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Assessment of an Incentive-Only Ride Specification for Asphalt Pavements

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Abstract:

Smoothness specifications are applied by almost all state transportation agencies, including the Virginia Department of Transportation (VDOT), to promote the overall quality and optimum ride quality of pavements. VDOT has a ride specification that provides a pay adjustment (either incentive or disincentive) depending on the smoothness of the final paved surface. VDOT's ride specification also has a provision to waive the disincentive and apply the incentive part only to projects where project geometry, etc., is perceived to make it difficult for the contractor to achieve the desired ride. When applied, the waiver is intended to encourage the contractor to apply additional efforts to improve the ride for otherwise difficult projects.

In late 2011, VDOT's executive leadership formed an Asphalt Quality Task Force to identify and recommend specific achievable measures to improve the quality of the asphalt paving in Virginia. The task force agreed to consider the proposal to make an incentive-only provision the default for projects that would otherwise not qualify for the regular ride specification application. This study documented and critically reviewed the pilot application of the incentive-only provision for rideability on selected asphalt resurfacing schedules for VDOT's 2013 construction season. Several lane-miles of control sites were compared with the "incentive-only" sites to determine if the prospects of added incentives led contractors to alter their paving procedures in pursuit of a higher quality ride.

There was no statistically reliable distinction between the achieved quality of the incentive-only and control sites. Further, it was found that the originally proposed incentive-only provisions did not provide any meaningful benefit to VDOT or contractors. The study developed a revised incentive-only specification and further recommended that the proposed provision be applied to a wider range of projects in VDOT's 2015 construction season.

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ABSTRACT

Smoothness specifications are applied by almost all state transportation agencies, including the Virginia Department of Transportation (VDOT), to promote the overall quality and optimum ride quality of pavements. VDOT has a ride specification that provides a pay adjustment (either incentive or disincentive) depending on the smoothness of the final paved surface. VDOT's ride specification also has a provision to waive the disincentive and apply the incentive part only to projects where project geometry, etc., is perceived to make it difficult for the contractor to achieve the desired ride. When applied, the waiver is intended to encourage the contractor to apply additional efforts to improve the ride for otherwise difficult projects.

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INTRODUCTION

Smoothness specifications are applied by almost all state transportation agencies, including the Virginia Department of Transportation (VDOT), to promote the overall quality and optimum ride quality of pavements. Pavement roughness affects the subjective quality of the ride for motorists and also affects the cost of operating the vehicle. Smooth-riding pavements provide a high level of comfort to highway users and allow for more efficient movement of vehicles over the roadway. Pavements that are excessively rough not only generate complaints from highway users but also can reduce optimum travel speeds, disrupt traffic flow, and create safety hazards. In addition, rough roads can cause vehicle damage and increase fuel consumption, factors that lead to increased traveling costs to highway users (Smith et al., 1997b). Smith et al. (1997a) found that added pavement life can be obtained by achieving higher levels of initial smoothness, a 25% increase in smoothness corresponding to a 9% increase in service life. Rough pavements provoke more severe dynamic loading from heavy trucks and as a consequence are likely to incur higher lifetime maintenance costs and provide a shorter service life. Pavement roughness may also affect the emission of combustion products and noise from a highway (Hanson et al., 2004). Studies have shown that smooth roads cost highway agencies less over the life of the pavement, resulting in decreased highway user operating costs, delay costs, fuel consumption, and maintenance costs (Federal Highway Administration, 1990).

VDOT has a ride specification that provides a pay adjustment (either incentive or disincentive) depending on the smoothness of the final paved surface. Through application of the ride specification, the ride quality for Virginia's rideability projects has continued to

improve. The average after paving ride on projects subject to the ride specification has improved significantly in the last decade (Nair et al., 2011).

The ride specification is applied to select projects that meet certain geometrical criteria. The guiding philosophy is to use the ride specification on projects that provide the contractor enough control and construction flexibility to improve/achieve the desired ride quality while not having features that may impair the ride testing with the available equipment. Interstate system projects are nearly always good candidates for ride specification application. For primary system projects, however, it is important to consider the criteria outlined in VDOT's Ride Specifications Application Guideline (VDOT, 2008). Generally, about 20% to 30% of projects on the interstate and primary systems combined are subject to VDOT's ride specification. VDOT's ride specification also has a provision to waive the disincentive and apply the incentive part only to projects where the project geometry is perceived to make it difficult for the contractor to achieve the desired ride. The intent is to encourage the contractor to apply additional efforts to improve ride for the difficult projects while still being able to make a profit. However, although allowed, this provision had not been widely applied by VDOT.

In late 2011, VDOT formed the Asphalt Quality Task Force composed of key members of VDOT and Virginia's asphalt industry with the charge to identify and recommend specific achievable measures to improve the quality of asphalt paving in Virginia. The task force stressed the need to provide an incentive for good paving work in order to encourage quality work rather than simply meeting the specification or worse, "racing to the bottom." The ride specification was identified as one promising "incentivizing tool." Among other approaches, the task force proposed making an incentive-only provision the default for projects that would otherwise not qualify for the regular ride specification (incentive/disincentive) application.

The task force recommended that a pilot study be conducted to determine the effectiveness of the incentive-only provision and to consider the prospects of making the provision a default for most asphalt resurfacing schedules. This provision is one mechanism for rewarding contractors who go beyond the minimum specification requirements. However, effective use must ensure superior outcome on the part of the contractor within fair boundaries of risk and cost for both VDOT and the contractor.

PURPOSE AND SCOPE

The purpose of this study was to review the viability of an incentive-only ride quality provision for near-universal application to VDOT asphalt paving projects that do not qualify for the incentive-disincentive ride specification. The review involved a series of pilot projects that were awarded and paved in 2013. The researchers examined the characteristics of these projects and contrasted them with those of similar control projects to seek answers to the following questions:

- Do contractors respond to the potential additional incentives by modifying paving procedures that result in higher quality work? If so, does the higher quality justify the

incentive being applied? Does the incentive payment offset the costs for the modified paving procedures and provide a reasonable profit to the contractor?

- Does the incentive-only clause as written represent a sufficient balance of risk and reward for VDOT and the contractor? That is, should the provision include overall project quality for incentives even in absence of disincentives?

The specific objectives were as follows:

1. Summarize and analyze the results of the "incentive-only" pilot projects.
2. Identify and quantify the benefit (if any) from the incentive-only provisions.
3. If warranted, recommend any changes that are deemed necessary to improve the initially proposed recommendation to make the incentive-only specification as a default on all projects not subject to the incentive-disincentive specification.

METHODS

Six tasks were performed to achieve the study objectives:

1. A literature review was conducted.
2. Pilot projects with sites that used the incentive-only provision and control sites were conducted.
3. Ride quality data collection and analysis were performed for the "incentive-only" and control sites.
4. Project site and mixture information was collected.
5. VDOT's Pavement Management System (PMS) ride data for routine maintenance resurfacing projects were analyzed.
6. VDOT's current incentive-only specification was reviewed.

Literature Review

A literature review was conducted to identify the experiences of VDOT and other transportation agencies with ride specifications. To identify such literature, various databases related to transportation engineering such as the Transport Research International Documentation (TRID) bibliographic database, the catalog of Transportation Libraries (TLCat), the Catalog of Worldwide Libraries (WorldCat), and the Transportation Research Board Research in Progress (RiP) and Research Needs Statements (RNS) databases were used.

Pilot Projects

The incentive-only provision for rideability was used on selected asphalt resurfacing schedules for VDOT's 2013 construction season. Several lane-miles of control sites were compared with incentive-only sites to determine if the prospects of added incentives led contractors to alter their paving procedures in pursuit of a higher quality ride.

Incentive-Only Sites

A limited number of sites in VDOT's Northern Virginia (NOVA) and Culpeper districts were selected for application of the incentive-only specification during the 2013 construction season. This pilot involved only two schedules and two contractors. All projects in the NOVA District (Table 1) were on urban roads, and all projects in the Culpeper District (Table 2) were on rural secondary roads except for two sections on U.S. 29. More details about these sites are provided in Appendix A.

Table 1. Northern Virginia District 2013 Incentive-Only Ride Specification Pilot Sites

Route	County	From	To	Length (mi)
SR 294	Prince William	PJ 106 Ft East of Dumfries Rd. Rt. 234 (Eastbound)	PJ 125 Ft West of Hasting Dr.	1.77
SR 294	Prince William	PJ 106 Ft East of Dumfries Rd. Rt. 234 (Westbound)	PJ 126 Ft West of Hasting Dr.	1.77
SR 294	Prince William	PJ 133 Ft East of Liberia Ave. (Eastbound)	113 Ft East of Yates Ford Rd. Rt. 612	1.8
SR 294	Prince William	PJ 120 Ft East of Smoketown Rd. Rt. 2000 (Eastbound)	PJ 138 Ft West of I-95 Sign Post Before Ramp to I-95SB	1.071
SR 294	Prince William	PJ 138 Ft West of I-95 Sign Post Before Ramp to I-95SB (Eastbound)	85 Ft East of York Dr. Rt. 1299	0.771
SR 294	Prince William	PJ 165 Ft West of I-95 Sign Post (Westbound)	126 Ft East of Summerland Dr. Rt. 1299	0.83
SR 294	Prince William	123 Ft East of Smoketown Rd. Rt. 2000 (Westbound)	PJ 165 Ft West of I-95 Sign Post	1.01
SR 294	Prince William	130 Ft East of Yates Ford Rd. Rt. 612 (Westbound)	176 Ft West of Fingerlake Rd. Rt. 3020	2.62
SR 294	Prince William	PJ 113 Ft East of Liberia Ave. (Westbound)	130 Ft East of Yates Ford Rd. Rt. 612	1.8

PJ = pavement joint.

Table 2. Culpeper District 2013 Incentive-Only Ride Specification Pilot Sites

Route	County	From	To	Length (mi)
US 29	Albemarle	Rt. 631	Rivanna River Bridge	1.5
US 29	Albemarle	0.098 Mi North Rt. 710	Hardware River Bridge	0.91
CR 609	Culpeper	Madison County Line	Rt. 29	2
CR 669	Culpeper	Rt. 675	Rt. 762	2.28
CR 729	Culpeper	Rt. 628 South Intersection	Rappahannock County Line	2.61
CR 609	Madison	Rt. 231	Culpeper County Line	7.53
CR 611	Orange	Rt. 692 East Intersection	0.07 Mi East Rt. 20	4.35
CR 614	Fauquier	Rt. 616	Stafford County Line	0.6
CR 647	Fauquier	0.15 Mi West Rt. 645	Rt. 688	2.05
CR 688	Fauquier	Rt. 730	Rt. 55	3.84
CR 713	Fauquier	Rt. 710	1.3 Mi North Rt. 710	1.32
CR 1000	Fauquier	Cul-de-sac	Rt. 674	0.92

Control Sites

In addition to the incentive-only sites, several lane-miles of control sites (sites for which no rideability specification was applied) were selected in VDOT's Fredericksburg, Richmond, Staunton, and Hampton Roads districts. The control sites were to be compared with the incentive-only sites to determine if the prospects of added incentives led contractors to alter their paving procedures in pursuit of a higher quality ride. The control sites, selected to have project characteristics similar to those of the incentive-only sites, are listed in Table 3. More details about the control sites are presented in Appendix A.

