2003 Ride Specification Testing Results – Maintenance Schedules

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

As a response to the public's desire for smoother roads and FHWA's goals to reduce road roughness and decrease vehicle use costs, VDOT implemented ride quality specifications using a profilograph and straight-edge. While both of these approaches were successful, they were slow. In the 1990's, VDOT started evaluating high-speed profilers as a replacement to the profilograph. Based on research conducted by the Virginia Transportation Research Council, initial high-speed profiler based ride quality specifications were developed in the mid-1990's. Since 1998, ride quality specifications have been in greater use with each successive year. At the same time, the ride quality specifications based on experiences have evolved, and enhanced to achieve the desired end product, smoother pavements.

This report utilizes data collected by VDOT's Non-Destructive Testing (NDT) unit as part of the Maintenance Program's Ride Spec program. These data were analyzed by district materials and pavement management personnel for the 2003 paving projects. This report will present trends statewide, by district, and by route type. Included in this report are the following:

- History and background of IRI-based ride specifications
- Before IRI results
- After IRI results
- Percentage improved
- Costs of ride specification
- Comparison of different mix types
- Effects of milling on roughness
- Comparison to previous years' results.

The results of the analysis show that the ride quality for Virginia's rideability projects have continued to improve with each successive year. Based on an analysis of the previous six years' data, the rideability projects in 2003 were the smoothest overall. Both US routes and State routes were smoother than in previous years. Only the interstate routes were slightly rougher when compared to last year. This decrease in ride quality may be due to the widespread implementation of Stone Matrix Asphalt (SMA) on the interstate in 2003. Some contractors were familiar with SMA and provided a smooth ride, other contractors had difficulty placing the material. As knowledge is gained with the placement of SMA, the ride quality will improve.

An analysis of the district IRI results show that six out of nine districts reported improvement in excess of 30%, while all nine showed positive improvement. While some districts paid more in incentives than disincentives (and vice versa), the statewide total cost was a very low percentage of the statewide total cost for plant mix schedules awarded in 2003. The Maintenance Program's Ride Spec program is more than worth the effort in terms of additional service life and reduced maintenance costs that smoother roads have been shown to provide.

PURPOSE OF THIS REPORT

Roughness is an important aspect of the condition of our highways, as it affects the quality of the ride and the user's perception of the pavement's condition. It is important to adequately measure and control the quality of pavement roughness.

Surveys of the public have shown that pavement conditions, of which ride quality is a major component, have rated near the top of characteristics that should receive the most attention and resources for improvement. This fact has helped spawn Federal Highway Administration's pavement smoothness initiative, which calls for improvement of the national highway system's smoothness level by 2008.

The purpose of this report is to provide VDOT management with the most accurate information available by presenting the results of the 2003 ride specification projects, noting trends statewide, and by District for Interstate, US, and SR routes, and presenting observations following data analysis.

BACKGROUND[1]

Beginning in 1998, VDOT began to implement new ride quality specifications, one that incorporated high-speed inertial profilers and the International Roughness Index (IRI). Since that time and based on several years of analysis, VDOT has enhanced and modified the ride specification several times. This report will detail the results of the 2003 ride specification projects from the Maintenance Program's Plant Mix Schedules.

VDOT's History of Ride Specifications

In 1995, VDOT's primary method for regulating smoothness of highway surfaces used a specification that was built around the California-type profilograph. The profilograph can be described as a long (25 ft) rigid frame assembly with several wheels at each end and a measurement wheel at the center. As the instrument moves along a surface, the center wheel travels up and down with variations in the surface. The amount of up and down movement is accumulated and reported as roughness. In some situations, a vehicle can tow the profilograph. More commonly, however, the instrument is pushed along the pavement by hand.

VDOT's engineers had very good reasons for being reluctant to use the existing smoothness special provision on a widespread basis. The first of those reasons was that administering the specification would involve manually propelling the profilograph for two passes over each of the lanes of a project, if all went perfectly. A nearly universal trend toward fewer state-force inspectors would have made it difficult to find and devote the necessary staff to what would have been a formidable task.

A second and perhaps more compelling reason for VDOT's aversion to the traditional specification was one of safety. According to statistics published by the Federal Highway Administration's Work Zone Safety Program, an average of 760 people are killed every year in work-zone-related accidents. Although most of these individuals are operating or traveling in motor vehicles, an average of 122 (16%) per year are non-motorists. Naturally, construction workers and inspectors make up the largest portion of the non-motorist who are killed or injured in work-zones. The fact that the existing Virginia special provision for smoothness involved performing manual tests within several feet of high-speed traffic made it very unattractive.

A New Smoothness Provision

Virginia's solution was a new specification, one with which testing could be conducted at highway speeds and without the need to expose workers directly to traffic. In place of the California Profilograph, the new provision incorporated an inertial road profiler. Inertial profilers are vehicle-mounted systems that measure longitudinal profiles in accordance with the American Society for Testing and Materials (ASTM) standard E950. These instruments typically combine accelerometers, height sensors, and electronic distance measuring equipment to collect two profiles with each pass, one representing the left and the other the right wheel-path. The conceptual difference between the inertial profiler and more traditional road roughness equipment is simple but important. Instead of measuring roughness as a response to the surface profile (e.g., Mays Meter), the inertial profiler directly measures the profile.

To complement the inertial profiler and supplant the profilograph index (PI), the new provision was constructed around the International Roughness Index (IRI). The IRI, which is calculated using ASTM's Standard E1926, is produced through a simulation that applies a "virtual" quarter-vehicle to an elevation profile such as that collected with the inertial profiler. The suspension motion resulting from this simulation is accumulated and divided by the distance traveled to yield the IRI. Smaller values (less roughness) imply a smoother ride and higher values are indicative of a rougher one.

