.17	1.18	1.19	1.16	1.21	1.12	1.17
5300	**5400**	**100**	**0.86**	**0.66**	**0.84**	**0.68**	**0.85**	**0.70**	0.77
5400	5500	100	0.55	0.52	0.54	0.54	0.55	0.52	0.53
5500	**5600**	**100**	**1.45**	**1.15**	**1.50**	**1.19**	**1.46**	**1.17**	1.32
5600	5700	100	0.54	0.61	0.59	0.60	0.56	0.57	0.58
5700	**5800**	**100**	**0.53**	**0.57**	**0.54**	**0.57**	**0.55**	**0.60**	0.56
5800	5900	100	0.55	0.63	0.57	0.63	0.54	0.62	0.59
5900	**6000**	**100**	**1.43**	**1.08**	**1.49**	**1.10**	**1.45**	**1.11**	1.28
6000	6100	100	1.55	1.61	1.54	1.63	1.57	1.60	1.58
6100	**6200**	**100**	**0.88**	**0.76**	**0.85**	**0.78**	**0.89**	**0.77**	0.82
6200	6300	100	0.66	0.75	0.70	0.73	0.68	0.73	0.71
6300	**6400**	**100**	**0.78**	**0.65**	**0.81**	**0.72**	**0.77**	**0.63**	0.73
6400	6500	100	0.61	0.60	0.66	0.56	0.61	0.58	0.60
6500	**6600**	**100**	**0.89**	**0.79**	**0.86**	**0.77**	**0.86**	**0.81**	0.83
6600	6700	100	0.82	0.63	0.82	0.64	0.82	0.64	0.73
6700	**6800**	**100**	**1.67**	**1.15**	**1.65**	**1.14**	**1.67**	**1.18**	1.41
6800	6900	100	0.92	0.70	0.84	0.73	0.81	0.77	0.79
6900	**7000**	**100**	**1.52**	**1.79**	**1.46**	**1.74**	**1.47**	**1.73**	1.62
7000	7100	100	0.78	0.71	0.81	0.72	0.77	0.71	0.75
7100	**7200**	**100**	**0.90**	**0.84**	**0.91**	**0.86**	**0.90**	**0.83**	0.87
7200	7300	100	0.90	0.82	0.86	0.78	0.89	0.85	0.85
7300	**7400**	**100**	**0.69**	**0.54**	**0.75**	**0.53**	**0.70**	**0.54**	0.62
7400	7500	100	1.11	0.80	1.04	0.77	1.06	0.76	0.92
7500	**7600**	**100**	**0.60**	**0.53**	**0.58**	**0.55**	**0.59**	**0.55**	0.57
7600	7700	100	0.62	0.50	0.58	0.48	0.61	0.50	0.55
7700	**7800**	**100**	**0.66**	**0.57**	**0.62**	**0.55**	**0.63**	**0.58**	0.60
7800	7900	100	0.75	0.74	0.82	0.82	0.75	0.72	0.77

Highway: Red Hill Valley Parkway
Date Tested: May 9, 2013

Direction:	Lane:	Length(km):
N	1	7.8±

From (m)	To (m)	Sublot Length (m)	Run 1		Run 2		Run 2		IRI Average
			IRI Left	IRI Right	IRI Left	IRI Right	IRI Left	IRI Right	
7900	8000	100	0.91	0.84	0.88	0.80	0.93	0.79	0.86
8000	8100	100	0.68	0.68	0.68	0.67	0.69	0.68	0.68
8100	8200	100	0.88	0.72	0.88	0.69	0.94	0.73	0.81
8200	8300	100	0.62	0.53	0.64	0.55	0.60	0.53	0.58
8300	8400	100	0.78	0.82	0.77	0.81	0.79	0.80	0.80
8400	8500	100	0.79	0.72	0.76	0.71	0.83	0.69	0.75
8500	8600	100	0.67	0.63	0.71	0.67	0.66	0.62	0.66
8600	8700	100	0.87	0.70	0.96	0.80	0.90	0.71	0.82
8700	8800	100	2.03	1.76	1.90	1.62	2.02	1.78	1.89
8800	8900	100	0.81	0.87	0.83	0.81	0.83	0.87	0.84
8900	9000	100	2.38	2.15	2.41	2.21	2.39	2.17	2.28
9000	9100	100	0.86	0.81	1.11	0.86	0.86	0.79	0.88
9100	9200	100	2.25	1.86	1.96	1.78	2.16	1.92	2.00
9200	9300	100	1.40	1.03	1.39	1.12	1.33	1.00	1.21
9300	9400	100	1.21	1.08	1.21	1.04	1.21	1.10	1.14
9400	9500	100	1.95	1.83	2.05	1.96	1.96	1.83	1.90
9500	9600	100	2.19	1.86	2.17	1.80	2.18	1.85	2.01
9600	9700	100	1.64	1.67	1.65	1.66	1.62	1.67	1.65
9700	9800	100	1.73	1.14	1.77	1.08	1.74	1.16	1.44
9800	9900	85	1.68	0.93	1.64	0.89	1.54	0.86	1.26

Highway: Red Hill Valley Parkway
Date Tested: May 9, 2013
Direction: N **Lane:** 2 **Length(km):** 7.8±

From (m)	To (m)	Sublot Length (m)	Run 1		Run 2		Run 3		IRI Average
			IRI Left	IRI Right	IRI Left	IRI Right	IRI Left	IRI Right	
2300	**2400.00**	**100**	**1.73**	**1.65**	**1.22**	**0.92**	**1.23**	**0.95**	1.28
2400	2500.00	100	1.46	1.46	0.98	1.15	1.00	1.15	1.20
2500	**2600.00**	**100**	**0.80**	**0.94**	**0.87**	**0.90**	**0.86**	**0.86**	0.87
2600	2700.00	100	0.75	0.87	0.86	0.89	0.85	0.91	0.85
2700	**2800.00**	**100**	**0.63**	**0.84**	**0.83**	**0.80**	**0.83**	**0.81**	0.79
2800	2900.00	100	0.60	0.61	1.58	1.99	1.56	1.65	1.33
2900	**3000.00**	**100**	**1.29**	**0.98**	**1.10**	**1.66**	**1.06**	**1.58**	1.28
3000	3100.00	100	1.01	1.09	1.10	1.77	1.06	1.08	1.18
3100	**3200.00**	**100**	**0.91**	**1.05**	**0.79**	**1.43**	**0.81**	**1.37**	1.06
3200	3300.00	100	0.84	0.82	1.16	1.20	1.17	1.23	1.07
3300	**3400.00**	**100**	**0.88**	**0.76**	**0.92**	**1.43**	**0.91**	**1.25**	1.02
3400	3500.00	100	1.65	1.73	0.73	0.78	0.73	0.79	1.07
3500	**3600.00**	**100**	**1.02**	**1.55**	**0.95**	**0.93**	**0.91**	**0.96**	1.05
3600	3700.00	100	1.05	1.69	1.09	1.14	1.10	1.17	1.21
3700	**3800.00**	**100**	**0.91**	**1.28**	**1.87**	**2.11**	**1.87**	**2.08**	1.69
3800	3900.00	100	1.10	1.33	0.91	0.85	0.89	0.82	0.98
3900	**4000.00**	**100**	**0.83**	**1.07**	**0.91**	**0.67**	**0.84**	**0.70**	0.84
4000	4100.00	100	0.80	0.87	1.78	1.39	1.78	1.41	1.34
4100	**4200.00**	**100**	**0.93**	**0.93**	**0.94**	**0.79**	**0.94**	**0.76**	0.88
4200	4300.00	100	1.06	1.23	0.80	0.72	0.80	0.77	0.90
4300	**4400.00**	**100**	**2.01**	**2.17**	**0.69**	**0.70**	**0.68**	**0.71**	1.16
4400	4500.00	100	0.69	0.59	0.79	0.88	0.81	0.93	0.78
4500	**4600.00**	**100**	**1.11**	**0.90**	**0.82**	**1.06**	**0.80**	**1.05**	0.96
4600	4700.00	100	1.56	1.24	0.82	1.07	0.84	1.06	1.10
4700	**4800.00**	**100**	**0.94**	**0.73**	**0.86**	**0.78**	**0.87**	**0.73**	0.82
4800	4900.00	100	0.72	0.75	0.91	0.83	0.92	0.85	0.83
4900	**5000.00**	**100**	**0.68**	**0.78**	**0.87**	**1.12**	**0.87**	**1.05**	0.89
5000	5100.00	100	0.85	0.90	0.85	0.82	0.88	0.84	0.86

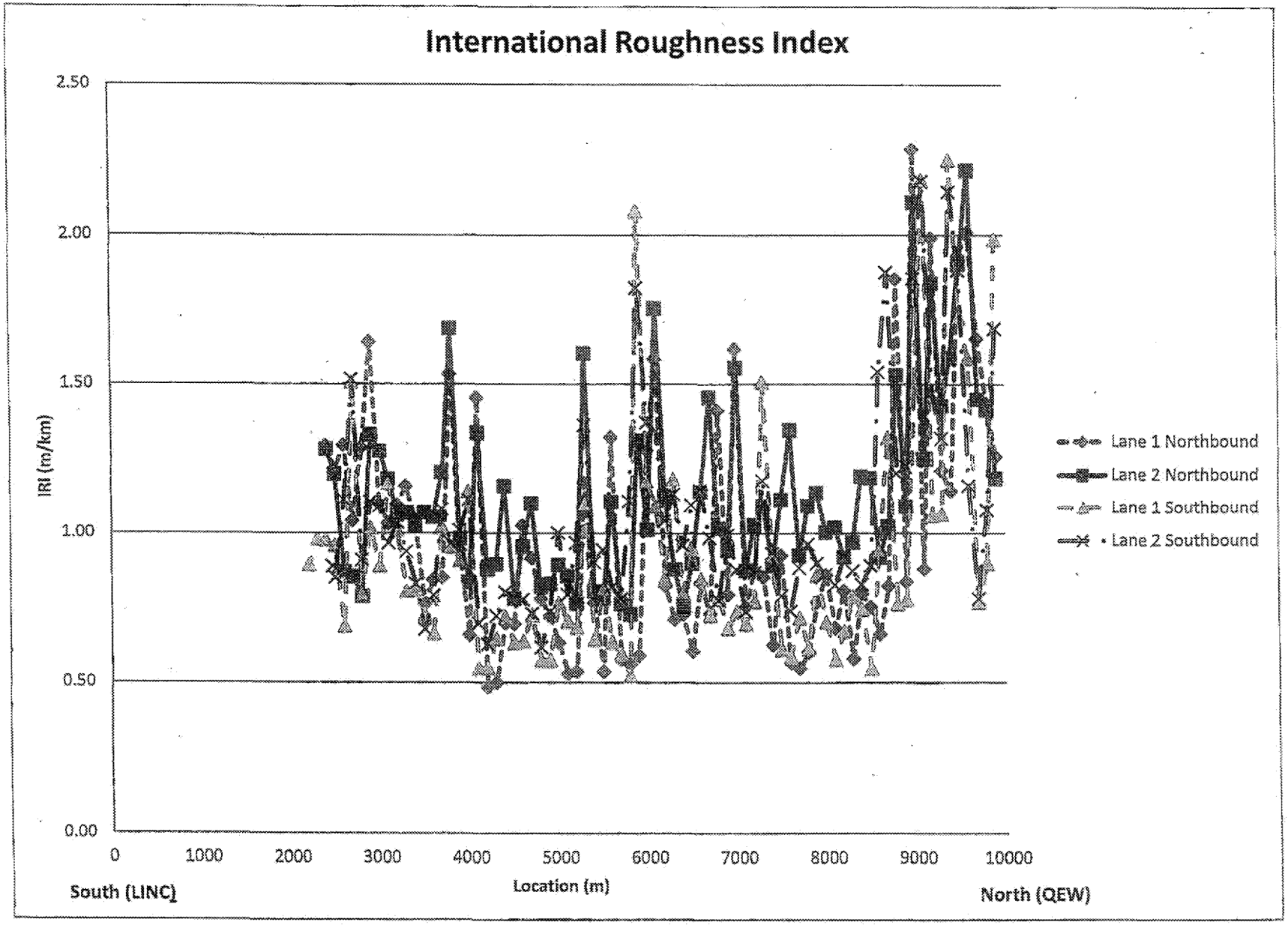
Highway: Red Hill Valley Parkway
Date Tested: May 9, 2013

