

Evaluation of Revised Incentive-Only Ride Specification for Asphalt Pavements

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Final Report VTRC 18-R11

Standard Title Page - Report on Federally Funded Project

1. Report No.: FHWA/VTRC 18-R11	2. Government Accession No.:	3. Recipient's Catalog No.:	
4. Title and Subtitle: Evaluation of Revised Incentive-Only Ride Specification for Asphalt Pavements		5. Report Date: June 2018	
		6. Performing Organization Code:	
7. Author(s): Harikrishnan Nair, Ph.D., P.E. , Kevin K. McGhee, P.E., Affan Habib, P.E., Michael Wells, P.E., and Bipad Saha, P.E.		8. Performing Organization Report No.: VTRC 18-R11	
9. Performing Organization and Address: Virginia Transportation Research Council 530 Edgemont Road Charlottesville, VA 22903		10. Work Unit No. (TRAIS):	
		11. Contract or Grant No.: 107486	
12. Sponsoring Agencies' Name and Address: Virginia Department of Transportation Federal Highway Administration 1401 E. Broad Street 400 North 8th Street, Room 750 Richmond, VA 23219 Richmond, VA 23219-4825		13. Type of Report and Period Covered: Final	
		14. Sponsoring Agency Code:	
15. Supplementary Notes:			
16. Abstract: <p>In late 2011, the executive leadership of the Virginia Department of Transportation (VDOT) formed an Asphalt Quality Task Force to identify and recommend specific achievable measures to improve the quality of asphalt paving in Virginia. The task force recommended that VDOT assess the feasibility of making an incentive-only provision for ride quality the default for projects that do not qualify for VDOT's regular specification for rideability, which includes both incentives and disincentives. A pilot application of the incentive-only provision was conducted during VDOT's 2013 construction season. Although the results indicated no statistically reliable distinction in ride quality between the projects under the incentive-only provision and those with no rideability requirement, the number of sites, VDOT districts, contractors, etc., included in the assessment was limited.</p> <p>The research summarized through this study addressed a concern that the criteria for the ride specification in the original (2013) incentive-only provision may have failed to reflect quality adequately beyond a limited 52.8 ft (0.01-mi) base length. The study documented the application of an incentive-only provision to a wider range of projects during VDOT's 2015 construction season. The revised criteria addressed some of the concerns associated with the original criteria. The revised provision maintains the potential for incentives while reducing the likelihood for "accidental" bonuses when the final ride quality is marginal on average but highly variable. Overall, there remains little statistically reliable distinction between the achieved ride quality of projects under the incentive-only provision and of general resurfacing projects with no ride quality requirement. However, based on before and after determinations of the International Roughness Index, greater improvements in ride quality were achieved with the incentive-only pilots (at least in some cases) as compared to sites under no ride quality requirement. The revised incentive-only provision provides a mechanism through which a contractor has an opportunity to recover costs associated with improved practices and perhaps even earn incentives based on good ride quality. It does this while reducing the risk that VDOT will be subject to incentives for otherwise marginal quality work.</p> <p>The study recommends that VDOT continue to promote and administer an incentive-only provision for qualifying resurfacing activities in accordance with the criteria recommended in this study. However, VDOT should continue to monitor the data from projects under the incentive-only provision and assess the effectiveness and benefit of the revised provision, provided in the Appendix, once it is applied on a larger basis.</p>			
17 Key Words: Ride specification, IRI , incentive-only specification, smoothness specification		18. Distribution Statement: No restrictions. This document is available to the public through NTIS, Springfield, VA 22161.	
19. Security Classif. (of this report): Unclassified	20. Security Classif. (of this page): Unclassified	21. No. of Pages: 25	22. Price:

FINAL REPORT
**EVALUATION OF REVISED INCENTIVE-ONLY RIDE SPECIFICATION
FOR ASPHALT PAVEMENTS**

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In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Virginia Transportation Research Council
(A partnership of the Virginia Department of Transportation
and the University of Virginia since 1948)

Charlottesville, Virginia

June 2018
VTRC 18-R11

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ABSTRACT

In late 2011, the executive leadership of the Virginia Department of Transportation (VDOT) formed an Asphalt Quality Task Force to identify and recommend specific achievable measures to improve the quality of asphalt paving in Virginia. The task force recommended that VDOT assess the feasibility of making an incentive-only provision for ride quality the default for projects that do not qualify for VDOT's regular specification for rideability, which includes both incentives and disincentives. A pilot application of the incentive-only provision was conducted during VDOT's 2013 construction season. Although the results indicated no statistically reliable distinction in ride quality between the projects under the incentive-only provision and those with no rideability requirement, the number of sites, VDOT districts, contractors, etc., included in the assessment was limited.

The research summarized through this study addressed a concern that the criteria for the ride specification in the original (2013) incentive-only provision may have failed to reflect quality adequately beyond a limited 52.8 ft (0.01-mi) base length. The study documented the application of an incentive-only provision to a wider range of projects during VDOT's 2015 construction season. The revised criteria addressed some of the concerns associated with the original criteria. The revised provision maintains the potential for incentives while reducing the likelihood for "accidental" bonuses when the final ride quality is marginal on average but highly variable. Overall, there remains little statistically reliable distinction between the achieved ride quality of projects under the incentive-only provision and of general resurfacing projects with no ride quality requirement. However, based on before and after determinations of the International Roughness Index, greater improvements in ride quality were achieved with the incentive-only pilots (at least in some cases) as compared to sites under no ride quality requirement. The revised incentive-only provision provides a mechanism through which a contractor has an opportunity to recover costs associated with improved practices and perhaps even earn incentives based on good ride quality. It does this while reducing the risk that VDOT will be subject to incentives for otherwise marginal quality work.

The study recommends that VDOT continue to promote and administer an incentive-only provision for qualifying resurfacing activities in accordance with the criteria recommended in this study. However, VDOT should continue to monitor the data from projects under the incentive-only provision and assess the effectiveness and benefit of the revised provision, provided in the Appendix, once it is applied on a larger basis.

