Report No. CDOT-2012-10
Final Report

ASSESSMENT OF CONCRETE PAVEMENT TEXTURING METHODOLOGIES IN COLORADO

Robert Otto Rasmussen
Richard C. Sohaney

October 2012

COLORADO DEPARTMENT OF TRANSPORTATION
DTD APPLIED RESEARCH AND INNOVATION BRANCH

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CDOT-2012-10		

4. Title and Subtitle	5. Report Date
ASSESSMENT OF CONCRETE PAVEMENT TEXTURING METHODOLOGIES IN COLORADO	October 2012
	6. Performing Organization Code
7. Author(s) Robert Otto Rasmussen and Richard C. Sohaney	8. Performing Organization Report No.
9. Performing Organization Name and Address The Transtec Group, Inc. 6111 Balcones Drive, Austin, TX 78731	10. Work Unit No. (TRAIS) 11. Contract or Grant No. 21.80
12. Sponsoring Agency Name and Address Colorado Department of Transportation DTD Applied Research and Innovation Branch 4201 E. Arkansas Ave., Shumate Bldg. Denver, CO 80222	13. Type of Report and Period Covered Final 14. Sponsoring Agency Code

15. Supplementary Notes

Prepared in cooperation with the US Department of Transportation, Federal Highway Administration

16. Abstract

This report presents information and data produced by the Colorado Department of Transportation's (CDOT's) long-term study of Portland cement concrete pavement (PCCP) textures used within the state. The information includes vehicle accident, friction, and texture data. This information was used as the basis for a review of proposed revisions to the CDOT texture measurement method, CP-77, and a specification for PCCP texturing found in Sections 106 and 412 of the Standard Specifications.

Implementation

The report presents specific recommendations for PCCP texture specifications including a recommended average texture depth greater than 0.05 inches. It further concludes that artificial turf drag is an adequate PCCP surface texture.

17. Keywords	18. Distribution Statement
Portland cement concrete pavement (PCCP), surface texture, tining, astro-turf drag, friction, skid resistance, tire-pavement noise, accident rates	This document is available on CDOT's website http://www.coloradodot.info/programs/research/pdfs

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	45	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

ASSESSMENT OF CONCRETE PAVEMENT TEXTURING METHODOLOGIES IN COLORADO

By

Robert Otto Rasmussen, PhD, INCE, PE (TX,FL,NC,KY,AZ)
Vice President & Chief Engineer, The Transtec Group, Inc.

Richard C. Sohaney, MSE, INCE
Project Manager, The Transtec Group, Inc.

Report No.
CDOT-2012-10

Prepared by
The Transtec Group, Inc.
6111 Balcones Drive
Austin, TX 78731

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

October 2012

Colorado Department of Transportation
DTD Applied Research and Innovation Branch
4201 E. Arkansas Ave., Shumate Bldg.
Denver, CO 80222

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support and effort of the project panel, including the study manager Roberto DeDios of DTD Research; technical field support by Skip Outcalt, Research; the technical panel leader Jay Goldbaum, Materials and Geotechnical; and study panel members Jim Zuffall, Materials and Geotechnical; Eric Prieve, Materials and Geotechnical; Donna Harmelink, FHWA, CO Division; and Richard Zamora, R-2 Materials. In addition, the authors acknowledge the support and efforts of Gary DeWitt, R-4 Materials, and Dave Weld of the Research Branch.

EXECUTIVE SUMMARY

In 2003, the Colorado Department of Transportation (CDOT) initiated a study of safety and durability of Portland cement concrete pavement (PCCP) textures used within the state, including longitudinal tine, turf drag, and others. In addition to vehicle crash and friction data, CDOT included tire-pavement noise in their data collection plan.

Two years later, in 2005, FHWA published Technical Advisory T 5040.36, *Surface Texture for Asphalt and Concrete Pavements*. The advisory lists the primary purpose of adequate surface texture as safety, that is, reducing wet-weather and total vehicle crashes. Safety performance is measured based on long-term monitoring of wet-weather crash performance and/or friction test results. Various PCCP textures are permitted, including tining, drag, and grinding, as long as adequate safety performance is demonstrated.

This report presents information and data produced by CDOT's long-term study on this topic. This information was used as the basis for a review of CDOT's proposed texture measurement method and specification for PCCP texture.

Implementation

As a result of this study, it can be concluded that:

1. An average texture depth (ATD) of 0.05 inches or greater is an adequate texture; and
2. Artificial turf drag texture is an adequate PCCP texture.

With respect to turf drag texture, not only does its use comply with FHWA safety and durability requirements, but another positive impact is reduced tire-pavement noise, which has been demonstrated through a complementary CDOT study that was recently completed (35.00).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

This report documents key findings from a CDOT study of Portland cement concrete pavement texturing that began in the year 2001. This report is organized as follows:

- Section 2 of this report describes the four-step work plan for producing this report.
- Section 3 describes the test sites and types of data that were collected for the project.
- Section 4 presents analyses and conclusions from correlating accident rates with friction and with texture.
- Section 5 reviews a draft of CP-77 (Standard Procedure for Determination of Macro-Texture of Planed Hot Mix Asphalt Pavement) revised to apply to PCCP.
- Section 6 presents some implementation recommendations.
- Appendix A contains tables of data.
- Appendix B presents the proposed revisions (at the time of publication of this report) to Sections 106 and 412 of CDOT's Standard Specifications.
- Appendix C presents the proposed (at the time of publication of this report) Procedure 77 Method B, Determination of Macrotexture Depth for Portland Cement Concrete Pavements.

2. WORK PLAN

The work plan consisted of four tasks.

Task 1 – Collate Data

Assemble and collate CDOT data that has been collected since 2003. Organize the data by test section and data type. Types of data include:

- Skid resistance (ASTM E 274, smooth and ribbed tire).
- Texture (CDOT procedure 77, macrotexture depth).
- Vehicle accident data from the transportation safety accident database.
- Tire-pavement noise (from CDOT Study 35.00).

Additionally, collect materials and construction specifications from other states with climate similar to Colorado (for example, Minnesota and Missouri).

Task 2 – Data analyses

Conduct analyses to assess if adequate safety performance is demonstrated.

Task 3 – Draft Specifications

Review revisions to CDOT procedures and provide recommendations.

- CDOT Standard Specifications for Construction, Section 106.06 (a) *Process Control Testing*, and Section 106.06 (b) *Acceptance Testing*.
- CDOT Standard Specifications for Construction, Section 412.12 (c) *Final Finish* and Section 412.12 (d) *Tining and Stationing*.
- CDOT Procedure 77 Method B, *Determination of Macrotexture Depth for Portland Cement Concrete Pavements*.