The format of the new special provision closely resembled the profilograph-based specification. Within the provision, an average IRI value is generated and reported for each 0.1-mile pay lot. These values are then compared to a pay adjustment schedule. This schedule incorporates a target band for full payment, as well as several pay ranges in which incentives or disincentives may be applied. In addition to the IRI values generated for each pay lot, IRI's are generated at 10 subintervals and these values are reviewed to identify localized roughness or bumps/dips. A threshold for allowable roughness (maximum IRI) exists for both the pay lot and the subintervals. Roughness above these thresholds is subject to correction.

Application and Evolution of Early Provision

Although high-profile construction projects are important, they represent only a fraction of the hot mix asphalt concrete (HMAC) pavement placed during a typical construction season. In Virginia, the annual maintenance resurfacing program is responsible for a much larger portion of new surfaces. Every year, VDOT's maintenance resurfacing program involves 2 million tons of HMAC covering almost 3,600 lane-mi. The real potential for a smoothness special provision of the type proposed would be realized only through its application to this program.

With this in mind, the 1996 resurfacing schedule was amended to include an application of the experimental smoothness specification to 41 lane miles of new surface. In its original form, the provision offered a single schedule of pay adjustments, regardless of highway system or other important characteristics of a project. To achieve 100% of the material bid price, a contractor needed to achieve a final surface IRI of 70 to 80 in/mi over the 0.1-mile lot. The maximum allowable IRI of any 0.01-mile interval was 120 in/mi.

In 1997, the pilot was expanded to 380 lane miles in six of Virginia's nine construction districts. Although not substantial, the special provision used in the second season of the pilot did incorporate a couple of minor changes. The maximum incentives and disincentives were softened (reduced) and the pay steps were broadened slightly. The target smoothness range necessary to achieve 100 percent payment remained unchanged, but the maximum IRI eligible for payment was increased to 110 in/mi. Perhaps the most significant of the changes was acknowledgment of the influence of original surface ride quality. For all practical purposes, the added language required that a before-overlay roughness survey be conducted. It specified that a project was not eligible for an incentive if the final surface was rougher after completion of the work; regardless of the average ride quality achieved. Conversely, if a contractor was able to effect at least a 25 percent improvement (over the original surface) in ride quality, he or she would not be subject to a disincentive, regardless of the degree of roughness remaining in the final surface.

By late summer, 1997, the specification revisions governing the 1998 construction season were complete. The 1998 version provided separate pay adjustment tables for interstate and non-interstate projects. According to these new pay schedules, contractors working within the special provision on an interstate highway were required to reduce the pavement roughness by an additional 10 in/mi with the new surface. The targets for non-interstate overlays remained unchanged. The updated pay adjustments were consistent with those applied to the interstate system projects, with the appropriate increase in allowable roughness.

Beginning in 2000, the Ride Spec committee revised the language in the 1998 special provision and modified the following areas:

- Section Length to Base Payment- Length was revised to 0.01 mile for payment. This length better reflected the "seat-of-the-pants" ride quality felt by the traveling public and allowed VDOT to penalize or require corrections on isolated locations.
- Pay Tables and IRI Ranges- Incentive and disincentive percentages were increased to encourage contractors to improve on paving processes, and to discourage the paving of

rougher pavements, knowing those pavements have a shorter service life. In addition, the number of pay ranges were reduced and combined to more accurately reflect variability.

- Percentage of Improvement- Realizing ride quality could be improved by a larger percentage and still protect contractors from being penalized for a poor initial condition, the Ride Spec committee increased the % improvement clause from 25% to 30%.
- Testing Period- Testing window was expanded from 60 to 180 days prior to paving and from 14 days to 30 days after completion of the final surface course after determining the change in IRI was minimal over that time period.

2002 Plant Mix Schedules

For the 2002 plant mix schedules, the most significant change made from the 2000 special provision was the addition of pay percentages for sections requiring corrective action. This gave VDOT the option to apply the disincentive or require the contractor to correct those sections. These pay ranges are displayed below:

Interstate Routes IRI Range	Non-Interstate Routes IRI Range	Pay Adjustment
100.1 – 120	110.1 – 130	60% or Corrective Action
120.1 – 140	130.1 – 150	40% or Corrective Action
140.1 – 160	150.1 – 170	20% or Corrective Action
> 160.1	> 170.1	0% or Corrective Action

2003 Plant Mix Schedules

For the 2003 plant mix schedules, the only significant change made from the 2002 paving season was in the administration of the percent improvement clause. The percent improvement clause was changed to apply to each 0.10-mile section rather than the entire project. This meant that a project might exceed 30 percent improvement but still have 0.1-mile sections subject to corrective action or disincentive. This was added to the special provision to enable VDOT to correct bumps or objectionable short sections, which were previously exempted from disincentive or correction due to the project's overall improvement (greater than 30%).

Ride Spec Site Selection

The development and implementation of ride specifications has been aiding in the improvement of ride quality across of the State of Virginia. Good ride quality not only benefits VDOT with longer lasting pavements, but rewards the contractors in the form of incentive payments for exceptional work. Therefore, ride specifications should be applied to roadways with mix types, project characteristics and pavement conditions that provide a contractor with ample opportunity to meet the requirements. To aid VDOT personnel that determine which projects the rideability specifications were to be applied, the following guidelines have been developed. These guidelines were based on VDOT's experiences since the original guidelines, developed July 3, 1997.