Table 3. 2013 Control Sites

Route	County	From	To	Length (mi)
Fredericksburg District				
US 1	Stafford	0.12 Mi North Rt. 687 (Hope Rd.)	0.10 Mi North Rt. 631 (Coal Landing Rd.)	1.48
US 1	Stafford	0.73 Mi South Rt. 1340 (Austin Run Blvd.)	0.07 Mi South, Austin Park Dr.	1.54
US 1	Stafford	0.07 Mi North Intersection Rt. 652 Truslow Rd.	0.15 Mi South Rt. 1005 Manning Dr.	0.9
SR 198	Gloucester	0.5 Mi East Rt. 673 Freeport Rd.	Mathews/Gloucester County Line	4.79
SR 14	Mathews	0.39 Mi East Rt. 626	0.04 Mi East Intersection Rt. 198	2.38
SR 198	Mathews	Intersection Rt. 3	0.12 Mi East. Rt. 14	7.05
US 33	Middlesex	0.21Mi East Rt. 628	0.20 Mi East Rt. 1103	2.86
Richmond District				
US 60	Chesterfield	0.26 Mi West Rt. 667/970	0.47 Mi East Rt. 754	2.19
Hampton Roads District				
SR 173	York	Newport News City Limit	Rt. 17	2.61
SR 238	York	Newport News City Limit	Rt. 17	3.43
SR 31	Surry	0.29 West Rt. 630	0.62 Mi East Rt. 630	0.9
Staunton District				
US 60	Rockbridge	0.31 Mi East US 11S On Ramp	Buena Vista County Line	4.9
US 340	Augusta	Near county line, Waynesboro	0.64 Mi North SR 611	1.78
US 340	Augusta	0.81 Mi South SR 619	Near county line Waynesboro	1.78

Ride Data Collection and Analysis

Data Collection

Ride quality surveys were conducted on all the incentive-only and control sites both before and after the paving activities. The surveys were conducted in a manner consistent with VDOT's standard procedure for measuring new asphalt overlays for acceptance. This procedure applies Virginia Test Method (VTM) 106 to measure wheel path elevation profiles from which a standard index of ride quality is produced. This standard index, the International Roughness Index (IRI), is generated using the American Society for Testing and Materials (ASTM) Standard Practice E 1926. Higher values of IRI suggest rougher surfaces, and lower values indicate smoother pavements. VDOT's full special provision for rideability defines target IRI ranges for full payment, as well as those quality ranges that will result in incentive or disincentive payments for smoothness.

VTM 106 incorporates an inertial road profiler. 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. Urban areas can present a particular challenge for the data collection process. High-speed inertial profilers are most reliable at a minimum speed of approximately 30 mph, which can prove difficult with numerous stoplights and heavier traffic conditions. Intersections and manholes, which provide significant challenges to the paving crew and the profiling equipment, can affect the overall roughness of the section of roadway. 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.

Analysis

After all ride-related data were collected from the incentive-only and control sites, the Federal Highway Administration's Pavement Profile Viewer and Analyzer, or ProVAL, software was used to analyze the before and after paving profiles. Version 3.0 of ProVAL was used to compute the mean roughness indices and generate continuous IRI distribution plots for the before versus after paving comparison. A percent improvement in ride quality was also computed based on the before and after paving IRI. Figure 1 shows one such example of the comparison of the before and after IRI.

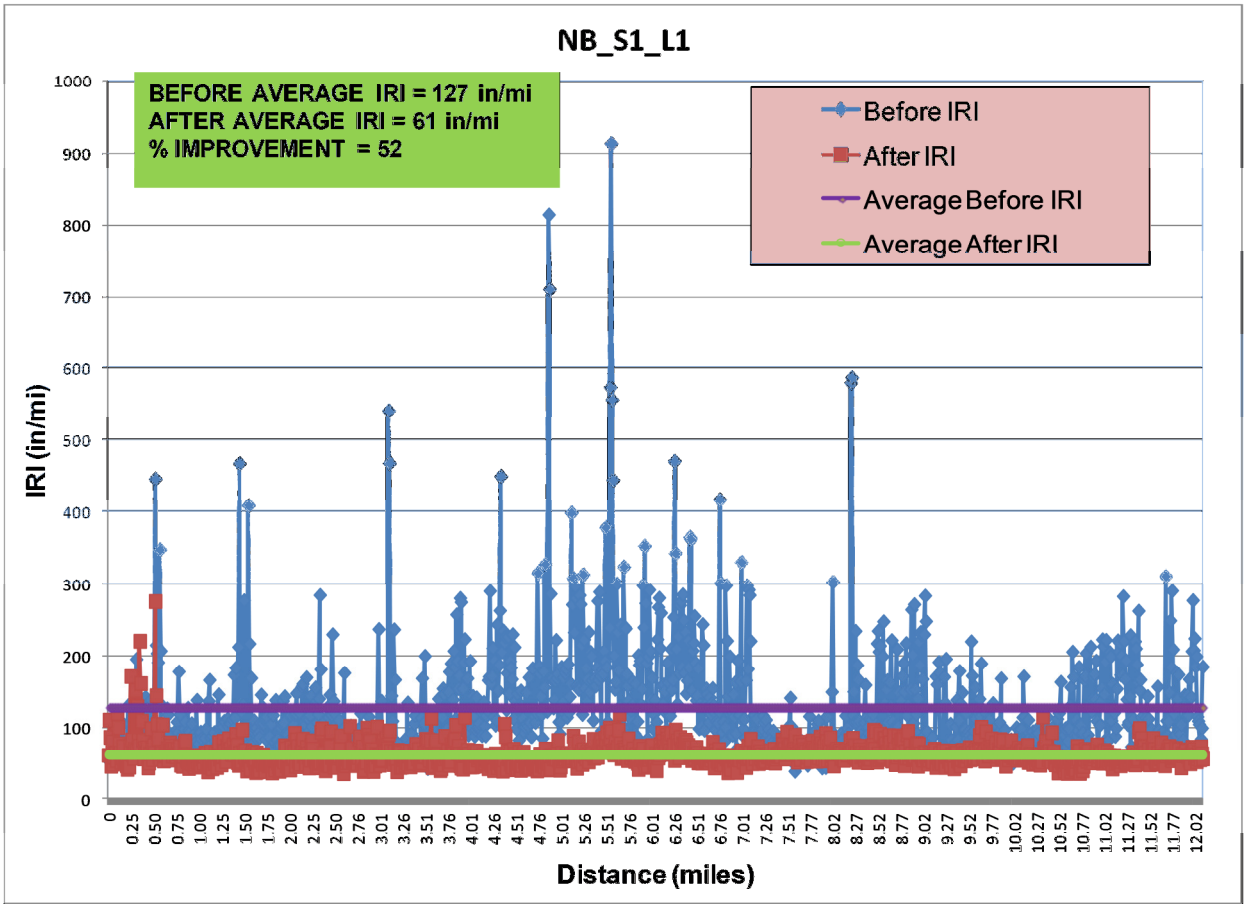

Figure 1. Comparison of Before and After IRI for Northbound Lane of Route 286 in Northern Virginia District. IRI = International Roughness Index.

Collection of Project Site and Mixture Information

Field reviews were performed using the questionnaire sent to field personnel on all sites to identify the equipment being used; type of milling (if any); presence of milling-related non-uniform delamination (i.e., scabbing); levelling courses (if any); paver automation; general conditions; levels of traffic; day/night work; length of paving per shift; geometric or pavement limitations (too narrow or too thin for the material transfer vehicle [MTV], etc.); and pre-existing condition of the roadway. Appendix B shows the questionnaire used for capturing field construction and asphalt mixture information.

Analysis of VDOT's PMS Ride Data for Routine Maintenance Resurfacing Projects

The preliminary results from the incentive-only and control sites in the pilot project prompted the researchers to explore the improvements achieved from maintenance resurfacing on a more routine and network basis. Data to support this objective came from VDOT's PMS, which annually collects distress data for the entire interstate and primary highway systems and approximately 20% of the secondary system. The network pavement condition data in the PMS

include IRI data for at least 6 years consecutively. In an effort to determine typical improvement with a resurfacing cycle, it was necessary to identify homogeneous pavement sections that were likely resurfaced between one distress cycle and the next. This was accomplished by seeking sections where the IRI was reduced by more than 10% between two successive years (e.g., 2007-2008). Load-related distresses; non–load-related distresses, and the overall condition index were then reviewed to confirm that the sections identified had indeed been repaved in the later year.

Review of VDOT's Current Incentive-Only Specification

The Asphalt Quality Task Force responded to preliminary findings from the pilot project by forming the Ride Specification Subcommittee composed of VDOT and industry representatives to guide revisions to the originally crafted incentive-only provision. A general concern of the task force involved the length basis upon which the incentive provisions were considered. Theoretically, a project could receive overall incentives even if the average ride quality for the project was made worse through the resurfacing activity. When incentives were determined (and totaled) based purely on achievement at the 0.01-mi level and there was no requirement for smoothness at longer base lengths, there was too much risk that a contractor would "accidentally" achieve incentives for work that was on the whole marginal at best.

The subcommittee reviewed in more depth the results from the pilot projects, as well as the analysis of network level data. This group then addressed the base length issues of the proposed language and contrasted various alternatives (length criteria and IRI targets) to find a combination that seemed a good balance of potential reward for the contractor without undue risk to VDOT.

RESULTS AND DISCUSSION

The results are presented in the following sections:

1. literature review
2. ride results of incentive-only and control sites
3. factors affecting achieved smoothness (from project and mixture information and ride analysis of routine maintenance resurfacing projects)
4. review of VDOT's current incentive-only specification.

Literature Review

An infrastructure survey by Keever et al. (2000) found that the traveling public considers pavement conditions, which include ride quality, to be the third most important improvement needed for highways, behind traffic flow and safety. A ride specification dictates the level of smoothness an agency will accept for full contractor payment and in many cases provides an

adjustment of the payment in the form of either a penalty for deficient smoothness or a bonus for superior smoothness. In 1995, VDOT's primary method for regulating smoothness of highway surfaces used a specification that was built around the California-type profilograph. Virginia's contemporary special provision replaces the California profilograph with an inertial road profiler.

Persistent use of the ride specification has led to a continued improvement in smoothness over the last 15 years, as shown in Figure 2. Figure 3 summarizes the average improvement for a more recent span of 8 years. Although the average improvement has varied some, the average after paving IRI has improved dramatically in the last few years when compared to that of the early 2000s. A total of 3,068 lane-miles was subject to the ride specification from 2005 to through 2009, and a net bonus of $4,928,422 was paid as an incentive to contractors in that period (Nair et al., 2011). It was determined that the long-term benefits of smoother pavement (i.e., long service life) justify the cost (incentive plus administrative) very well (Nair et al., 2011).

The literature and other resources showed that 89% of the states provided pay adjustments (incentives and disincentives) for pavement smoothness specifications. Three percent of the states used ride specifications with disincentives, but no incentives. Others included incentives with must-correct criteria for "out-of-spec" areas, and some provided neither incentives nor disincentives but required corrections for out-of-spec areas (Merritt et al., 2015).

The Texas Department of Transportation has an incentive-only provision that does not require corrective action (called Schedule 3 in the specification). Pay adjustment is made when after paving IRI values are less than 60 in/mi. Use of incentive-only specifications (without corrective action) is limited among other state transportation agencies (SmoothPavements.com, 2014).

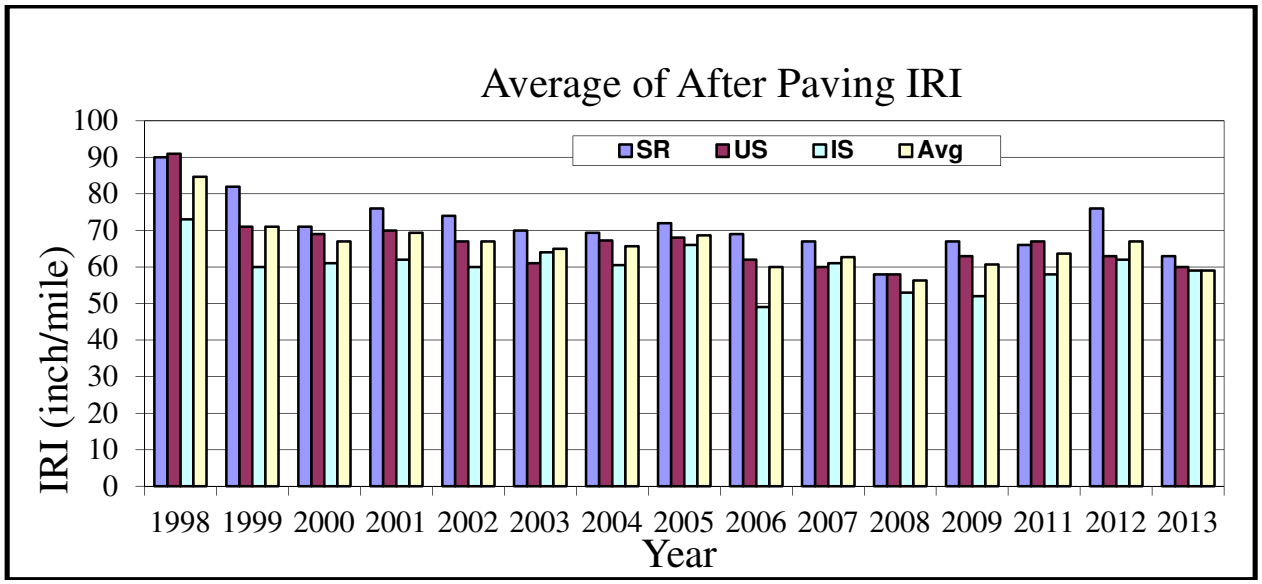

Figure 2. After IRI Trends Over Last 15 Years. IRI = International Roughness Index; SR = State Routes; US = U.S. Routes; IS = Interstate System; Avg = average.