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INTRODUCTION

Rough roads lead not only to user discomfort but also to higher vehicle operating costs. 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. Smith et al. (1997) found that pavement life can be extended by achieving higher levels of initial smoothness, with a 25% increase in smoothness corresponding to a 9% increase in service life. Research has 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).

A smoothness specification encourages innovation and improved workmanship. Quality-focused contractors understand that one of the least expensive ways to improve pavement smoothness is to maintain a continuous, uninterrupted paving process. It is also important to maintain a uniform blending of materials and temperatures, which can be facilitated through good loading, hauling, truck-to-paver transfer, and even field remixing practices.

The literature and other resources indicate that 89% of the 35 state highway agencies surveyed provide pay adjustments (incentives and/or disincentives) through pavement

smoothness specifications. Three percent of the states use ride specifications with disincentives but not incentives. Other specifications include incentives with “must correct” criteria for “out-of-spec” areas, and some provide neither incentives nor disincentives but require corrections for out-of-spec areas (Merritt et al., 2015). The use of incentive-only specifications (without corrective action) is limited among state transportation agencies (Smoothpavements.com, 2014). The Texas Department of Transportation has an incentive-only provision that does not require corrective action (designated Schedule 3 paving). With this provision, work pay adjustments are made when the International Roughness Index (IRI) of the final surface is less than 60 in/mi.

The Virginia Department of Transportation (VDOT) uses a fairly common approach for promoting ride quality: a specification that provides both incentives and disincentives for those projects that qualify (VDOT, 2017). Throughout this report, this specification is referred to as the “regular ride spec.”

VDOT uses the following selection guidelines to determine when a project does not qualify for (or is exempt from) the incentive/disincentive provisions of the regular ride spec (VDOT, 2008):

1. The project is less than 0.5 mi long.
2. The full lane width is not being paved.
3. The project includes an excessive grade change (>6%).
4. The posted speed limit is less than 45 mph.
5. The project has 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 mi.
6. There is curb and gutter within 4 ft from the pavement edge stripe.
7. The lane width is less than 10 ft.
8. The project involves a one-lift asphalt overlay on an excessively distressed surface without correction.

If a project has any of the features mentioned in the guidelines (VDOT, 2008), a part of or the entire project may be excluded from the requirements of the regular ride spec or an incentive-only provision for ride quality (hereinafter “incentive-only provision”) may be applied in lieu of the regular incentive-disincentive provision. However, a historical review of VDOT’s program shows that VDOT does not commonly exercise the option of using an incentive-only provision.

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 asphalt paving in Virginia. The incentive-only provision was identified as a promising “incentivizing tool” for

projects that were not candidates for the regular ride spec requirement. As per their recommendation, a pilot study was conducted during VDOT’s 2013 construction season to explore the impact of more routine use of an incentive-only provision. Results indicated that there was no statistically reliable distinction between the achieved ride quality of the incentive-only projects and those with no ride specification (hereinafter “non-ride spec”) requirement (Nair et al., 2015). However, a limited number of sites, districts, contractors, etc., was represented in the 2013 pilot. The study also noted that the piloted provision did not include any negative pay adjustment computed for any 0.01-mi segment and calculated project-long pay solely on the incentive-quality 0.01-mi segments. That is, the original incentive-only provision permitted incentive payment only for the 0.01-mi segments with the specified good ride quality irrespective of the overall or average ride quality for the project.

In an effort to make the provision more effective in a larger quality context, a revised method was proposed that would estimate incentives and disincentives for each 0.01-mi segment and then summed for a 0.1-mi summation value. If the net (over this 0.1 mi) was negative, the contractor was not penalized for that 0.1-mi section. If the net was positive, the contractor was awarded that net amount for the 0.1-mi section. Incentives (if any) for each 0.1-mi section were summed over the entire project to calculate the total incentive for the project. Figure 1 is a visual depiction of the original and revised incentive-only criteria.



Figure 1. Example Framework for Incentive-Only Pay Adjustments. Green bars = incentive; red bars = disincentive.

The researchers also thought that the revised framework would largely eliminate the likelihood that contractors who achieved highly inconsistent IRI results would achieve “accidental incentives.” Although the researchers acknowledged that revisions would likely require deliberate changes in processes and/or added equipment, the study proposed revisions to the pay adjustment schedule to improve the chances that a contractor could recover any additional costs. The revised targets are shown in Table 1.

Finally, the study of the 2013 pilot (Nair et al., 2015) recommended that the incentive-only provision be applied to a wider range of projects to represent more contractors and Virginia’s geographic and administrative diversity. The intent was to encourage the contractor to apply additional effort to improve ride quality for difficult projects while limiting the financial risk of both the industry and VDOT.

Table 1. Original and Revised Pay Adjustments for Incentive-Only Provision

Pay Adjustment (Percent Pavement Unit Price for Surface Mix Only)	IRI After Completion (in/mi)	
	Original (Pre-2013)	Revised (2015)
115	55.0 and Under	60.0 and Under
110	55.1-65.0	60.1-70.0
100	65.1-80.0	70.1-85.
90	80.1-90.0	85.1-95.0
80	90.1-100.0	95.1-105.0
70	100.1-110.0	105.1-115.0
60	110.1-130.0	115.1-135.0
40	130.1-150.0	135.1-155.0
20	150.1-170.0	155.1-175.0
0	Over 170.1	Over 175.1

IRI = International Roughness Index.

PURPOSE AND SCOPE

The purpose of this study was to document the results of the 2015 expanded pilot study of VDOT’s incentive-only provision for rideability and recommend finalized criteria for applying an incentive-only provision to a project. The pilot was conducted during VDOT’s 2015 construction season (as recommended in a previous study by Nair et al., 2015) with a variety of typical asphalt resurfacing projects using the criteria revised after the more limited 2013 pilot study.

METHODS

2015 Pilot Study

Projects

A total of 34 asphalt resurfacing projects (representing all nine VDOT districts) were selected to apply the revised incentive-only provision during VDOT’s 2015 construction season. These projects involved plant mix resurfacing contracts and 10 Virginia contractors. Details of the projects are presented in Table 2.

