Roughness on Virginia's Roads

2004 Annual Interstate Roughness Report

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Executive Summary

To most people, a smooth road is a good road. Although transportation agencies measure many parameters to assess the condition of a highway network, ride quality of the pavement is the main attribute the traveling public measures. This conclusion is also reflected in numerous national studies that have placed ride quality at or near the top of the list of importance to travelers. Accordingly, the Federal Highway Administration set ride quality goals for the national highway system network to reduce road roughness, decrease vehicle use costs, and prolong the life of pavements.

This report utilizes data collected for FHWA to provide an overview of the interstate road conditions throughout Virginia and present trends in ride quality statewide, as well as by district. Included in this annual report are the following:

- Discussion of roughness collection data,
- Summary of the work completed in 2004, and
- Summary of observations based on the findings of the study.

Roughness data is collected through a *road profiler* mounted on the front of a van. The road profiler is a sensor package consisting of one laser and accelerometer mounted in each wheel path and a third sensor located in the center of the bumper. It is equipped with software that converts the longitudinal profile readings to International Roughness Index (IRI). The IRI data is summarized for each district and highway system into one of five qualitative categories as shown below. An IRI of zero represents a perfectly smooth pavement; as IRI increases, so does the roughness.

Qualitative Category	IRI Range (inches/mile)
Excellent	<60
Good	60-100
Fair	100-140
Poor	140-200
Very Poor	>200

Data quality must be accurate and repeatable so that analysis will lead to valid conclusions. A formal verification program was implemented in 2001 to verify the equipment and operators used for roughness data collection. A one-mile section on Technology Boulevard (located at the Materials Division) was selected as a test site to verify the equipment. In 2003, an additional verification site was established near the Lynchburg NDT unit office. Tests were performed on a weekly and monthly basis with the profiler, and in-house sensor checks were performed every week to ensure all equipment was working properly.

The results of this study indicate an overall improvement since 1998 in overall ride quality for interstate highways and most significantly from 2003 to 2004. Much of this improvement in ride quality can be attributed to the increase in additional maintenance and asphalt paving that occurred after the winter breakup of 2002-2003. While the 2004 interstate data was collected during the same time frame, in February and March, the winter breakup was not as pronounced as 2003.

The overall average IRI on the interstate has fluctuated between a high of 87 in/mi in 1998 and 2003 to a low of 84 in/mi in 2002. In 2004, the average IRI was measured at 85 in/mi. The average IRI on the interstates has been within a range of 3 in/mi over the last 6 years.

Positive trends can be seen in the increase in the distribution of mileage where the ride quality is "excellent". This increase in "excellent" mileage can be attributed to more widespread usage of the ride specification program. For interstate paving projects in 2003, the average IRI was 64 in/mi. However, the mileage paved under the schedules (with or without the ride spec) has not been enough to offset an increase in "poor" and "very poor" mileage.

This report was based on a high-level analysis of ride quality data collected over the last year and compared to data collected since 1998. Although the author noted trends and observations, in-depth pavement data analysis was beyond the scope of this report. Areas for further research may include but are not limited to:

- Relationship of vehicle miles traveled to IRI by district,
- Analysis of Highway Performance Monitoring System (HPMS) goals to VDOT's paving program,
- Comparison of maintenance expenditures to pavement performance,
- Comparison of maintenance activities to pavement performance, and
- Evaluation of pavement performance targets based on ride quality.
- Comparison of IRI and pavement age.

INTRODUCTION[1]

VDOT's Mission Statement is - "VDOT will plan, deliver, and maintain on-time and on-budget, the best possible transportation system for the traveling public".[2] This statement further emphasizes a goal set in 1998 that VDOT was to become a more customer-driven, customer-focused organization.[3] VDOT's customers want the agency to be good financial stewards of the tax dollars and provide the best highway network to ensure efficient movement of people and goods.

These statements are in line with findings from surveys conducted by the FHWA in 1995 and 2000 that reflect an increase in satisfaction with major highways. From the many attributes of the major highways that travelers were more satisfied in 2000 than 1995, pavement condition was noted. (For the purpose of the survey, pavement condition included surface appearance, durability and quiet ride.) Results from the survey indicated that 21% of responding highway travelers named pavement conditions as the characteristic that should receive the most attention and resources for improvement. This characteristic came third behind traffic flow (28%) and safety (26%) as chosen by the public.[4]

Every year, money and resources are allocated towards the maintenance and repair of the roads throughout the Commonwealth of Virginia. With good information on the roughness condition of the roadways in Virginia, it would be possible to allocate resources in a way that maximizes their performance.

An additional response to increase customer satisfaction took place in 1998, with the implementation of a new special provision for rideability (Ride Specification Program). Widely implemented within the last few years, Ride Spec outlines how pavement smoothness is determined by a profiler and categorized with International Roughness Index (IRI) values. Based on these values, a new pay incentive/disincentive program was implemented and applied to the final surface course of the pavement. Ride Spec provides VDOT a method for controlling the quality of the paving throughout the state where it is used.

PURPOSE

In order to continue increasing the overall satisfaction with our highway system, it is important to consider attributes that affect travelers. Roughness is an important aspect of the condition of our highways, as it affects the quality of the ride. It is important to adequately measure and control the quality of the pavement roughness.

In order for VDOT to allocate its resources in a productive manner and produce the best product for its customers, it is necessary to be aware of the conditions of the roads. Accordingly, the purpose of this report is to provide VDOT management with the most accurate information available through an overview of the road roughness throughout Virginia, noting trends statewide and by district for interstate and non-interstate routes, and presenting observations following data analysis.