Task 4 – Reporting

Generate a short report explaining the methodology, key findings, and results of the specification reviews. Also, present directly to CDOT at a Materials Advisory Committee (MAC) or other appropriate panel meeting.

3. COLLATE DATA

Table 1 summarizes the test sites and data that were collated in the CDOT study. In general, accident and friction data were collected in each year from 2003 through 2010. Texture data were collected in 2012, and noise data were collected in years 2006, 2007, 2009, and 2011. Tables of data and values are listed in Appendix A.

The accident data is drawn from a database that includes factors such as:

- Total number of accidents;
- Number of accidents on dry roads;
- Number of accidents on wet, muddy, snowy, icy, and slushy roads; and
- Annual average daily traffic (AADT).

The friction data includes values from tests using two types of tires:

- Smooth tire; and
- Ribbed tire.

Texture data is obtained by Colorado Procedure 77 Method B, which is sometimes referred to as a *sand patch* method (although for many years, the test procedure has utilized glass beads in lieu of sand). The noise data that were evaluated in CDOT Study 35.00 were largely obtained using the on-board sound intensity (OBSI) test method, standardized as AASHTO TP 76.

Table 1. CDOT test sites and types of data collected.

Roadway	No of Sites	Accident	Friction	Texture	Noise
US 40	3	Yes	Yes	Yes	Yes
I-70	11	Yes	Yes	Yes	Yes
SH 83	3	Yes	Yes		
US 85	1	Yes	Yes		Yes
SH 160	1	Yes	Yes	Yes	
I-270	1	Yes	Yes		
US 285	2	Yes	Yes	Yes	Yes
US 287	2	Yes	Yes	Yes	

In addition to the this CDOT study, relevant data are available from a Concrete Pavement Technology Center (CP Tech Center) study under Transportation Pooled Fund TPF-5(139). These are shown in Table 2 along with the years for which data were collected. For the CP Tech Center study, accident data were not collected.

Table 2. Additional test sites and data from a CP Tech Center project.

Roadway	No of Sites	Accident	Friction	Texture	Noise
SH 76	2		2004-2008	2012	
US 287	7		2004-2010	2011	2005, 7, 9
SH 52	1		2007, 2010		

4. DATA ANALYSES

4.1. Accident Rate and Friction

The results of correlation analyses between friction and accident rate are shown graphically in Figure 1 to Figure 4, along with the trend line obtained from a linear regression analysis. The coefficient of determination (R-squared values) associated with the regression analyses are listed in Table 3. In these analyses, the friction value for a test site is equal to the average value for all the years friction was measured at the site, for either the ribbed or smooth tire. The accident rate is presented in terms of number of accidents per 100,000 vehicles, and is an average over the eight-year data collection period for accidents (2003 to 2010). For wet roads, the accident count includes all types of non-dry roads in the accident database (wet, muddy, snowy, icy, and slushy roads).

The correlation between accident rate and friction is very low. This indicates other factors besides friction may be more significant to accident rate; for example, highway alignment and vehicle speed.

Table 3. Coefficients of determination (R^2) from linear regression analyses.

	Wet Road	Dry Road
Ribbed Tire	0.04	0.06
Smooth Tire	0.04	0.05

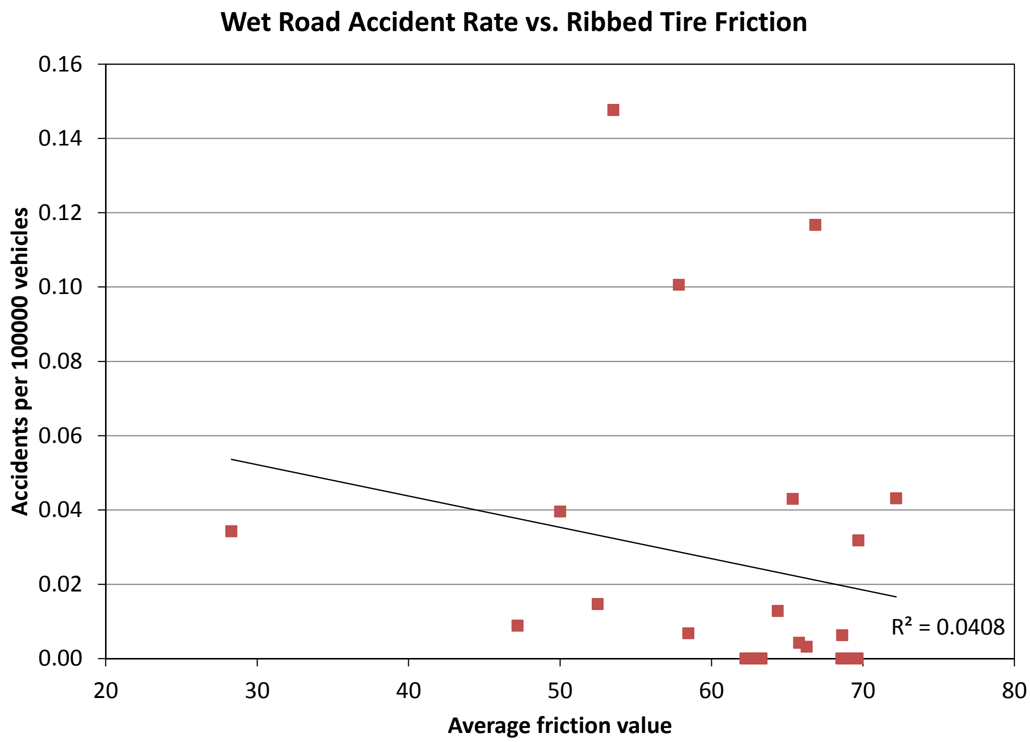


Figure 1. Wet road accident rate versus average ribbed tire friction.