Direction:	Lane:	Length(km):
N	2	7.8±

From (m)	To (m)	Sublot Length (m)	Run 1		Run 2		Run 3		IRI Average
			IRI Left	IRI Right	IRI Left	IRI Right	IRI Left	IRI Right	
5100	**5200.00**	**100**	**0.75**	**1.04**	**0.73**	**0.66**	**0.72**	**0.68**	0.76
5200	5300.00	100	0.91	0.98	1.82	2.08	1.82	2.03	1.61
5300	**5400.00**	**100**	**0.89**	**0.69**	**0.81**	**0.79**	**0.83**	**0.83**	0.81
5400	5500.00	100	0.96	0.91	0.73	0.66	0.75	0.67	0.78
5500	**5600.00**	**100**	**0.87**	**1.06**	**1.16**	**1.16**	**1.19**	**1.20**	1.11
5600	5700.00	100	0.87	0.77	0.73	0.75	0.72	0.74	0.76
5700	**5800.00**	**100**	**0.69**	**0.65**	**0.71**	**0.81**	**0.71**	**0.80**	0.73
5800	5900.00	100	1.81	2.08	1.03	0.93	0.99	1.09	1.31
5900	**6000.00**	**100**	**0.84**	**0.80**	**1.13**	**1.10**	**1.14**	**1.06**	1.01
6000	6100.00	100	0.72	0.61	2.23	2.30	2.32	2.35	1.76
6100	**6200.00**	**100**	**1.24**	**1.25**	**1.16**	**1.08**	**1.05**	**0.98**	1.13
6200	6300.00	100	0.67	0.76	0.97	0.96	0.96	0.95	0.88
6300	**6400.00**	**100**	**0.75**	**0.85**	**0.82**	**0.62**	**0.84**	**0.65**	0.75
6400	6500.00	100	1.04	0.90	0.82	0.90	0.84	0.90	0.90
6500	**6600.00**	**100**	**1.31**	**1.29**	**1.04**	**1.09**	**1.00**	**1.09**	1.14
6600	6700.00	100	2.29	2.29	1.02	1.03	1.06	1.04	1.45
6700	**6800.00**	**100**	**0.92**	**0.88**	**1.06**	**1.07**	**1.08**	**1.09**	1.02
6800	6900.00	100	1.00	0.94	0.84	1.04	0.83	1.02	0.94
6900	**7000.00**	**100**	**0.89**	**0.80**	**2.04**	**1.78**	**2.07**	**1.76**	1.59
7000	7100.00	100	0.81	0.78	0.88	0.93	0.92	0.93	0.88
7100	**7200.00**	**100**	**1.19**	**1.27**	**0.95**	**0.88**	**0.97**	**0.90**	1.03
7200	7300.00	100	0.95	0.91	1.21	1.14	1.24	1.09	1.09
7300	**7400.00**	**100**	**1.02**	**0.97**	**0.90**	**0.77**	**0.91**	**0.79**	0.89
7400	7500.00	100	0.87	1.15	1.17	1.15	1.18	1.16	1.11
7500	**7600.00**	**100**	**2.06**	**1.69**	**1.02**	**1.19**	**1.05**	**1.08**	1.35
7600	7700.00	100	0.95	0.88	0.99	0.86	1.01	0.86	0.93
7700	**7800.00**	**100**	**1.05**	**1.00**	**1.04**	**1.17**	**1.06**	**1.23**	1.09
7800	7900.00	100	1.09	0.94	1.18	1.15	1.23	1.22	1.14

Highway: Red Hill Valley Parkway
Date Tested: May 9, 2013
Direction: N **Lane:** 2 **Length(km):** 7.8±

From (m)	To (m)	Sublot Length (m)	Run 1		Run 2		Run 3		IRI Average
			IRI Left	IRI Right	IRI Left	IRI Right	IRI Left	IRI Right	
7900	8000.00	100	1.01	0.85	1.06	1.06	1.06	0.99	1.00
8000	8100.00	100	1.18	1.29	0.83	1.04	0.80	0.97	1.02
8100	8200.00	100	1.01	1.03	0.78	0.91	0.80	0.99	0.92
8200	8300.00	100	0.98	0.86	0.94	1.09	0.95	1.01	0.97
8300	8400.00	100	1.05	1.20	1.27	1.15	1.27	1.21	1.19
8400	8500.00	100	1.21	1.20	1.07	1.30	1.05	1.30	1.19
8500	8600.00	100	1.02	1.11	0.94	0.73	0.98	0.73	0.92
8600	8700.00	100	0.83	0.99	1.02	1.09	1.04	1.17	1.02
8700	8800.00	100	0.78	0.99	1.81	1.97	1.72	1.93	1.53
8800	8900.00	100	0.98	0.99	1.03	1.15	1.10	1.29	1.09
8900	9000.00	100	1.12	1.11	2.31	2.88	2.39	2.85	2.11
9000	9100.00	100	1.09	1.32	1.29	1.30	1.26	1.25	1.25
9100	9200.00	100	1.09	0.92	2.26	2.24	2.27	2.25	2.00
9200	9300.00	100	1.70	1.80	1.16	1.35	1.18	1.40	1.43
9300	9400.00	100	1.01	1.20	1.73	1.92	1.72	1.98	1.59
9400	9500.00	100	1.18	1.37	1.94	2.40	2.02	2.50	1.90
9500	9600.00	100	2.36	2.90	2.06	1.99	2.05	1.93	2.22
9600	9700.00	100	1.33	1.25	1.53	1.55	1.58	1.47	1.45
9700	9800.00	100	2.04	2.17	1.16	0.99	1.15	0.97	1.42
9800	9900.00	100	1.24	1.44	1.20	1.24	1.14	0.86	1.19


International Roughness Index
2.50
2.00
1.50
1.00
0.50
0.00
IRI (m/km)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
South (LINC)
Location (m)
North (QEW)
Lane 1 Northbound
Lane 2 Northbound
Lane 1 Southbound
Lane 2 Southbound

APPENDIX D

Falling Weight Deflectometer Results

TABLE D-1
RED HILL VALLEY PARKWAY
NORTHBOUND LANE 1
SUMMARY OF FWD DEFLECTION RESULTS

STATION (km)	NORMALIZED DEFLECTION (mm)	PAVEMENT SURFACE MODULUS (MPa)
3.150	0.18	797
3.250	0.20	739
3.350	0.22	666
3.450	0.22	674
3.550	0.18	824
3.650	0.23	650
3.750	0.16	917
3.850	0.11	1358
3.950	0.10	1404
4.050	0.14	1032
4.150	0.14	1077
4.251	0.16	923
4.350	0.09	1629
4.450	0.24	612
4.550	0.15	960
4.650	0.18	819
4.750	0.18	821
4.850	0.20	738
4.951	0.19	761
5.050	0.23	649
5.150	0.17	854
5.250	0.17	881
5.350	0.17	869
5.450	0.16	943
5.550	0.15	976
5.650	0.17	883
5.751	0.19	768
5.850	0.13	1144
5.950	0.16	924
6.050	0.17	872
6.150	0.15	964
6.251	0.14	1014
6.351	0.12	1230
6.450	0.21	712
6.550	0.18	837
6.650	0.19	783
6.750	0.15	1005
6.850	0.11	1302
6.950	0.16	937
7.050	0.14	1026

TABLE D-1
RED HILL VALLEY PARKWAY
NORTHBOUND LANE 1
SUMMARY OF FWD DEFLECTION RESULTS

STATION (km)	NORMALIZED DEFLECTION (mm)	PAVEMENT SURFACE MODULUS (MPa)
7.150	0.14	1084
7.251	0.13	1158
7.350	0.09	1571
7.450	0.14	1059
7.550	0.15	977
7.650	0.15	960
7.750	0.13	1174
7.850	0.15	951
7.951	0.13	1171
8.050	0.12	1222
8.150	0.15	967
8.250	0.12	1185
8.350	0.15	1013
8.451	0.19	783
8.550	0.17	862
8.651	0.15	964
8.750	0.15	965
8.851	0.15	953
8.950	0.12	1218
9.050	0.15	990
9.150	0.17	856
9.250	0.17	872
9.350	0.13	1173
9.450	0.13	1104
9.550	0.13	1148
9.650	0.15	953
9.750	0.12	1227
9.851	0.12	1212
9.950	0.15	974
Mean	0.16	981
Standard Deviation	0.03	206
Mean + 2SD	0.22	-
Static Deflection	0.35	-
Spring Deflection	0.53	-