History

The data collection effort at VDOT has a long history that can trace its roots back to the late 1980s, when the first windshield rating teams were established. There has been several data collection initiatives in the last six years, each focused on a different aspect of highway management. The Pavement Management Program (PMP), the Highway Performance Monitoring System (HPMS), and the Ride Specification Program (Ride Spec) all utilize roughness as a component within their analyses. However, individual program requirements dictate the scope of the collection effort. Because of the differences in the requirements of these studies the data sets vary in the total mileage and what portions of the network were collected.

In 1995, the Maintenance Division of VDOT entered into a four-year contract with PaveTech, Inc. to collect pavement condition data such as distress, rutting, faulting and roughness. Using data collected in 1997, a study was conducted by Mr. Naveed Sami (previously with the Pavement Management Program) to analyze the roughness condition of the state highway network – interstate, primary and selected secondary routes.[5] This study was conducted as part of VDOT's strategic plan, in which the department committed itself to becoming the most effective customer-oriented public agency in Virginia by the year 2000. A similar study was also carried out based on data collected in 1998.[6] Although the 1997 report focused only on roughness, the 1998 report included pavement condition data. These reports outlined the results of the data collection, provided information useful for the allocation of maintenance funds, and established a pavement performance database that could prove very useful in managing the quality of Virginia's roadway system.

After 1998, network level data collection was to be completed as part of the Inventory and Condition Assessment Survey (ICAS); however, various issues with the contractor prevented the data collection. As a result network level pavement data collection testing was not performed during 1999 and 2000.

Materials' Non-Destructive Testing unit (NDT), which is a part of the Pavement Design and Evaluation (PD&E) Section performs special request testing for VDOT. Besides special requests, the NDT section is responsible for collecting roughness data on maintenance and construction projects where the special provision for rideability (Ride Spec) is applied. This unit was used to supply the Federal Highway Administration (FHWA) with data for its Highway Performance Monitoring System (HPMS) program.

The HPMS program is a long-term study that is using roughness to track highway deterioration and develop life cycle measurements. Every year, under this program each state must submit roughness data. As per HPMS guidelines, ride quality data must be updated on two-year cycles. The HPMS program has its own road inventory, which consists of interstate, primary, and secondary roads. This inventory is a sub-set of the entire network and as per the reporting requirements; the roughness is only collected in the primary direction of travel as defined by FHWA. Thus the lane miles collected for HPMS is less than the amount that had been collected by Maintenance during the PaveTech contract. Since network level data had not been collected since 1998, the Pavement Design and Evaluation (PD&E) Section of the Materials Division was requested by the Information Technologies Application Division (formerly Data Management Division) to collect this information. Using VDOT personnel and equipment, supplemented with vendor resources secured through a Maintenance Division contract, IRI data was collected and processed to comply with a HPMS submission deadline of June 2001.

For the June 2003 HPMS submission to FHWA, the PD&E Section initiated data collection in January 2002. While ride quality data must be refreshed on a two-year cycle to meet HPMS requirements, the PD&E section decided to collect interstate roughness on an annual basis to ensure the most current data possible was supplied to FHWA. Additionally, data collection focused on both primary (north and east) and secondary (south and west) directions to provide a complete picture of roughness. For the non-interstate system, data will be collected on a bi-annual basis. Network level data collection was completed in March 2003.

In March 2004, interstate data collection was completed and those results are the basis for this report. A later report to be issued in 2005 will report on both the interstate and non-interstate systems, in conjunction with the June 2005 HPMS submittal to FHWA.

ROUGHNESS DATA COLLECTION

Roughness Data

Roughness is defined as the deviations of a surface from a true planar surface with characteristic dimensions that affect vehicle dynamics, ride quality, dynamic loads and drainage (ASTM E867).[7] Longitudinal surface profile data are collected through sensors mounted on the front of a van as shown in Figure 1. The sensor package, known as a *road profiler*, consists of one laser and accelerometer mounted in each wheel path, and a third sensor located in the center of the bumper. The sensors located over the wheel paths are used for roughness measurements. The sensor mounted in the middle of the bumper is used for rut-depth calculations.

Figure 1 – Road Profiler

The International Roughness Index (IRI) is used to categorize the quality of the roadways profiled using the equipment described above. The IRI is an index resulting from a mathematical simulation of vehicular response to the longitudinal profile of a traveled surface using the quarter car simulation model and a traveling speed of 50 miles per hour.[8] Typically, average IRI values for individual wheel paths are reported for every 0.1-mile section for network level analysis. The road profiler is equipped with a data acquisition system and software that converts the longitudinal profile readings to International Roughness Index (IRI) values, which have units of inches per mile. Lower IRI means less deviation in the pavement's surface; an IRI of zero represents a perfectly smooth pavement.

A standardized method of categorizing the IRI into qualitative descriptions has been developed over the years and was used to determine the roughness categories used in this report. This method is based on the following nationally recognized equation that correlates the IRI and the Present Serviceability Index (PSI): [9]

$$PSI=5 \times e^{-0.0041xIRI}$$

The PSI is used to represent the serviceability of a pavement. Since the functional performance of a pavement concerns how well the pavement serves the user, ride quality/ride comfort is considered the dominant characteristic. To quantify riding comfort, the "serviceability-performance" concept was developed by the AASHO Road Test staff in 1957. Comfort or riding quality is a matter of user opinion and can be expressed by the mean of the ratings given by all highway users. This method yields a serviceability rating. Some physical characteristics of a pavement can be measured objectively and then related to subjective evaluations. This procedure produces an objective serviceability index. The PSI is obtained from measurements of roughness and distress such as cracking, patching and rut depth, at a particular time during the service life. The scale for PSI ranges from 0 through 5, with a value of 5 representing the highest index of serviceability. [10]

In order to provide the most accurate comparison over time, this report employs the same categories utilized within Mr. Sami's 1997 report. Table 1 contains a summary of these roughness categories..