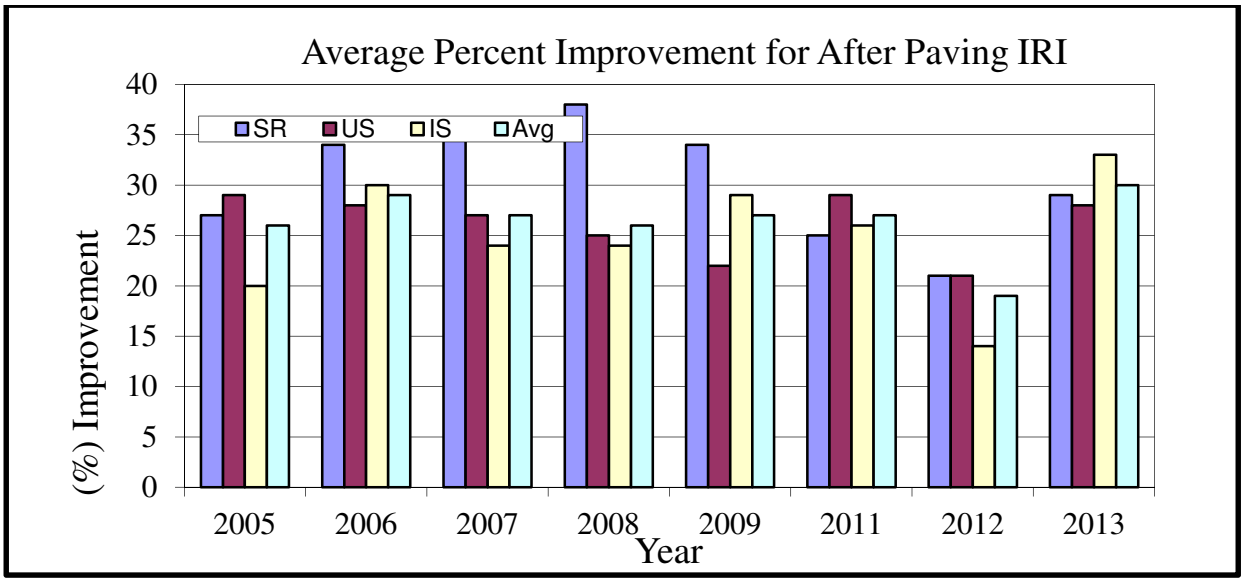

Figure 3. Percent Improvement in After Paving IRI for Different Years. IRI = International Roughness Index; SR = State Routes; US = U.S. Routes; IS = Interstate System; Avg = average.

A smoothness specification may also describe what forms of corrective action are permitted (e.g., diamond grinding for asphalt concrete pavement surfaces or full removal and replacement or an additional overlay for correction of asphalt concrete pavement). The majority of states that provide incentives in their specifications will not pay incentives after corrective action has been completed unless the corrective action consisted of full removal and replacement (Merritt et al., 2015).

VDOT has developed site selection guidelines for use of rideability specifications to optimize the use of ride specifications (VDOT, 2008). These guidelines are based on VDOT's experience throughout the years and has been in use for last 15 years. If a project contains any of the features mentioned in the guideline, a part or the entire project may be excluded from ride specification requirements or an incentive-only provision may be applied in lieu of the regular incentive-disincentive specification. A historical review of Virginia's program showed that an incentive-only option is not commonly exercised by VDOT. From 2008 to through 2013, a total of 4,215 lane-miles (interstate and primary routes) was subject to the full ride specification (incentive/disincentive), which was about 36% of total lane-miles paved. For interstate routes, 1,797 lane-miles (or 92%) of the paving was subject to the specification. For primary routes (U.S. and S.R.), 2,418 lane-miles (25%) were subject to the full ride specification (VDOT, 2014). These data show that more opportunity exists to apply the incentive-only option for primary routes if site selection criteria prohibit using the full incentive/disincentive provision.

Ride Results of Incentive-Only and Control Sites

Incentive-Only Sites

Urban Incentive-Only Sites

Two incentive-only sites were in the NOVA District: Prince William Parkway (PWP) and Fairfax County Parkway (FFXP). The PWP project was specifically selected as a pilot for this project. Although the FFXP work had been completed the year before (2012), it was included in the analysis since the project used the incentive-only provision. Both projects were composed of a 2 in mill and replacement with 2 in of stone matrix asphalt (SMA-12.5). Although the two facilities are functionally similar, the PWP is more geometrically constrained with a higher density of signalized intersections, utilities, and curb and gutter.

Tables 4 and 5 summarize the ride quality for sections as defined by major intersections along the overall projects. For the FFXP (Table 4), the average percentage improvement was about 42% with an average after IRI of 68 in/mi; the average before IRI value was 119 in/mi. For the PWP (Table 5), the average percentage improvement was about 27% with an average after IRI of 99 in/mi; the average before IRI for the PWP was 139 in/mi.

Figures 4 and 5 show the frequency distribution of the final surface IRI values. For the FFXP (Figure 4), about 80% of the project had IRI values of 80 in/mi or lower with few remaining local high-roughness lots. For the PWP (Figure 5) only 19% of the project had IRI values below 80 in/mi with considerable local high-roughness lots. Figure 6 plots the improvement (reduction) in IRI versus the original pavement IRI. It shows that for the same original condition, a higher level of improvement was achieved on the FFXP than on the PWP. Correspondingly, the contractor on the FFXP was awarded a substantially higher incentive than the contractor on the PWP project.

There were several important differences between the two projects. They were completed by different contractors. The original surface on the PWP was considerably rougher (higher IRI) and the final surface paving was constrained by a higher density of existing curb and gutter. There were also more frequent signalized intersections on the PWP, which complicates asphalt laydown and profile testing. Finally, about 40% of the FFXP project used a levelling course with asphalt concrete; there was no levelling course used on the PWP.

Rural Incentive-Only Sites

The incentive-only sites in the Culpeper District with the exception of U.S. 29 were 1.5 in straight overlays on low volume secondary routes over rough existing surfaces that were not milled. Table 6 shows the before and after IRI and the percentage improvement in IRI for different routes. Average after IRI for the single primary route (U.S. 29) was 68 in/mi and for the secondary routes was 110 in/mi. However, the average before IRI for secondary routes was 167 in/mi.

Table 4. Incentive-Only Ride Analysis Results: Fairfax County Parkway

Direction	Section No.	Surface Mix	Lane No.	Average IRI (in/mi)		
				Before	After	% Improvement
Northbound	S1	SMA	L1	127	61	52
			L2	111	71	36
	S2	PFC	L1	87	50	43
			L2	101	54	47
	S3	SMA-AR	L1	137	61	55
			L2	106	61	42
	S4	SMA	L1	109	66	39
			L2	108	64	41
	S5	SMA	L1	121	76	37
			L2	113	76	33
Southbound	S1	SMA	L1	130	86	34
			L2	120	85	29
	S2	SMA	L1	175	67	62
			L2	144	65	55
	S3	SMA	L1	101	73	28
			L2	119	82	31
	S4	PFC	L1	96	42	56
			L2	122	47	61
	S5	SMA-AR	L1	117	57	51
			L2	120	63	48
	S6	SMA	L1	118	67	43
			L2	152	67	56
	S7	SMA	L1	98	77	21
			L2	122	112	8

IRI = International Roughness Index; SMA = stone matrix asphalt; PFC = porous friction course; AR = asphalt rubber.

Table 5. Incentive-Only Ride Analysis Results: Prince William Parkway

Direction	Section No.	Surface Mix	Lane No.	Average IRI (in/mi)		
				Before	After	% Improvement
Eastbound	S1	SMA	L1	160	88	45
			L2	166	57	66
	S3	SMA	L1	145	116	20
			L2	132	96	27
	S4	SMA	L1	188	124	34
			L2	125	102	18
Southbound	S1	SMA	L1	179	148	17
			L2	180	123	32
	S2	SMA	L1	175	112	36
			L2	145	89	39
	S4	SMA	L1	97	88	9
			L2	97	76	22
	S5	SMA	L1	86	87	0
			L2	81	77	5
	S6	SMA	L1	135	107	21
			L2	135	91	33

IRI = International Roughness Index; SMA = stone matrix asphalt.

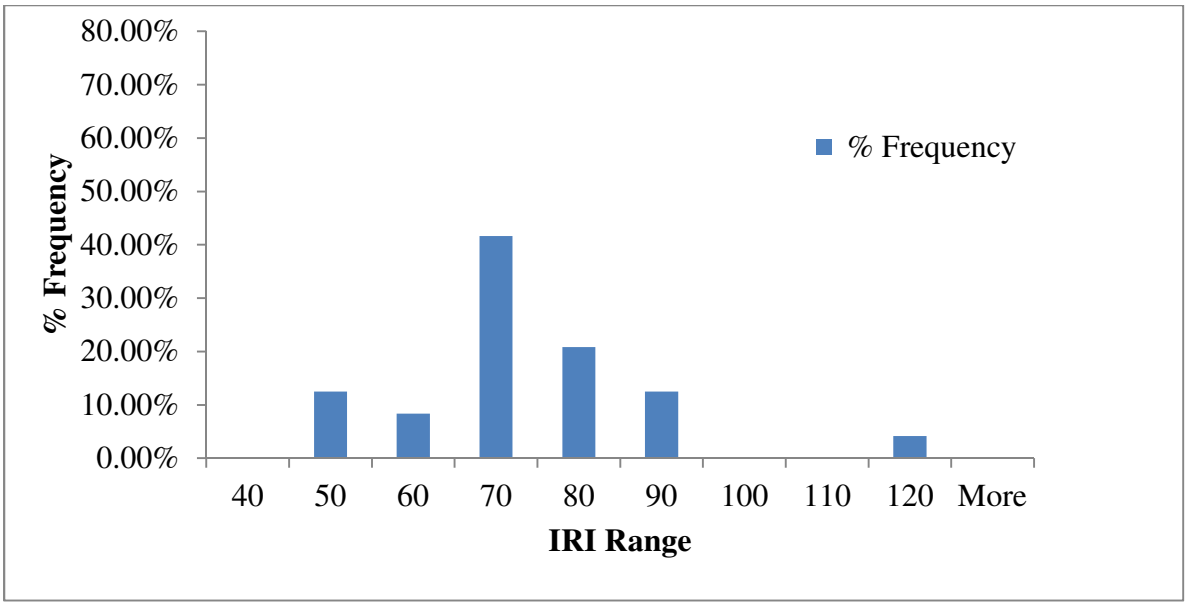

Figure 4. IRI Distribution for Fairfax County Parkway. IRI = International Roughness Index.