FIGURE D-1A
RED HILL VALLEY PARKWAY
NORTHBOUND LANE 1
PAVEMENT FWD DEFLECTION

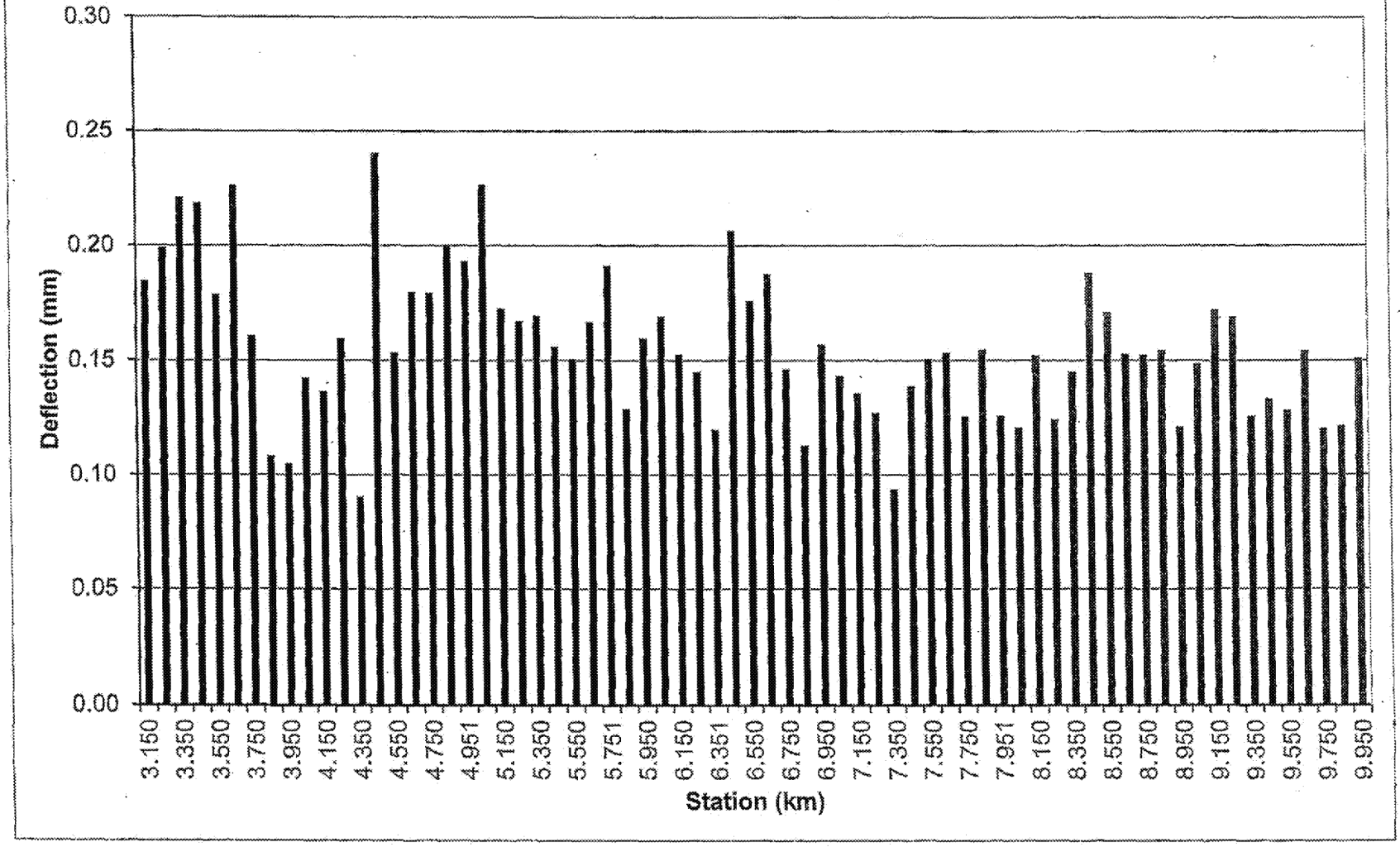


FIGURE D-1B
RED HILL VALLEY PARKWAY
NORTHBOUND LANE 1
PAVEMENT SURFACE MODULUS

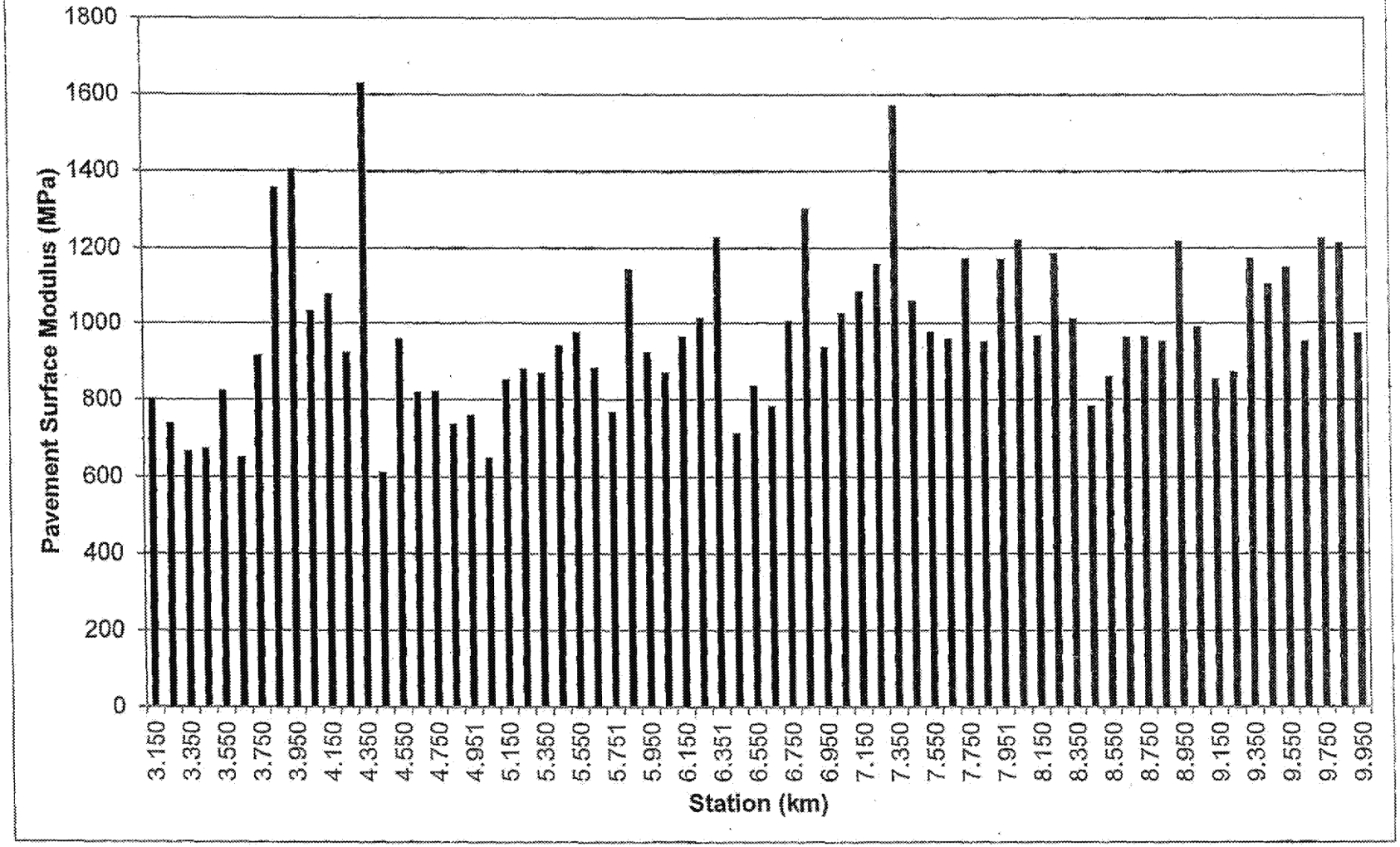


TABLE D-2
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 1
SUMMARY OF FWD DEFLECTION RESULTS

STATION (km)	NORMALIZED DEFLECTION (mm)	PAVEMENT SURFACE MODULUS (MPa)
10.000	0.17	864
9.900	0.18	812
9.800	0.13	1112
9.700	0.15	953
9.600	0.09	1555
9.500	0.12	1180
9.400	0.18	800
9.300	0.14	1034
9.200	0.14	1047
9.100	0.15	967
9.000	0.14	1053
8.900	0.15	955
8.800	0.15	989
8.700	0.17	885
8.600	0.15	964
8.500	0.16	928
8.400	0.15	962
8.300	0.14	1066
8.200	0.12	1250
8.099	0.13	1109
8.000	0.12	1247
7.900	0.14	1043
7.800	0.14	1020
7.700	0.15	972
7.600	0.16	928
7.500	0.15	995
7.400	0.14	1043
7.300	0.16	903
7.200	0.15	977
7.100	0.14	1032
7.000	0.19	792
6.901	0.14	1052
6.800	0.16	914
6.700	0.16	926
6.600	0.21	717
6.500	0.21	698
6.400	0.19	760
6.300	0.19	768
6.200	0.19	790
6.100	0.18	839

TABLE D-2
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 1
SUMMARY OF FWD DEFLECTION RESULTS

STATION (km)	NORMALIZED DEFLECTION (mm)	PAVEMENT SURFACE MODULUS (MPa)
6.000	0.19	765
5.900	0.20	722
5.799	0.21	706
5.700	0.16	940
5.600	0.17	858
5.500	0.21	685
5.400	0.16	934
5.300	0.20	732
5.200	0.22	667
5.100	0.21	700
5.000	0.20	749
4.900	0.13	1093
4.800	0.19	785
4.701	0.18	833
4.600	0.16	916
4.500	0.18	836
4.418	0.21	708
4.171	0.15	981
4.100	0.12	1262
4.000	0.12	1218
3.900	0.11	1376
3.800	0.14	1017
3.699	0.17	882
3.600	0.19	782
3.500	0.21	708
3.400	0.26	569
3.300	0.24	623
3.200	0.22	672
3.100	0.22	662
Mean	0.17	917
Standard Deviation	0.03	187
Mean + 2SD	0.23	-
Static Deflection	0.37	-
Spring Deflection	0.56	-

FIGURE D-2A
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 1
PAVEMENT FWD DEFLECTION

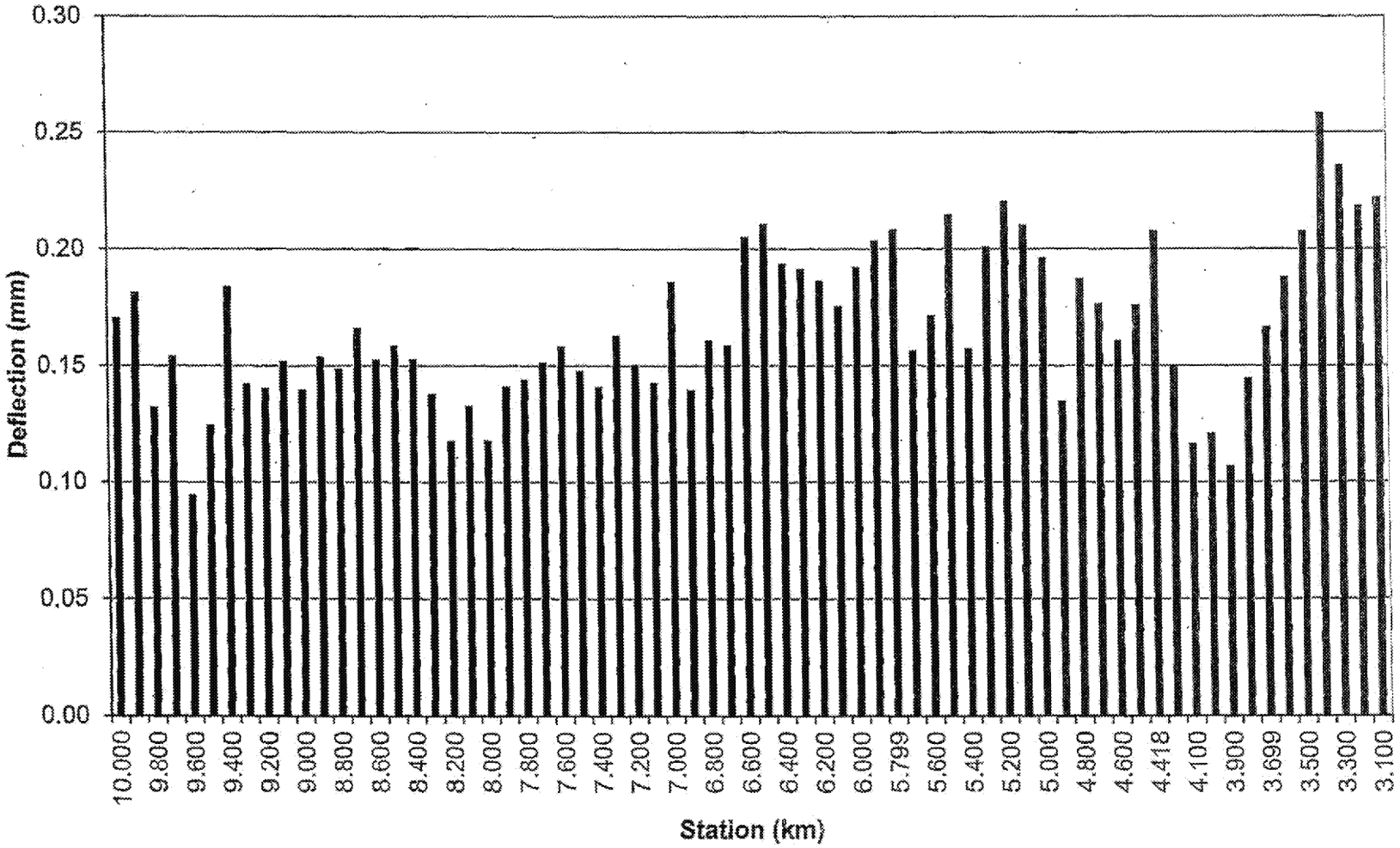


TABLE D-2B
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 1
PAVEMENT SURFACE MODULUS

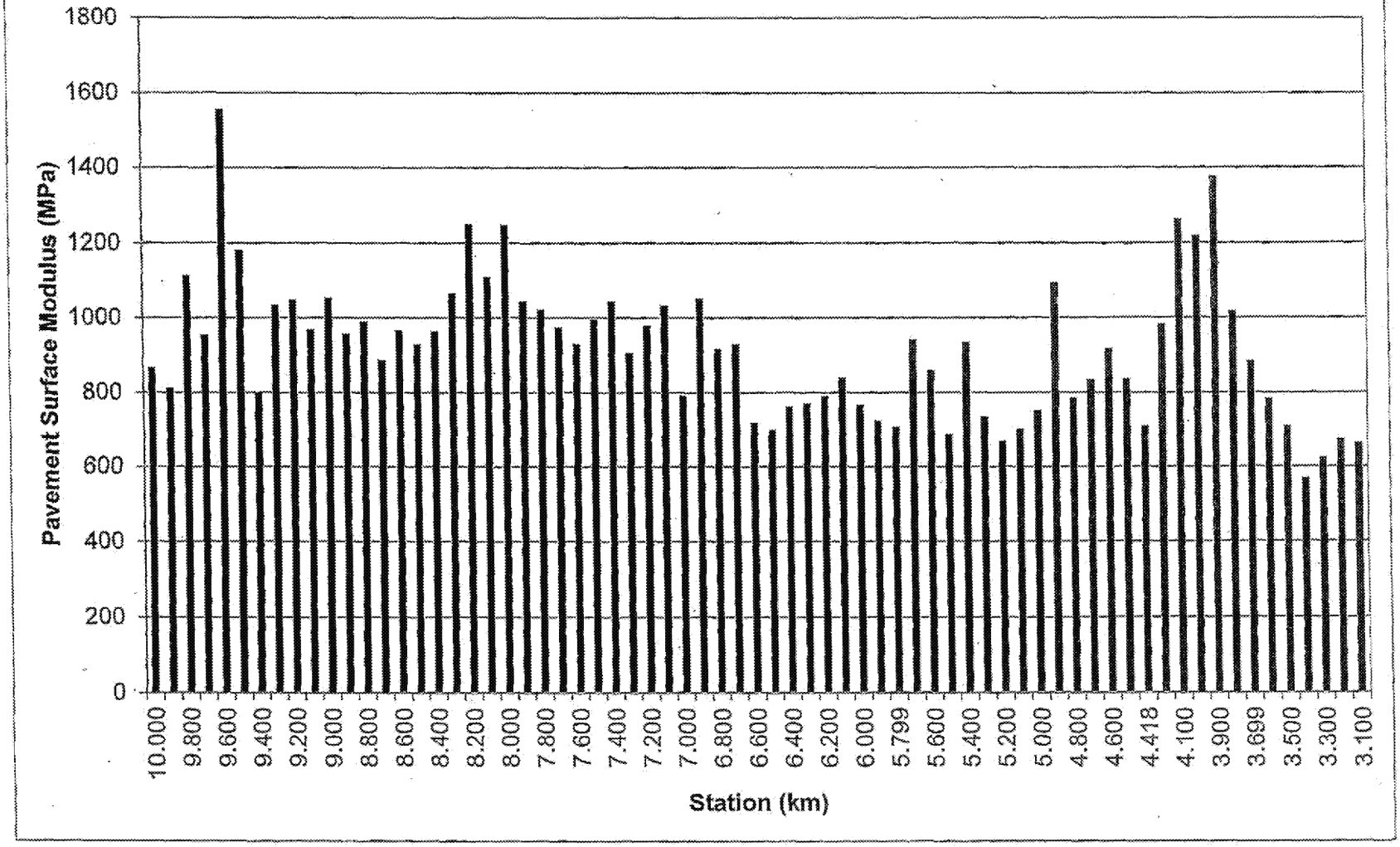


TABLE D-3
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - From Barton Street to Queenston Road
SUMMARY OF FWD DEFLECTION RESULTS

STATION (km)	NORMALIZED DEFLECTION (mm)	PAVEMENT SURFACE MODULUS (MPa)
9.097	0.19	785
9.050	0.14	1024
9.000	0.30	490
8.949	0.12	1203
8.900	0.15	975
8.850	0.14	1088
8.801	0.15	987
8.750	0.17	864
8.700	0.13	1154
8.650	0.12	1226
Mean	0.16	980
Standard Deviation	0.05	211
Mean + 2SD	0.26	-
Static Deflection	0.42	-
Spring Deflection	0.63	-

FIGURE D-3A
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM BARTON STREET TO QUEENSTON ROAD
PAVEMENT FWD DEFLECTION