Table 2. 2015 Incentive-Only Sites

District	County	Route	Route Name	Direction	No. of Lanes	County MP From	County MP To	Length (mi)	Application Rate (lb/yd ²)	Thickness (in)
Bristol	Scott	SR	72	North	1	19.17	24.94	5.77	165	1.50
Bristol	Scott	SR	72	South	1	19.17	24.94	5.77	165	1.50
Bristol	Wise	SR	68	East	1	0	3.25	3.25	220	2.00
Bristol	Wise	SR	68	West	1	0	3.25	3.25	220	2.00
Salem	Henry	SC	684	North/South	2	-0.1	4.62	4.72	165	1.50
Salem	Bedford	SC	619	East/West	2	2.9	6.3	3.4	165	1.50
Lynchburg	Buckingham	US	60	East	2	12.99	14.386	1.396	180	1.50
Richmond	Hanover	SC	642	North	2	0.014	0.83	0.816	220	0.00
Richmond	Hanover	SC	642	South	2	0.014	0.83	0.816	220	2.00
Hampton Roads	Accomack	US	13	North	1	3.57	4.69	1.12	165	1.50
Hampton Roads	Accomack	US	13	South	1	3.57	4.69	1.12	165	1.50
Hampton Roads	Northampton	SR	184	West	1	0	1.48	1.48	165	1.50
Hampton Roads	Northampton	SR	184	East	1	0	1.52	1.52	165	1.50
Hampton Roads	Sussex	SR	40	West	1	0.04	1.11	1.07	165	1.50
Hampton Roads	Sussex	SR	40	East	1	0.04	1.11	1.07	165	1.50
Fredericksburg	Westmoreland	SR	3	East	1	14.78	16.15	1.37	165	1.50
Fredericksburg	Westmoreland	SR	3	West	1	14.78	16.15	1.37	165	1.50
Culpeper	Albemarle	US	250 EB	East	1	27.088	33.15	6.062	230	2.00
Culpeper	Albemarle	US	250 WB	West	1	27.088	33.15	6.062	230	2.00
Culpeper	Albemarle	CR	1150 EB	East	1	0.59	1.42	0.83	230	2.00
Culpeper	Albemarle	CR	1150 WB	West	1	0.59	1.42	0.83	230	2.00
Culpeper	Culpeper	CR	633 NB	North	1	0.33	2.13	1.8	230	2.00
Culpeper	Culpeper	CR	633 SB	South	1	0.33	2.13	1.8	230	2.00
Culpeper	Fauquier	CR	738	North	1	3.46	5.26	1.8	230	2.00
Culpeper	Fauquier	CR	738	South	1	3.46	5.27	1.81	230	2.00
Staunton	Rockingham	US	33	East	2	43.413	45.74	2.327	220	2.00
Staunton	Rockingham	US	33	West	2	45.37	45.74	0.37	220	2.00
Staunton	Page	US	340	North	1	3.94	5.69	1.75	185	1.75
Northern Virginia	Loudoun	SC	1582	North	2	0.055	2.44	2.385	240	2.00
Northern Virginia	Loudoun	SC	1582	South	2	0.055	2.44	2.385	240	2.00
Northern Virginia	Prince William	SC	641	East	3	3.72	5	1.28	185	1.50
Northern Virginia	Prince William	SC	641	West	3	3.7	5.01	1.31	185	1.50
Northern Virginia	Fairfax	SC	645	East	1	15.72	16.66	0.94	185	1.50
Northern Virginia	Fairfax	SC	645	West	1	15.72	16.66	0.94	185	1.50

MP = milepost; SR = state road; SC = secondary route; US = U.S road; CR = county road; EB = eastbound; WB = westbound; NB = northbound; SB = southbound.

Project Site and Mix Information

Field reviews were performed on all sites to identify the paving equipment being used, type of treatment (milling vs. straight overlay), type of milling (if any), mixture type, application rate, paver automation, hauling time, day/night work, quantity paved per day, and delay between trucks.

Ride Quality

Ride quality was measured on all sites both before and after the paving activities. Testing for rideability was conducted in a manner consistent with VDOT's standard procedure for measuring new asphalt overlays for acceptance (VDOT, n.d.). This standard procedure estimates ride quality in terms of the IRI, an index generated in accordance with ASTM E1926.

Analysis

After all the ride-related data from the projects were collected, software developed by VDOT (Ridenet) was used to review IRI data incrementally, contrast the measured IRI with the target criteria, and estimate pay adjustments. A proportional improvement in ride quality was also computed based on the IRI before and after paving (hereinafter the "before IRI" and the "after IRI").

Comparison Data

The rideability results from the incentive-only 2015 pilot projects were compared with those from the routine resurfacing projects that were not subject to ride requirements (non-ride spec sites). Data to support this objective came from VDOT's Pavement Management System (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 condition assessment 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. Finally, the identified dataset was compared against the list of recently paved projects that were known to have included the regular ride spec to remove any benefit from those added construction requirements.

RESULTS AND DISCUSSION

General Project and Construction Characteristics

Available project details and mixture information were collected and are summarized in Table 3. Nineteen of the projects were single-lift overlays, and 15 projects involved milling out

the previous layer before “filling” in with the new (i.e., mill and fill). Two of the milled projects incorporated performance milling (more teeth on milling drums at a closer spacing compared to regular milling). Contractors who opt for this approach are permitted to expose the milled surface to traffic for a longer time before overlaying because it creates a smoother milled surface and a less uncomfortable ride; this approach is reportedly capable of providing a smoother and more uniform construction platform for the overlay.

Eleven of the 34 projects were constructed using a material transfer vehicle (MTV). The capabilities of MTVs vary, but they are generally used to isolate the paver from the supply truck. They also often provide additional on-site capacity for plant mix, which can reduce the impact of temporary material shortages that can result from shipping delays. Higher-function MTVs can remix material (which helps reduce segregation of the mixture) and promote better finished quality.