Project Considerations

In order for the Materials Division's Non-Destructive Testing Section to perform ride quality testing and to give the contractor opportunity to provide a smooth surface, the characteristics of the project must be considered. Below is a list of rejection criteria. If a project meets one of these criteria, it should **NOT BE** considered for rideability specifications:

- Projects with a total pavement overlay length less than 0.5 miles
- Projects where the total lane width has not been paved
- Projects with excessive grade changes within it's limits (>6%)
- Projects with a design speed less than 45 mph
- Projects where the testing equipment is not able to maintain a speed between 25 and 60 mph
- Projects with Signalized Intersections where the distance between any two adjacent intersections or where the distance between an intersection and the project limits is less than 0.5 miles
- Projects with Stop Sign Controlled Intersection where the distance between any two adjacent intersections or where the distance between an intersection and the project limits is less than 0.5 miles
- Projects containing Railroad Crossings where the distance between the railroad crossing and the project limits is less than 0.5 miles
- Projects with Permanent Obstructions in the lane such as manhole, valve and vault covers.
- Projects where the overlay was constrained due to existing curb and gutter limitations at edge of lane (less than 4 feet between edge stripe to curb and gutter)
- Projects with lane widths less than 9 feet
- Projects with excessive surface distress (rutting, shoving, corrugation, etc.) where surface removal was not intended and only one AC lift will be placed
- Projects that are a surface treatment
- Projects with pavement transitions at construction tie-ins not leaving 0.5 miles to test

In addition, the following pavements should not be tested:

- Pavement Shoulders
- Truck climbing lanes less than 0.5 miles in length
- Acceleration, Deceleration Lanes or ramp pavements

If a project contains any of the rejecting criteria outlined above and the District wants the ride specs applied, then the requesting individual must provide copied notes indicating specific areas (by station) for application to apply the ride specifications.

QUALITY MANAGEMENT FOR RIDEABILITY TESTING[1]

In the late 1990's when VDOT began ride testing with inertial profilers, a quality management program was implemented. For the first few years, the program was informal. However, with the incorporation of the 1998 Special Provision and later the 2000 and 2001 Special Provisions, a formal detailed quality management program was necessary.

Equipment and Operators

The keys to good ride data are good equipment and experienced operators. VDOT owns and operates four International Cybernetics Corporation, Inc. inertial profilers. All four profilers are equipped with lasers and accelerometers for longitudinal profiler data collection. Many studies over the last ten years have pointed out the variability between equipment manufactures. For that reason, VDOT has only used one equipment type for data collection.

VDOT equipment operators have over 30 years of experience using inertial profilers. Their driving experience is key to measuring the longitudinal wheel path profiles. Additionally, the operators are able to adapt testing procedures to project requirements. This experience has reduced the variability in IRI results.

Verification of Equipment

VDOT's quality management program requires inertial profile equipment be verified. The verification procedures apply to the lasers, accelerometers and distance measuring instruments. These procedures are part of a two-tier process – weekly verification and monthly verifications.

At the beginning of each week, three verifications are performed. The laser sensors are the first pieces of equipment verified. Placing an object of known height under the sensor and recording the measurement performs a static verification. If the lasers pass this verification, then the next check is performed. Following the procedures recommended by the manufacturer, the accelerometers are verified. Finally, the entire system including the operator is verified by testing a roughness route near the NDT Unit Office. These weekly checks allow VDOT to reduce the risk of collecting bad data to one week.

Each month VDOT performs a controlled verification of the inertial profile system. On a one-mile site near Richmond or Lynchburg, each profiler performs five runs. The results from these runs are used to determine the repeatability and accuracy of the equipment. Since these runs are under a controlled environment, drifts in the sensors can be detected that may not be noticed during the weekly verifications.

Virginia Test Method 106

To ensure the consistent collection of data from one Rideability site to the other, Virginia Test Method (VTM) 106 was developed. The major highlights of this VTM are:

- Optical triggering;
- Minimum of two runs per lane; and
- Acceptance criteria for data in the field.

The use of optical triggering is to initiate testing. This allows data for all runs to be referenced to a fixed location. This is crucial in VDOT's data analysis process because the lowest IRI value for each 0.01-mi. increment is used in payment determination. Statistically, the more runs collected on a lane the variability is reduced. However, from a production standpoint, fewer passes result in more sites being tested. Based on analysis of historic VDOT ride quality data, it was determined that two passes are acceptable. Finally, the VTM outlines the method to accept data results in the field. If the average IRI for two runs is within 5% or 3 in/mi, whichever is greater, then the data is approved. If the average is outside of this tolerance, then the data are discarded and two additional runs are made. If the average is once again outside of this tolerance, then based on VDOT experience the inertial profiler system has an error and must be repaired.

By combining reliable equipment, experienced operators, verification processes, and documented testing procedures, VDOT has a sound quality management program.

RESULTS

At the end of each Plant Mix Schedule season, VDOT and asphalt pavement industry personnel want to know the statewide and district ride spec results. Typical questions are:

- How many sites were tested?
- What were the results by district and system?
- How much money was spent in incentives or withheld in disincentives?
- In terms of roughness, how did Stone Matrix Asphalt (SMA) mixes compare to Superpave mixes?
- What was the effect of milling or not milling on roughness?

The following sections will provide the answers to these questions.

Number of Sites and Lane Miles per District

For the 2003 resurfacing season, all Districts used the same special provision for rideability, the 2002 version. Tables 1 and 2 show the number of ride spec sites and number of lane miles by District and System, respectively. IS are interstate routes; US are United States routes; and SR are State Routes. For the following tables and figures, the districts will be referenced by District Number as shown in Table 1.

Based on an analysis of the 2003 plant mix schedules, the number of ride spec sites was significantly less than the number tested in 2002. The total number of sites tested in 2003 declined from 164 to 113, while the number of lane miles declined from 752 to 669. However, a substantial number of ride spec sites on the 2003 plant mix schedules were not paved; thus, they were carried over to the 2004 paving season. With the inclusion of these carryover sites, the number of sites selected was approximately equal and the number of lane miles were slightly higher than in 2002. Table 3 shows the number of sites and lane miles selected for rideability in 2003 that were not completed in 2003.