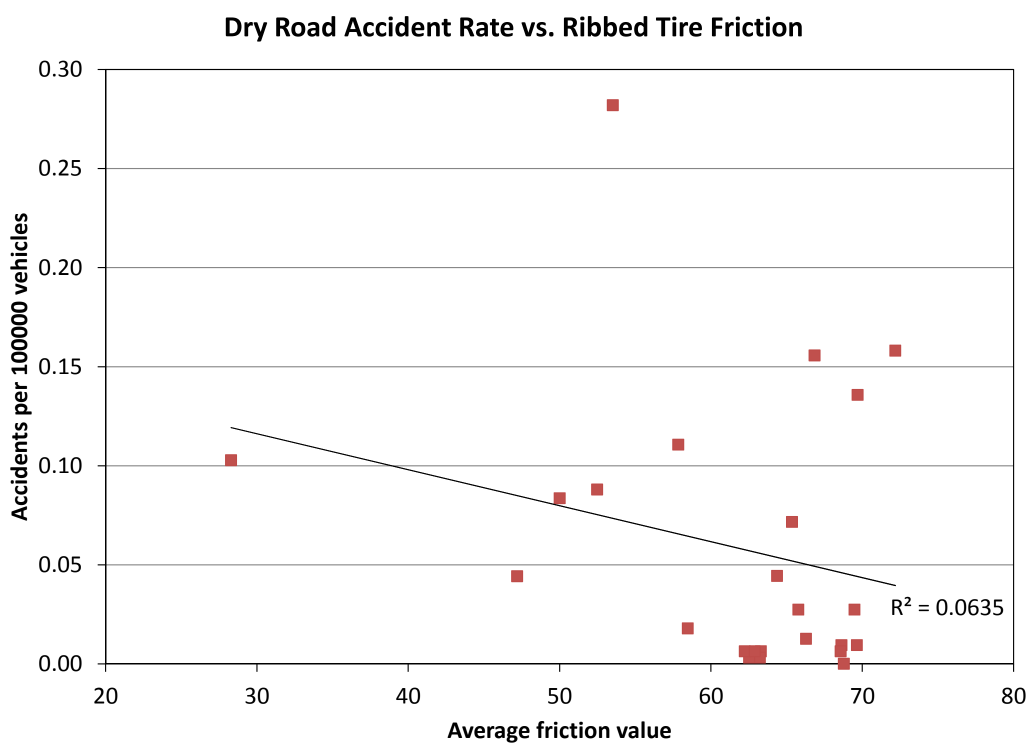


Figure 2. Dry road accident rate versus average ribbed tire friction.

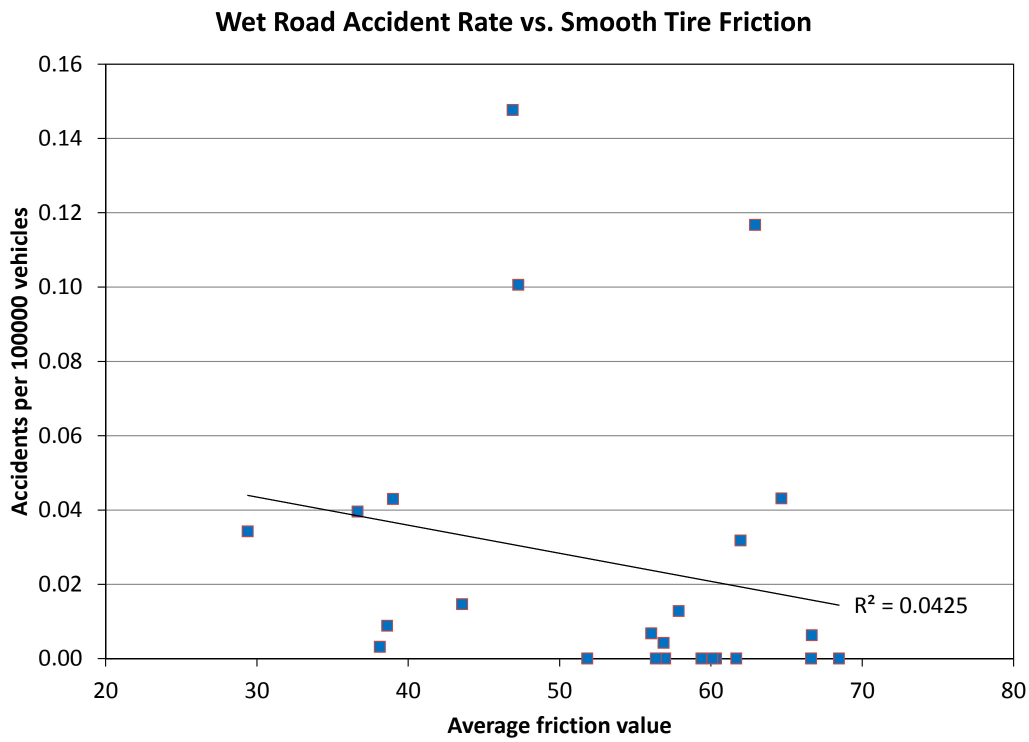


Figure 3. Wet road accident rate versus average smooth tire friction.

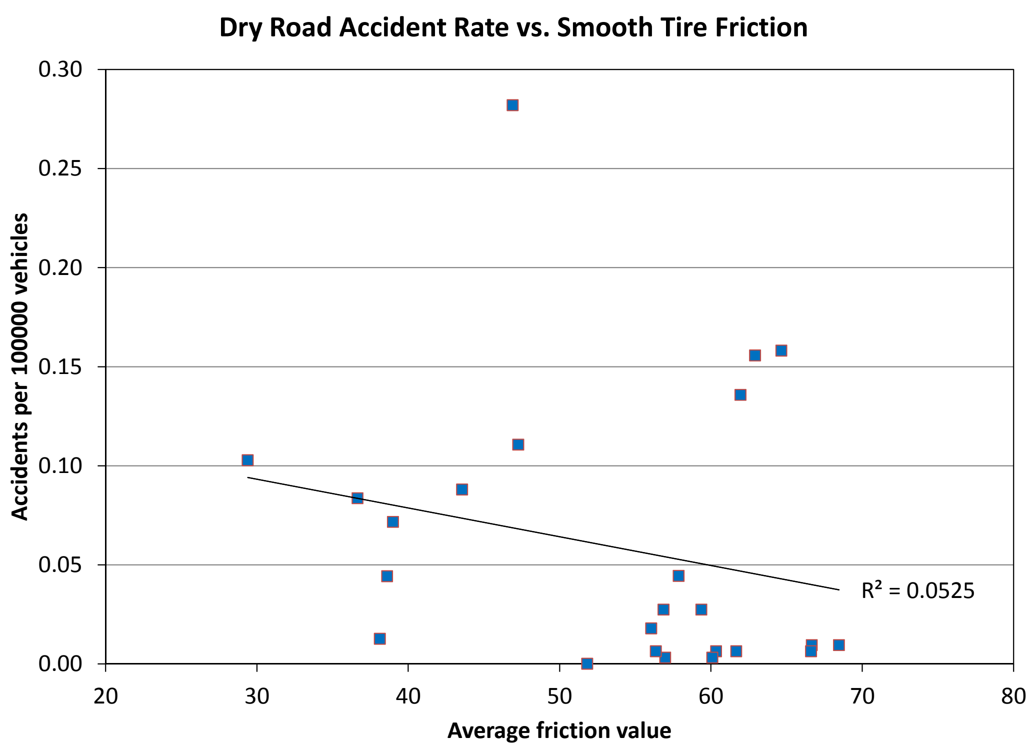


Figure 4. Dry road accident rate versus average smooth tire friction.