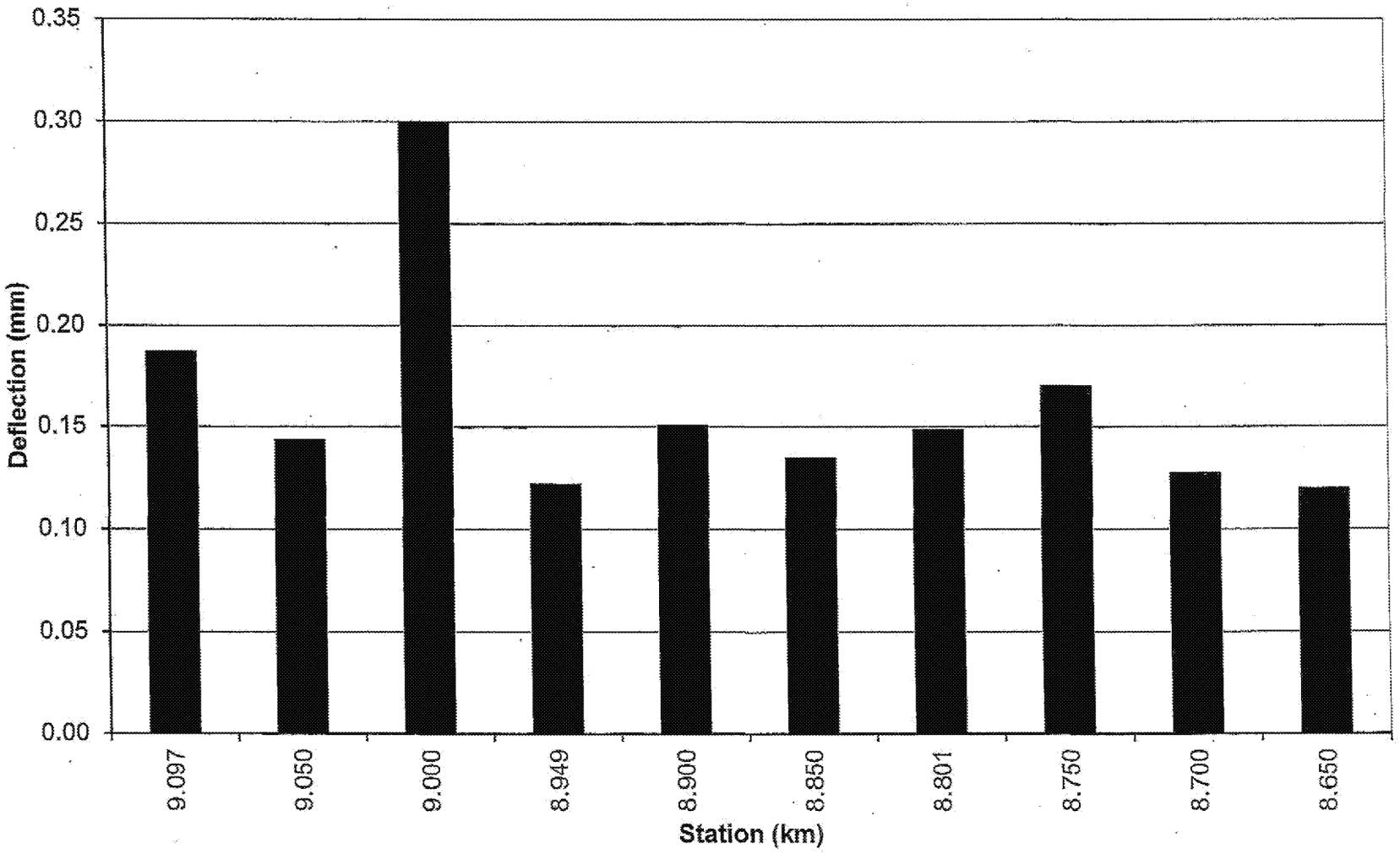


FIGURE D-3B
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM BARTON STREET TO QUEENSTON ROAD
PAVEMENT SURFACE MODULUS

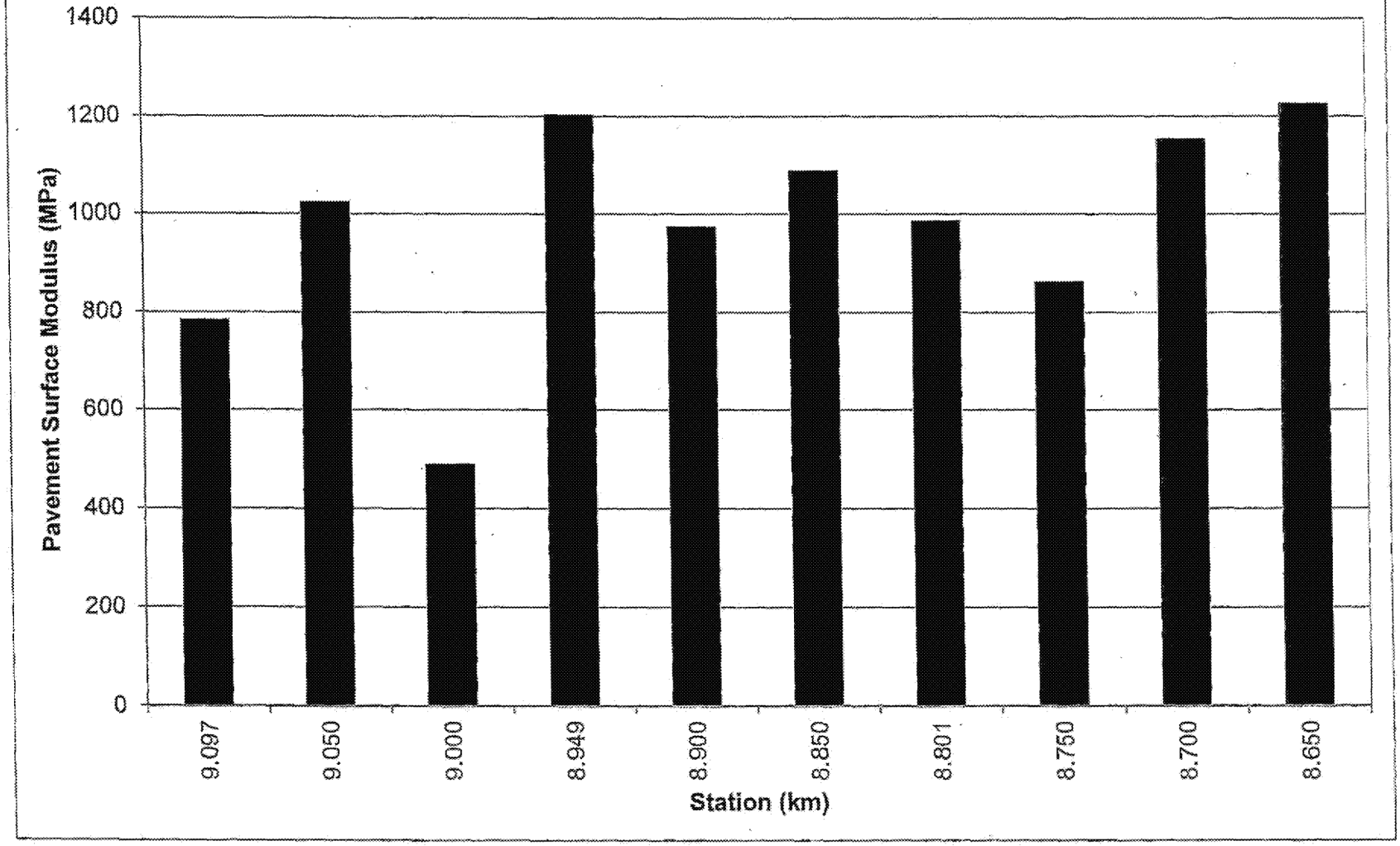


TABLE D-4
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM KING STREET TO GREENHILL AVENUE
SUMMARY OF FWD DEFLECTION RESULTS

STATION	NORMALIZED DEFLECTION	PAVEMENT SURFACE MODULUS
(km)	(mm)	(MPa)
7.660	0.14	1054
7.606	0.15	1007
7.550	0.17	874
7.498	0.14	1018
7.448	0.15	951
7.400	0.14	1081
7.100	0.12	1200
7.050	0.15	959
7.000	0.16	925
6.945	0.16	905
6.900	0.16	929
6.844	0.15	955
6.800	0.18	796
6.700	0.17	868
6.650	0.16	905
6.600	0.25	580
Mean	0.16	938
Standard Deviation	0.03	131
Mean + 2SD	0.22	-
Static Deflection	0.35	-
Spring Deflection	0.52	-

FIGURE D-4A
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM KING STREET TO GREENHILL AVENUE
PAVEMENT FWD DEFLECTION

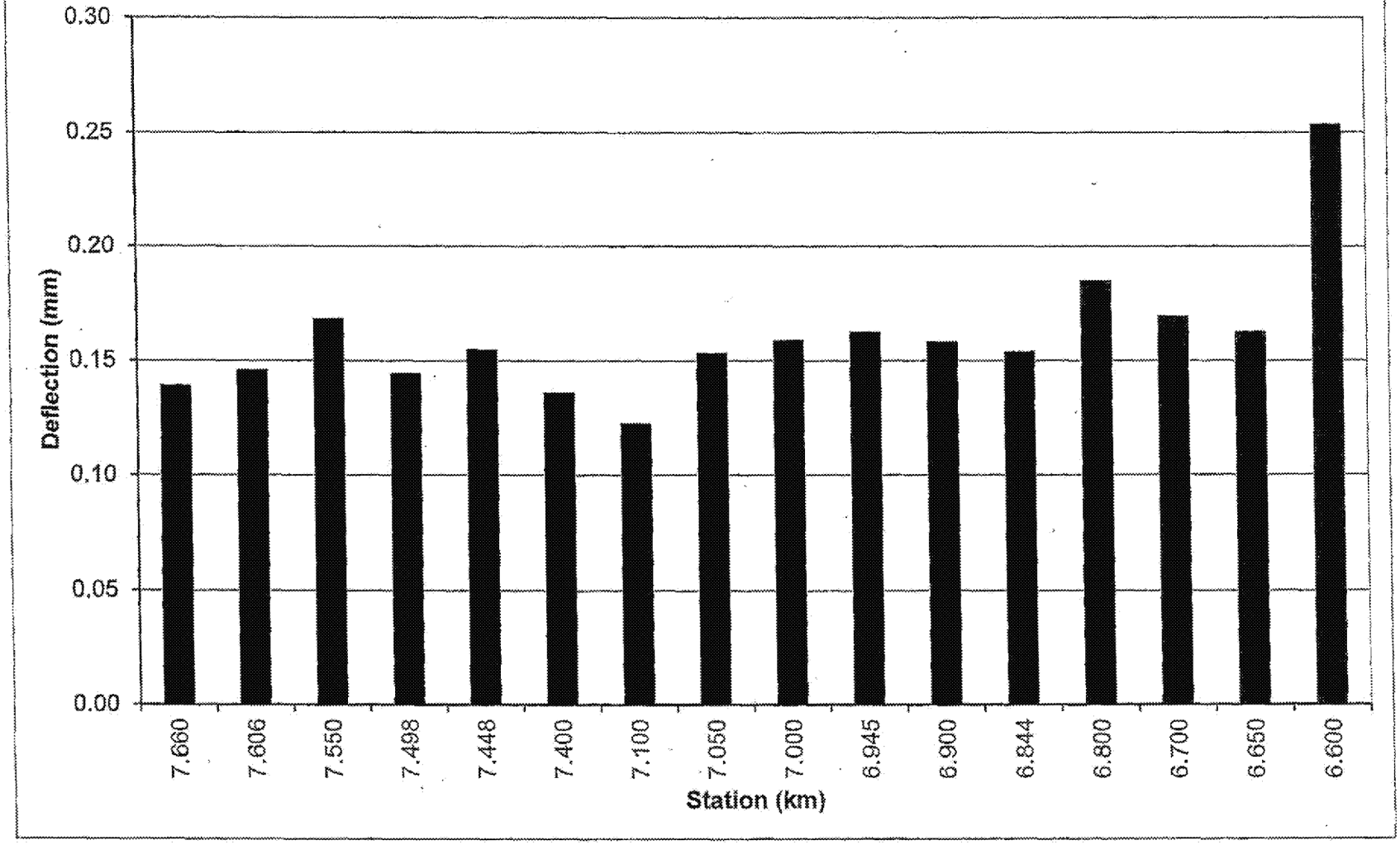


FIGURE D-4B
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM KING STREET TO GREENHILL AVENUE
PAVEMENT SURFACE MODULUS