Qualitative Category	IRI Range (inches/mile)
Excellent	<60
Good	60-100
Fair	100-140
Poor	140-200
Very Poor	>200

Table 1 – Roughness Categories

Limitations

For any pavement evaluation project, there are limitations in the data collection and data analysis. The following sections outline the predominate limitations.

Data Collection

A number of factors that have an effect on the validity of the data collected with the road profiler must be taken into consideration during the measurement process. For example, bridge decks and approach slabs typically produce significantly different roughness values than the adjacent paved sections. Urban areas also present a challenge for the data collection process. The equipment used to collect the data must be operated at a minimum speed of approximately 30 mph to obtain reliable data, which can prove difficult with numerous stoplights and heavier traffic conditions. Additionally, intersections and manholes produce significantly different roughness values than their surroundings, which can affect the overall roughness of the section of roadway. This results in some routes not having reportable ride quality data. Road geometry can also present some challenges for the data collection process when there are numerous sharp curves, intersections and steep grades within the section that may adversely affect IRI values. Finally, construction projects will restrict collection efforts.

It is important that these areas are noted during the data collection process to enable the user to remove sections of questionable data from the analysis. This process is consistent with the HPMS data collection guidelines and department protocols as well.

Data Analysis

An important consideration when comparing data from year to year is that the number of miles tested varied from year to year. This is because this report utilizes data from several different sources namely PMP and HPMS. It is therefore not possible to compare results based on lane miles. For this study, percentage of total miles tested was used. Because of the size of the network tested, a comparison based on percentages provides a good method for analysis.

Quality Management

Prior to 2001, an informal program was performed by VDOT consisting of in-house sensor checks and field-testing of selected sites. In 2001, a formal verification program was implemented and an additional field test site was established at Elko (Materials Division office). This verification program was not only necessary for VDOT equipment, but also for the vendor that assisted VDOT with the 2001 HPMS data collection. Although the formal program was established to ensure the quality of the data collected for the HPMS submission, it serves to ensure the quality of all further data collection. In 2003, an additional verification site was established near the Lynchburg NDT unit office.

Prior to network level data collection, operators and equipment had to be approved on a one-mile section of roadway located at the Materials Division. This section of road was marked to ensure accurate start and end locations. The ride quality on this section of road varied from approximately 50 in/mi to 110 in/mi. For the verification, a run consisted of five passes along this section. Once the data was collected and processed, the results for each 0.01-mile interval were analyzed. In order for a profiler (operator and equipment) to pass, several criteria on the repeatability of the results had to be met. The repeatability criteria were established using multiple passes of VDOT's and Virginia Transportation Research Council's (VTRC) profilers. The percent difference approach was selected using highest and lowest IRI value from all five runs. Since the section was 1 mile in length, one hundred 0.01-mile sections and ten 0.1-mile sections were analyzed. Table 2 shows the criteria used. As shown in the table, ninety of the one hundred 0.01-mile sections and ten of the 0.1-mile sections are required to meet the 15 percent difference criteria. Also, seventy-five of the one hundred 0.01-mile sections and ten of the 0.1-mile sections are required to meet the 10 percent difference criteria. Additionally, nine of the 0.1-mile sections are required to meet the 5 percent difference criteria.

Percent Difference (Min IRI / Max IRI)	**Minimum Number of Passing Sections per Length**	
	0.01 mi.	**0.1 mi.**
15%	90	10
10%	75	10
5%	N/A	9

Table 2 – IRI Verification Criteria

The accuracy of each profiler is verified by checking the average of the 5 runs of the control site against the ground-truth values established by numerous runs of VDOT's three profilers. The average of 5 runs of the control site had to be within 5% of the ground-truth value for each 0.1-mile section and within 2% of the ground-truth value for the total section to meet the accuracy requirements.

If the profiler did not meet these criteria, then retesting of the site was performed. If after a second retesting acceptable results were not achieved, then maintenance on the equipment was required.

Once the profiler passed the repeatability check, testing was initiated. For the HPMS data collection, a verification run was performed before any testing was conducted, every 30-calendar days after commencement of testing, and at the completion of the project. Even when HPMS testing is not underway, monthly runs at a verification site are required for VDOT equipment.

WORK SUMMARY FOR 2004

For the data collection period ending March 2004, approximately 2,200 directional miles of Interstate routes were collected by the Materials Division. Of these 2,200 miles, approximately half of the mileage is used for VDOT's HPMS submission to the Federal Highway Administration for performance monitoring and annual reporting. Table 3 provides a breakdown of directional miles tested by district.

Directional Miles of Highways Tested in 2004 (by District)										
System	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
Interstate	250	235	-	522	302	90	139	469	183	2193

Note: 1=Bristol, 2=Salem, 3=Lynchburg, 4=Richmond, 5=Hampton Roads, 6=Fredericksburg, 7=Culpeper, 8=Staunton, 9=Northern Virginia

Table 3 – Directional Miles Tested (2004)

Figure 2 shows the distribution of roughness within individual districts for the Interstate system. Similar to previous years, Bristol, Salem, and Staunton districts had the highest percentage of interstates in "excellent" and "good" conditions, with the Culpeper District a close fourth. The Richmond and Northern Virginia districts had the lowest percentage of interstates in the "excellent" category, while the Hampton Roads district had the greatest percentage of interstates in the "poor" and "very poor" category. Bristol, Salem, Fredericksburg, Culpeper, and Staunton districts all had negligible (less than 1.0 mile) "very poor" mileage.