District Number	District	Number of Rideability Projects			
		Total	**IS**	**US**	**SR**
1	Bristol	5		3	2
2	Salem	12	5	7	
3	Lynchburg	6		6	
4	Richmond	22	10	5	7
5	Hampton Rds.	23		11	12
6	Fredericksburg	18	2	9	7
7	Culpeper	13	2	10	1
8	Staunton	10	9	1	
9	No.Va.	4		1	3
	Total	**113**	**28**	**53**	**32**

Table 1 – Rideability Projects in 2003 by District and System

District Number	District	No.of Lane Miles of Rideability projects			
		Total	**IS**	**US**	**SR**
1	Bristol	31		15	16
2	Salem	68	28	41	
3	Lynchburg	24		24	
4	Richmond	125	75	20	31
5	Hampton Rds.	127		74	53
6	Fredericksburg	95	4	43	47
7	Culpeper	76	9	62	5
8	Staunton	91	87	4	
9	No.Va.	29		9	20
	Total	**669**	**203**	**292**	**173**

Table 2 – Lane Miles in 2003 by District and System

District Number	District	Rideability Projects Carried Over to 2004 Paving Season	
		Number of Sites	Number of Lane Miles
1	Bristol	8	29
2	Salem	4	18
3	Lynchburg	6	32
4	Richmond	7	24
5	Hampton Rds.	17	64
6	Fredericksburg	5	25
7	Culpeper	1	3
8	Staunton		
9	No.Va.		
	Total	**48**	**195**

Table 3 – Rideability Projects in 2003 Carried Over to 2004

Before IRI Testing Results

Prior to the beginning of the paving season in 2003, before IRI testing was conducted on all of the rideability sites where the data were required. As can be expected, the average IRI for the Interstates was the lowest, and the state route category was the highest. Figure 1 summarizes the results of the before IRI testing for each district and Figure 2 has a breakdown of the results by system.

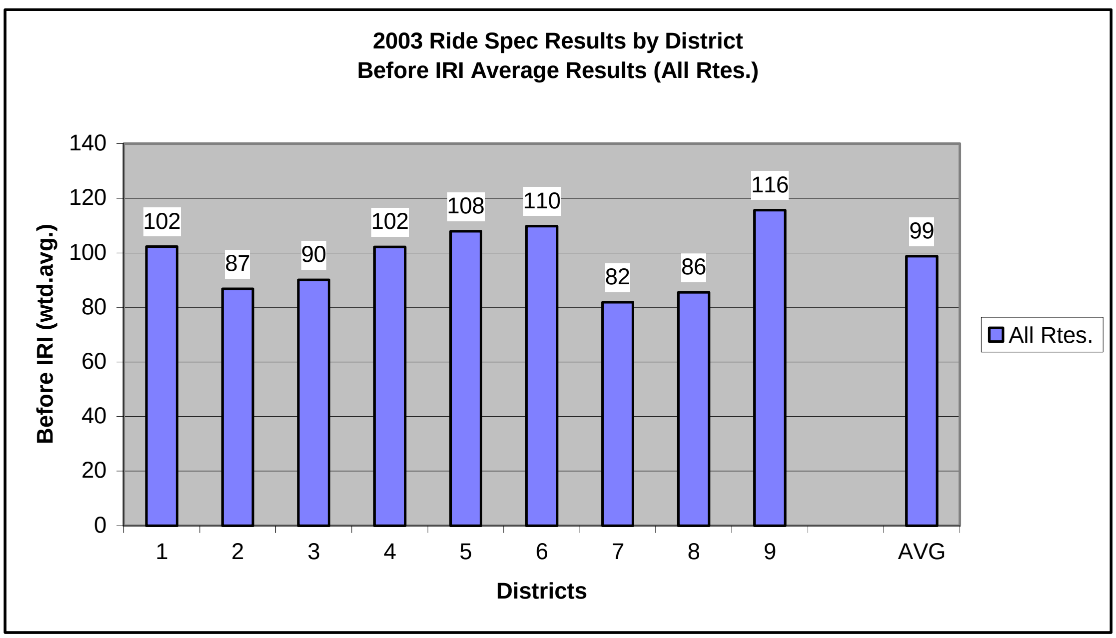
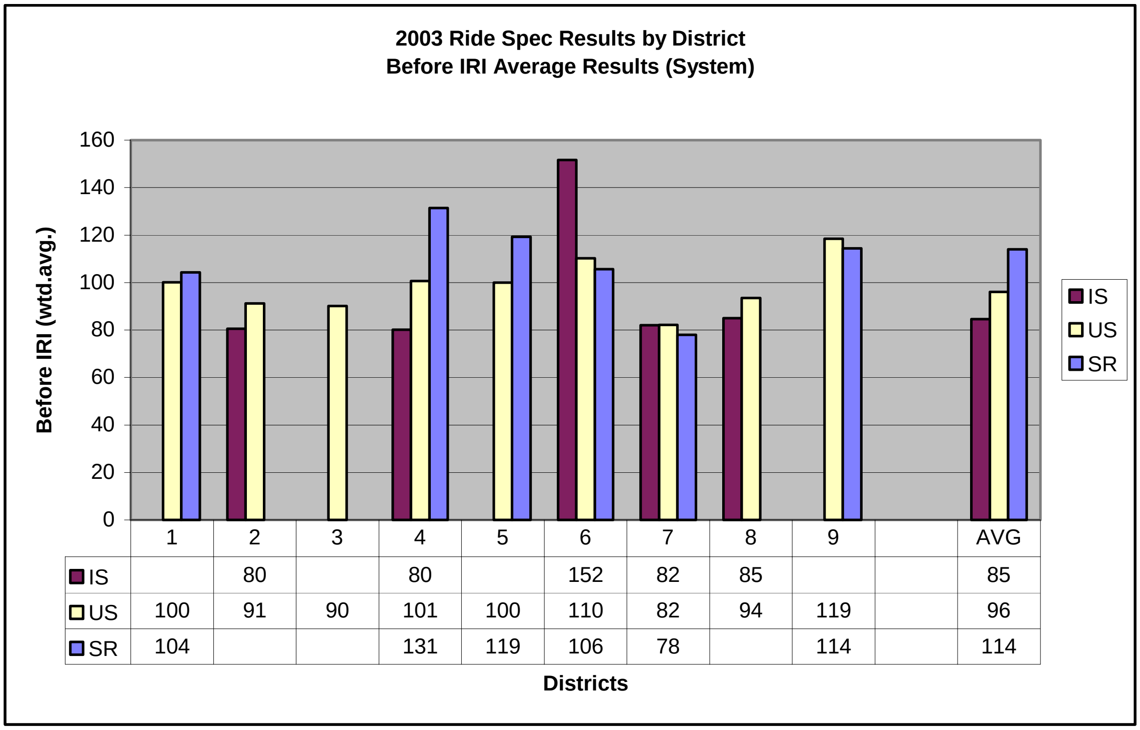


Figure 1 – Before IRI Average Results by District



	1	2	3	4	5	6	7	8	9		AVG
IS		80		80		152	82	85			85
US	100	91	90	101	100	110	82	94	119		96
SR	104			131	119	106	78		114		114

Figure 2 – Before IRI Average Results by System

After IRI Testing Results

Within 30 days of completion of paving, IRI testing was conducted on the finished surface course of the rideability sites. Interestingly, the after IRI results show a different trend from the before IRI results, with the US routes smoothest, followed by the Interstate routes and the State routes. Figure 3 summarizes the results of the After IRI testing for each district and Figure 4 has a breakdown of the results by system.