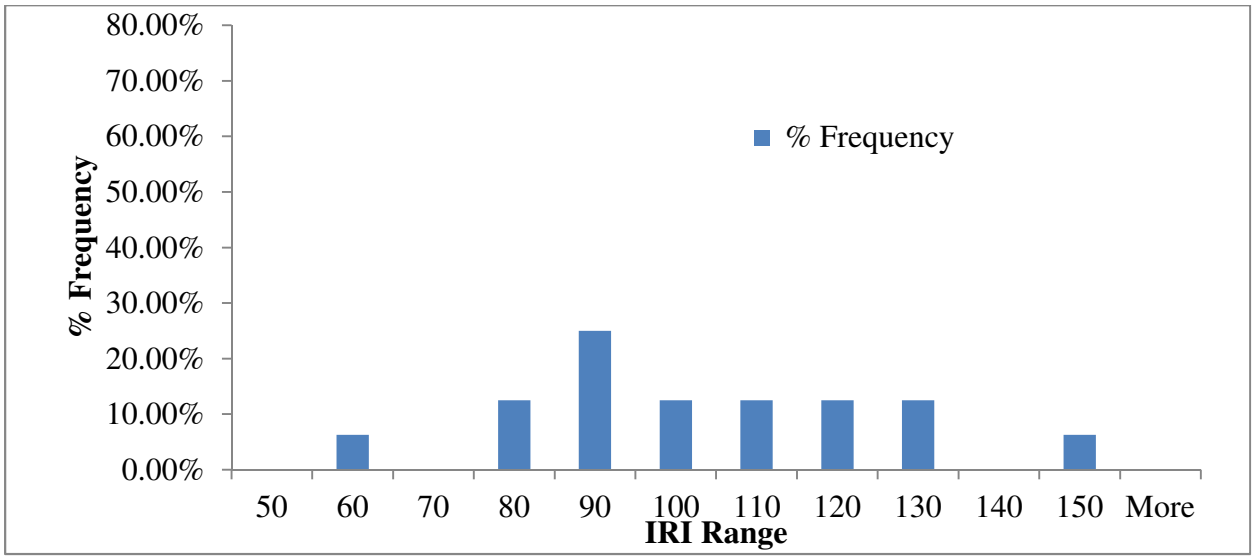

Figure 5. IRI Distribution for Prince William Parkway. IRI = International Roughness Index.

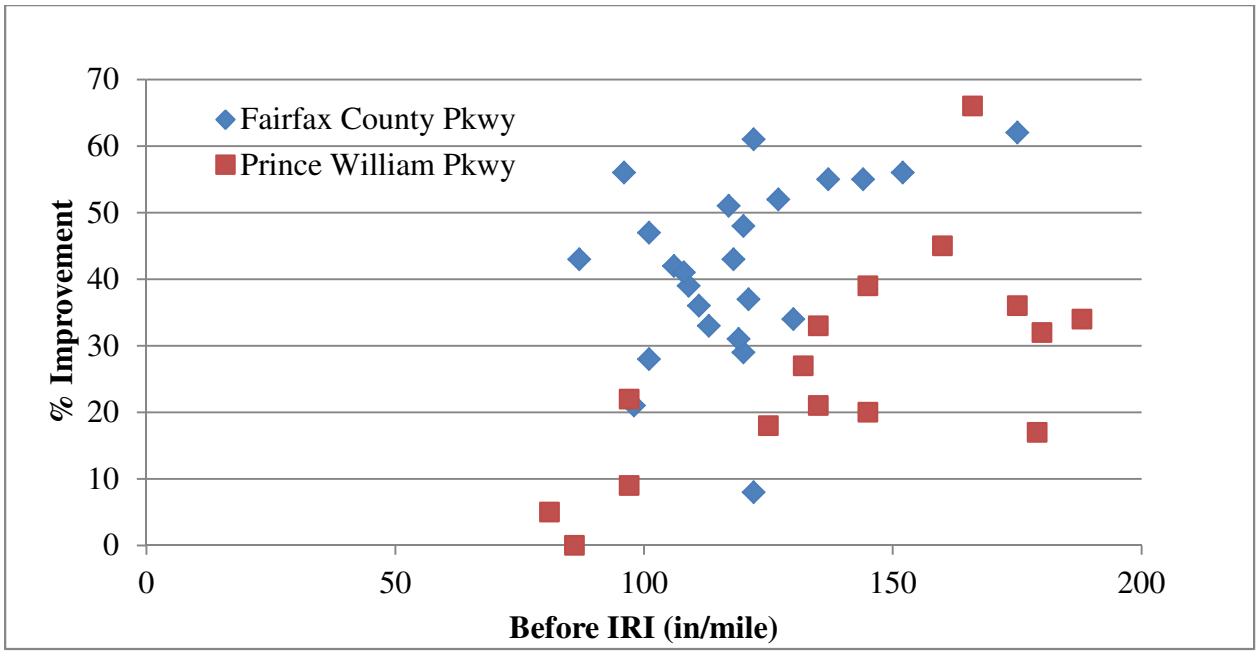

Figure 6. Before IRI Versus % Improvement. IRI = International Roughness Index.

Table 6. Incentive-Only Ride Analysis Results: Culpeper District

Route	Lane No.	Surface Mix	Average IRI (in/mi)		
			Before	After	% Improvement
29	L1	SM 12.5D	81	69	15
	L2	SM 12.5D	69	64	7
29	L1	SM 12.5D	125	89	29
	L2	SM 12.5D	100	57	43
	L3	SM 12.5D	98	56	43
	L4	SM 12.5D	127	75	41
609	L1	SM 9.5A	127	98	23
	L2	SM 9.5A	126	92	27
611	L1	SM 9.5A	146	93	36
	L2	SM 9.5A	148	91	39
688	L1	SM 12.5A	232	138	41
	L2	SM 12.5A	253	159	37
609	L1	SM 9.5A	124	86	31
	L2	SM 9.5A	86	84	2
669	L1	SM 9.5A	216	91	58
	L2	SM 9.5A	185	85	54
729	L1	SM 9.5A	134	95	29
	L2	SM 9.5A	135	95	30
614	L1	SM 12.5A	120	117	3
	L2	SM 12.5A	139	135	3
647	L1	SM 12.5A	212	119	44
	L2	SM 12.5A	192	116	40
713	L1	SM 12.5A	241	132	45
	L2	SM 12.5A	211	134	36
1000	L1	SM 12.5A	171	124	27
	L2	SM 12.5A	144	124	14

IRI = International Roughness Index.

Figure 7 shows the frequency distribution of the after IRI values for the rural pilot projects. Most of the sections had high values, indicating rougher sections. From Figure 8 it can also be seen that higher percent improvement is achievable when there is more "room for improvement" (i.e., higher before IRI values).

Incentives were minimal on the low volume secondary routes (because of higher after IRI values) although the smoothness was improved significantly. Natural characteristics of many secondary routes limit the contractor's ability to alter field processes to lower final IRI values further. The MTV was among the possible ride-improving additions that were not practical for use on geometrically constrained (i.e., narrow lanes) secondary roads.

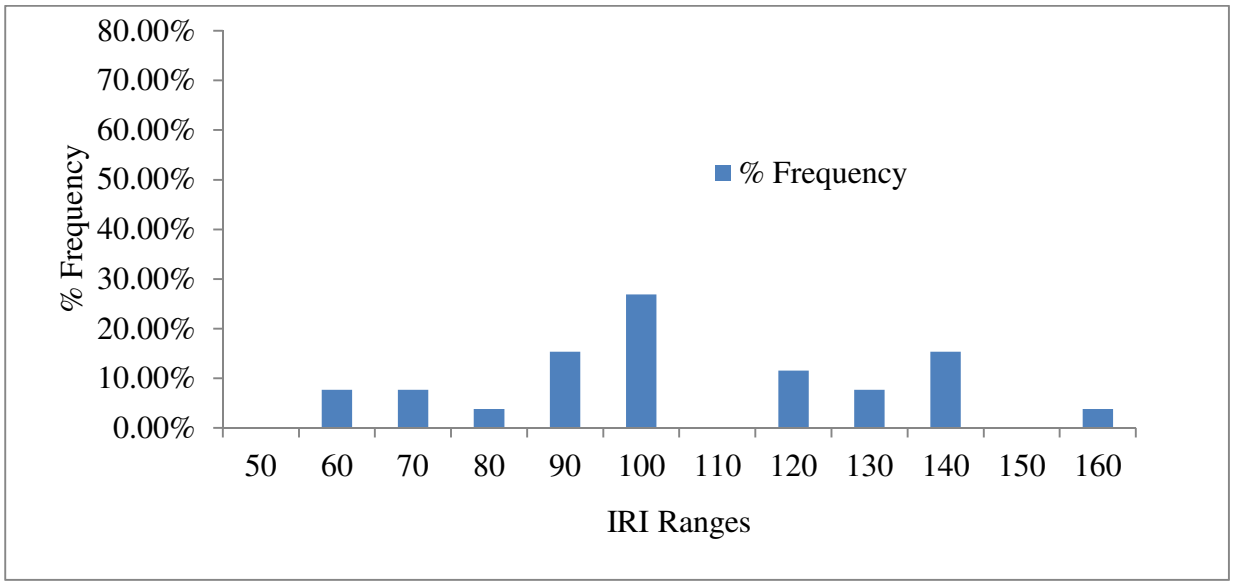

Figure 7. IRI Distribution for Culpeper District Incentive-Only Sites. IRI = International Roughness Index.

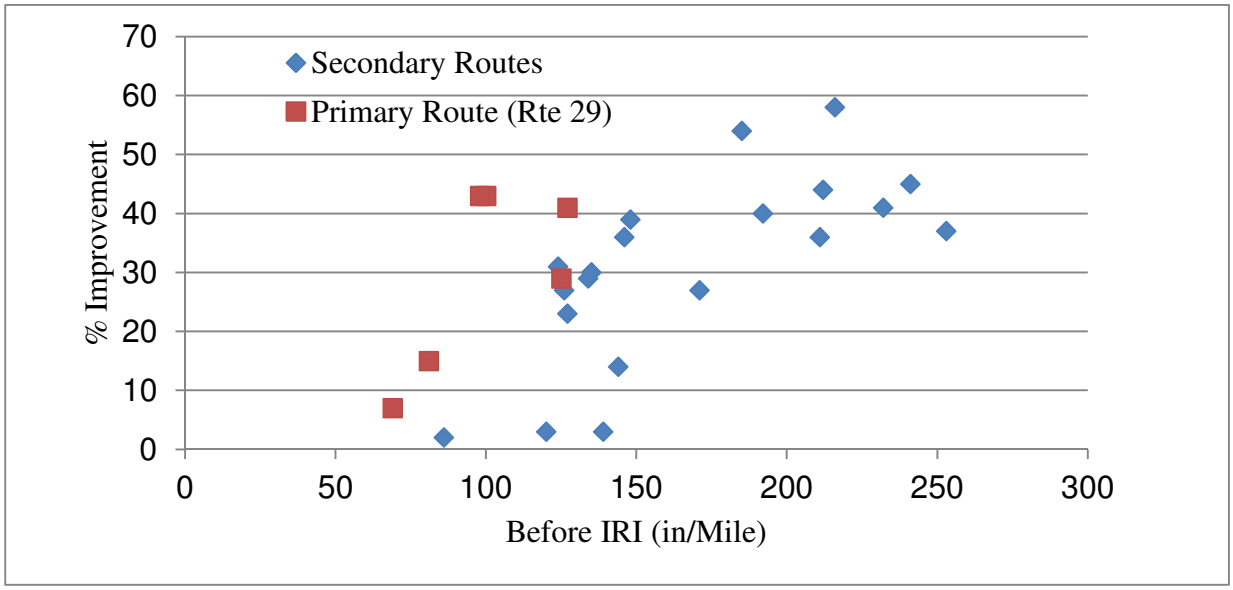

Figure 8. Before IRI Versus % Improvement for Culpeper District. IRI = International Roughness Index.

Control Sites

Table 7 shows the before and after IRIs and the percentage improvement for the control sections in the Fredericksburg, Hampton Roads, Staunton, and Richmond districts. Average after IRI was 75 in/mi (Fredericksburg District, 72 in/mi; Richmond District, 83 in/mi; Staunton District, 82 in/mi; and Hampton Roads District, 76 in/mi). A combined 25% average improvement was achieved among all the control sections. Average before IRI was 103 in/mi for all sections.