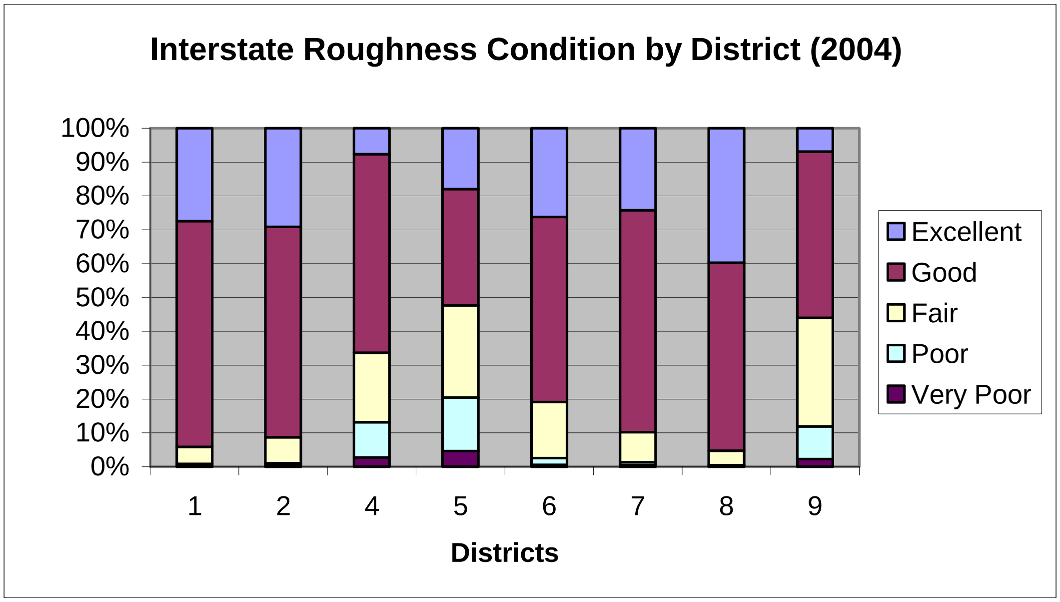


Figure 2 – Interstate Roughness Distribution (2004)

RESULTS AND TRENDS

Over the last six years, results and trends have been noted for the interstate system. The interstate has not deteriorated in overall average ride quality since 1998. While the 2002-2003 winter breakup caused a decrease in ride quality when measured in 2003, the 2004 results show that the ride quality has improved to the levels reported in 2001 and 2002.

In order to establish trends in ride quality, data must be examined over a multiple year period. The following graph (Figure 6) shows the statewide Interstate IRI distribution for each year by category of Excellent, Good, Fair, Poor and Very Poor. The data indicate a steady increase in the "excellent" category from 1998 to 2004. The data also shows a significant rise in the "excellent" category and a decrease in the "fair" and "poor" categories from 2003 to 2004.