A total of 19 projects were paved with systems that used automation/skis. In addition to maintaining correct thickness, automatic screed and grade controls with averaging skis are specifically intended to complement other good material and lay-down practices to deliver optimum smoothness.

Difficulties in achieving the required field density were noted for only 2 projects. Hauling time from the asphalt plant to the project site varied from 10 to 100 min. Paving of 23 of the projects was completed during the day; the remaining projects required night work.

Ride Quality

Original Surface

Figure 2 is a histogram representing the before IRI of the incentive-only sites. The values for 21 projects (63%) were 101 to 160 in/mi.

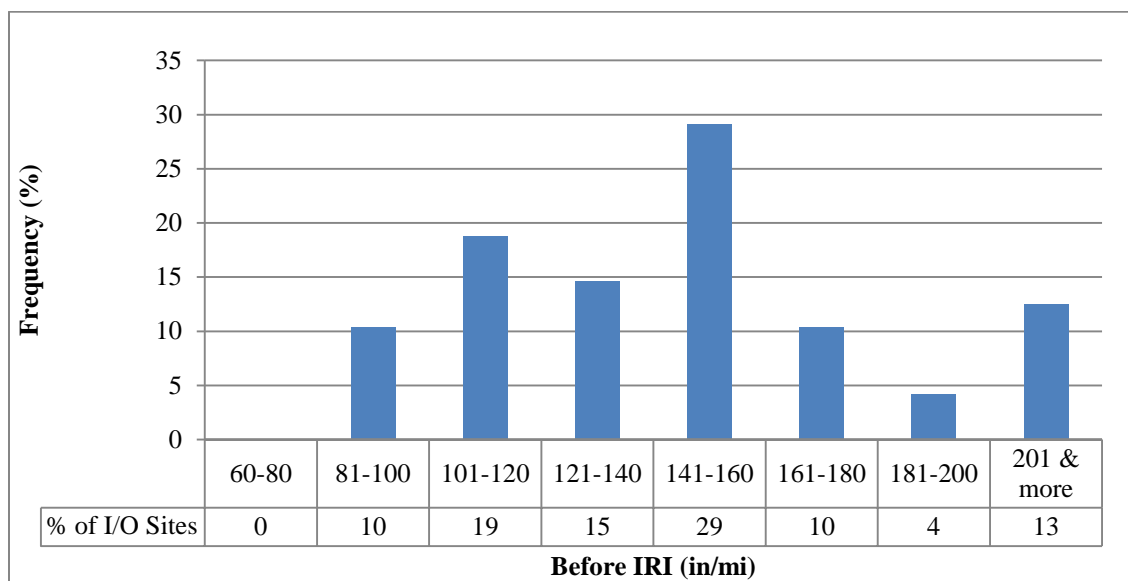


Figure 2. Before IRI of Incentive-Only (I/O) Sites. IRI = International Roughness Index.

Table 3. Project and Mix Information of 2015 Incentive-Only Projects

Route Type	Before IRI	After IRI	% Improve	Mix Type	Treatment Type	Contractor ID	MTV Used?	Type of Milling	Day/ Night Work	Hauling Time (min)	Tonnage Paved/ Day	Compaction/ Density Issue	Automation in Paver?
SR-72N	166	126	24	SM-12.5A	SO	A	Yes	NA	Day	45	1050	No	Yes
SR-72N	194	138	29	SM-12.5A	SO	A	Yes	NA	Day	45	1050	No	Yes
SR68-E	161	124	23	SM-12.5E	SO	A	Yes	NA	Day	50	1180	No	Yes
SR68-W	183	136	26	SM-12.5E	SO	A	Yes	NA	Day	50	1180	No	Yes
SC684-N	145	64	56	SM-9.5D	SO	B	No	NA	Day	5	1043	No	No
	153	66	57	SM-9.5D	SO	B	No	NA	Day	5	1043	No	No
SC619-E	149	84	44	SM-9.5D	SO	C	No	NA	Day	-	-	No	-
	150	77	49	SM-9.5D	SO	C	No	NA	Day	-	-	No	-
US60-E	107	71	34	SM-9.5D	MF	D	Yes	Regular	Day	60	600	No	No
	120	75	38	SM-9.5D	MF	D	Yes	Regular	Day	60	600	No	No
SC642-N	139	133	4	SM-12.5E	MF	E	No	Regular	Night	40	600	No	No
	159	137	14	SM-12.5E	MF	E	No	Regular	Night	40	600	No	No
SC642-S	158	140	11	SM-12.5E	MF	E	No	Regular	Night	40	600	No	No
	128	126	2	SM-12.5E	MF	E	No	Regular	Night	40	600	No	No
US13-N	113	78	31	SM-9.5D	MF	F	Yes	Regular	Day	30	850	No	Yes
US13-N	108	74	31	SM-9.5D	MF	F	Yes	Regular	Day	30	850	No	Yes
SR184-E	160	121	24	SM-9.5A	MF	F	No	Regular	Day	55	600	No	Yes
SR184-W	162	120	26	SM-9.5A	MF	F	No	Regular	Day	55	600	No	Yes
SR40-W	121	78	36	SM-9.5D	MF	E	No	Regular	Day	45	500	Yes	No
SR40-E	112	77	31	SM-9.5D	MF	E	No	Regular	Day	45	500	Yes	No
SR3-E	103	80	22	SM-12.5A	MF	F	Yes	Perform	Night	30	800	No	Yes
SR3-W	148	98	34	SM-12.5A	MF	F	Yes	Perform	Night	30	800	No	Yes
US250-E	102	83	19	SM-12.5D	SO	G	No	NA	Night	10	850	No	No
US250-W	95	71	25	SM-12.5D	SO	G	No	NA	Night	10	850	No	No
CR1150-E	151	105	30	SM-12.5A	SO	H	No	NA	Day	30	700	No	No
CR1150-W	152	103	32	SM-12.5A	SO	H	No	NA	Day	30	700	No	No
CR633-N	210	105	50	SM-12.5A	SO	I	No	NA	Day	45	1172	No	Yes
CR633-S	210	101	52	SM-12.5A	SO	I	No	NA	Day	45	1172	No	Yes
CR738-N	100	97	3	SM-12.5A	SO	I	No	NA	Day	30	890	No	Yes
CR738-N	103	102	1	SM-12.5A	SO	I	No	NA	Day	30	890	No	Yes
US33-E	108	70	35	SM-12.5A	SO	E	No	Regular	Day	30	1050	No	Yes
	98	70	29	SM-12.5A	SO	E	No	Regular	Day	30	1026	No	Yes
US33-W	112	85	24	SM-12.5A	SO	E	No	Regular	Day	40	590	No	Yes
	115	74	36	SM-12.5A	SO	E	No	Regular	Day	40	576	No	Yes
USBUS340-N	122	82	33	SM-12.5A	MF	E	No	Regular	Day	65	730	No	Yes
	135	95	30	SM-12.5A	MF	E	No	Regular	Day	65	730	No	Yes
SC1582N	146	105	28	SMA-2.5E	MF	I	-	Regular	Day	-	-	-	-
	143	110	23	SMA-2.5E	MF	I	-	Regular	Day	-	-	-	-
SC1582S	132	91	31	SM-12.5A	MF	I	-	Regular	Day	-	-	-	-
	137	79	42	SM-12.5A	MF	I	-	Regular	Day	-	-	-	-