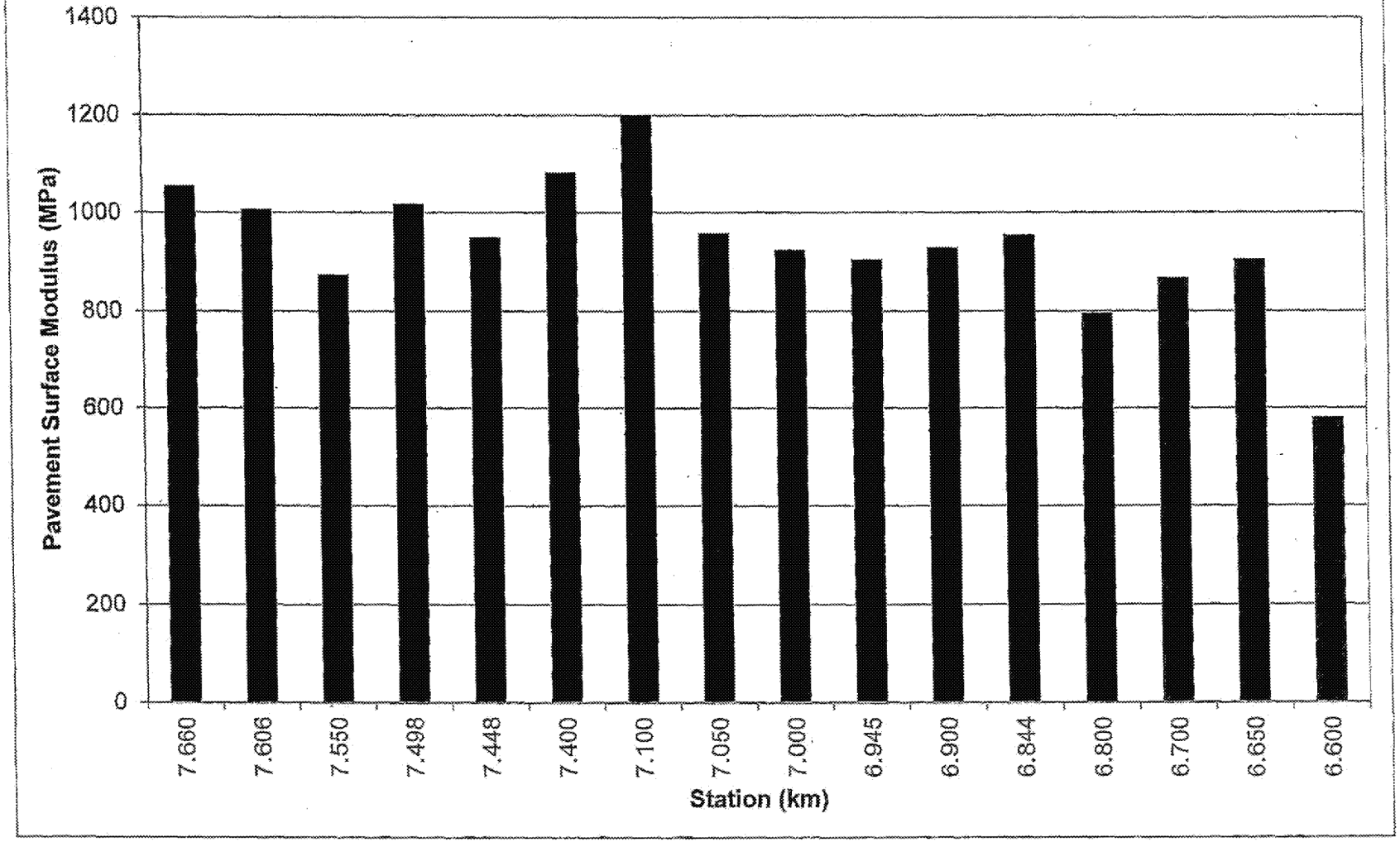


Table D-5
RED HILL VALLEY PARKWAY
NORTHBOUND LANE 1
SUMMARY OF LAYER MODULI

Station	Asphalt Modulus (MPa)	Base/Subbase Modulus (MPa)	Subgrade Modulus (MPa)
3.150	5584	150	289
3.250	4662	260	98
3.350	4084	240	100
3.450	3852	251	114
3.550	4397	331	129
3.650	3671	242	81
3.750	3539	464	207
3.850	3540	703	388
3.950	3909	624	468
4.050	4161	410	170
4.150	4156	354	298
4.251	3389	9253	63
4.350	3999	3286	329
4.450	3110	207	129
4.550	3307	545	278
4.650	3825	373	174
4.750	4331	322	167
4.850	4175	270	143
4.951	3338	364	186
5.050	3248	280	123
5.150	3521	367	207
5.250	3974	404	180
5.350	3774	398	193
5.450	5009	364	188
5.550	4791	409	185
5.650	4286	425	168
5.751	4354	270	196
5.850	4997	537	243
5.950	4531	409	172
6.050	4739	357	145
6.150	4529	440	188
6.251	5234	414	167
6.351	4476	535	236
6.450	3544	281	215
6.550	4093	387	153
6.650	3630	354	192
6.750	4881	440	238
6.850	11760	86	200
6.950	5083	402	184
7.050	4529	464	296

Table D-5
RED HILL VALLEY PARKWAY
NORTHBOUND LANE 1
SUMMARY OF LAYER MODULI

Station	Asphalt Modulus (MPa)	Base/Subbase Modulus (MPa)	Subgrade Modulus (MPa)
7.150	4826	466	321
7.251	4290	608	239
7.350	5257	916	204
7.450	4610	475	296
7.550	5213	455	178
7.650	4736	439	234
7.750	5252	497	273
7.850	5113	402	194
7.951	4946	542	268
8.050	6533	446	337
8.150	5975	367	161
8.250	4699	574	298
8.350	4605	509	203
8.451	5045	299	141
8.550	4863	367	161
8.651	5989	340	230
8.750	5259	366	260
8.851	3419	504	265
8.950	5121	580	246
9.050	5157	409	191
9.150	4520	373	168
9.250	4216	339	168
9.350	5449	513	293
9.450	4282	541	245
9.550	4397	572	259
9.650	4951	453	215
9.750	5695	570	311
9.851	4831	564	354
9.950	4332	325	368
Mean	4498	417	217
Standard Deviation	720	132	76
Typical	4157	362	173
Note: Values highlighted in yellow were not included in the calculation of the summary statistics			