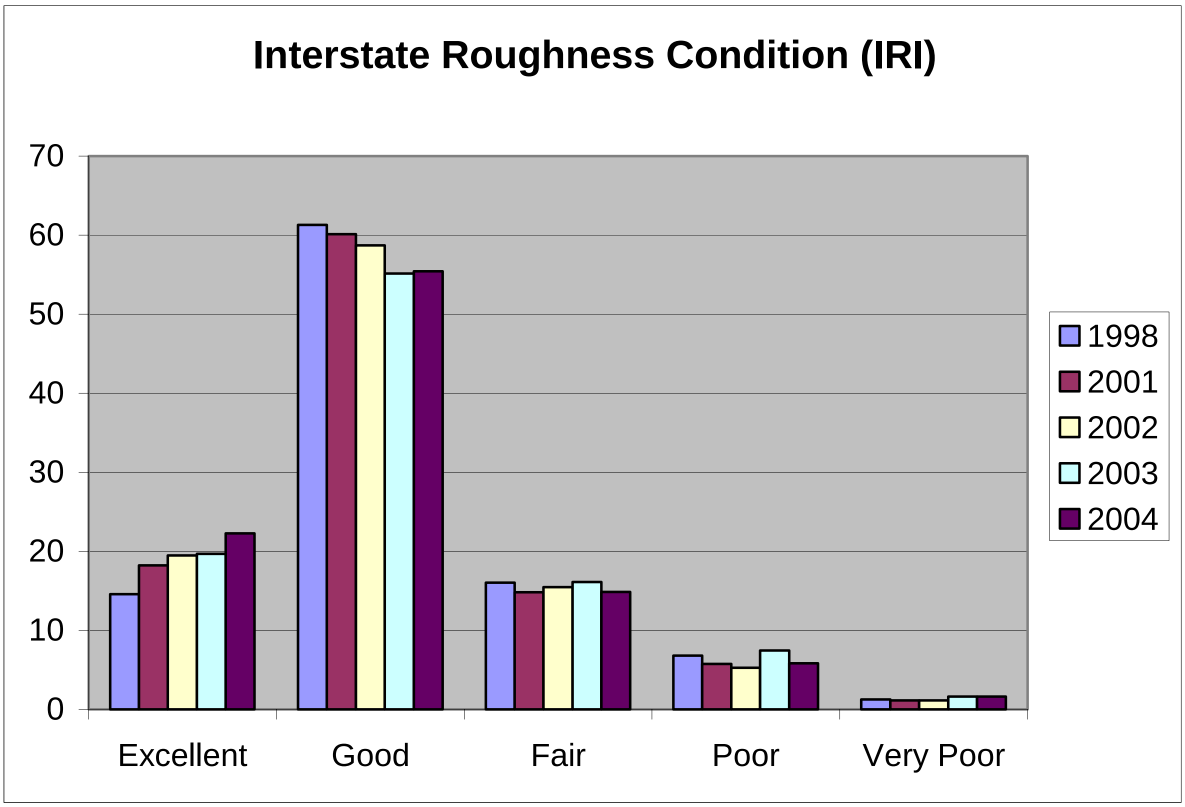


Figure 3 – Statewide Interstate IRI by Year

While Figure 3 displays the trends statewide, Table 4 summarizes the change in mileage tested by category for each district from 1998 to 2004. This table offers each district a view of their progress within the six-year span since the mileage collected has remained constant.

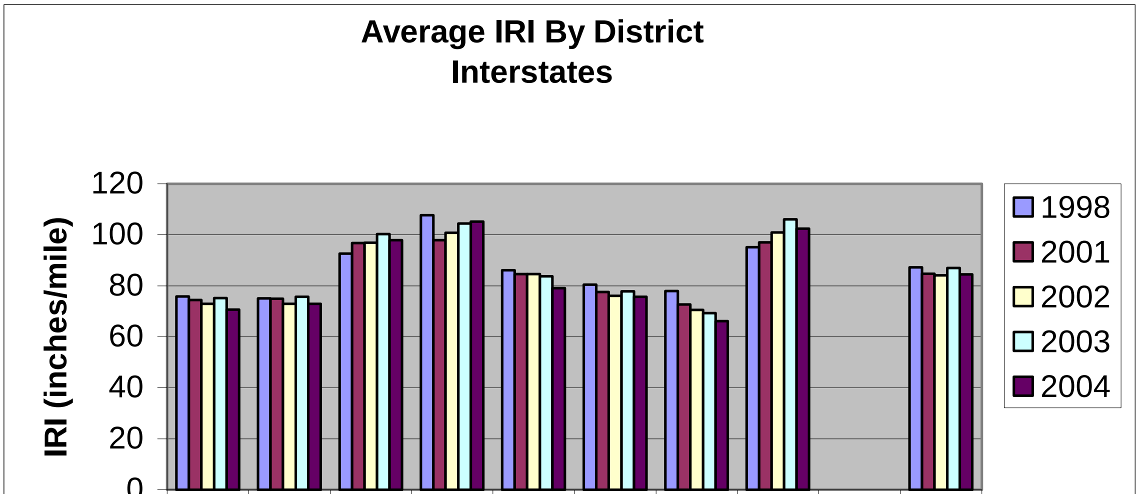
Category	District							
	1	2	4	5	6	7	8	9
Excellent	14.10	10.00	-21.40	15.50	17.30	20.50	106.50	-3.00
Good	3.60	-4.30	5.70	-36.00	-44.00	-16.40	-70.20	-28.90
Fair	-9.00	-2.30	-9.50	4.80	-6.40	-0.10	-26.60	8.10
Poor	-4.80	-4.10	9.90	-11.10	-2.10	-4.40	-10.20	0.60
Very Poor	-0.20	0.20	5.20	0.40	0.30	0.20	-0.20	1.20

Table 4 – Change in Directional Miles Tested by Category from 1998 to 2004

To interpret Table 4, the following generalities are provided:

- If the "Excellent" or "Excellent" and "Good" categories are positive and remaining categories are negative, then the overall condition of the roads has improved.
- If the "Excellent" and "Good" categories are negative and the "Fair", "Poor" and "Very Poor" categories are positive, then the overall condition of the roads has declined.
- For all other cases, the change in percentages must be evaluated.

Following these generalities, Figure 4 reflects the average IRI by district for the Interstates from 1998 to 2004. The actual average IRI values for each year are shown on the graph.



	1	2	4	5	6	7	8	9		AVG
1998	76	75	93	108	86	80	78	95		87
2001	74	75	97	98	85	78	73	97		85
2002	73	73	97	101	85	76	70	101		84
2003	75	76	100	104	84	78	69	106		87
2004	71	73	98	105	79	76	66	102		85

Figure 4 – Interstate Average IRI by District and Year

Except for Richmond, and Northern Virginia districts, the remaining six districts are showing an improvement in the average IRI for their interstates from 1998 to 2004. Only Hampton Roads district saw an increase in IRI from 2003 to 2004. While grinding of the PCC occurred in 2003, the improvement in ride quality for that section of I-64 was minimal. No other section of interstate in the Hampton Roads District saw a pavement improvement in terms of AC overlay. Conversely, seven of eight districts are showing a decrease in IRI from 2003 to 2004. The average decrease in IRI statewide for the interstate system from 2003 to 2004 was 2 inches per mile. This decrease in IRI is consistent with the results reported from 1998 to 2002. Much of the reason for the improvement in ride quality appears to be attributable to the additional maintenance and asphalt paving that occurred after the winter breakup of 2002 –2003. While the 2004 interstate data was collected during the same time frame as the 2003 data, the winter breakup was not as pronounced. In addition, widespread usage of the ride spec on interstate routes has contributed to an overall improvement in ride quality.

Appendix A contains the percentages used to develop Figures 3 and 4 and Table 7.