SC641-E	222	172	23	SM-12.5A	MF	F	No	Regular	Night	40	800	No	Yes
	166	118	29	SM-12.5A	MF	F	No	Regular	Night	40	800	No	Yes
	173	130	25	SM-12.5A	MF	F	-	Regular	Day	-	-	-	-
SC641-W	206	188	9	SM-12.5A	MF	F	No	Regular	Night	40	800	No	Yes
	143	105	27	SM-12.5A	MF	F	No	Regular	Night	40	800	No	Yes
	154	108	30	SM-12.5A	MF	F	-	Regular	Day	-	-	-	-
SC645	253	119	53	SM-12.5A	MF	J	-	Regular	Day	-	-	-	-
SC645	227	134	41	SM-12.5A	MF	J	-	Regular	Day	-	-	-	-

IRI = International Roughness Index; % Improve = % improvement; MTV =Material Transfer Vehicle; SR = state route; US = US route; CR = county road; SC = secondary route; SO = straight overlay; MF = mill and fill; Perform = performance; - = not available; NA = not applicable.

Final Surface

Figure 3 compares the average after IRI to the average before IRI for each project (to include one average IRI per lane when multiple lanes are present). Most of the sections had an after IRI well above the 100% pay range, with only two sections (one project) achieving an after IRI lower than 70 in/mi (bonus range). Figure 3 also shows that once the before IRI exceeds 160, there are no longer examples of projects that would even meet the 100% pay range, much less achieve a bonus.

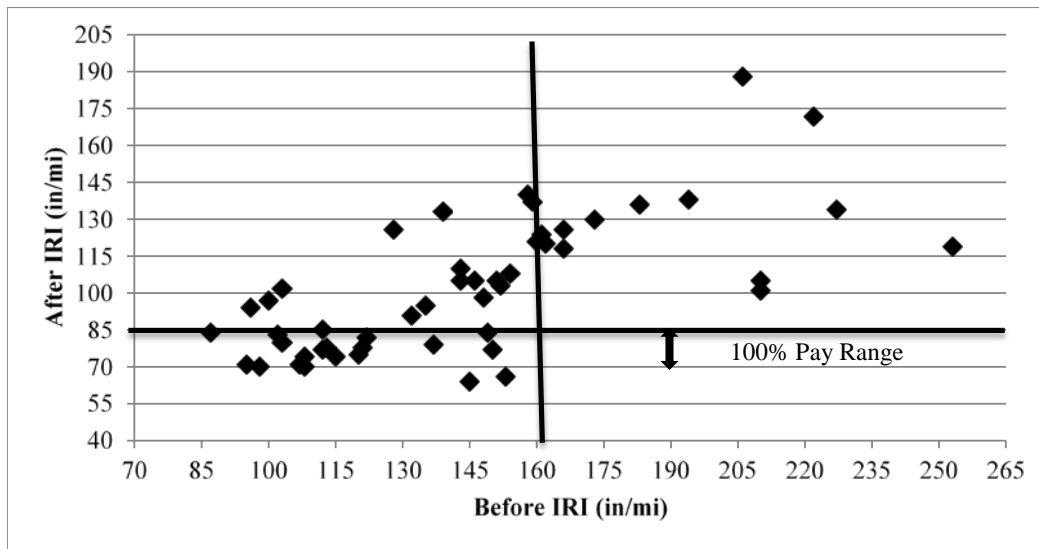


Figure 3. Before IRI vs. After IRI for 2015 Pilot Projects. IRI = International Roughness Index.

Improvement

Figure 4 shows the improvement achieved for the 2015 pilot projects with regard to the before IRI. In general, greater improvement is achievable when there is more “room for improvement” (i.e., a higher before IRI). However, in very few instances was the improvement greater than 40%.

Incentives

Figures 5 and 6 shows incentive per lane-mile obtained for each project with respect to the before and after IRIs. Figure 6 suggests that even when the average IRI is in the 100% pay range, contractors are able to “net” incentive. However, referring to Figure 5, once the before IRI exceeds 160 in/mi, overall incentives are scarce.

With respect to what is more universally achievable, it is important to remember that this context already reflects a significant “selection bias” process. That is, projects that were deemed appropriate for an incentive-only provision were already deemed inappropriate for the regular ride spec. Although a before IRI of 160 in/mi has been shown not to preclude significant incentives regarding the final surface on qualifying rideability projects (VDOT, 2014), these incentive-only projects by definition include roughness-inducing characteristics that likely cannot be milled and/or paved out.