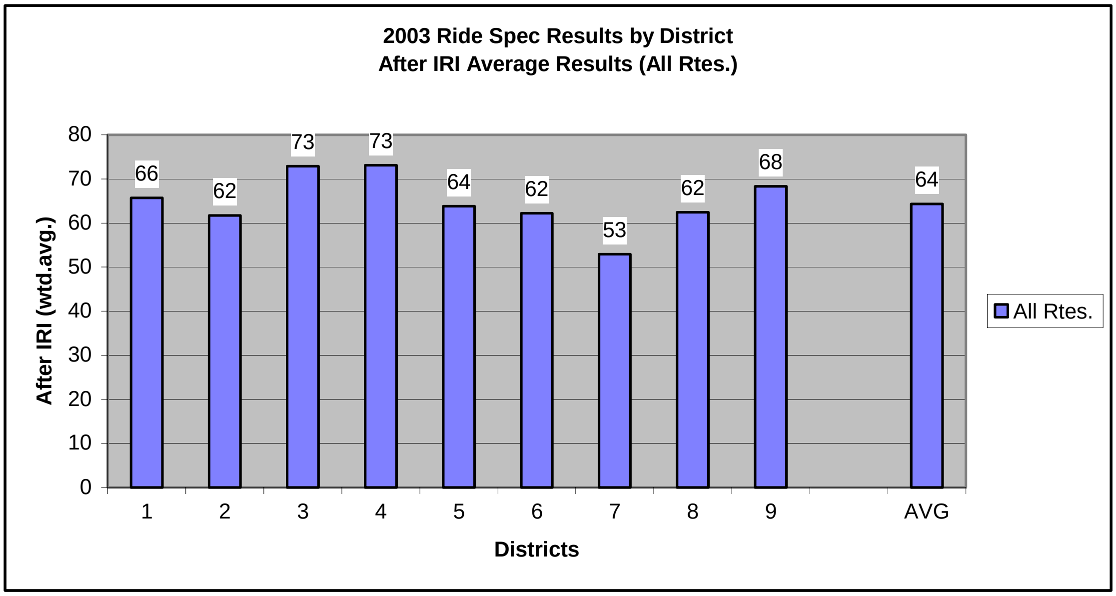
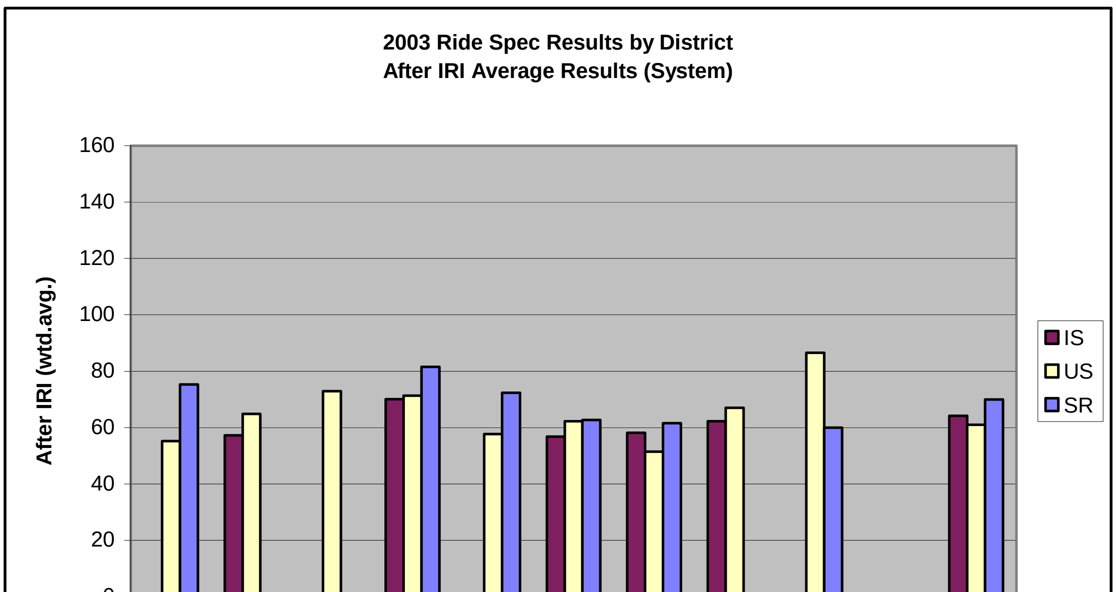


Figure 3 – After IRI Average Results by District



	1	2	3	4	5	6	7	8	9		AVG
IS		57		70		57	58	62			64
US	55	65	73	71	58	62	51	67	87		61
SR	75			82	72	63	62		60		70

Figure 4 – After IRI Average Results by System

Percent Improvement

Based on the results of the before and after rideability testing, the percent improvement was calculated. As expected, the system with the highest before IRI, state routes, had the greatest percent improvement, followed by US routes and Interstate routes. In part, this is due to the fact that SR routes were, on average, 34% rougher prior to paving than IS routes and are generally in poorer condition prior to resurfacing. The statewide average percent improvement was 34%, while six Districts reported improvement in excess of 30%. Compared to 2002, the percent improvement increased from 29 to 34 percent. Figure 5 summarizes the results of the percent improvement for each district and Figure 6 has a breakdown by system.