Table 7. Incentive-Only Ride Analysis Results: Control Sections

Route	Direction	Lane No.	Average IRI (in/mi)		
			Before	After	% Improvement
Fredericksburg District					
198	EB	L1	104	69	34
	WB	L1	99	65	34
198	EB	L1	111	85	23
	WB	L1	112	82	27
1	NB	L1	147	62	58
		L2	132	62	53
1	SB	L1	87	49	44
		L2	83	51	39
1	NB	L1	119	97	18
		L2	91	63	31
	SB	L1	116	90	22
		L2	91	54	41
14	EB	L1	104	79	24
	WB	L1	105	74	30
SR 33	SB	L1	113	89	21
		L2	91	53	42
	EB	L1	98	93	5
		L2	88	88	0
Hampton Roads District					
173	EB	L1	77	69	10
	WB	L2	75	66	12
238	EB	L1	113	91	19
	WB	L2	112	85	24
31	NB	L1	106	73	31
	SB	L2	99	72	27
Staunton District					
60	EB	L1	87	63	28
		L2	79	61	23
340	NB	L1	128	99	23
		L2	104	80	23
340	SB	L1	120	101	16
		L2	110	87	21
Richmond District					
60	EB	L1	134	82	39
		L2	99	69	30
		L1	95	90	5
		L2	89	89	0

IRI = International Roughness Index; EB = eastbound; WB = westbound; NB = northbound; SB = southbound.

Figure 9 shows the frequency distribution of after IRI values: 57% of the projects showed IRI values of less than 80 in/mi. From Figure 10 it can be seen that a higher percentage improvement was achieved in some districts (different contractors).

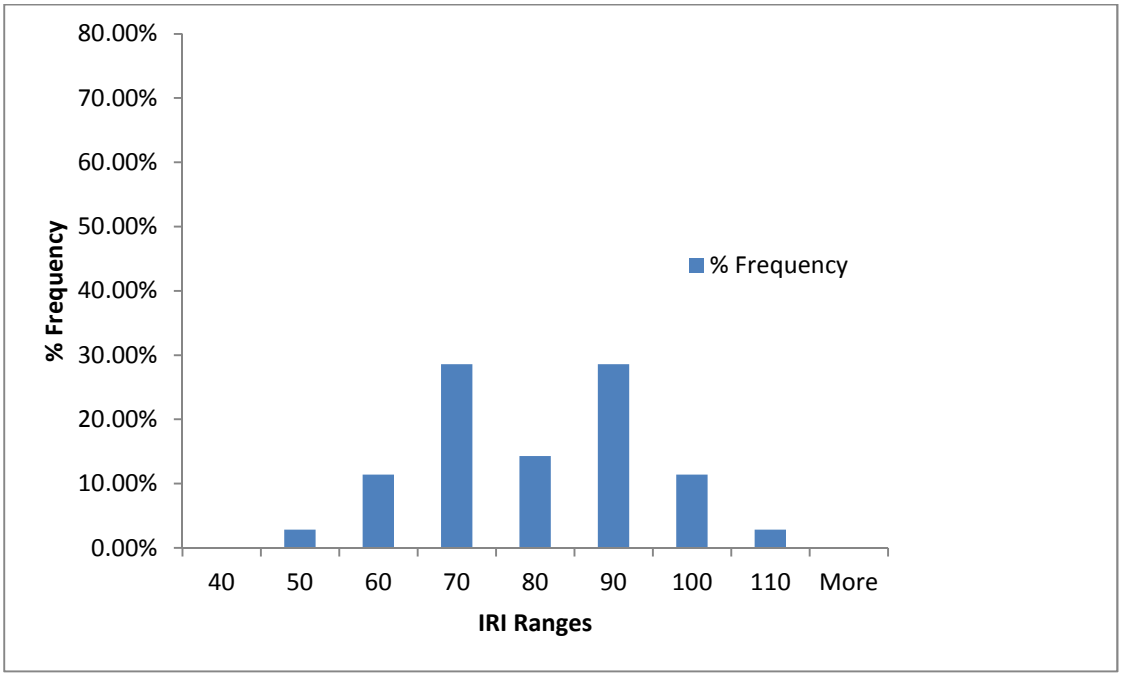

Figure 9. IRI Distribution of Incentive-Only Sites: Control Sites. IRI = International Roughness Index.

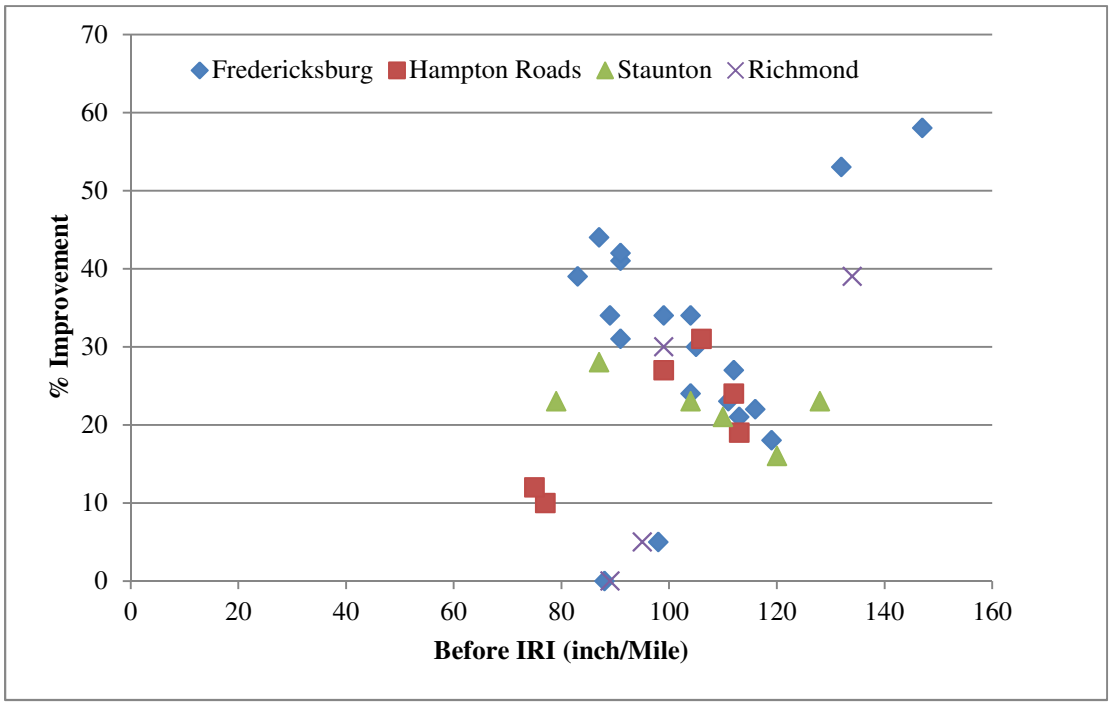

Figure 10. Before IRI Versus % Improvement: Control Sites. IRI = International Roughness Index.

Factors Affecting Achieved Smoothness

Project and Mixture Information

Available project details and mixture information are summarized in Table 8. All incentive-only projects except for the secondary routes and most control projects used an MTV in the paving process. With the exception of the secondary routes and one control project, most projects used automation/skis in the paving process. Some of the control projects also used performance milling, which can provide a smoother paving surface. The non-secondary projects were mill and fill operations, and most had no issues with achieving field density. Hauling time from asphalt plant to project site varied from 10 to 100 min. Two of contractors were involved with multiple paving sections, and the remaining had only one section. Unfortunately, the limited dataset precluded a detailed statistical analysis of different variables. Analysis of the limited data showed that the contractor and the before IRI seemed to influence the after IRI.

Ride Analysis of Routine Maintenance Resurfacing Projects

Apart from the control site, the study also analyzed the ride data for routine maintenance resurfacing projects. The intent was to establish a baseline difference between ride and non-ride specification projects and develop goals for applying the incentive-only specification. Table 9 presents network level data with regard to the average improvement in ride quality that is achieved through routine maintenance resurfacing. The table includes the average before IRI, the average after IRI, and the average improvement in IRI for 5 years of network distress ratings. The data are further broken down to identify those sections for which the conventional ride specification was and was not applied. Figure 11 presents combined before IRI and after IRI data, and Figure 12 shows percentage improvement versus before IRI for different years. The average before IRI for non-ride specification sites was 121 in/mi (standard deviation [SD] = 27) and that of ride specification sites was 96 in/mi (SD = 20). The corresponding after IRI values of non-ride specification and ride specification sites were 87 in/mi (SD = 20) and 67 in/mi (SD = 13), respectively. The average improvement during the first three cycles indicated better results when the ride specification was applied. However, more recent trends suggest essentially the same level of improvement irrespective of the use of the specification.

From the before paving data (Table 9), it can be seen that average non-ride specification sites were rougher by about 25 points than ride specification projects. Data from after paving show that average non-ride specification sites were rougher by about 20 points than ride specification projects. Figure 12 shows that it can be easier to achieve a higher level of improvement (both ride specification and non-ride specification projects) for rougher pavements. Table 10 presents the after IRI and the improvement for ride specification and non-ride specification projects for different before IRI ranges. It can be seen that at higher before IRI ranges, ride specification projects provide smoother pavements and larger improvements than non-ride specification projects. The objective of an incentive-only provision should be to reduce this average gap in the after paving ride quality by encouraging extra effort even when some project conditions naturally challenge the contractor's ability to achieve better smoothness.

Table 8. Project and Mixture Information of Incentive-Only and Control Projects

Route	After IRI	% Improve-ment	Route Type	MTV Used?	Mill/ Fill?	Type of Milling	Day/ Night Work	Hauling Time (min)	Tonnage Paved/ Day	Delay Between Trucks?	Compaction/ Density Issue?	Mix Used	Con-tractor Code	Automation in Paver?
Incentive-Only Sites														
Prince William Pkwy.	99	27	Primary	Yes	Yes	Regular	Day	20	-	No	No	SMA 12.5	A	Yes
Fairfax County Pkwy.	68	42	Primary	Yes	Yes	Regular	Night	-	-	No	No	SMA 12.5	B	Yes
Rt. 29	68	30	Primary	Yes	Yes	Regular	Day	-	-	No	No	SM 12.5D	B	-
729	95	30	Secondary	No	No	-	Day	19	700	No	No	SM 9.5A	B	No
669	88	56	Secondary	No	No	-	Day	10	1102	No	No	SM 9.5A	B	Yes
647	118	42	Secondary	No	No	-	Day	43	1225	No	No	SM 9.5A	B	No
1000	124	21	Secondary	No	No	-	Day	29	521	No	No	SM 9.5A	B	No
713	133	41	Secondary	No	No	-	Day	39	854	No	No	SM 9.5A	B	No
Control Sites														
Richmond														
US 60	83	19	Primary	Yes	Yes		Night	12	524	Yes	No	SM 12.5A	C	Yes
Fredericksburg														
198 (Gloucester Co.)	67	34	Primary	Yes	Yes	Performance	Day	63	1037	Yes	Yes	SM 12.5A	D	Yes
198 (Mathews Co.)	84	25	Primary	Yes	Yes	Performance	Day	100	1000	Yes	No	SM 12.5A	D	Yes
1 (MP 1.99- MP 9.04)	62	56	Primary	Yes	Yes	Performance	Night	30	1649	No	No	SM 12.5E	B	Yes
1 (MP 8.48-MP 9.96)	50	42	Primary	Yes	Yes	Performance	Night	35	1691	No	Yes	SM 12.5E	B	Yes
1 (MP 8.48-MP 10.02)	76	28	Primary	Yes	Yes	Performance	Night	18	1771	Yes	No	SM 12.5E	B	No
33	81	17	Primary	Yes	Yes	Regular	Day	60	1560	Yes	No	SM 12.5A	D	Yes
14	77	27	Primary	Yes	Yes	Regular	Day	70	1051			SM 12.5A	D	Yes
Hampton Roads														
173	68	11	Primary	Yes	Yes	Performance	Night	50	1000	No	No	SM 9.5D	D	Yes
238	88	22	Primary	Yes	Yes	Regular	Day	60	1200	No	No	SM 9.5D	D	Yes
31	73	29	Primary	No	No	-	Day	90	575	Yes	No	SM 9.5D	E	Yes
Staunton														
60	62	26	Primary	Yes	Yes	Regular	Day	10	1321	No	No	SM 12.5D	F	Yes
340	92	21	Primary	No	Yes	Regular	Day	40	945	NO	No	SMA 9.5	G	Yes

IRI = International Roughness Index; MTV =Material Transfer Vehicle; Co. = County.

Table 9. Ride Analysis Results From VDOT Pavement Management System (2007-2013)

Details	Specification	2007-2008	2008-2009	2009-2010	2011-2012	2012-2013
No. of Sections	Ride	45	78	72	115	112
	Non-Ride	55	77	36	88	34
Average Before IRI	Ride	100	97	97	94	96
	Non-Ride	123	119	118	119	128
Average After IRI	Ride	66	62	66	66	72
	Non-Ride	89	84	88	85	96
Average % Improvement in IRI	Ride	32	34	30	29	24
	Non-Ride	27	28	24	29	24

IRI = International Roughness Index.