4.2. Accident Rate and Texture

The results of correlation between average texture depth (ATD) and accident rate are shown in Figure 5 and Figure 6. The average texture depth is equal to the average of the ATD measured in the right wheel path and the center of lane for the year the data were collected. In the figures, the trend line obtained from a regression analysis is shown along with the R-squared value. In these cases, the analyses used a logarithmic regression (not a linear regression), which is why the trend line is slightly curved and not a straight line.

Even though the R-squared values from the regression analyses in Figure 5 and Figure 6 are low, indicating lack of correlation, it is possible to establish a threshold value for ATD above which the accident rate is very low. This value is shown in the figures by the vertical, red bar at an ATD of 0.04 inches. The sites to the left of the red bar have values of ATD less than 0.04 inches and some of these sites have higher accident rates. Sites to the right of the red bar have values of ATD greater than 0.04 inches and these sites generally have lower accident rate.

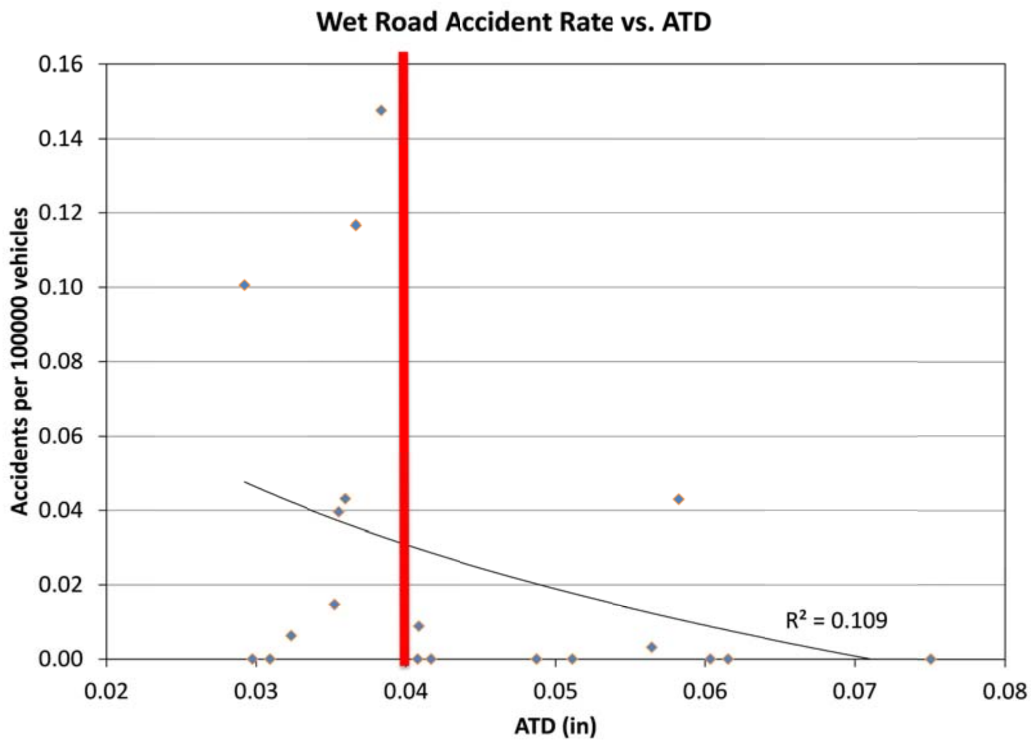


Figure 5. Wet road accident rate versus ATD.

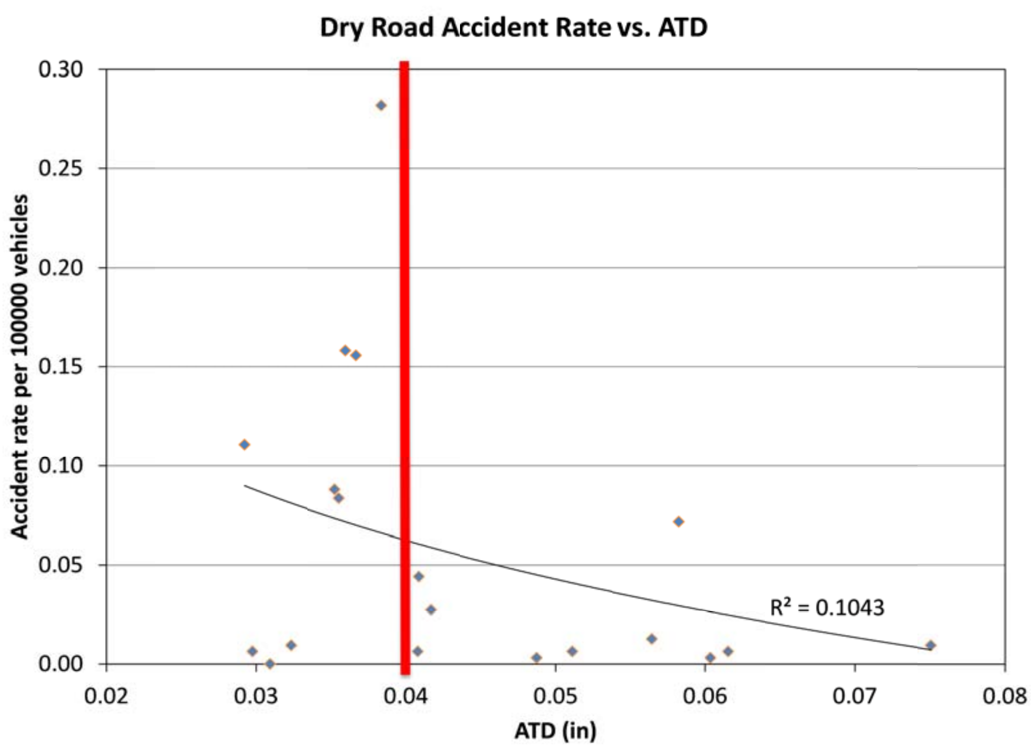


Figure 6. Dry road accident rate versus ATD.

4.3. Friction and Texture

Figure 7 and Figure 8 show the correlation between friction and texture for smooth and ribbed tires. The purpose of examining these analyses is to check the friction value associated with the threshold ATD value of 0.04 inches. In the figures, the vertical, red bar is again at an ATD value of 0.04 inches. The average friction value associated with this level of texture is represented by the intersection of the red bar with the linear regression line. From the figures, for both the smooth and ribbed tires, an average friction value of 52 to 53 is associated with an ATD of 0.04 inches.