Pavement Surface Type

Two surface types exist on the interstate system in Virginia – asphalt concrete (AC) and Portland Cement Concrete (PCC). Only three districts have interstate mileage where more than 8 centerline miles of each type were present - Richmond, Northern Virginia and Hampton Roads. Except for sections of I-64 in Hampton Roads and a section of I-66 in Northern Virginia, most of the existing PCC surfaces have been in service for more than 15 years. Many of these surfaces have experienced varying levels of distress, which has resulted in less than desired ride quality. For the AC surfaces in these same districts, the majority has been in place less than 10 years. Recognizing the difference in condition and ages, an analysis was performed to determine the effect of surface type on these districts IRI averages and distributions from 1998 to 2004.

As in 2003, all of the interstate network was collected in both directions. Figure 5 shows the distribution by pavement type and district. Table 5 provides the mileage collected and average IRI by pavement type.

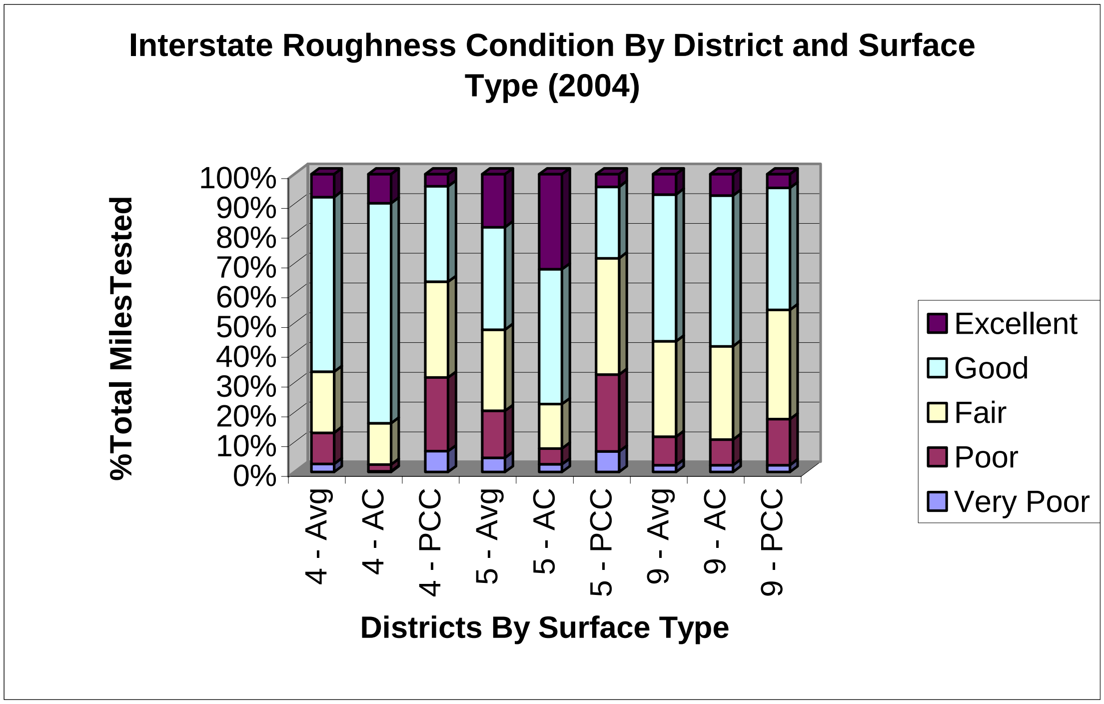


Figure 5 – Interstate IRI by District and Surface Type (2004)

District	Mileage			IRI		
	PCC	AC	Average	PCC	AC	Average
Richmond	190	331	521	124	83	98
Hampton Roads	155	149	304	127	83	105
Northern Virginia	26	160	186	110	101	102

Table 5 – Mileages and Average IRI by Pavement Type (2004)

Effect of Surface Type on Average Interstate IRI

For each of the three districts in Virginia that have a substantial amount of PCC and AC surfaces on the interstate system, the average ride quality is a function of the surface. In the Hampton Roads and Richmond Districts, the ride quality is much worse on the PCC surfaces compared to the AC surfaces. In 2004, the average IRI on PCC surfaces was over 35 inches per mile higher than the AC surfaces. Additionally, these three Districts had the highest overall average IRI, with both the Hampton Roads and Northern Virginia District average over 100.

Table 6 summarizes the change in directional miles tested for each category from 1998 to 2004 and for each district based on surface type. This table offers each district a view of their progress within the six-year span. Again, 1998 was selected as the baseline year for trend comparisons due to its data quality.

Category	Mileage Change By District from 1998 - 2004								
	4 - Avg	**4 - AC**	**4 - PCC**	**5 - Avg**	**5 - AC**	**5 - PCC**	**9 - Avg**	**9 - AC**	**9 - PCC**
Excellent	-213	-164	-49	160	125	35	-29	-40	10
Good	45	142	-80	-275	-67	-210	-275	-253	-29
Fair	-100	27	-119	76	-121	192	89	60	26
Poor	100	-68	173	-102	-115	9	8	-22	28
Very Poor	50	-18	69	8	-10	16	12	6	6

Table 6 – Change in Miles Tested by Category and Surface Type from 1998 – 2004

For the PCC surfaced interstate in all three Districts, the average IRI has increased from 1998 to 2004. From 2003 to 2004, the average IRI has decreased in Richmond, remained unchanged in Northern Virginia and increased in Hampton Roads for PCC surfaces. As a result, the average IRI for PCC surfaces remained unchanged from 2003 to 2004. The improvement in the Richmond District may have resulted from extensive patching to repair deteriorated sections of pavement. In addition, portions of Interstates 64 and 295 were overlaid with asphalt concrete in the summer of 2003.