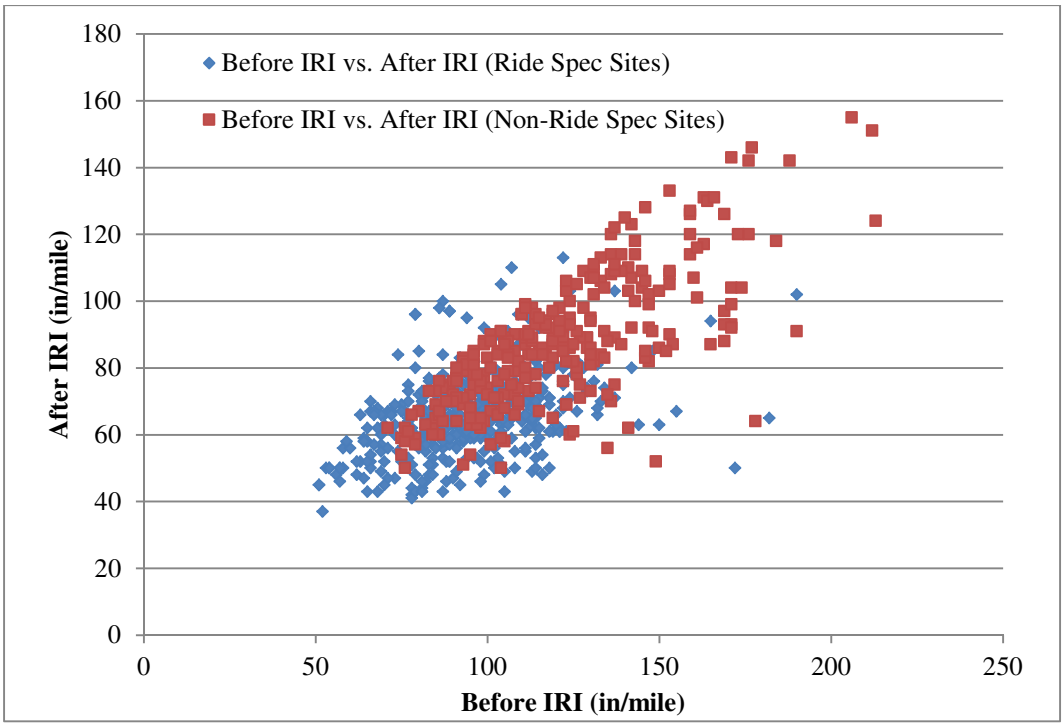

Figure 11. Before IRI Versus After IRI: PMS Data. IRI = International Roughness Index.

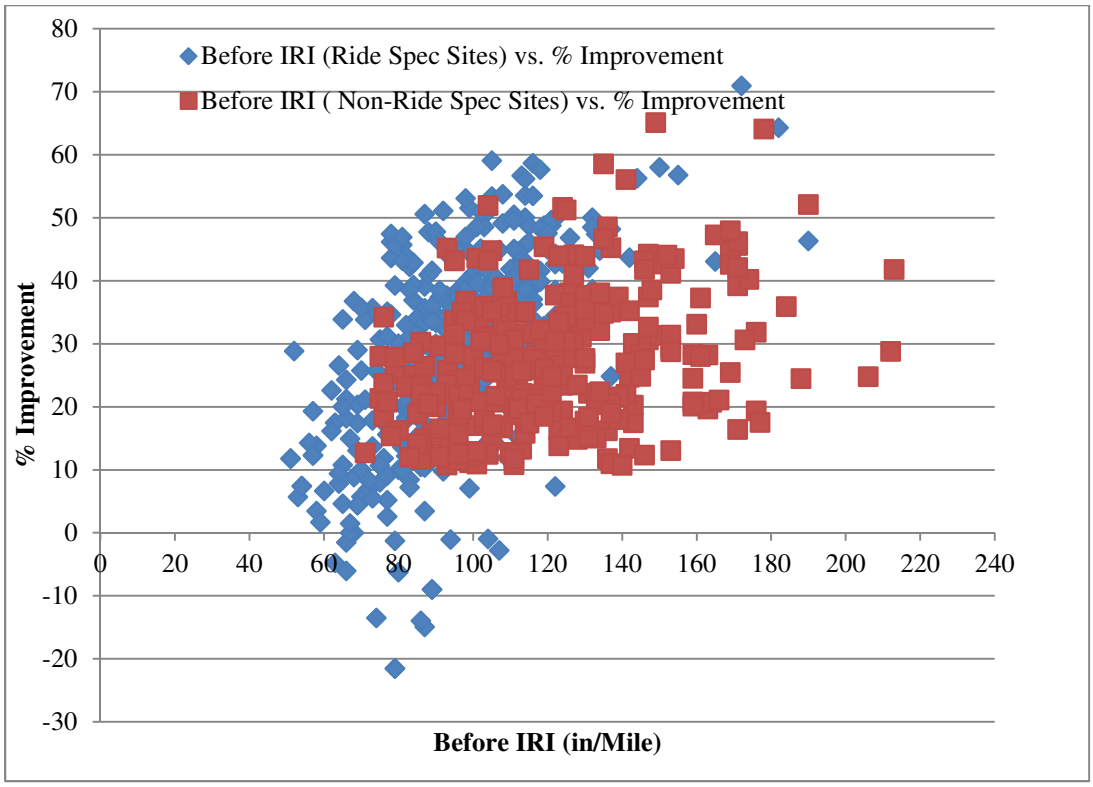

Figure 12. Before IRI Versus % Improvement: PMS Data. IRI = International Roughness Index.

Table 10. Ride Analysis Results for Different IRI Ranges

Before IRI Range	Average After IRI (in/mi)		Average % Improvement	
	Ride Spec. (No. of Projects)	Non-Ride Spec. (No. of Projects)	Ride Spec.	Non-Ride Spec.
65-80	69 (86)	60 (12)	28	22
81-100	67 (167)	72 (60)	29	22
101-120	70 (130)	82 (82)	35	25
121-Above	76 (39)	99 (136)	41	31

IRI = International Roughness Index; Spec. = specification.

Review of Current Incentive-Only Provisions

The Ride Specification Subcommittee first addressed the concern that the originally proposed provision may fail to consider quality adequately beyond the 52.8-ft (0.01-mi) base length. The current provision rejects any negative pay adjustment computed at a 0.01-mi segment and sums only the incentives on any 0.01-mi segments. This means the specification will allow an incentive to be paid for the isolated good 0.01-mi segments irrespective of the overall or average ride quality for any project. This has been echoed by VDOT staff that the current incentive-only provision as written fails to provide any safeguard from the contractor getting a bonus (irrespective of how small) on even a very rough paving project. This necessitates revising the current incentive-only provisions.

In one approach, consideration was given to comparing the after paving IRI with the before paving IRI and allowing incentive-only if the contractor achieved a minimum improvement. However, without moving the testing and acceptance responsibility to the contractor, this would require VDOT to measure both before and after paving IRIs. This would have a significant impact on the logistics with the planned wider application of the incentive-only provision. In a second approach, consideration was given to modifying the pay adjustment calculation process that would allow an incentive payment only if the contractor can provide better ride over a significant section instead of just isolated 0.01mi segments. A third approach that considered an incentive pay adjustment calculation over a 0.1-mi stretch looked promising. In this approach, a pay adjustment (both positive and negative) would be calculated at each 0.01-mi segment and summed over a 0.1-mi section. If the net (over this 0.1 mi) was negative, the contractor would not be penalized over that 0.1-mi section and if the net was positive, the contractor would be awarded the amount for that 0.1-mi section. Incentives over 0.1-mi sections (if any) would be summed over the entire project to calculate the total incentive for the project. In this method, it is surmised that a 0.1-mi length is good enough to serve as the basis for paying any incentive to the contractor and thus provides a more meaningful approach for an incentive-only provision. The third approach is described in further detail here.

Figure 13(a) depicts a realistic application of the incentive-only criteria to two consecutive 0.1-mi segments of overlay. The positive (green) and negative (red) bars depict the corresponding incentive and disincentive, respectively, that may be warranted for each 0.01-mi sublot along the segment if the full incentive/disincentive ride specification is in effect. The blue bar at the end of each 0.1-mi segment represents the total pay adjustment that would be due the contractor (for each 0.1 mi) according to the originally proposed incentive-only provisions. Since inferior quality ride (i.e., the sublots shown as red bars) is ignored, the pay adjustments for each lot are simply the total of the green bars and always a net positive.

Figure 13(b) illustrates the subcommittee's recommended revised approach to arrive at a fair incentive while not subjecting a contractor to potential disincentives. The segment is the same 0.2-mi segment depicted in Figure 13(a). The net pay adjustment for each 0.1 mi is the net of the individual simulated adjustments or zero, whichever is more. With this approach, the contractor still has the potential to earn incentives for ride quality without the risk of a disincentive. But it would be more difficult for a contractor to earn bonuses while leaving VDOT with a net inferior quality ride (e.g., the second 0.1-mi segment in each chart).

(a) Originally proposed provision

(b) Alternative provision

Figure 13. Example Framework for Incentive-Only Pay Adjustments. Green bars indicate Incentive; red bars indicate Disincentive.

The subcommittee thought that the aforementioned change in framework largely eliminated the likelihood that contractors would achieve significant "accidental incentives." Recognizing that this should necessitate deliberate changes in processes and/or added equipment, the subcommittee likewise proposed revisions in the pay adjustment schedule to improve the chances that a contractor could recover any additional costs. The proposed revised targets are shown in Table 11. Figure 14 shows the before IRI and the improvement obtained for primary system projects that were not subjected to the ride specification (from the PMS data discussed earlier). The minimum improvement required to achieve a bonus using the proposed revised targets (IRI < 70) was calculated and shown in the graph. The pavement sections represented by the red diamonds to the left of the blue arc could be eligible for some incentive under the new targets. The fraction of the population to the left of the arc is clearly the smaller of the two (20% of the total non-ride specification projects), suggesting that contractors would normally need to apply additional effort to achieve a lower IRI and thus an incentive. The complete revised incentive-only specification is provided in Appendix C.

Table 11. Current and Revised Pay Adjustment for Incentive-Only Specification: Non-Interstate System

IRI After Completion (in/mi)	Current Pay Adjustment (Percent Pavement Unit Price)	IRI After Completion (in/mi)	Revised Pay adjustment (Percent Pavement Unit Price)
55.0 and Under	115	60.0 and Under	115
55.1-65.0	110	60.1-70.0	110
65.1-80.0	100	70.1-85.	100
80.1-90.0	90	85.1-95.0	90
90.1-100.0	80	95.1-105.0	80
100.1-110.0	70	105.1-115.0	70
110.1-130.0	60	115.1-135.0	60
130.1-150.0	40	135.1-155.0	40
150.1-170.0	20	155.1-175.0	20
Over 170.1	0	Over 175.1	0

IRI = International Roughness Index.