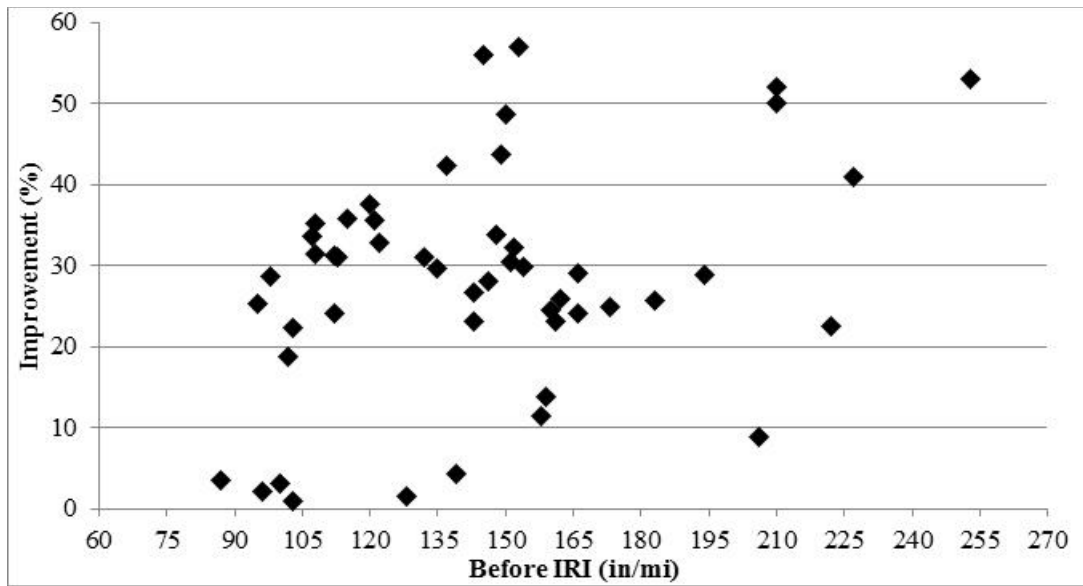


Figure 4. Before IRI vs. % Improvement for 2015 Pilot Projects. IRI = International Roughness Index.

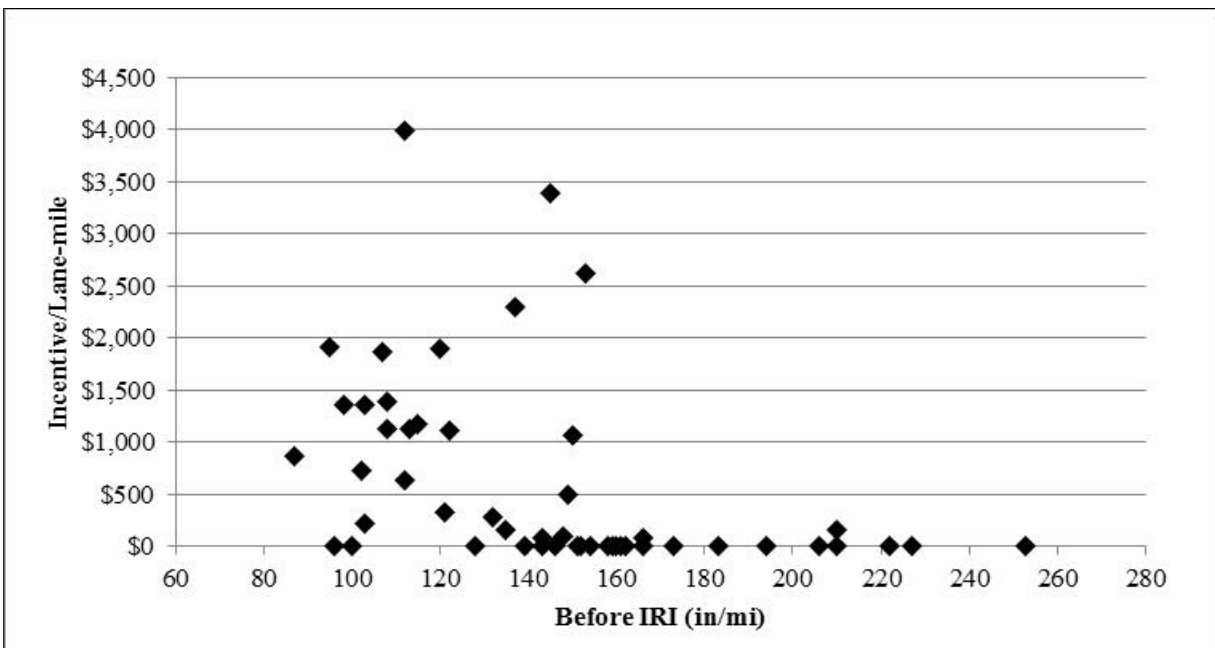


Figure 5. Before IRI vs. Incentive per Lane-Mile (Incentive-Only Specification). IRI = International Roughness Index.

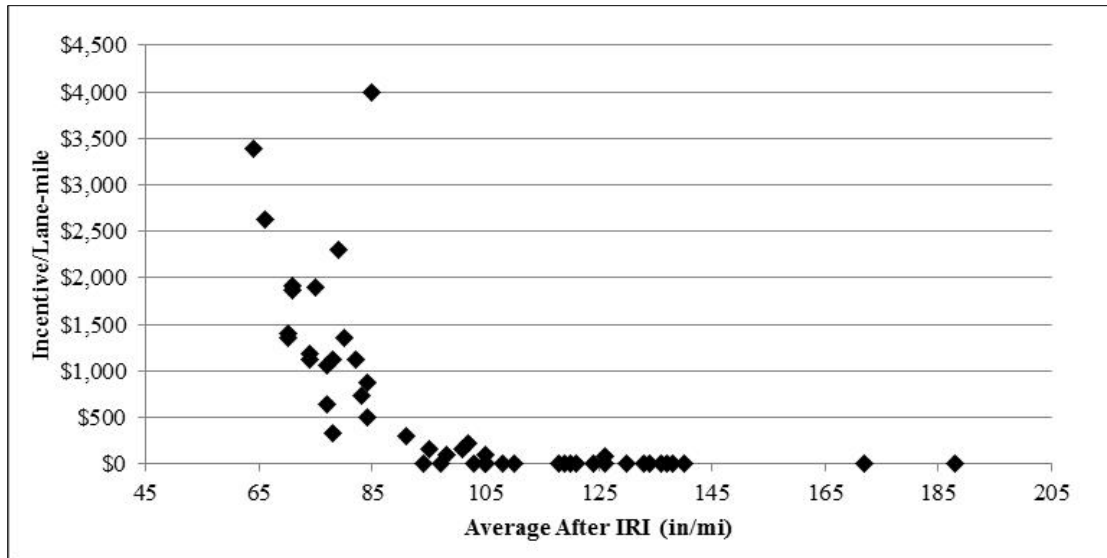


Figure 6. After IRI vs. Incentive per Lane-Mile for 2015 Pilot Projects. IRI = International Roughness Index.