4.4. Data Analysis Summary

The following conclusions are drawn from the data analysis:

- Limiting texture to an ATD of 0.04 inches appears to be reasonable.
- While virtually no correlation, accident rates are very low in sections with ATD > 0.04 in.
- While poorly correlated, ATD = 0.04 in corresponds on the average to skid numbers of 50 to 55 for both ribbed and smooth tires.
- To account for texture depth changes due to traffic and environment, the project team suggests a construction compliance threshold that is slightly higher; namely, 0.05 in.
- An ATD of 0.05 inches using Colorado procedure 77 corresponds to the CP Tech Center recommended MTD of 0.03 inches (per ASTM E 965). The basis for this conversation is provided in the next section.

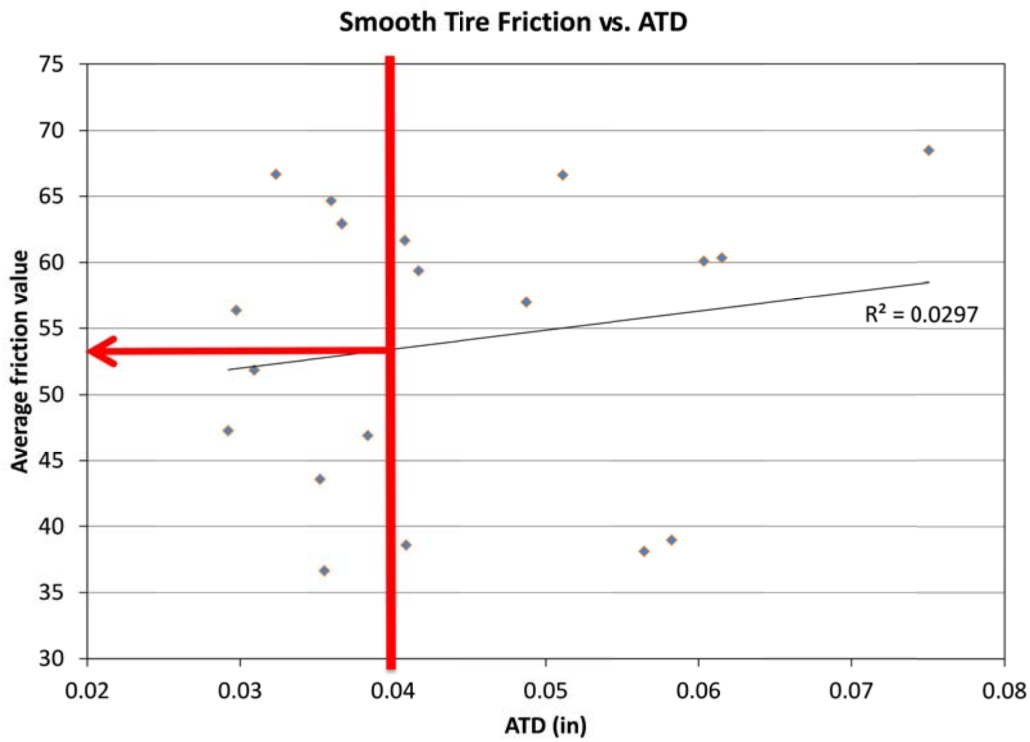


Figure 7. Smooth tire friction value versus ATD.

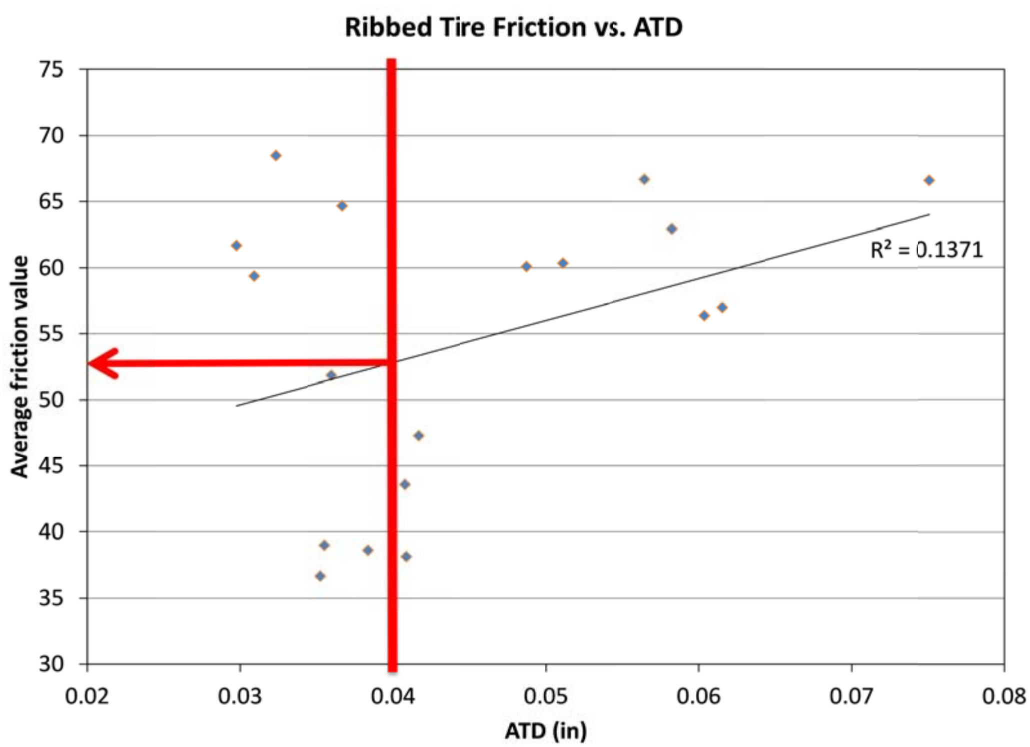


Figure 8. Ribbed tire friction value versus ATD.

5. SPECIFICATION REVIEW – DRAFT CP 77

CDOT has an existing texture specification CP 77-09, *Standard Procedure for Determination of Macro-Texture of Planed Hot Mix Asphalt Pavement*. This specification evaluates texture using a sand patch method, similar to ASTM E 965. CDOT is revising CP 77 to create a specification to apply to PCCP, CP 77 Method B. This section is a review of the draft CP 77 Method B specification for determining macrotexture depth of PCC pavements.

5.1. Deviations from ASTM E 965

It is acceptable for state agencies to have their own, unique procedures that differ from ASTM or AASHTO standard procedures. As such, while CDOT CP 77 is very similar to ASTM E 965, there are some notable differences. Some of these differences include:

- Glass Bead size and roundness – AASHTO M 247 in CDOT CP 77 versus ASTM D 1155 per ASTM E 965
- Spreader – 2 to 6" in CDOT CP 77 versus 2.5 to 3" per ASTM E 965
- Tamping – "gently tap the side" in CDOT CP 77 versus "tap the base several times on a rigid surface" per ASTM E 965
- Cleaning – "be careful not to dislodge bonded material" – while not a difference per se, the interpretation of this is reasonably subjective, and may lead to results that are operator dependent.