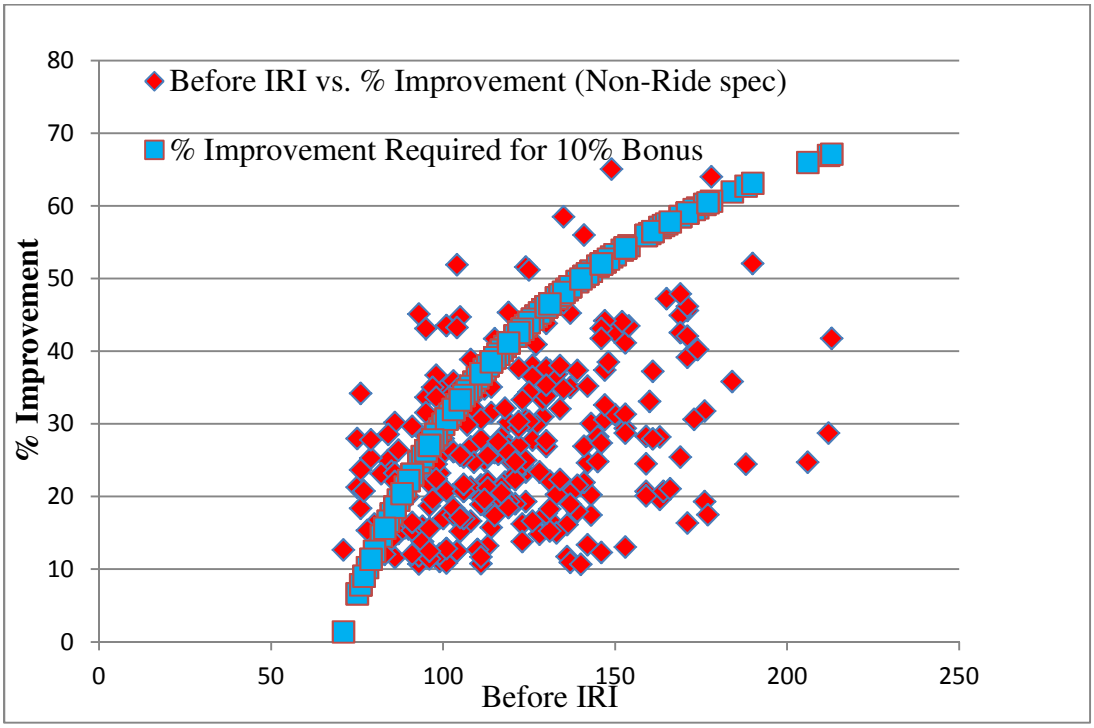

Figure 14. Before IRI Versus % Improvement Required for Incentive Bonus. IRI = International Roughness Index.

Finally, the subcommittee recognized that the "back-application" of proposed changes to previously conducted paving was insufficient to guarantee success moving forward. It was therefore further recommended that the proposed incentive-only provision be applied to a wider range of projects in the 2015 construction season. Engineers from VDOT's Materials Division and the Virginia Center for Transportation Innovation and Research (VCTIR) would then analyze the results and make specific recommendations in order to finalize the incentive-only specification for routine use.

CONCLUSIONS

- *There was no statistically reliable distinction between the achieved quality of the incentive-only and control sites.* This may have been due to the limited number of sites, districts, contractors, etc., for the incentive-only projects. The site selection also might have played a role.

- *Meeting the same surface smoothness criteria by repaving is more challenging for contractors on secondary roads than on primary roads.*

- *The originally proposed incentive-only provisions do not provide any meaningful benefit to VDOT or contractors.*

RECOMMENDATIONS

1. *VDOT's Materials Division should adopt the revised incentive-only specification provided in Appendix C, which has a modified method for calculating incentives and revised pay bands.*

2. *VCTIR and VDOT's Materials Division should analyze the data from the 2015 pilot project to evaluate the effectiveness of the revised incentive-only specification before making final recommendations.*

BENEFITS AND IMPLEMENTATION

Benefits

Although limitations exist in applying the IRI-based ride specification, such as to intersections, short project lengths, and low-speed routes, the study recommends that VDOT continue to apply the ride specification to paving projects statewide in order to continue to realize the benefits of smooth pavements. An earlier study (McGhee and Gillespie, 2006) demonstrated that application of the ride specification leads to smoother roads. Smoother roads lead to a direct benefit to VDOT and an indirect benefit to the traveling public. The earlier study indicated that when working under a contract with a rideability specification, paving contractors produce surfaces that are on average smoother, by 8.8 in/mi IRI than the pavement they deliver when working under similar conditions without such a specification. The same study showed that by deferring resurfacing activity by 2 years, VDOT may possibly save $1,295/lane-mile. A cost of $52.25 per ton of asphalt was used in the computation, and the benefit is expected to vary from year to year depending on the price of asphalt. With the current average asphalt price of $80 per ton, the savings can be as high as $2,000 per lane-mile. Indirect benefits are expected in the following forms: (1) better fuel efficiency, (2) reduced vehicle maintenance, and (3) lower emissions.

Implementation

Appendix C provides a Special Provision for Rideability with modified criteria for incentive-only projects for use when the incentive/disincentive ride specification cannot be applied because of geometric or other constraints. These modified criteria reflect the findings of this study. The essential implementation action from this study is for VDOT's Materials Division to move forward with an expanded pilot in the 2015 construction season to determine whether the modifications result in an effective final product. The following criteria are provided to aid in the selection of those projects:

1. not a candidate for the regular incentive/disincentive ride specification
2. geometry and traffic-level diversity
3. represent multiple resurfacing contracts (to include more contractors)
4. primary or high volume (>10,000 vehicles per day, secondary) routes
5. minimum 1 mi length and 11 ft lane width
6. sound pavement structure
7. right lane IRI (from PMS data) less than150 in/mi.

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REFERENCES

Federal Highway Administration. *Highway Performance Monitoring System Field Manual,* Appendix J. Washington, DC, 1990.

Hanson, D.I., James, R.S., and NeSmith, C. *Tire/Pavement Noise Study.* Report No. 04-02. National Center for Asphalt Technology, Auburn, AL, 2004.

Keever, D.B., Weiss, K.E., and Quarles, R.C. *Moving Ahead: The American Public Speaks on Roadways and Transportation in Communities.* FHWA-OP-01-017. Federal Highway Administration, Washington, DC, 2000.

McGhee, K.K., and Gillespie, J.S. *Impact of a Smoothness Incentive/Disincentive on Hot-Mix Asphalt Maintenance Resurfacing Costs.* VTRC 06-R28. Virginia Transportation Research Council, Charlottesville, 2006.

Merritt, D.K., Chang, G.K., and Rutledge, J.L. *Best Practices for Achieving and Measuring Pavement Smoothness, A Synthesis of State-of-Practice.* Final Report 550. Louisiana Transportation Research Center, Baton Rouge, 2015.

Nair, H., Habib, A., Saha, B., and Nelson, S. Ride Specifications: Virginia's Experience, Accomplishments and Challenges. In *Transportation Research Record: Journal of the Transportation Research Board,* No. 2227. Transportation Research Board of the National Academies, Washington, DC, 2011, pp. 189-196.

Smith, K.L., Smith, K.D., Evans, L.D., Hoerner, T.E., and Darter, M.I. Effect of Initial Pavement Smoothness on Future Smoothness and Pavement Life. In *Transportation Research Record: Journal of the Transportation Research Board,* No. 1570. Transportation Research Board of the National Academies, Washington, DC, 1997a, pp. 60-70.

Smith, K.L., Smith, K.D., Evans, L.D., Hoerner, T.E., Darter, M.I., and Woodstrom, J.H. *Smoothness Specifications for Pavements.* NCHRP Web Document 1, 1997b. http://www.nap.edu/catalog/6337.html. Accessed August 10, 2012.

SmoothPavements.com. Smoothness Specifications Online, 2014. Accessed December 12, 2014.

Virginia Department of Transportation, Materials Division. Application of the Rideability Specifications. Memorandum. Richmond, August 2008.

Virginia Department of Transportation, Materials Division. *2013 Ride Specification Paving Results.* Richmond, 2014.

APPENDIX A

INCENTIVE-ONLY AND CONTROL SITES IN PILOT PROJECT

Table A1. Northern Virginia District 2013 Incentive-Only Ride Specification Sites

Schedule	Route	Dir.	Co.	MP	From	MP	To	Length	Speed Limit (mph)	No. of Lanes	Lane-Miles	Comments
PM-9P-13	294	E	76	0.02	PJ 106 Ft East of Dumfries Rd. Rt. 234	1.79	PJ 125 Ft West of Hasting Dr.	1.77	45	2	3.5	Type II Patching
PM-9P-13	294	W	76	0.02	PJ 106 Ft East of Dumfries Rd. Rt. 234	1.79	PJ 126 Ft West of Hasting Dr.	1.77		2	3.5	
PM-9P-13	294	E	76	1.91	PJ 133 Ft East of Liberia Ave.	3.71	113 Ft East of Yates Ford Rd. Rt. 612	1.8		2	3.6	
PM-9P-13	294	E	76	13.374	PJ 120 Ft East of Smoketown Rd. Rt. 2000	14.45	PJ 138 Ft West of I-95 Sign Post Before Ramp to I-95SB	1.071		2	2.1	
PM-9P-13	294	E	76	14.445	PJ 138 Ft West of I-95 Sign Post Before Ramp to I-95SB	15.22	85 Ft East of York Dr. Rt. 1299	0.771		2	1.5	
PM-9P-13	294	W	76	14.39	PJ 165 Ft West of I-95 Sign Post	15.22	126 Ft East of Summerland Dr. Rt. 1299	0.83		3	2.5	
PM-9P-13	294	W	76	13.38	123 Ft East of Smoketown Rd. Rt. 2000	14.39	PJ 165 Ft West of I-95 Sign Post	1.01		3	3.0	
PM-9P-13	294	W	76	3.71	130 Ft East of Yates Ford Rd. Rt. 612	6.33	176 Ft West of Fingerlake Rd. Rt. 3020	2.62		2	5.2	
PM-9P-13	294	W	76	1.91	PJ 113 Ft East of Liberia Ave.	3.71	130 Ft East of Yates Ford Rd. Rt. 612	1.8		2	3.6	

Table A2. Culpeper District 2013 Incentive-Only Ride Specification Sites

Schedule	Route	Dir.	Co.	MP	From	MP	To	Length	Speed Limit (mph)	No. of Lanes	Lane-Miles	Comments	Maintenance Action	Mix Type
PM-7A-13	29	S	2	23.04	Rt. 631	24.54	Rivanna River Bridge	1.5	45	4	3	Multiple Signals	Mill and Fill 2.0 in	SM-12.5D
PM-7A-13	29	S	2	9.62	0.098 Mi North Rt. 710	10.53	Hardware River Bridge	0.91	60	2	1.82	Type II Patching	Mill and Fill 2.0 in	SM-12.5D
PM-7C-13	609	B	23	0	Madison County Line	2	Rt. 29	2	45+	2	4	Posted 45 in Haywood	Overlay 1.5 in	SM-9.5A
PM-7C-13	669	B	23	3.7	Rt. 675	5.98	Rt. 762	2.28	45+	2	4.56	Posted 25 in Brandy	Overlay 1.5 in	SM-9.5A
PM-7C-13	729	B	23	7.9	Rt. 628 South Intersection	10.51	Rappahannock County Line	2.61	45+	2	5.22	ACOT	Overlay 1.5 in	SM-9.5A
PM-7C-13	609	B	56	1.16	Rt. 231	8.66	Culpeper County Line	7.53	45+	2	15.06	ACOT	Overlay 1.5 in	SM-9.5A
PM-7C-13	611	B	68	6.98	Rt. 692 East Intersection	11.33	0.07 Mi East Rt. 20	4.35	45+	2	8.7	ACOT	Overlay 1.5 in	SM-9.5A
PM-7E-13	614	B	30	0	Rt. 616	0.6	Stafford County Line	0.6	45+	2	1.2		Overlay 2.0 in	SM-12.5A
PM-7E-13	647	B	30	0.84	0.15 Mi West Rt. 645	2.89	Rt. 688	2.05	45	2	4.1		Overlay 2.0 in	SM-12.5A
PM-7E-13	688	B	30	16.76	Rt. 730	20.6	Rt. 55	3.84	45	2	7.68	ACOT	Overlay 2.0 in	SM-12.5A
PM-7E-13	713	B	30	3.94	Rt. 710	5.26	1.3 Mi North Rt. 710	1.32	35	2	2.64	ACOT	Overlay 2.0 in	SM-12.5A
PM-7E-13	1000	B	30	0	Cul-de-sac	0.92	Rt. 674	0.92	25	2	1.84	No Centerline	Overlay 2.0 in	SM-12.5A