Comparison of Original and Revised Criteria

Figure 7 shows incentive per lane-mile obtained under the original (2013) and revised (2015) incentive-only criteria. The general concern with the original incentive-only provision was that the contractor might inadvertently be rewarded for a marginal to very rough riding paving project. Figure 7 shows that with the original criteria, contractors would receive significant incentives despite a high after IRI. It likewise demonstrates that this effect is largely eliminated with the revised provision. The new criteria appear to represent a good balance of potential reward for the contractor without undue risk to VDOT. It would also seem that it would be more difficult for a contractor to earn bonuses when delivering a net inferior quality ride.

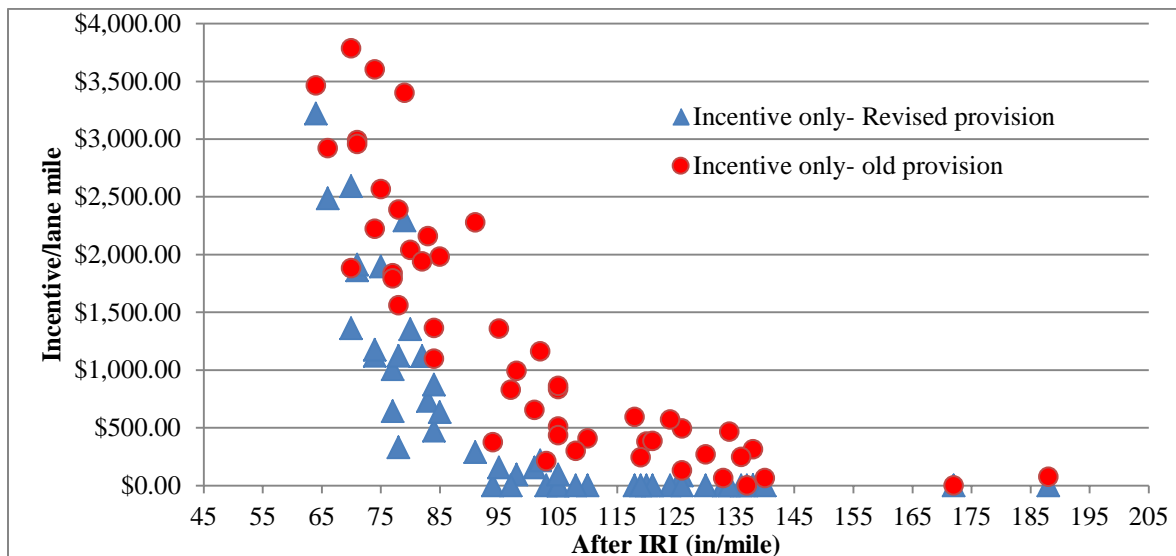


Figure 7. Comparison of Incentive/Lane-Mile vs. After IRI for Original and Revised Incentive-Only Criteria. IRI = International Roughness Index.

Comparison With Status Quo

Figure 8 shows the before and after IRIs for non-ride spec projects (from the PMS data) and for incentive-only sites from the 2015 pilot projects. Overall, there was no statistically reliable distinction between the achieved ride quality of the incentive-only pilot projects and the non-ride spec (general) paving projects. However, it should be noted that data from non-ride spec sites related to considerably more projects (2007-2013, 288 sites) and consisted only of primary routes whereas incentive-only sites included both primary and a few secondary routes.

Figure 9 is a histogram showing improvement characteristics from the same two datasets. Although a 30% improvement is historically common (VDOT, 2008), it is perhaps encouraging to see more instances of 40%, 50%, and 60% improvement among the incentive-only projects.

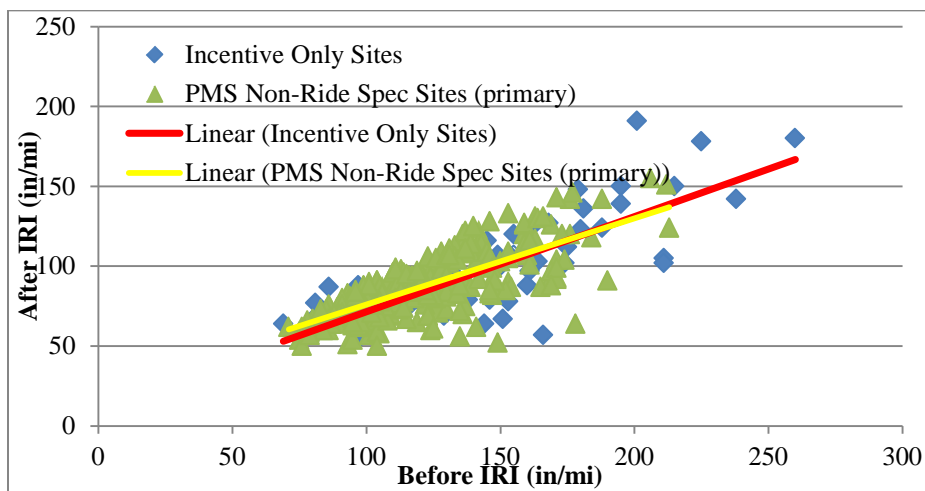


Figure 8. Before vs. After IRI for Incentive-Only and PMS Non-Ride Spec Projects. IRI = International Roughness Index; PMS = VDOT’s Pavement Management System.