5.2. Glass Bead Size and Roundness

The difference in glass bead size and roundness between draft CP 77 Method B and ASTM E 965 is significant in that it can lead to a bias in texture depth results. CP 77 Method B specifies glass beads meeting AASHTO M 247 which are about twice as large in diameter as the beads specified in the ASTM E 965 standard. Both procedures specify spreading a known volume of beads on the pavement. However, with larger diameter beads, fewer beads will fill the known volume and spreading these will cover a disproportionally smaller area. The result is larger diameter beads lead to a greater calculated texture depth.

This bias effect is illustrated in Figure 9 which show the cumulative distribution of texture depth for CDOT's test sites along with two other independent data sources; PCCP test sections at the Mn/ROAD test facility and in the TPF-5(139) pooled fund (Concrete Pavements Surface Characteristics Program). The TPF-5(139) pooled fund data includes texture of pavements in Texas, Minnesota, California, New York, Wisconsin, Iowa, and Washington. CDOT's texture data is obtained following the CP 77 standard. Texture from the other studies is obtained following ASTM E 965. In the cumulative distributions, CDOT's 50th percentile texture depth is about 0.041 in. (1.05 mm) while the comparators are less, 0.02 to 0.024 in. (0.55 to 0.6 mm).

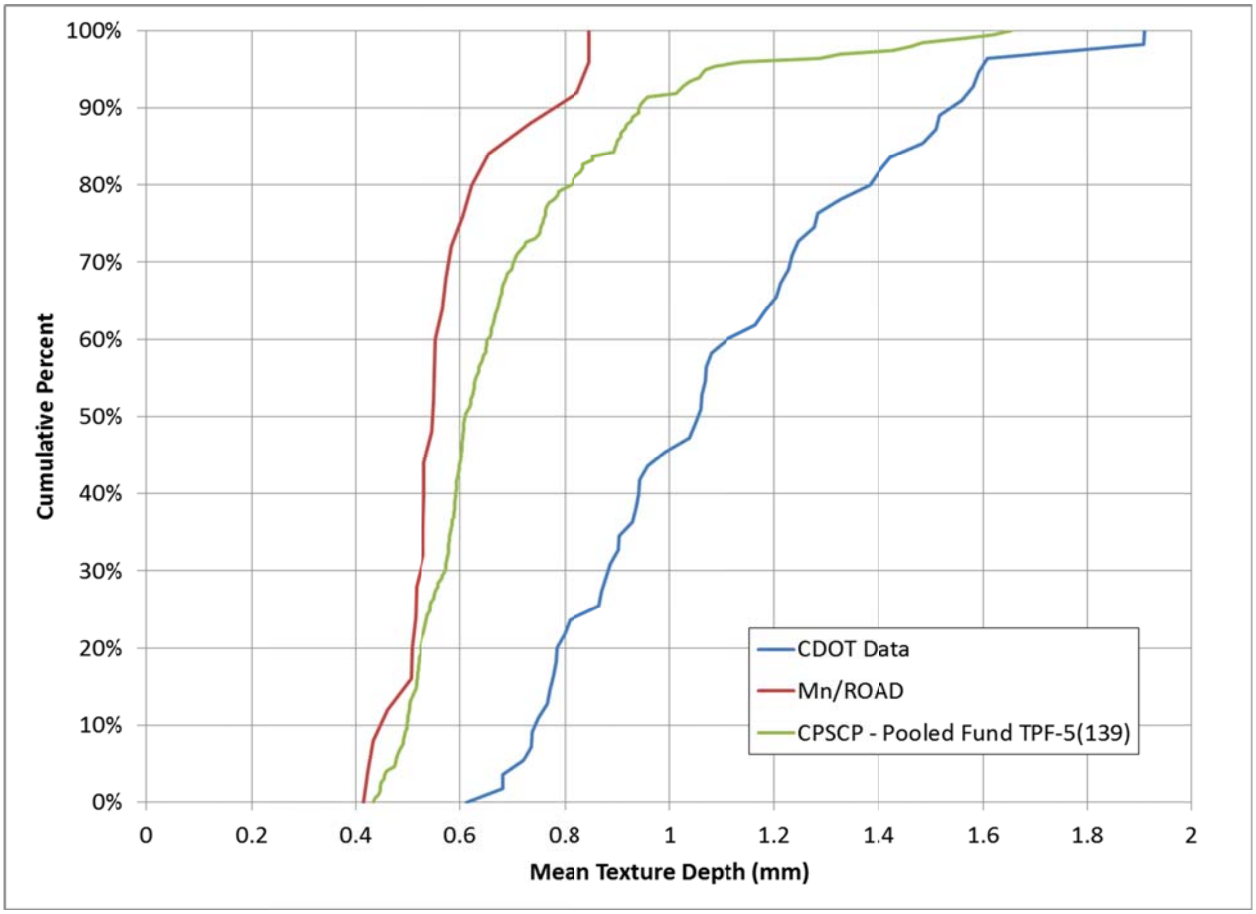


Figure 9. Cumulative distribution of CDOT texture depth measured following CP 77 compared to PCCP test sites at Mn/ROAD and in the TPF-5(139) pooled fund study measured using ASTM E 965 [note: 1 inch = 25.4 mm, 1 mm = 0.039 inches].

5.3. Dislodge Bonded Material

In the draft CP 77 Method B, Section 7.4, the standard states “Gently clean an area of about 1 foot by 1 foot for the sample location using the stiff wire brush to remove any, residue, debris or loosely bonded material. Be careful not to dislodge bonded material.” This requirement deserves careful consideration in the context of newly constructed PCCP. Texturing operations on wet concrete (tine and drag finishes) may produce burrs or nodules on the surface as illustrated in Figure 10. Some of these features can wear off after exposure to initial public traffic; however, conformance testing shouldn’t deliberately abrade these during testing.

Figure 10. Photographs of newly constructed and textured PCCP surfaces.

6. RECOMMENDATIONS

The following recommendations are presented for consideration in:

- Draft CP 77 Method B;
- Colorado Standard Specifications for Construction Section 106.06; and
- Colorado Standard Specifications for Construction Section 412.12.

6.1. Mean Profile Depth

Consider allowing for Mean Profile Depth (MPD) following ASTM E 1845. This procedure evaluates texture from a profile measurement, typically performed with a laser. The mean texture depth is estimated from the profile results as an Estimated Texture Depth (ETD) which is comparable to the Mean Texture Depth (MTD). Given the unique measurement method in CP 77 Method B, a new mathematical transform would need to be developed. Two commercially available profile measuring devices are shown in Figure 11. Profile based measurement methods have the advantage of less variability over sand patch methods.