FIGURE D-5A
RED HILL VALLEY PARKWAY
NORTHBOUND LANE 1
ASPHALT MODULUS

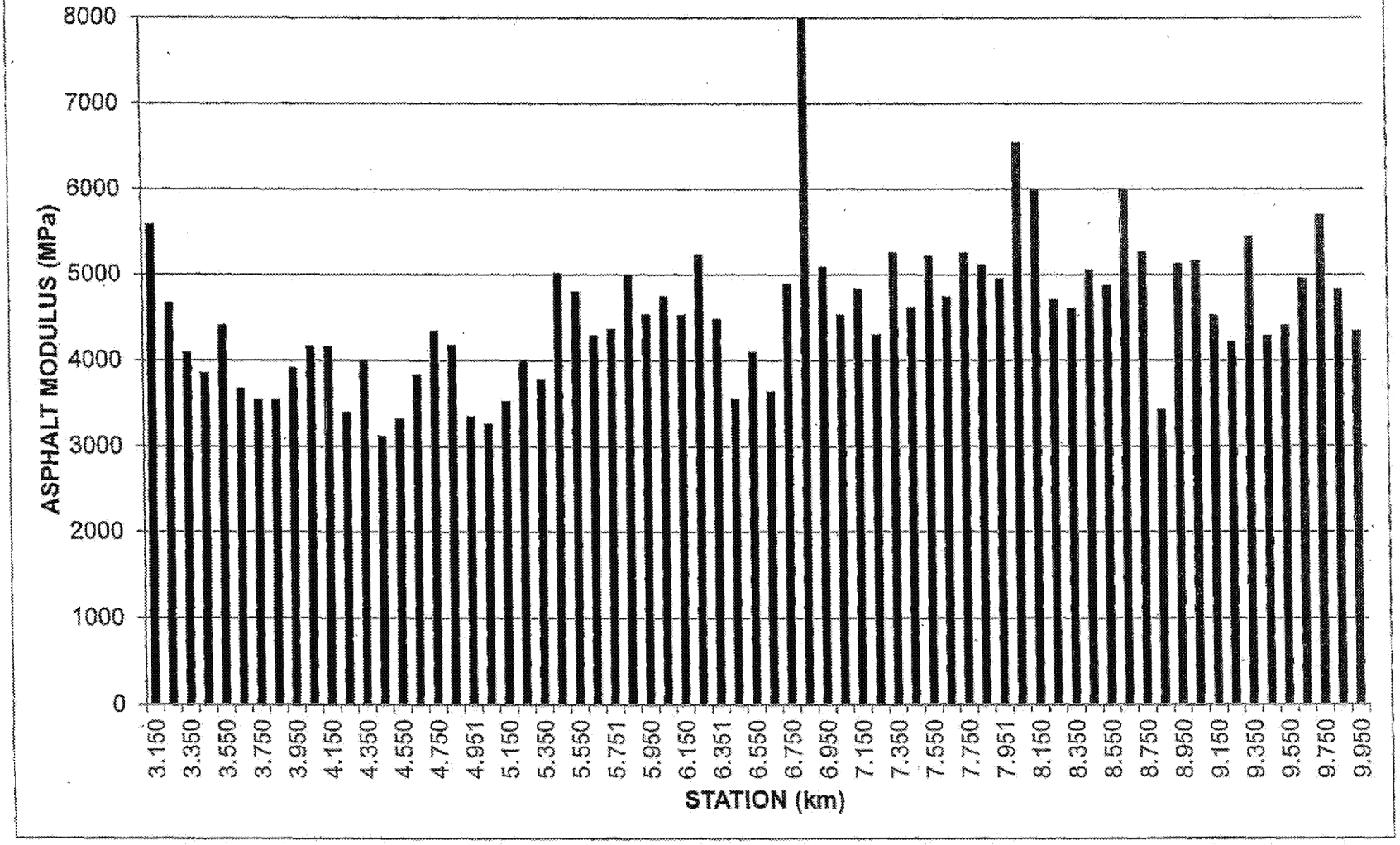


FIGURE D-5B
RED HILL VALLEY PARKWAY
NORTHBOUND LANE 1
BASE/SUBBASE MODULUS

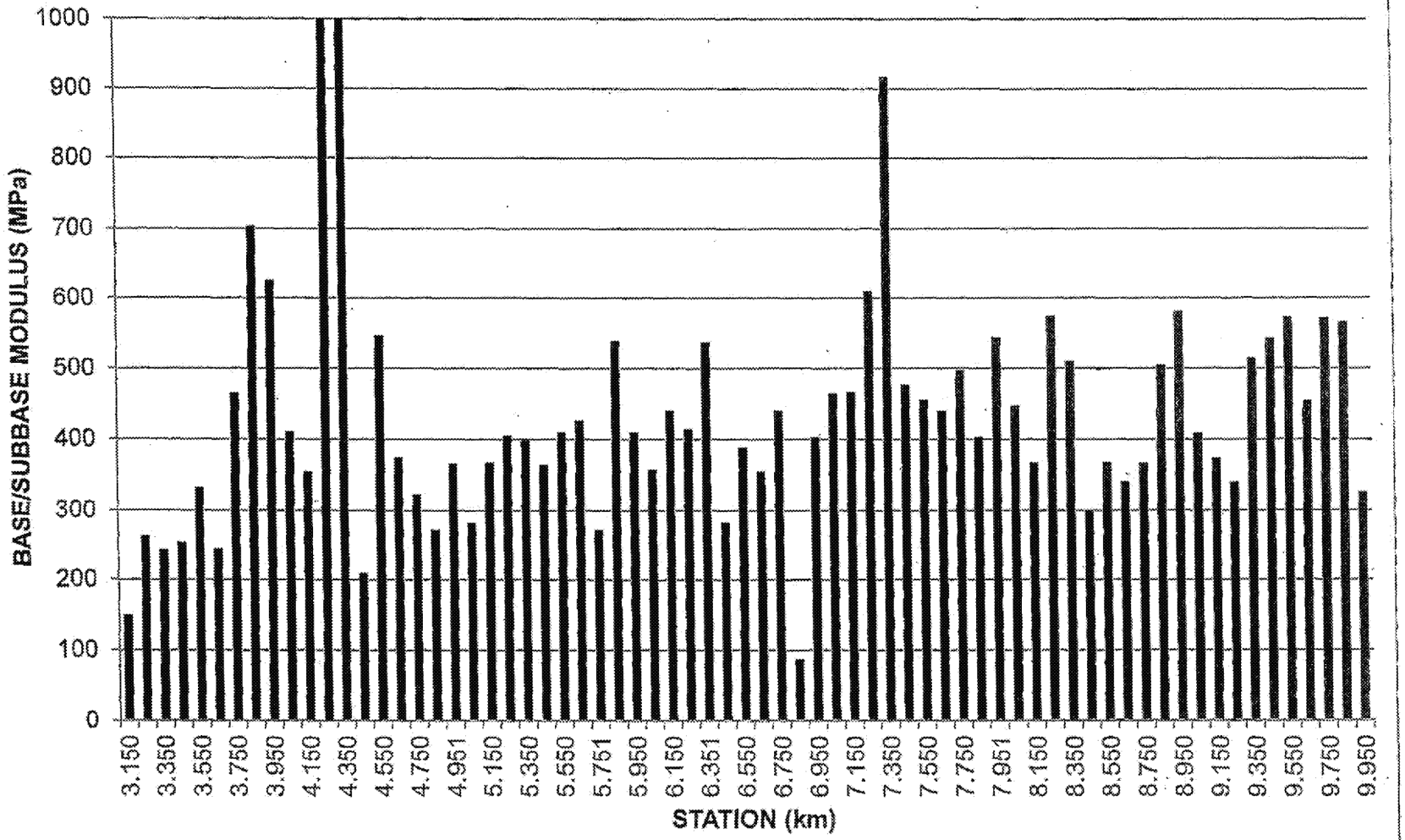


FIGURE D-5C
RED HILL VALLEY PARKWAY
NORTHBOUND LANE 1
SUBGRADE MODULUS

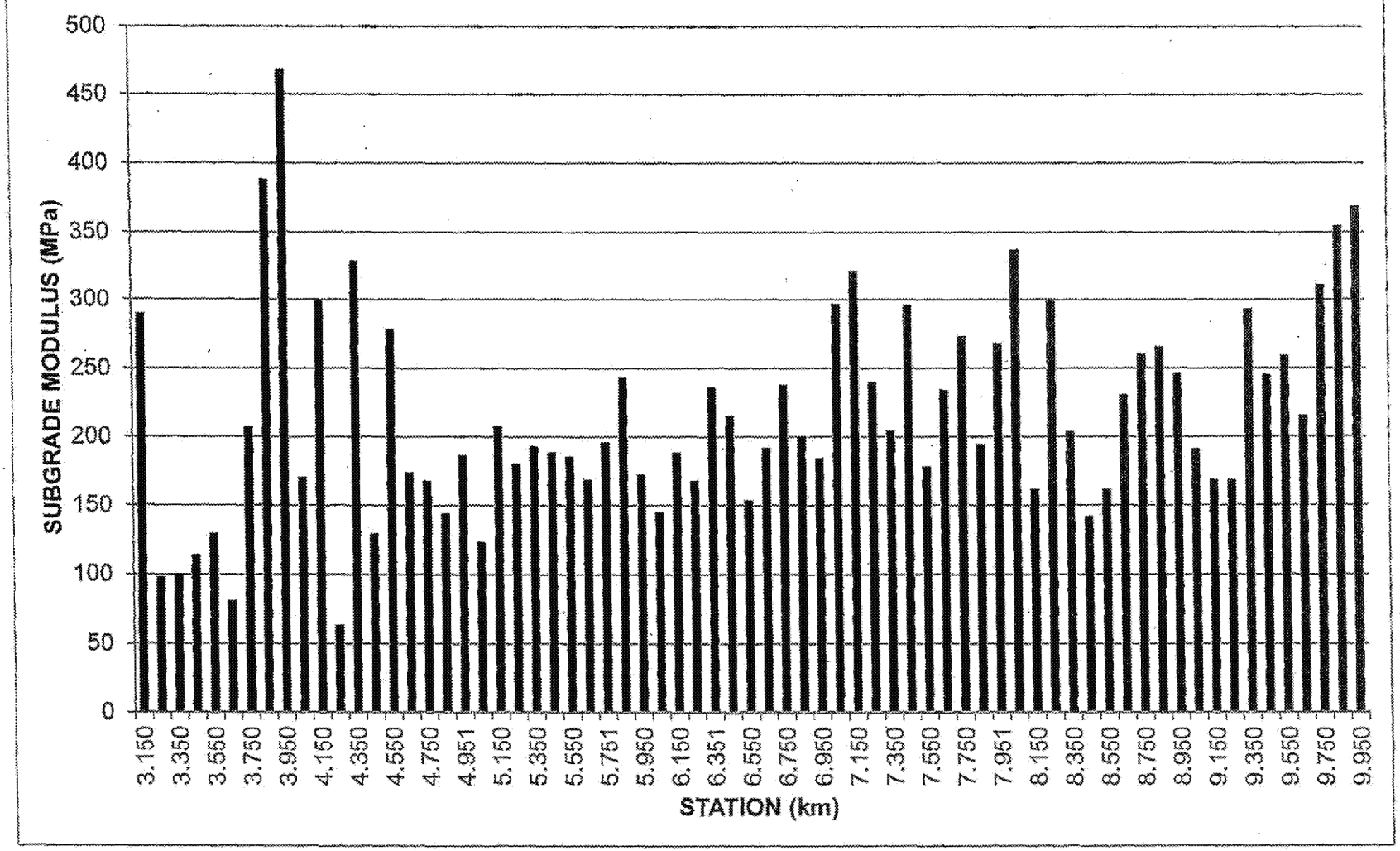


Table D-6
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 1
SUMMARY OF LAYER MODULI

Station	Asphalt Modulus (MPa)	Base/Subbase Modulus (MPa)	Subgrade Modulus (MPa)
3.100	2527	340	127
3.200	3471	286	109
3.300	3346	262	97
3.400	3430	192	81
3.500	3770	288	94
3.600	3481	331	126
3.699	4352	362	174
3.800	3386	444	308
3.900	4035	514	442
4.000	3630	493	352
4.100	3716	614	270
4.171	3888	424	266
4.418	3282	268	134
4.500	3255	333	240
4.600	2979	422	376
4.701	3200	321	316
4.800	3079	313	254
4.900	4631	503	269
5.000	3832	251	206
5.100	3482	274	138
5.200	3273	271	145
5.300	3401	338	146
5.400	3342	399	265
5.500	3592	298	84
5.600	3442	325	207
5.700	3832	368	235
5.799	2963	240	155
5.900	3779	250	136
6.000	3711	269	146
6.100	4082	303	149
6.200	3650	291	147
6.300	3183	316	141
6.400	3971	285	142
6.500	3716	277	131
6.600	3454	307	154
6.700	3717	404	302
6.800	3774	376	221
6.901	3639	449	225
7.000	3211	316	192
7.100	4228	462	232

Table D-6
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 1
SUMMARY OF LAYER MODULI

Station	Asphalt Modulus (MPa)	Base/Subbase Modulus (MPa)	Subgrade Modulus (MPa)
7.200	4303	371	223
7.300	4102	379	174
7.400	4052	484	274
7.500	4696	384	179
7.600	4235	343	205
7.700	4132	408	194
7.800	4578	373	296
7.900	4720	404	244
8.000	5538	440	361
8.099	4551	413	253
8.200	4488	462	479
8.300	4343	429	212
8.400	3805	477	215
8.500	4106	373	208
8.600	4883	366	196
8.700	3671	358	292
8.800	3943	380	331
8.900	4337	382	200
9.000	4235	466	226
9.100	4072	423	188
9.200	4274	475	247
9.300	4274	429	243
9.400	4188	307	145
9.500	4519	493	285
9.600	2070	28493	161
9.700	3415	449	269
9.800	3472	493	411
9.900	3454	340	178
10.000	2889	486	236
Mean	3798	373	218
Standard Deviation	580	83	84
Typical	3461	317	157
Note: Values highlighted in yellow were not included in the calculation of the summary statistics			

FIGURE D-6A
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 1
ASPHALT MODULUS

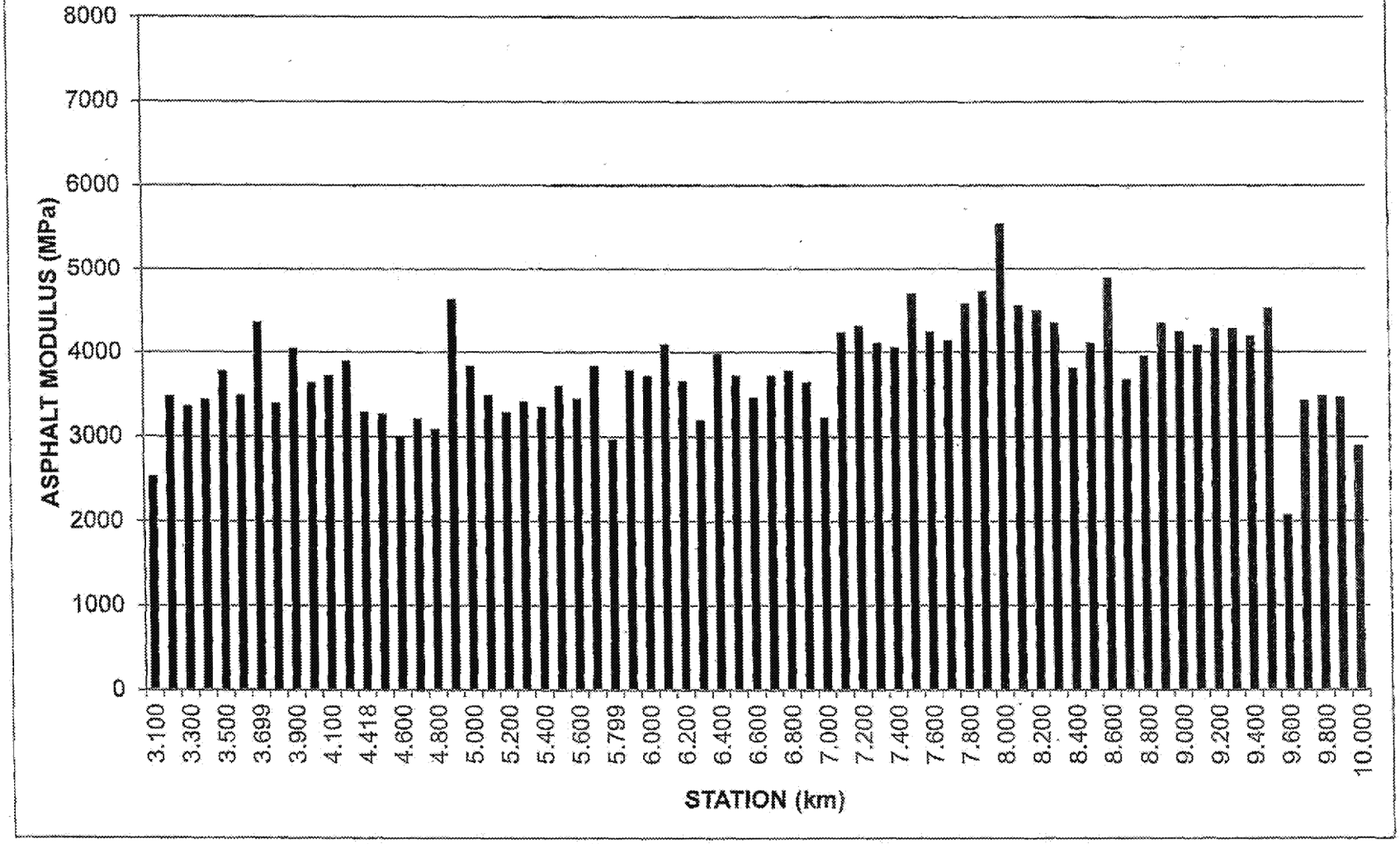


FIGURE D-6B
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 1
BASE/SUBBASE MODULUS

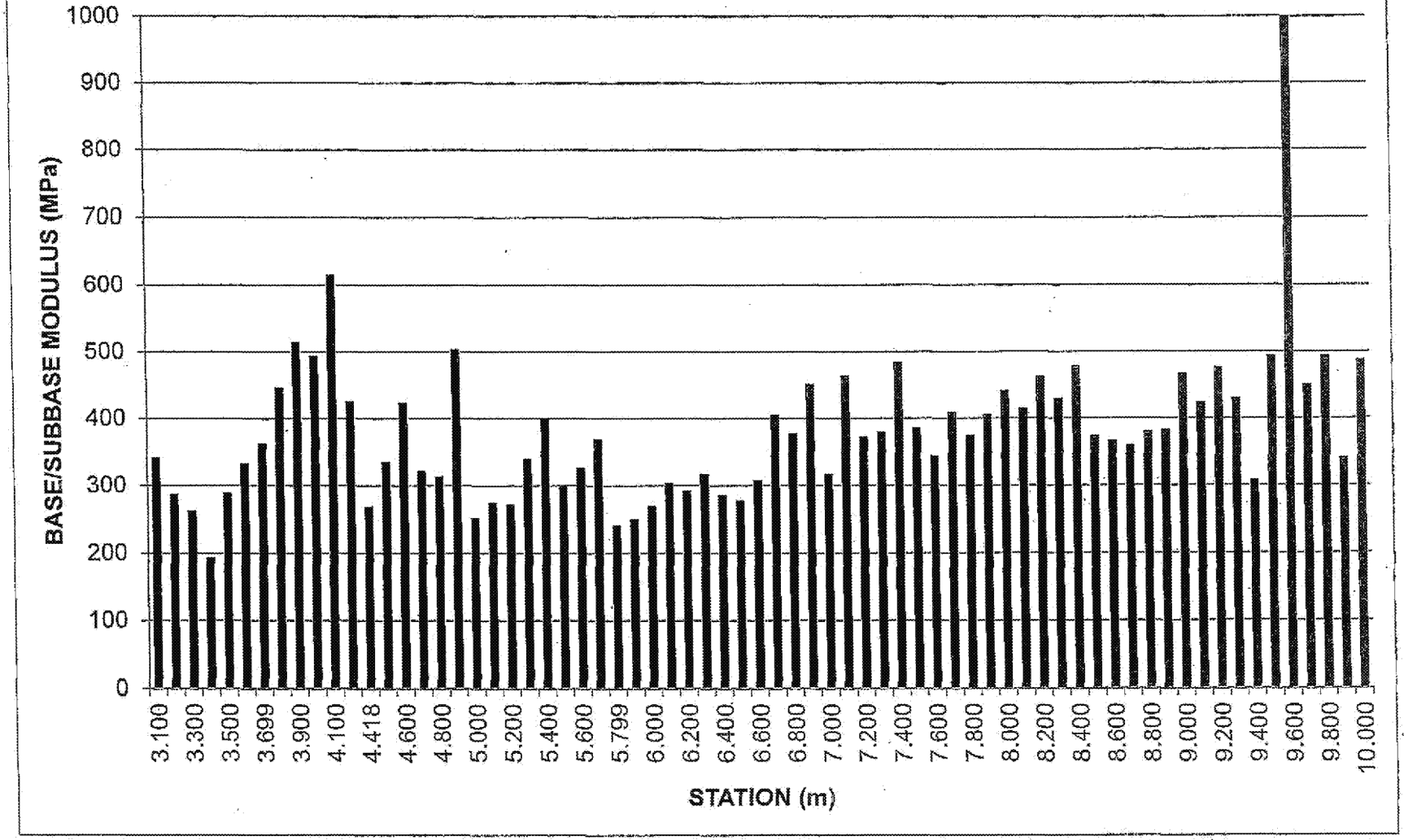


FIGURE D-6C
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 1
SUBGRADE MODULUS