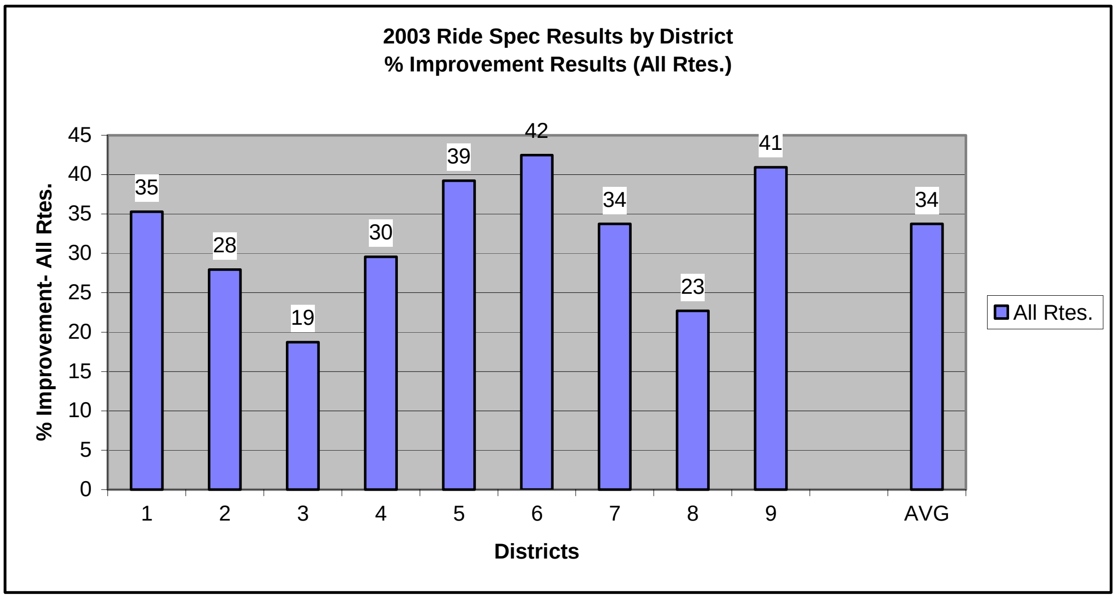


Figure 5 – Percent Improvement Results by District

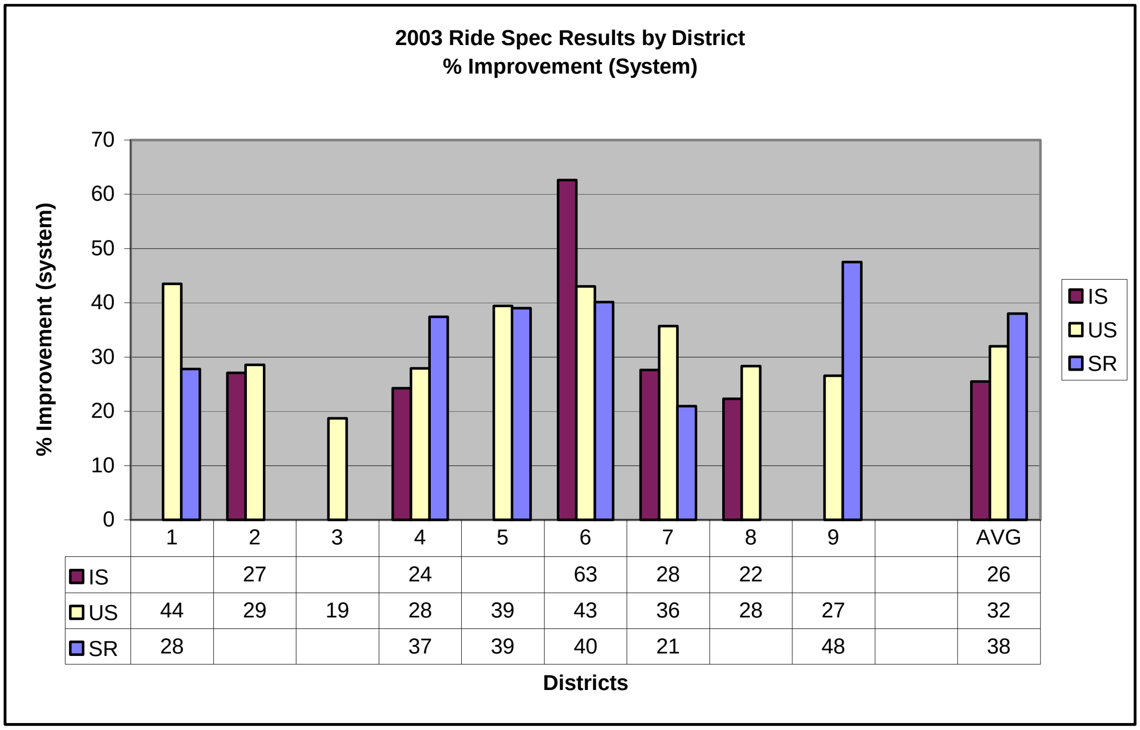


Figure 6 – Percent Improvement Results by System

Discussion of Interstate Results

In 2003, a majority of the interstate system was paved with Stone Matrix Asphalt Mixes (SMA) as part of a statewide implementation effort. While this is not a new mix for Virginia, 2003 was the first year in which it was widely used. This was the first experience several contractors had with producing and placing SMA. Of the 203 lane miles paved under the RideSpec on the interstate, a total of 148 lane miles (73%) were paved with SMA mixes. The remainder were paved with Superpave mixes.

Table 4 shows the average IRI for the interstate with the mix types separated. The data show that the overall average IRI for SMA mixes, 67, is significantly higher than Superpave mixes, 58, or approximately 15% rougher for the SMA mixes. It is expected as the number of SMA projects increase statewide and experience is gained in placing these mixes, smoother pavement will be achieved and be comparable to Superpave projects.