Figure 11. Commercially available laser based texture profilers. Left: Ames Engineering model 9200 Texture Scanner. Right: Nippo Sangyo Co., Ltd. Circular Track Meter (CTM).

6.2. More Stringent Curing Specification

For PCCP surfaces, in particular those finished using drag operations, the texture is defined by the top surface layer of mortar. The curing operation is vital to the durability of the surface mortar, and thus the texture. As a result, the following curing specifications are recommended for consideration:

- Use of double application of curing compound, with each application a minimum of 180 ft^2/gal.
- Single application is acceptable under ideal conditions.
- 1st coat within 10 minutes of paving; 2nd coat within 30 minutes.

6.3. Texture Depth Limit

The previous data analysis concluded a texture depth of 0.04 inches measured using CP 77 Method B as an acceptable lower limit. However, this level is based on data from existing, aged pavements. For newly constructed pavement, it is recommended to use a limit of 0.05 inches to allow for wear due to traffic and aging. An upper limit is not recommended because it may unnecessarily restrict negative (downward pointing) texture that would have a beneficial effect to tire-pavement noise, all else being equal. In addition, the texture depth should be obtained from an average of several measurements to account for variability in surface texture.

The following are recommended:

- Average texture depth ≥ 0.05 in. as measured using draft CP 77 Method B.
- No upper limit on texture depth.
- Results based on an average of at least three tests for a given slab panel.

6.4. Clarifications to Standard Specifications for Construction

The following clarifications/revisions to the Colorado Standard Specifications for Construction are recommended (per the draft revision provided in June 2012).

- Section 106.06 (b), add “or shoulder” as needed in addition to “full lane width” for correcting surface texture deficiencies by diamond grinding.
- Section 106.06 (b), clarify the use of the term “limits” in the 2^{nd} paragraph.
- Section 412.12 (c), allow for construction traffic, but not public traffic, before the surface texture has been accepted.

APPENDIX A. DATA TABLES

A.1. Site Information

Table 4. Identification of sites at which accident, texture, friction, and tire-pavement noise were collected.

Hwy	Site mp	From	To	Dir	Location	Year Accepted	Surface Texture	Comment
US-40	429.53	422.2	429.4	W	Wild Horse	2002	Astro-Turf Drag + Tines	
US-40	429.75	429.4	429.7	W	Wild Horse	2002	Astro-Turf Drag Only	
US-40	430.05	429.7	431.7	W	Wild Horse	2002	Tines Only	
I-70	94	86.5	94	E	Rifle east	1979	Ground	Diamond Ground in 2005
I-70	95.75	95	96.2	E	Rifle east	1979	Not ground	
I-70	Sect 1	335.3	335.8	E	Deer Trail - 1	1995	1” Transverse Tines	Sta 2715 - 2743
I-70	Sect 2	335.8	336.3	E	Deer Trail - 2	1995	Transverse Astro-Turf Drag	Sta 2743 - 2768
I-70	Sec 3t	336.3	336.7	E	Deer Trail - 3	1995	Astro-Turf Drag + Random Transverse Tines	Sta 2768 - 2789
I-70	Sect 4	336.7	337	E	Deer Trail - 4	1995	Astro-Turf Drag + ½” Transverse Tines	Sta 2789 - 2806
I-70	Sect 5	337	337.2	E	Deer Trail - 5	1995	Astro-Turf Drag + Random Sawing	Sta 442 - 452 e/o bridge
I-70	Sect 6	337.2	337.7	E	Deer Trail - 6	1995	Astro-Turf Drag + 1” Transverse Tines	Sta 452 - 480

Hwy	Site mp	From	To	Dir	Location	Year Accepted	Surface Texture	Comment
I-70	Sect 7	337.7	337.9	E	Deer Trail - 7	1995	Astro-Turf Drag + ¾" Longitudinal Sawing	Sta 480 - 490
I-70	Sect 8	337.9	338.1	E	Deer Trail - 8	1995	Longitudinal Astro-Turf Drag Only	Sta 490 - 500
I-70	Sect 9	338.1	338.3	E	Deer Trail - 9	1995	Astro-Turf Drag + ¾” Longitudinal Tines	Sta 500 - 510
I-76	95	95	97	E	Brush - Atwood	1966	Transverse Tines	Diamond Ground in 2010
I-76	181	176	184	E	State Line	1969	3/4" Longitudinal Tines	Reconstructed in 2007
SH-83	63	62.3	63.9	N	Parker north	2002	No Tines	
SH-83	64	63.9	65.5	N	Parker north	1997	No Tines	
SH-83	67.2	66.6	68.6	N	Parker north	1999	Longitudinal Tines	
US-85	19	188.3	189.6	N	Sedalia	2007	No Tines	
US-160	186	182.9	186.3	W	South Fork	1996	No Tines	
I-270	3.2	3.2	4.5	E	Denver	2006	3/4" Longitudinal Tines	
US-285	243	241.4	243.6	N	Turkey Creek	1999	Longitudinal Tines	
US-285	244	243.6	245.4	N	Turkey Creek	1997	Transverse Tines	Diamond Ground in 2001
US-287	23	21.3	23.6	N	Springfield	1997	3/4" Longitudinal Tines	
US-287	88	86	95.2	N	n/o Wiley Jct.	2004	Longitudinal Tines	

Hwy	Site mp	From	To	Dir	Location	Year Accepted	Surface Texture	Comment
US-287	Sect 1	325.8	326.1	S	Berthoud bypass	2006	Random Longitudinal Tines	1600' section
US-287	Sect 2	326.1	326.3	S	Berthoud bypass	2006	Meandering Longitudinal Tines	1000' section
US-287	Sect 3	326.3	326.5	S	Berthoud bypass	2006	¾" Tines – no Astro-Turf Drag	1000' section
US-287	Sect 4	326.5	326.7	S	Berthoud bypass	2006	Heavy Astro-Turf Drag and No Tines	1000' section
US-287	Sec 7t	326.7	327	S	Berthoud bypass	2006	¾" longitudinal tine (CO std)	1500' section
US-287	Sect 5	328.3	328.5	N	Berthoud bypass	2006	Longitudinal Sawing	1000' section
US-287	Sect 6	328.5	328.7	N	Berthoud bypass	2006	Longitudinal Ground	1000' section

A.2. Texture Data

Table 5. Texture data.