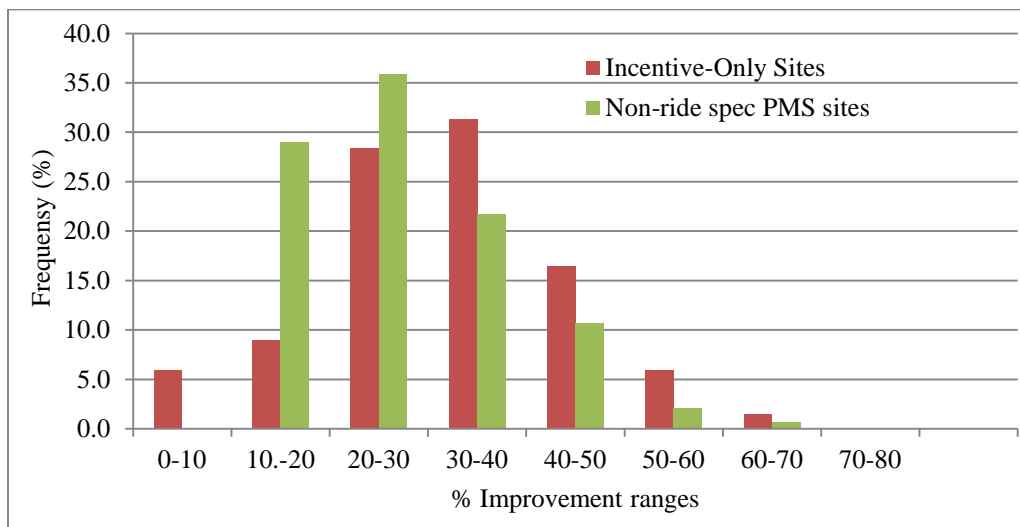


Figure 9. Percentage Improvement in IRI for Incentive-Only and PMS Non-Ride Spec Projects. IRI = International Roughness Index; PMS = VDOT’s Pavement Management System.

CONCLUSIONS

- *Use of the revised criteria for the incentive-only provision results in a substantial improvement in the calculation of incentives versus the original criteria. Use of the revised criteria maintains the potential for incentives while reducing the likelihood of accidental bonuses on jobs where the final riding surface is of marginal quality on average but highly variable from segment to segment.*
- *Although the minimum after IRI required to achieve a bonus under the revised targets is 70 in/mi, contractors can achieve net bonuses even when the overall IRI is in the current 100% pay range (70 to 85 in/mi).*
- *When the before IRI for incentive-only project sites is higher than 160 in/mi, the average after IRI is rarely less than 85 in/mi. If project characteristics disqualify a project from application of the regular ride spec and the before IRI exceeds 160 in/mi, the use of the incentive-only provision is unlikely to be very effective. Further, in *Improving FHWA's Ability to Assess Highway Infrastructure Health: Phase I Results* (2011), a threshold of 170 in/mi for acceptable ride quality is recommended for the Federal Highway Administration's strategic plan for the National Highway System.*
- *Overall, there is no statistically reliable distinction between the achieved ride quality of incentive-only pilot projects and the general non-ride spec paving projects.*
- *The level of improvement in ride quality is greater (Figure 9) with the incentive-only pilots than with the non-ride spec projects.*

RECOMMENDATIONS

1. *VDOT's Maintenance Division and Materials Division should continue to promote and administer the revised incentive-only provision provided in the Appendix with the following criteria for selecting projects:*
 - *The project is not a candidate for the regular ride specification.*
 - *The project is on a primary or higher volume secondary route and the posted speed limit is greater than or equal to 40 mph (or a route selected at the discretion of the district).*
 - *The before IRI for the right lane (from PMS) is less than or equal to 170 in/mi.*
 - *The paving length of the project is a minimum of 0.5 mi and the lane width is 10 ft.*
2. *VDOT's Materials Division and the Virginia Transportation Research Council (VTRC) should analyze data from future projects under the revised incentive-only provision to assess the effectiveness and benefit of the provision once it has been applied on a larger scale.*

BENEFITS AND IMPLEMENTATION

Benefits

Research has shown that initial smoothness is important to both future smoothness and pavement life. McGhee and Gillespie (2006) showed that pavements that are smoother when constructed remain smoother over their life when compared to pavements that have higher initial roughness levels. An increase in service life attributable to smoother pavements implies that VDOT will be able to put off the costs of resurfacing the road.

Although this study found no distinction in rideability between projects under the non-ride spec and those under the incentive-only provision, the incentive-only provision is still a mechanism for motivating contractors to improve their basic lay-down practice. Potential incentives may also offset investment costs in modern paving equipment and construction technologies and be used to reward the contractor's workforce.

Recommendation 1 will help VDOT select the right projects for using the incentive-only provision. Recommendation 2 will help VDOT to make future decisions for the continued use of the incentive-only provision.

Implementation

Regarding Recommendation 1, VDOT's Materials Division has already adopted the revised incentive-only provision as shown in the Appendix and the project selection criteria for future use.

Regarding Recommendation 2, the VDOT districts used the revised incentive-only provision for 400+ lane-miles in the 2017 construction season. VTRC and the Materials Division are analyzing the data, and the work is expected to be complete by August 2018. VTRC provided implementation funding to cover the expenses for IRI testing before construction.

ACKNOWLEDGMENTS

The authors thank the NDT Unit of VDOT's Lynchburg District for their efforts in data collection and testing. Special thanks go to Jim Gillespie of VTRC for his help in the statistical analysis. A special acknowledgment goes to VDOT district materials and pavement management personnel for their assistance in providing project and mix details. The authors appreciate Linda Evans of VTRC for editorial assistance. The authors also appreciate the technical review panel for their expertise and guidance: Tanveer Chowdhury, Sungho Kim, Sean Nelson, and David Shiells of VDOT; Jim Gillespie of VTRC; and Trenton Clark of the Virginia Asphalt Association.

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APPENDIX

PROPOSED SPECIAL PROVISION FOR RIDEABILITY

**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.