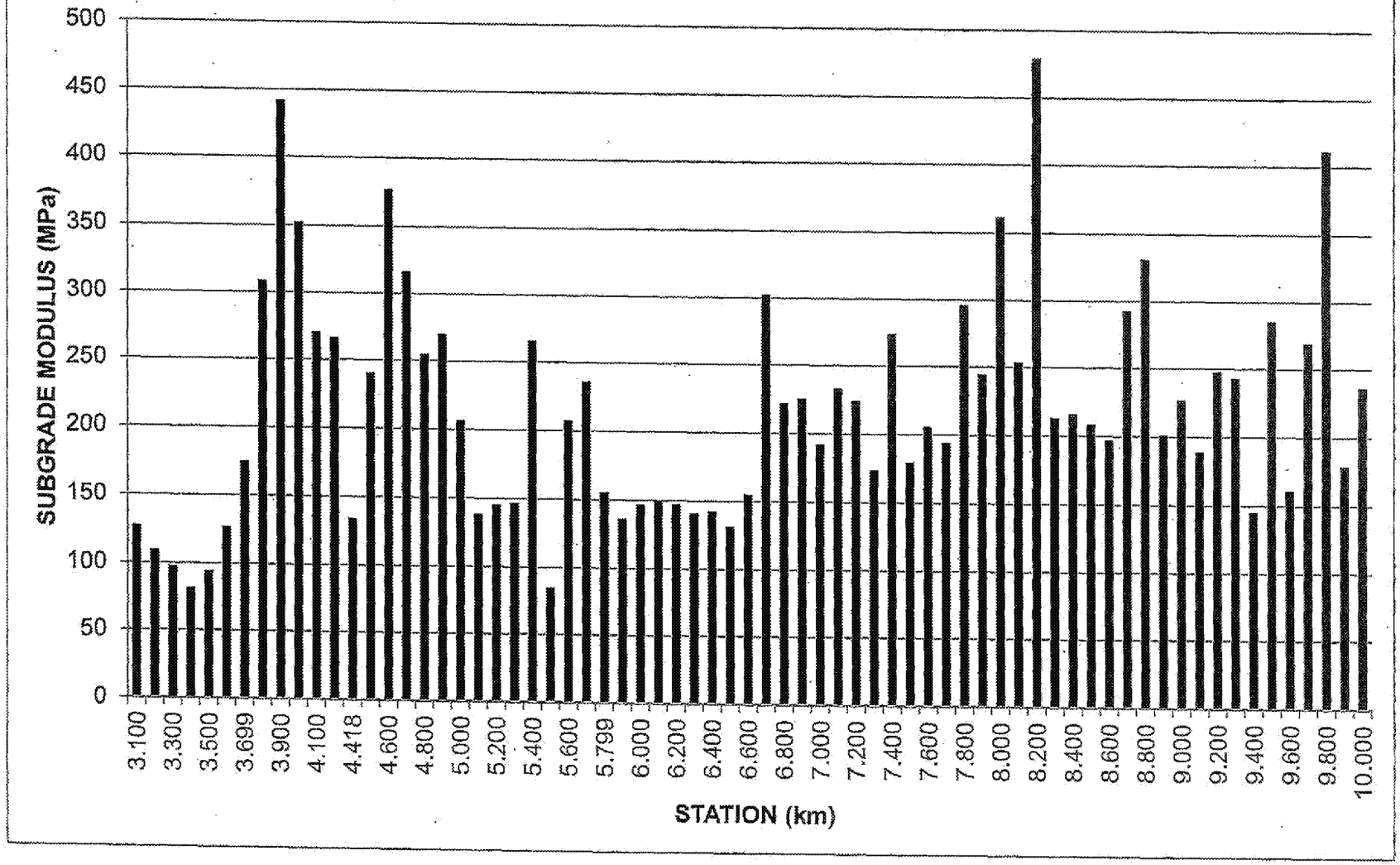


Table D-7
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM BARTON STREET TO QUEENSTON ROAD
SUMMARY OF LAYER MODULI

Station	Asphalt Modulus (MPa)	Base/Subbase Modulus (MPa)	Subgrade Modulus (MPa)
8.650	7421	471	314
8.700	6631	463	262
8.750	5505	334	160
8.801	5659	314	259
8.850	5186	480	299
8.900	5199	388	205
8.949	6680	479	258
9.000	1737	472	209
9.050	6200	382	213
9.097	4354	322	155
Mean	5457	381	233
Standard Deviation	1582	99	54
Typical	5195	381	208