Route Type	Average IRI	La. Miles Tested
Interstate(All)	64	203
Interstate(Superpave mixes)	58	56
Interstate(SMA mixes)	67	148
Non-Interstate	64	465
All Projects	64	669

Table 4 – All Rideability Projects Tested in 2003

Costs

Two separate costs were evaluated to determine the impact of administering the ride specification. First, incentives and disincentives, as reported by District Materials and Pavement Management personnel, were evaluated. Second, the costs of VDOT personnel to test and process the rideability projects were evaluated. Overall, the total costs of administering the rideability specification were low, approximately $347,000, or 0.30% of the statewide total for plant mix schedules awarded in 2003.

Incentives/Disincentives

Table 5 shows the results of the amount paid in incentives/disincentives for the rideability projects in 2003. In general, the districts with the lowest after IRI paid the greatest amount in incentives, while the districts with the highest after IRI assessed the greatest amount in disincentives. Table 5 also shows the greatest amount of incentives were paid for US routes, which were the smoothest overall. The total amount of incentives paid statewide was approximately $207,000, less than 0.2% of the statewide total for plant mix schedules awarded in 2002.

District	Total Incentive/ Disincentive($)	IS	US	SR	Total Plant Mix Sch.Amt($)	Percentage of of Total Sch. Amt.(%)
Bristol	$33,012		$24,063	$8,949	$ 9,914,729.81	0.33%
Salem	$27,152	$14,521	$12,632		$ 12,547,895.15	0.22%
Lynchburg	($13,992)		($13,992)		$ 8,700,497.53	-0.16%
Richmond	($29,708)	($19,126)	($7,501)	($3,081)	$ 10,079,719.18	-0.29%
Hampton Rds.	$79,233		$68,933	$10,300	$ 14,886,930.81	0.53%
Fredericksburg	$61,127	$4,618	$26,065	$30,444	$ 12,018,328.96	0.51%
Culpeper	$98,723	$4,549	$90,536	$3,638	$ 13,388,862.86	0.74%
Staunton	($50,429)	($51,313)	$885		$ 17,115,993.81	-0.29%
No.Va.	$2,213		($17,560)	$19,774	$ 22,706,497.94	0.01%
Total	$ 207,332.20	$ (46,751.69)	$ 184,060.20	$ 70,023.69	$ 121,359,456.05	0.1708%

Table 5 – Incentive/Disincentive for Rideability Projects in 2003

Employee Costs

Based on the average length ride specification site of 5.92 lane miles, the total employee costs were calculated for testing and processing ride specification sites. The total costs of employees to perform ride specification testing and processing was approximately $140,000, approximately 0.12% of the statewide totals for plant mix schedules awarded in 2003. These costs are shown in Table 6.

Activity	Cost/Site	Total Costs
Testing(Before and After,2 runs/lane)*	$ 999.64	$ 112,959.32
Processing(requests,analysis,report)**	$ 237.02	$ 26,783.26
Total Employee Costs	**$ 1,236.66**	**$ 139,742.58**

*Testing costs include equipment(1 van) and personnel(2 persons) and are based on an average of 9.0 hrs./ site.

**Processing costs include personnel(1 person) and are based on an average of 6.0 hrs./ site.

Table 6 – Employee Costs for Rideability Projects in 2003

2002 vs. 2003 Results

Since the pay bands and IRI ranges were left unchanged from 2002 to 2003, a comparison was made between the 2002 and 2003 average IRI results. For reasons previously discussed, the interstate average IRI increased from 60 to 64. However, the other categories of routes, US and SR, both decreased. Overall, the statewide average was lowered from 67 to 64. Figure 7 shows the results of the 2002 vs. 2003 comparison of average IRI for each category of road.

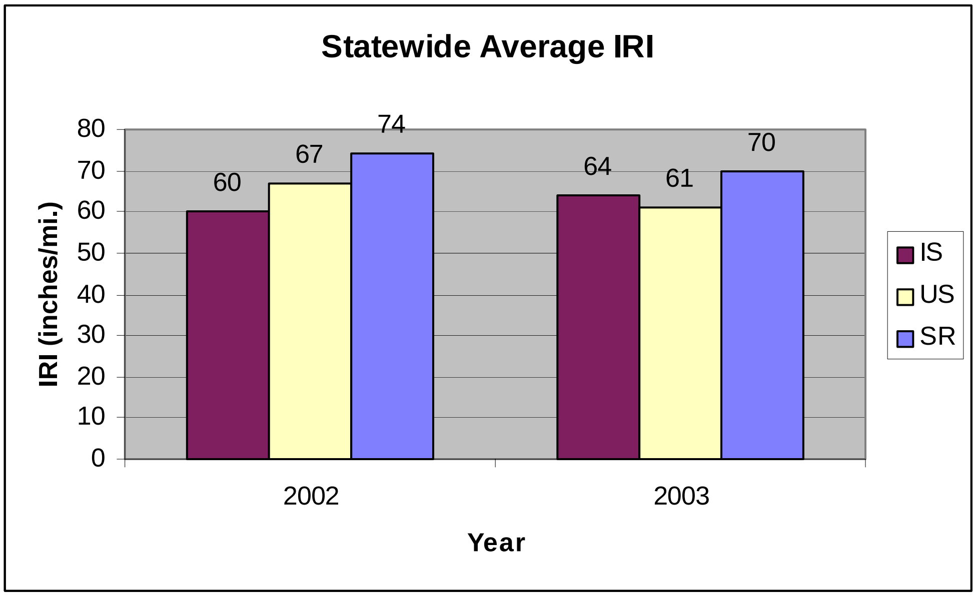


Figure 7 – Statewide Average IRI for 2002 vs. 2003

Effect of Milling

Analysis was conducted to determine if milling had an effect on roughness. Table 7 shows the results of the analysis. As seen in Table 7, projects with milling were, on average, about 10 percent smoother, with a final IRI of 60 vs. a final IRI of 65 for overlay only projects. In particular, the non-interstate projects with milling were smoothest overall, with an average IRI of 57. Four of these projects, all with an average IRI less than 50 had an additional intermediate or base layer prior to the final surface course. However, projects with only 2.0 inches or less of mill and replace were smoother than projects with only a 2.0 inch or less overlay. Single layer milled projects had an average IRI of 62 versus an average IRI of 65 for the single layer overlay projects. In addition, the smoothest projects before milling, those with an average IRI less than 80, were also smoother after paving, with a decrease in IRI from 74 to 60, or an 18% improvement.