The AC surfaced Interstates in these three Districts were showing the same trend, with one notable exception. The Hampton Roads District has significantly lowered the average IRI for AC surfaces from 1998 to 2004, from 95 to 83. This effect has also lowered the average IRI for all surfaces from 108 to 105 in Hampton Roads District. In contrast, both Richmond and Northern Virginia have seen an increase in average IRI from 1998 to 2004 for AC surfaces. However, the average IRI for AC surfaces decreased by 3 IRI from 2003 to 2004, which mirrored the statewide trend toward lower IRI. The average IRI was 124 for PCC surfaces and 87 for AC surfaces in 2004 for the three Districts analyzed.

IRI by Route Number

An analysis was conducted to determine the smoothest interstate routes from a statewide average and by District. As can be seen in Table 7, Interstate 81 was the smoothest overall. Much of this can be attributed to a significant investment by the Staunton District to rehabilitate significant portions of Interstate 81 over the last several years. Following the same trend as the overall District averages, the four smoothest routes were all contained in the three Districts with the smoothest interstates, Bristol, Salem, and Staunton. Many of the roughest interstate routes were the shortest, which tended to skew the results toward higher IRI.

Average IRI by Interstate Route, District									
Route	**1**	**2**	**4**	**5**	**6**	**7**	**8**	**9**	**Avg**
81	70	73					63		68
581		73							73
77	72	74							73
381	75								75
95			90	61	79			101	83
66						69	64	99	83
85			88						88
64			100	117		79	73		93
495								99	99
664				109					109
295			112						112
395								122	122
264				123					123
464				123					123
564				171					171
195			194						194

Table 7 – Average IRI by Route Type, District (Lowest to Highest IRI)

CONCLUSIONS

The overall ride quality on Virginia's interstates has improved since 1998 and most significantly, since 2003. Much of this improvement in ride quality can be attributed to the increase in additional maintenance and asphalt paving that occurred after the winter breakup of 2002 – 2003. While the 2004 interstate data was collected during the same time frame, in February and March, the winter breakup was not as pronounced to have an effect on the 2004 interstate IRI results. In addition, widespread usage of the ride spec on interstate routes has contributed to the improved ride quality. The benefits of the ride spec are shown in Figure 7, where interstate paving projects averaged an IRI of 64 in 2003. [11,12,13]

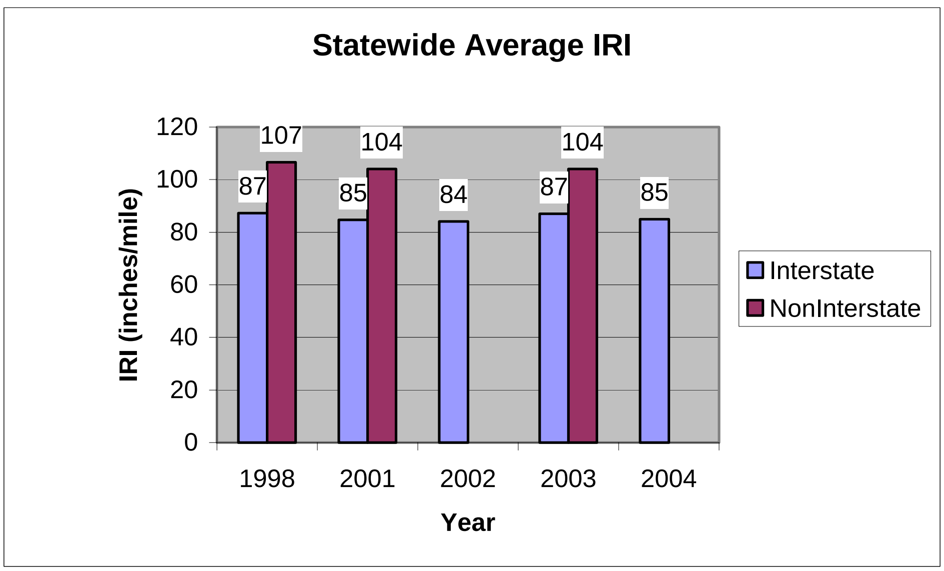


Figure 6 – Statewide Average IRI by System and Year

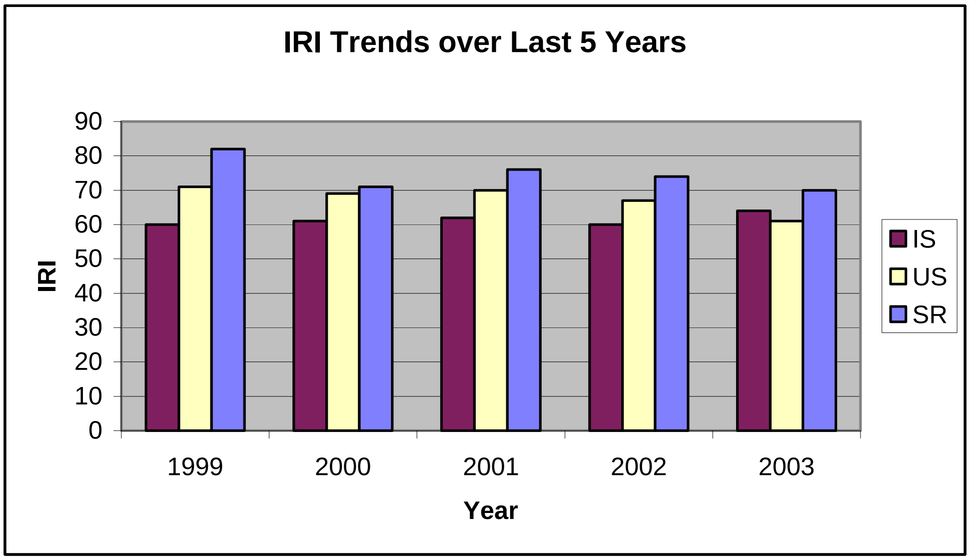


Figure 7 – Maintenance Projects with Ride Spec

This report was based on a high-level analysis of ride quality data collected over the last five years. While the author noted trends and observations, in-depth pavement data analysis was not conducted. Areas for further research may include but not limited to:

- Relationship of vehicle miles traveled to IRI by district,
- Comparison of maintenance expenditures to pavement performance,
- Comparison of maintenance activities to pavement performance, and
- Evaluation of pavement performance targets based on ride quality.

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APPENDIX A – DATA SUMMARY FOR INTERSTATES

Interstate Roughness Condition - Statewide

	1998	2001	2002	2003	2004
Excellent	14.57	18.2	19.47	19.67	22.26
Good	61.3	60.12	58.69	55.15	55.43
Fair	16.05	14.8	15.46	16.12	14.86
Poor	6.82	5.74	5.26	7.45	5.84
Very Poor	1.26	1.14	1.12	1.60	1.61

Interstate Roughness Condition by District - 1997

	1	2	4	5	6	7	8	9
Excellent	2	0	0	2	0	0	0	0
Good	81	71	65	51	58	73	65	21
Fair	17	29	29	29	36	27	32	72
Poor	0	1	5	15	6	0	3	6
Very Poor	0	0	1	3	0	0	0	1

Interstate Roughness Condition by District - 1998

	1	2	4	5	6	7	8	9
Excellent	22.17%	24.85%	11.52%	11.77%	5.11%	9.46%	17.04%	7.59%
Good	66.23%	63.83%	56.49%	42.59%	74.54%	77.29%	70.38%	57.98%
Fair	8.72%	8.61%	21.95%	23.58%	17.08%	8.88%	9.85%	24.68%
Poor	2.63%	2.54%	8.34%	17.89%	3.11%	4.01%	2.55%	8.28%
Very Poor	0.24%	0.17%	1.69%	4.17%	0.16%	0.36%	0.17%	1.46%

Interstate Roughness Condition by District - 2001

	1	2	4	5	6	7	8	9
Excellent	28.56%	26.68%	7.47%	23.55%	9.83%	13.98%	23.71%	6.11%
Good	60.59%	62.53%	58.31%	36.07%	70.73%	76.08%	68.61%	56.79%
Fair	7.30%	8.24%	21.91%	23.17%	16.24%	7.64%	6.70%	28.62%
Poor	3.20%	2.29%	10.49%	13.56%	2.99%	2.16%	0.90%	6.67%
Very Poor	0.36%	0.25%	1.82%	3.65%	0.21%	0.14%	0.09%	1.81%

Interstate Roughness Condition by District - 2002

	1	2	4	5	6	7	8	9
Excellent	23.49%	29.32%	6.80%	18.97%	12.47%	19.56%	29.66%	6.42%
Good	68.79%	61.42%	58.53%	36.49%	65.87%	70.71%	63.13%	50.73%
Fair	6.41%	8.05%	23.14%	27.40%	17.75%	8.71%	6.51%	31.74%
Poor	1.30%	0.89%	9.61%	13.70%	3.84%	0.60%	0.60%	9.17%
Very Poor	0.00%	0.32%	1.92%	3.43%	0.08%	0.43%	0.10%	1.93%

Interstate Roughness Condition by District - 2003

	1	2	4	5	6	7	8	9
Excellent	22.71%	26.47%	5.98%	16.96%	19.38%	21.92%	35.86%	6.57%
Good	66.36%	60.33%	57.61%	34.98%	57.29%	65.92%	56.12%	47.54%
Fair	7.82%	10.27%	21.45%	28.49%	19.06%	8.83%	6.13%	29.60%
Poor	2.87%	2.84%	12.06%	15.74%	4.05%	2.60%	1.70%	13.14%
Very Poor	0.24%	0.08%	2.89%	3.82%	0.21%	0.72%	0.19%	3.14%

Interstate Roughness Condition by District - 2004

	1	2	4	5	6	7	8	9
Excellent	27.48%	29.15%	7.64%	17.93%	26.22%	24.18%	39.76%	6.87%
Good	66.69%	62.13%	58.68%	34.40%	54.65%	65.64%	55.53%	49.18%
Fair	4.99%	7.65%	20.56%	27.22%	16.59%	8.82%	4.20%	32.06%
Poor	0.68%	0.81%	10.40%	15.78%	1.99%	0.86%	0.38%	9.60%
Very Poor	0.16%	0.25%	2.72%	4.66%	0.55%	0.50%	0.13%	2.29%

Percent Change by District from 1998 - 2004

	1	2	4	5	6	7	8	9
Excellent	5.31%	4.30%	-3.88%	6.16%	21.11%	14.72%	22.72%	-0.72%
Good	0.46%	-1.70%	2.19%	-8.19%	-19.89%	-11.65%	-14.85%	-8.80%
Fair	-3.73%	-0.96%	-1.39%	3.64%	-0.49%	-0.06%	-5.65%	7.38%
Poor	-1.95%	-1.73%	2.06%	-2.11%	-1.12%	-3.15%	-2.17%	1.32%
Very Poor	-0.08%	0.08%	1.03%	0.49%	0.39%	0.14%	-0.04%	0.83%