Table A3. 2013 Control Sites: Fredericksburg

Schedule	Route	Dir.	Co.	MP	From	MP	To	Length (mi)	Speed Limit (mph)	No. of Lanes	Lane-Miles	Comments	Maintenance Action
PM-6B-13	1	NBL	Stafford	8.48	0.12 Mi North Rt. 687 (Hope Rd.)	9.96	0.10 Mi North Rt. 631 (Coal Landing Rd.)	1.48	45	2	3.0	Stafford Wayside, Paved Bridge	12.5E
PM-6B-13	1	SBL	Stafford	8.48	0.73 Mi South Rt. 1340 (Austin Run Blvd.)	10.02	0.07 Mi South of Austin Park Dr.	1.54	45	2	3.1	Stafford Wayside, Paved Bridge	2 in Mill and Fill, 12.5E
PM-6B-13	1	NBL & SBL	Stafford	0.72	0.07 Mi North Int. Rt. 652 Truslow Rd.	1.62	0.15 Mi South Int. Rt. 1005 Manning Dr.	0.9	45	4	3.6	Near Truslow Rd.	2 in Mill and Fill, 12.5E
PM-6C-13	198	EBL & WBL	Gloucester	6.68	0.5 Mi East Rt. 673 Freeport Rd.	11.47	Mathews/ Gloucester County Line	4.79	55		9.6	2 Lane Undivided, Alignment	2 in Mill and Fill, 12.5A
PM-6C-13	14	EBL & WBL	Mathews	4.94	0.39 Mi East Rt. 626	7.32	0.04 Mi East Int. Rt. 198	2.38	55		4.8	2 Lane	2 in Mill and Fill 12.5A
PM-6C-13	198	EBL & WBL	Mathews	1.99	Int. Rt. 3	9.04	0.12 Mi East of Int. Rt. 14	7.05	55		14.1	2 Lane	2 in Mill and Fill 12.5A
PM-6C-13	33	EBL & WBL	Middlesex	14.31	0.2 Mi East Rt. 628	17.17	0.20 Mi East Rt. 1103	2.86	55		5.7	2 Lane Undivided	2 in Mill and Fill 12.5A

Table A4. 2013 Control Sites: Richmond, Hampton Roads, and Staunton Districts

Schedule	Route	Dir.	Co.	MP	From	MP	To	Length	Speed Limit (mph)	No. of Lanes	Lane-Miles	Comments	Maintenance Action
Richmond													
PM-4C-13	US-60	E&W	Chesterfield	3.07	0.26 Mi West Rt. 667/970	5.26	0.47 Mi East Rt. 754	2.19	55, 45, 35	4	8.8	EB length is longer than WB, Curb& Gutter, Signals, Utility Vaults/Covers	Mill 4 in, Repave 2 in IM-19.0A and 2 in SM-12.5A
Hampton Roads													
	173	E&W	99	0.00	Newport News City Limit	2.61	Rt. 17	2.61	55	2	5.2		Mill 1.5 in Pave 1.5 in
	238	E&W	99	0.00	Newport News City Limit	3.43	Rt. 17	3.43	35, 45, 40	2	6.9		Mill 1.5 in Pave 1.5 in
PM-5F-13	31	N&S	90	0.00	0.29 West Rt. 630	0.91	0.62 Mi East Rt. 630	0.9	55	2	1.8		1.5 in Pave
Staunton													
PM8D-081-F13, N501	60	E	Rockbridge Co.	16.85	0.31 mi East US 11S On Ramp	21.75	Buena Vista CL	4.9	55	2	9.8	I-81Bridge, Acceleration, & Deceleration Lanes	Mill 1.5 in & pave 1.5 in
PM8E-007-F13, N501	340	N	Augusta Co.	17.94	NCL Waynesboro	19.72	0.64 Mi North SR 611	1.78	40	3	5.34	Curb & Gutter, Manholes, Water Valves	Mill 2 in & pave 2 in
PM8E-007-F13, N501	340	S	Augusta Co.	17.94	0.81 Mi South SR 619	19.72	NCL Waynesboro	1.78	40	2	3.56	Curb & Gutter, Manholes, Water Valves	Mill 2 in & pave 2 in

APPENDIX B
FIELD SECTION INFORMATION

Research Project: Assessment of Incentive-only Ride Specification for Asphalt Pavement

Date:					
Project Name/Location			**TL- 57,58**		
Length and Width			Roller # 1 (size of roller)		
Weather at Project:					
VDOT Inspector's Name:			Roller # 2		
Paving Contractor:					
Paving thickness			Roller # 3		
Hauling Distance/Time From Plant:					
Total Tonnage Paved in Project Section					
Length of Paving per shift					
Is there any delay between the trucks?					
Tonnage Paved /day			Roller Pattern	Vib	Stat
Day/Night work					
Type of Paver			Target Density		
Vibration	On	Off			
Type of Screed					
MTV (Material Transfer Vehicle) Used?	Yes	No	Control Strip Air Voids (Field)		
Any Geometric Limitation? (too narrow for MTV, etc.)			Is there any compaction issue?		
Length and type of Skis					
Use of Automation in Paver	Yes	No			
Laser equipment used	Yes	No			
Other Special Equipment Used					
Rate of Application (lbs/sq yd)			**Condition of the Surface**		
Tack Application Rate and type			Milled?	Yes	No
Compacted Lift Thickness			Type of Milling Used	Regular	Performance
Delivery Temperature			Free of Scabbing/Loose Material?	Yes	No
Laydown Temperature			Other Notes on the Surface		
Pavement Surface Temperature (beginning of paving)			Scratch layer used in this project	Yes	No
High/Low Ambient Temperatures			Upfront Survey conducted for this project:	Yes	No
Level of Traffic					
Type of traffic control used for this project:					
SPECIAL NOTES					

Mix Information, Job Mix Number:		
Mix Type Produced:		
Producer:		
Plant Location:		
ASPHALT BINDER USED		
Asphalt Content %		
RECYCLED ASPHALT PRODUCT (RAP)		
Percentage Used in Mix		
Warm Mix	Yes	No
Type of warm mix	Foam	Additive

Geometrics		
Longitudinal Grades	Flat	Rolling
No. of lanes		
Width of lanes		
Curb and/or gutter ?	Yes	No
Approximate length of curb		
Manholes ?	Yes	No
Approximate number of Manholes		
Paved shoulder ?	Yes	No

APPENDIX C

PROPOSED SPECIAL PROVISION FOR RIDEABILITY

S315R00-1209

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
RIDEABILITY

September 2, 2014

SECTION 315—ASPHALT CONCRETE PAVEMENT of the Specifications is amended as follows:

Section 315.07 Pavement Tolerances is amended to include the following:

For pavements designated in the Contract, the final ride quality acceptance will be based on the lowest average International Roughness Index (IRI) for each 0.01-mile section produced by a minimum of two test runs, using a South Dakota style road profiling device and reported for each travel lane. The device shall measure both wheelpaths with laser height sensing instruments. The Department will conduct the testing within 30 calendar days from Contractor's written notification for testing following the completion of the final surface course and final pavement striping over the designated section. If temporary pavement marking is placed and the lanes are clearly delineated over the final surface course, the Contractor may request ride testing in writing. Testing will be conducted in accordance with VTM 106. The Department will conduct the testing as soon as possible after completion, provided the Contractor can arrange unimpeded access to the paved surface for constant highway speed test runs.

Acceptance

An IRI number in inches per mile will be established for each 0.01-mile section for each designated lane. The last 0.01-mile (52 feet) section before a bridge, the first 0.01-mile (52 feet) section after a bridge, and the beginning and end 0.01-mile (52 feet) sections of the final surface will not be subject to a pay adjustment.

Areas excluded from testing by the road profiling device will be tested using a 10-foot straightedge. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall not be more than 1/4 inch. Humps and depressions exceeding the specified tolerance shall be subject to correction as directed by the Engineer, at no additional cost to the Department.

The following tables provide the acceptance quality of pavement based on the finished rideability for interstate and non-interstate roadways.

TABLE A - INTERSTATE SYSTEM	
IRI After Completion (Inches Per Mile)	**Pay Adjustment (Percent Pavement Unit Price)**
45.0 and Under	115
45.1-55.0	110
55.1-70.0	100
70.1-80.0	90
80.1-90.0	80
90.1-100.0	70
100.1-120.0	60 or Subject To Corrective Action
120.1-140.0	40 or Subject to Corrective Action
140.1-160.0	20 or Subject to Correction Action
Over 160.1	0 or Subject to Corrective Action

TABLE B - NON- INTERSTATE SYSTEM	
IRI After Completion (Inches Per Mile)	**Pay Adjustment (Percent Pavement Unit Price)**
55.0 and Under	115
55.1-65.0	110
65.1-80.0	100
80.1-90.0	90
90.1-100.0	80
100.1-110.0	70
110.1-130.0	60 or Subject To Corrective Action
130.1-150.0	40 or Subject to Corrective Action
150.1-170.0	20 or Subject to Corrective Action
Over 170.1	0 or Subject to Corrective Action

The Department holds the right to require corrective action. The method of correction shall be reviewed and approved by the Department and correction shall be performed at the Contractor's expense. The Department may require correction of any or all adjoining traffic lanes or shoulders at the Contractor's expense to assure uniform cross section. Methods of correction may include, but are not limited to, diamond grinding, remove and replace, and asphalt concrete (AC) overlay.

Where corrections are made after the initial Department rideability test, the pavement will be retested by the Department to verify that corrections have produced the acceptable ride surface. No incentives will be provided for sections on which corrective actions have been required by the Engineer. In the event the corrective action(s) does not result in 100 percent payment, then the Contractor will be assessed the corresponding percent payment. Additional corrections may be required by the Department based on the retested IRI measurements at the Contractor's expense.

Single-Lift Construction

An AC layer is defined as a material lift equal to or greater than 2.5 times the maximum nominal aggregate size for the AC mix(es) specified in the Contract. A material lift less than the specified application rate or less than 2.5 times the maximum nominal aggregate size for the AC mix(es) specified in the Contract is considered a "scratch course" and not an AC layer.

Where only one AC layer shall be placed, the Department will test pavement sites subject to this special provision prior to work by the Contractor. Upon request by the Contractor, the Department will provide the IRI testing results. If this IRI testing is conducted more than 180 calendar days prior to the scheduled beginning of the work, the Department or Contractor may request new IRI testing.

Based on the average IRI (original surface and completed overlay) for each 0.1-mile length of each travel lane subject to this special provision, no corrective action will be required if the completed surface has IRI test results that indicate a 30 percent or more improvement in the ride quality. This percent improvement is based on the 0.1-mile paved section average IRI and not the individual 0.01-mile increments. When the percent improvement is achieved for a 0.1-mile section, the payments (incentives, disincentives, and full payment) for the individual 0.01-mile increments will be summed. The Contractor will then be paid the greater of the total adjusted payments or 100 percent for that 0.1-mile section.

This rideability specification does not relieve the Contractor from responsibility concerning workmanship in accordance with the requirements of the Specifications, other contract requirements, or as defined by the Department.

Incentive Only Projects

For projects designated as "incentive only," Table C will be applied for calculating pay adjustment. The pay adjustment will be calculated at each 0.01-mile segment and summed over each 0.1 mile. Any penalties, thus calculated at each 0.1 mile, will be ignored for incentive only projects. Only the incentive calculated for each 0.1-mile (if any) section will be summed to calculate the total incentive over the project. *Therefore, no disincentive will be assessed over the entire project. The Contractor will be paid the greater of the total incentive or 100 percent payment for the project.* The standard exemptions will be applied to calculate the average IRI over the lane. Incentive only projects will not be subject to corrective action as a result of the rideability results. Ride testing prior to paving by the Department is not required for incentive only projects.

Pay adjustments will be applied to the theoretical tonnage of the surface mix asphalt material for the lane width and section length tested.

This rideability specification does not relieve the Contractor from responsibility concerning workmanship in accordance with the requirements of the Specifications, other contract requirements, or as defined by the Engineer.

TABLE C – INCENTIVE ONLY PROJECT	
IRI After Completion (Inches Per Mile)	**Pay Adjustment (Percent Pavement Unit Price)**
60.0 and Under	115
60.1-70.0	110
70.1-85.0	100
85.1-95.0	90
95.1-105.0	80
105.1-115.0	70
115.1-135.0	60
135.1-155.0	40
155.1-175.0	20
Over 175.1	0

Payment

Pay adjustments will be applied to the theoretical tonnage of the surface mix asphalt material for the lane width and section length tested (generally 12 feet wide and 52.8 feet long) based on testing prior to any corrective action directed by the Engineer. For the section(s) where corrective action is required, pay adjustment will be based on the testing after the corrective action has been accomplished.