The smoothest projects before paving were also analyzed to determine if milling the shoulders had an effect on the after IRI and percent improvement. As shown in Table 8, the projects with shoulders milled were not any smoother than projects without shoulder milling. In addition, the percent improvement was nearly equal regardless of the shoulders being milled or not. From this analysis, it is apparent that additional smoothness can be achieved by milling, regardless of whether the shoulders are milled or not. Significant improvement in smoothness can be achieved if an additional intermediate or base layer is specified.

Effect of Milling on After IRI, % Improvement				
Projects	**Before IRI**	**After IRI**	**Avg. % Improve.**	**Lane Miles**
Milling - All Projects	95	60	33	223
Milling - Interstate	86	62	24	143
Milling - Non-Interstate	107	57	44	80
Milling - Mill & Inlay 1 layer Only (2.0 in. or less)	97	62	31	165
Overlay w/out Milling - All Projects (1 layer only)	101	65	34	410
Overlay w/out Milling - Interstate	79	55	30	25
Overlay w/out Milling - Non-Interstate	102	66	34	385

Table 7 - IRI Comparison for Projects with and without Milling

Effect of Milling on After IRI, % Improvement				
Projects	**Before IRI**	**After IRI**	**Avg. % Improve.**	**Lane Miles**
Milling - Smoothest Projects Before Paving (IRI<=80) - All	74	60	18	63
Milling - Smoothest Projects Before Paving (IRI<=80) - Shoulders Milled	76	61	19	25
Milling - Smoothest Projects Before Paving (IRI<=80) - Shoulders Not Milled	72	59	18	38

Table 8 – Smoothest Projects (IRI<=80) Before Paving With and Without Milled Shoulders

DISCUSSION

Overall, a majority (68) of sites (60%) paid incentives based on rideability in 2003. By a similar measure, 67 sites (59%) had an overall improvement of 30% or greater. While some of these sites received disincentives, a greater majority received incentives. From this analysis, the removal of the 30% overall project improvement clause did not adversely impact incentives paid.

CONCLUSION AND RECOMMENDATIONS

The overall ride quality for Virginia's rideability projects has continued to improve as the rideability specification has continued to evolve. (See Figure 8).

In 2003, the average improvement in ride quality increased to nearly 35% after paving was completed. In 2003, the Department began a major initiative toward the placement of stone matrix asphalt (SMA) mixes on higher volume routes. Much of the SMA was placed on the interstate in 2003. Consequently, the roughness was somewhat higher than with Superpave mixes. It is expected that as greater experience is gained with these mixes, smoother pavement will result. In 2003, all other categories of non-interstate routes and interstate Superpave routes were smoother than in previous years.

Despite the successes of the ride spec program, the number of sites selected has remained approximately the same. The sites submitted for testing in 2004 indicate the same trend. There is still reluctance to apply the ride spec on many two-lane non-divided primary routes. The results from this analysis show that significant improvement, as well as incentives, can be achieved on even the roughest roads. A significant number of the sites that received incentives had average Before IRI values in excess of 100. It is also apparent that the ride spec is not being utilized on all routes where it is applicable, such as Interstates and 4-lane divided routes.

The costs to VDOT to administer the rideability specification were minimal. The additional service life and reduced agency costs attributed to smoother roads more than offset the additional costs of the rideability specification. A National Cooperative Highway Research Program analysis showed that improved smoothness extends a pavements' performance life by up to 50%.[3] Furthermore, increased smoothness reduces vehicle operating costs and provides other measurable and intangible benefits to the user. The results show that all categories of routes can be improved through widespread usage of the ride specifications. While limitations exist in applying the IRI-based ride specification, such as intersections, urbanized areas, and low-speed routes, it is recommended that the number of ride specification projects selected substantially increase statewide.

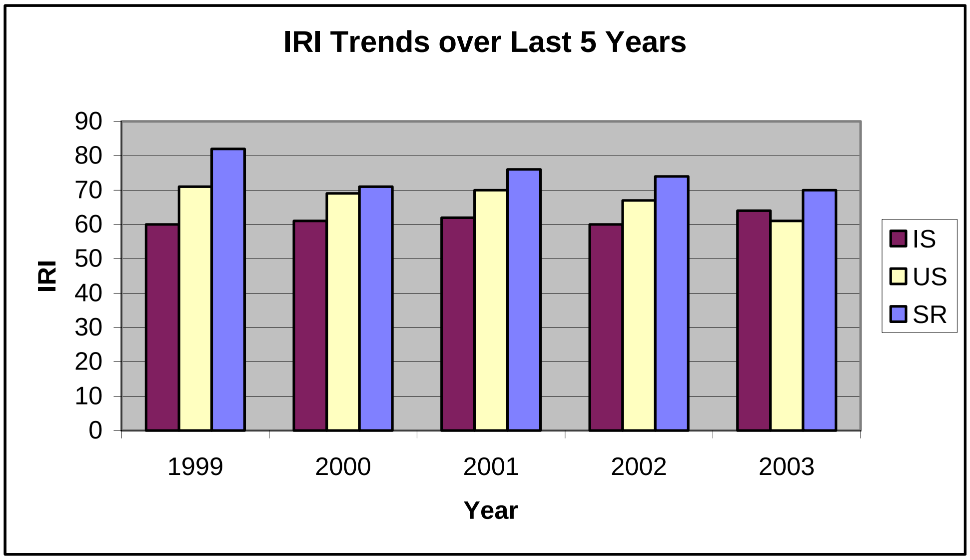


Figure 8 – Maintenance Projects with Ride Spec

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