FIGURE D-7A
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM BARTON STREET TO QUEENSTON ROAD
ASPHALT MODULUS

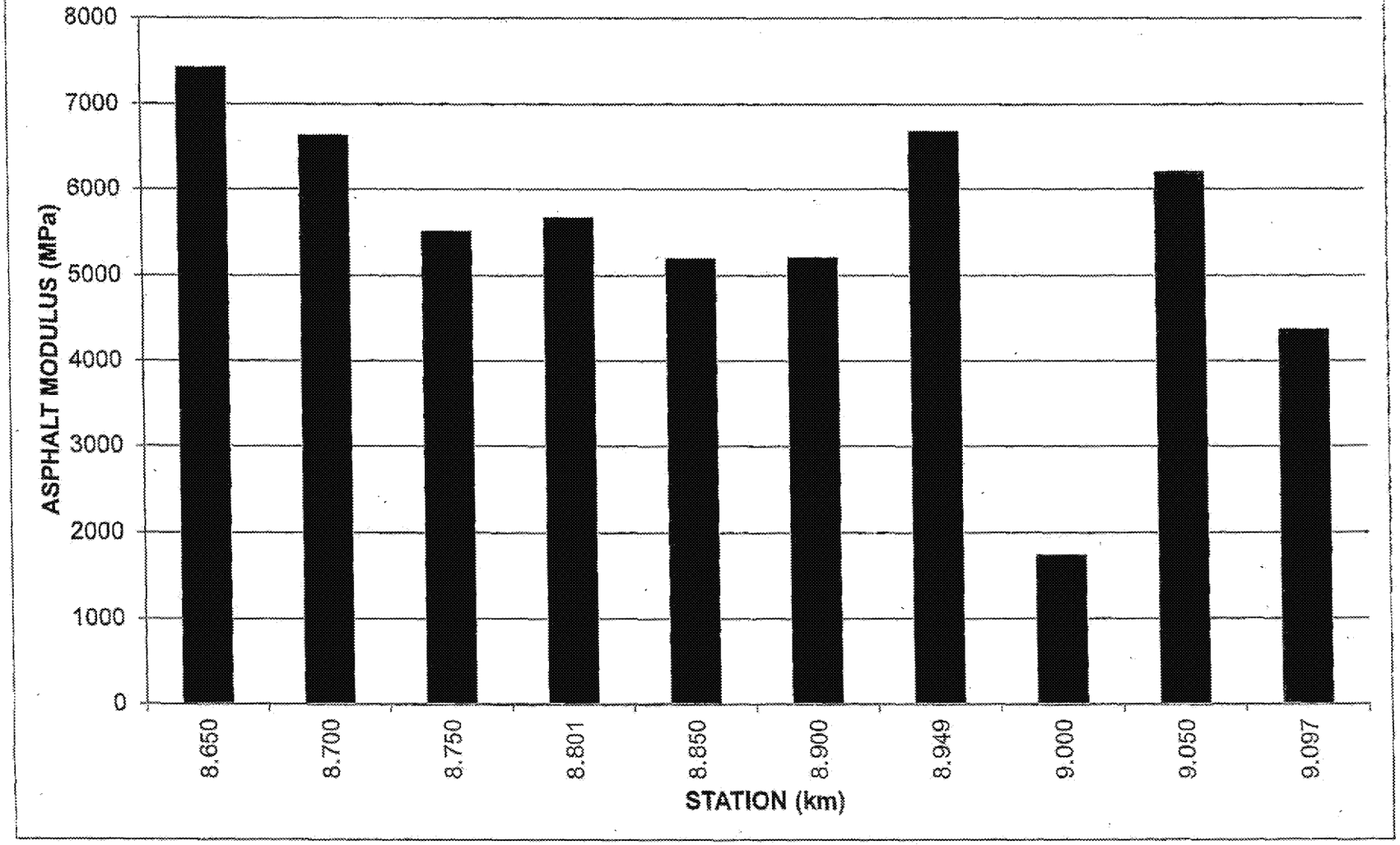


FIGURE D-7B
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM BARTON STREET TO QUEENSTON ROAD
BASE/SUBBASE MODULUS

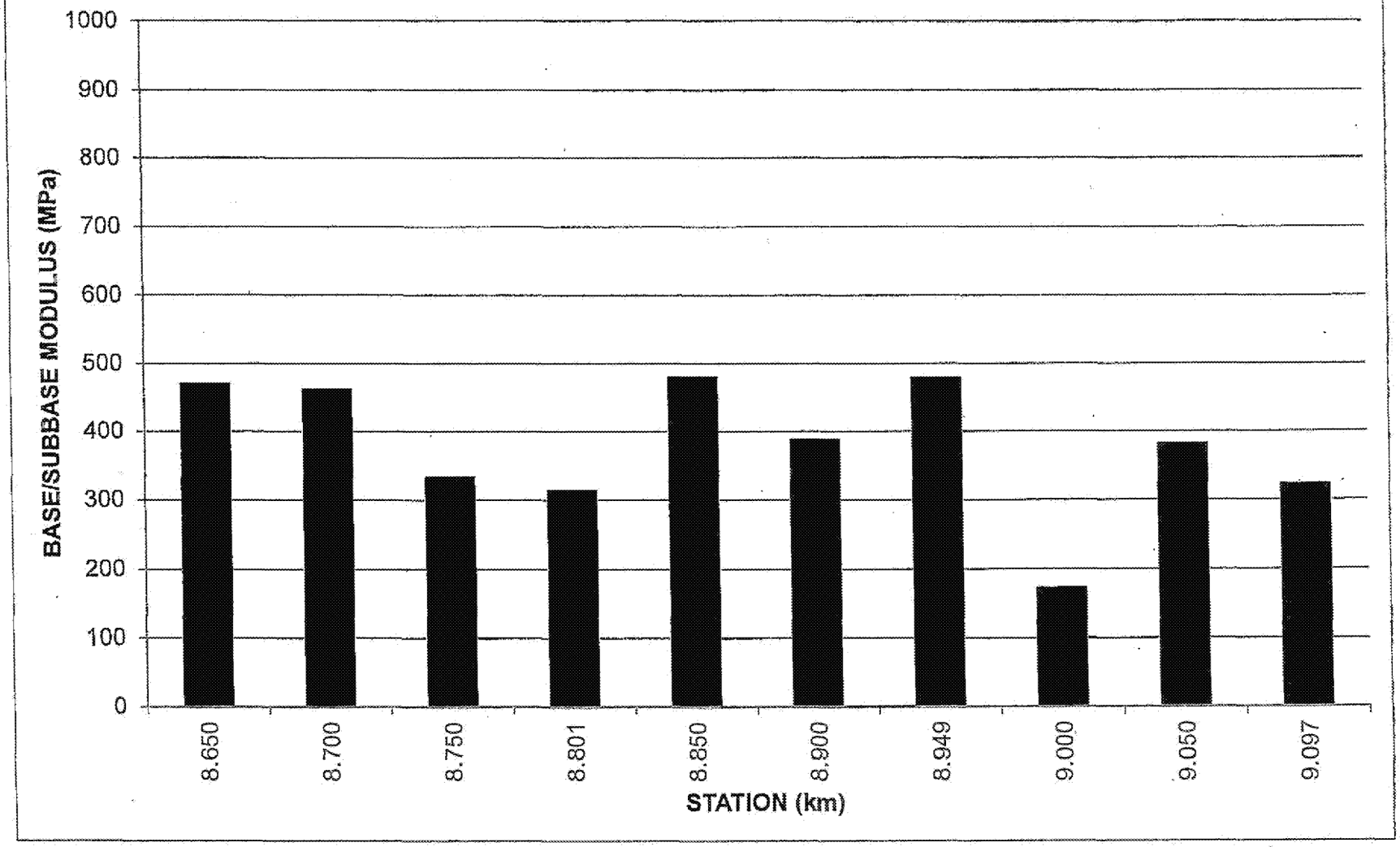


FIGURE D-7C
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM BARTON STREET TO QUEENSTON ROAD
SUBGRADE MODULUS

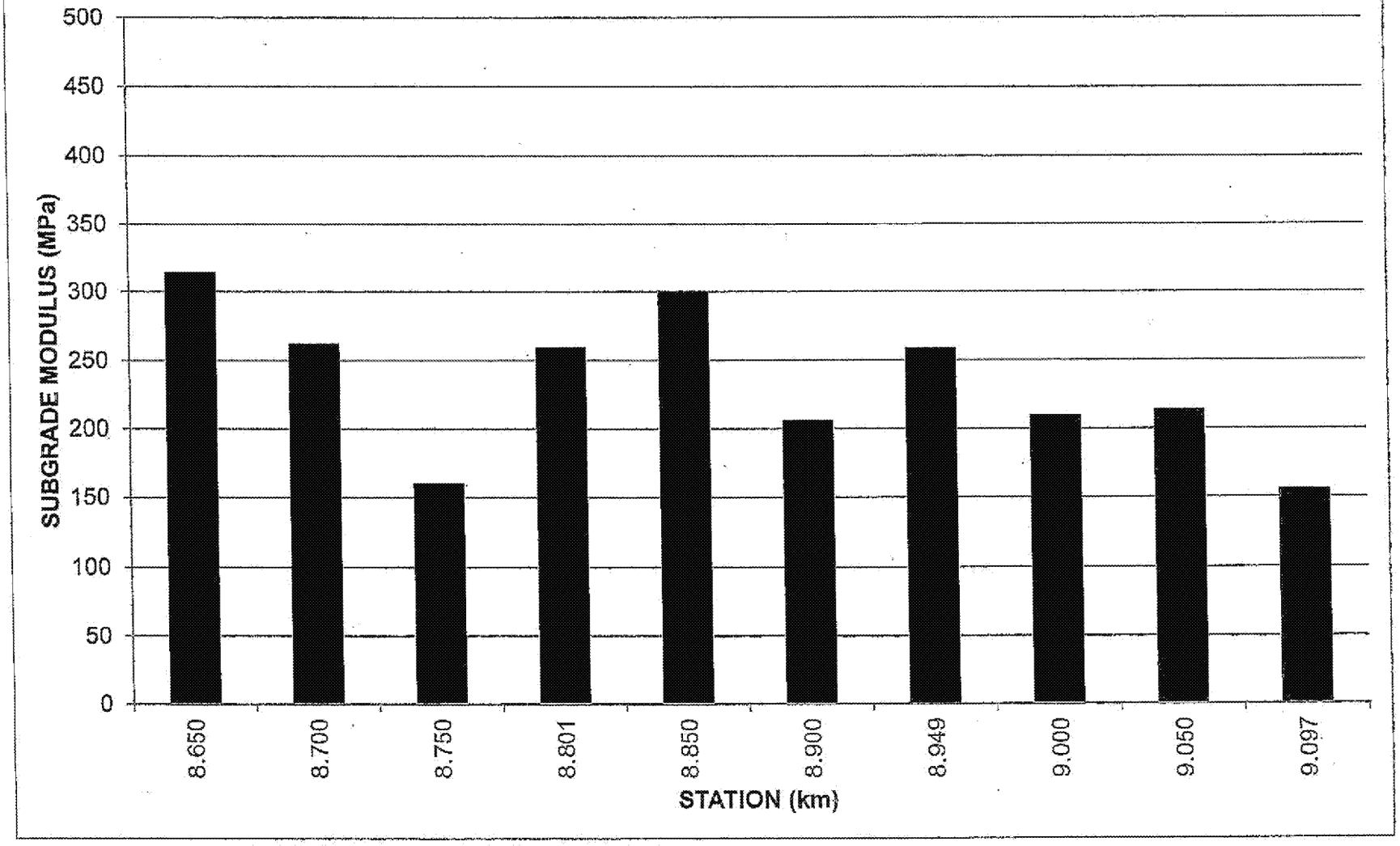


Table D-8
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM KING STREET TO GREENHILL AVENUE
SUMMARY OF LAYER MODULI

Station	Asphalt Modulus (MPa)	Base/Subbase Modulus (MPa)	Subgrade Modulus (MPa)
6.600	3940	204	110
6.650	5110	419	168
6.700	4421	345	252
6.800	4140	301	165
6.844	5176	399	144
6.900	5597	346	142
6.945	5234	373	174
7.000	4979	367	208
7.050	4871	353	274
7.100	6442	532	245
7.400	5388	779	114
7.448	5560	345	249
7.498	5510	380	212
7.550	5285	353	178
7.606	5314	415	212
7.660	5498	420	301
Mean	5154	396	197
Standrd Deviation	607	123	57
Typical	5045	350	167

FIGURE D-8A
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM KING STREET TO GREENHILL AVENUE
ASPHALT MODULUS

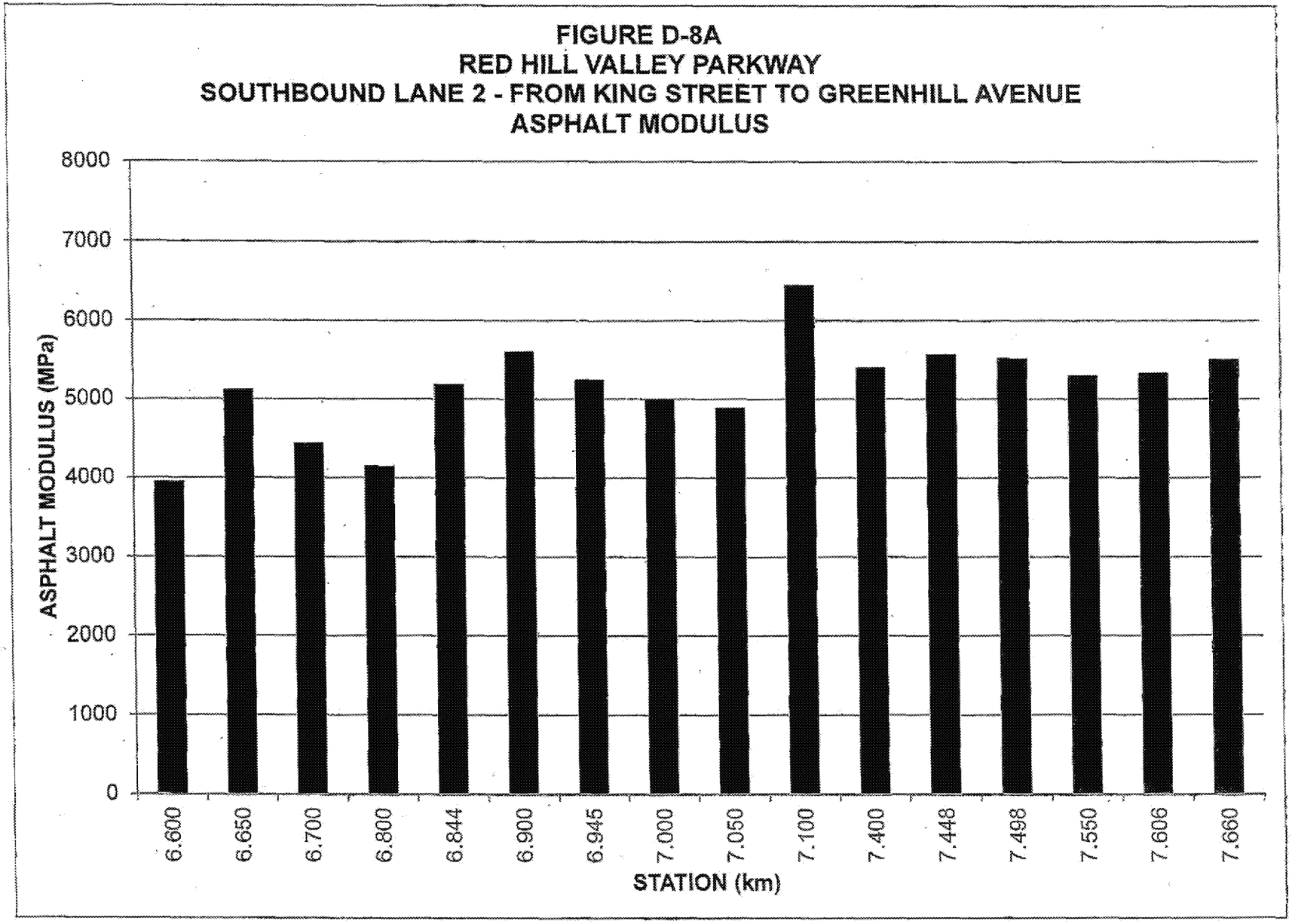


FIGURE D-8B
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM KING STREET TO GREENHILL AVENUE
BASE/SUBBASE MODULUS

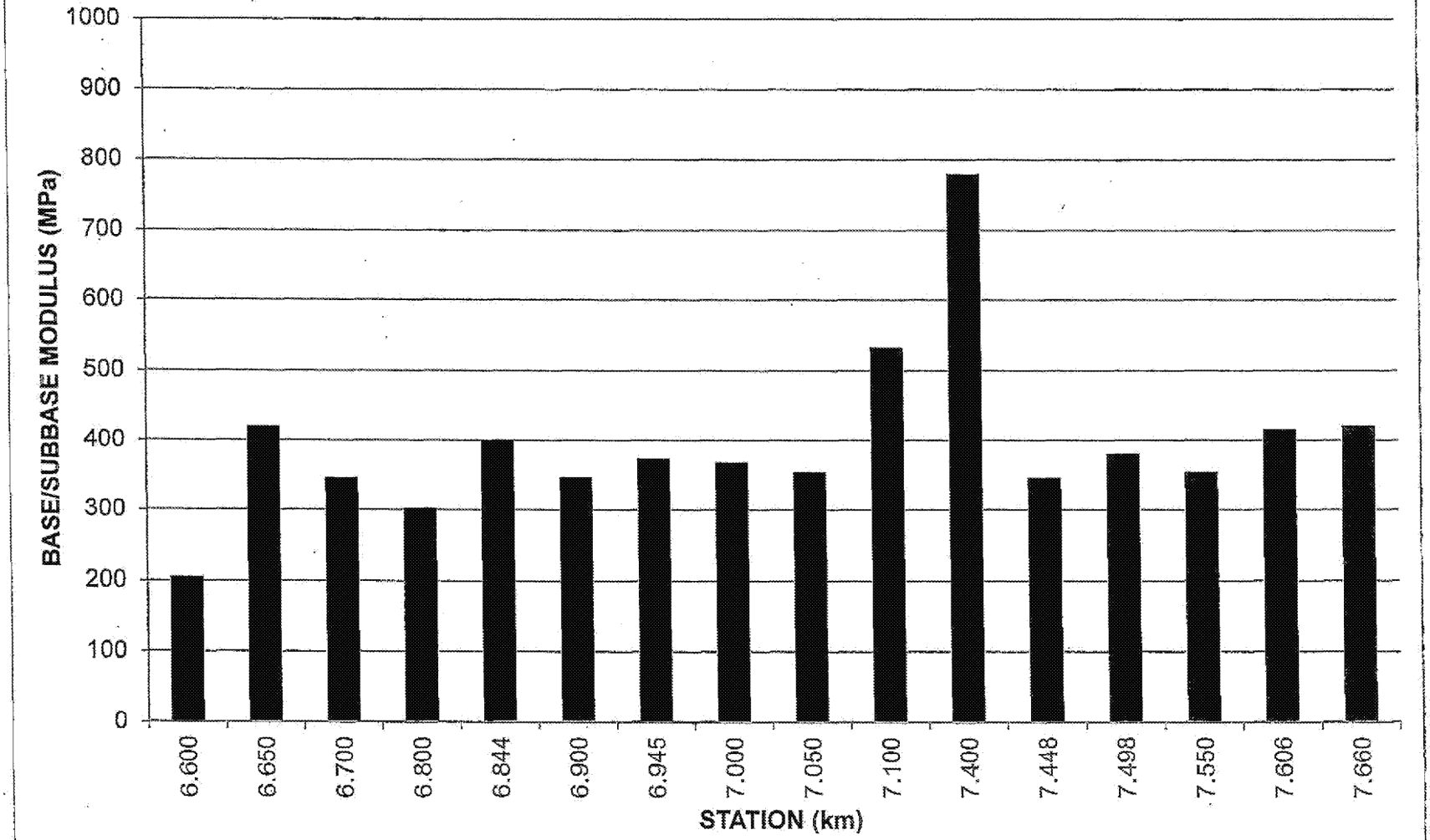


FIGURE D-8C
RED HILL VALLEY PARKWAY
SOUTHBOUND LANE 2 - FROM KING STREET TO GREENHILL AVENUE
SUBGRADE MODULUS