Hwy	Site mp	From	To	Dir	Location	Date Tested	Location	Average Texture Depth (inches)
US-40	429.53	422.2	429.4	W	Wild Horse	01/18/12	center	0.04
						01/18/12	RWP	0.04
US-40	429.75	429.4	429.7	W	Wild Horse	01/18/12	center	0.03
						01/18/12	RWP	0.03
US-40	430.05	429.7	431.7	W	Wild Horse	01/18/12	center	0.04
						01/18/12	RWP	0.03
I-70	94	86.5	94	E	Rifle east	04/24/12	center	0.03
						04/24/12	RWP	0.05
I-70	95.75	95	96.2	E	Rifle east	04/26/12	center	0.03
						04/26/12	RWP	0.05
I-70	Sect 1	335.3	335.8	E	Deer Trail - 1	12/14/11	center	0.06
						12/14/11	RWP	0.05
I-70	Sect 2	335.8	336.3	E	Deer Trail - 2	12/14/11	center	0.03
						12/14/11	RWP	0.04
I-70	Sec 3t	336.3	336.7	E	Deer Trail - 3	12/14/11	center	0.08
						12/14/11	RWP	0.08
I-70	Sect 4	336.7	337	E	Deer Trail - 4	12/14/11	center	0.05
						12/14/11	RWP	0.05
I-70	Sect 5	337	337.2	E	Deer Trail - 5	12/14/11	center	0.06
						12/14/11	RWP	0.06
I-70	Sect 6	337.2	337.7	E	Deer Trail - 6	12/14/11	center	0.05
						12/14/11	RWP	0.05
I-70	Sect 7	337.7	337.9	E	Deer Trail - 7	12/14/11	center	0.06
						12/14/11	RWP	0.06
I-70	Sect 8	337.9	338.1	E	Deer Trail - 8	12/14/11	center	0.03
						12/14/11	RWP	0.03

Hwy	Site mp	From	To	Dir	Location	Date Tested	Location	Average Texture Depth (inches)
I-70	Sect 9	338.1	338.3	E	Deer Trail - 9	12/14/11	center	0.04
						12/14/11	RWP	0.04
I-76	95	95	97	E	Brush - Atwood	03/14/12	center	0.04
						03/14/12	RWP	0.03
I-76	181	176	184	E	State Line	03/14/12	center	0.05
						03/14/12	RWP	0.05
SH-83	63	62.3	63.9	N	Parker north			
SH-83	64	63.9	65.5	N	Parker north			
SH-83	67.2	66.6	68.6	N	Parker north			
US-85	19	188.3	189.6	N	Sedalia			
US-160	186	182.9	186.3	W	South Fork	04/26/12	center	0.03
						04/26/12	RWP	0.03
I-270	3.2	3.2	4.5	E	Denver			
US-285	243	241.4	243.6	N	Turkey Creek	01/19/12	center	0.03
						01/19/12	RWP	0.04
US-285	244	243.6	245.4	N	Turkey Creek	01/19/12	center	0.03
						01/19/12	RWP	0.04
US-287	23	21.3	23.6	N	Springfield	02/02/12	center	0.06
						02/02/12	RWP	0.05
US-287	88	86	95.2	N	n/o Wiley Jct.	02/02/12	center	0.04
						02/02/12	RWP	0.04
US-287	Sect 1	325.8	326.1	S	Berthoud bypass	12/13/11	center	0.04
						12/13/11	RWP	0.03
US-287	Sect 2	326.1	326.3	S	Berthoud bypass	12/13/11	center	0.04
						12/13/11	RWP	0.05

Hwy	Site mp	From	To	Dir	Location	Date Tested	Location	Average Texture Depth (inches)
US-287	Sect 3	326.3	326.5	S	Berthoud bypass	12/13/11	center	0.04
						12/13/11	RWP	0.04
US-287	Sect 4	326.5	326.7	S	Berthoud bypass	12/13/11	center	0.03
						12/13/11	RWP	0.03
US-287	Sec 7t	326.7	327	S	Berthoud bypass	12/13/11	center	0.04
						12/13/11	RWP	0.05
US-287	Sect 5	328.3	328.5	N	Berthoud bypass	12/13/11	center	0.06
						12/13/11	RWP	0.06
US-287	Sect 6	328.5	328.7	N	Berthoud bypass	12/13/11	center	0.03
						12/13/11	RWP	0.02

A.3. Friction Data

Table 6. Friction (skid) data.

							Skid Data							
Hwy	**Site mp**	**From**	**To**	**Dir**	**Location**	**Tire**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
US-40	429.53	422.2	429.4	W	Wild Horse	ribbed	75.6	73.6	71.5	70.5	73.1	68.1	72.9	
						smooth	64.3	68.1	60.5	63.8	69.6	62.7	63.6	
US-40	429.75	429.4	429.7	W	Wild Horse	ribbed	72	70.1	68.1	67.2	69.8	64.9	69.4	
						smooth	50.8	53.8	47.8	50.5	55.3	49.6	55	
US-40	430.05	429.7	431.7	W	Wild Horse	ribbed	73.1	71.8	68.2	68.2	68.3	65.9	70.5	
						smooth	58.8	62.2	58.4	58.4	59.7	57.6	63.6	
I-70	94	86.5	94	E	Rifle east	ribbed	60.5	54.5	58.5	53	47	51.2	50.9	52.6
						smooth	53.6	52.3	56.2	46.2	36.2	41.1	42.5	47.1
I-70	95.75	95	96.2	E	Rifle east	ribbed	52.2	48.8	49.4	37.8	47	50.3	39.8	52.3
						smooth	38	39.9	35.8	34.5	37.1	39.9	37.4	46.3
I-70	Sect 1	335.3	335.8	E	Deer Trail - 1	ribbed	68.7	64.8	63.5	67.4	64.2	64.8	70.6	
						smooth	46.1	35.8	35.1	37.3	35.5		39	
I-70	Sect 2	335.8	336.3	E	Deer Trail - 2	ribbed	73.1	71.2	69.2	68.3	65.9	62.2	70.5	
						smooth	66.1	70.7	62.2	65.6	64.5		71.6	
I-70	Sec 3t	336.3	336.7	E	Deer Trail - 3	ribbed	74.2	72.3	70.2	69.3	66.9	63.2	71.5	
						smooth	67.9	71.9	63.9	67.4	66.2		73.5	
I-70	Sect 4	336.7	337	E	Deer Trail - 4	ribbed	72	69.8	72.3	69.8	64.6	65.3	66.3	
						smooth	71.4	63.7	69.8	66.9	61.6		66.3	
I-70	Sect 5	337	337.2	E	Deer Trail - 5	ribbed	63.7	63.3	63.7	63.3	62	61	66.1	
						smooth	61	60.8	61.1	60.6	64.6		54	
I-70	Sect 6	337.2	337.7	E	Deer Trail - 6	ribbed	64.3	62	63.7	63	65.1	63.8	60.8	
						smooth	58.5	57.8	57	52.9	58.4		57.3	
I-70	Sect 7	337.7	337.9	E	Deer Trail - 7	ribbed	61.9	63.1	62.5	61.8	63.6	62.3	62.5	
						smooth	63.5	61.3	57.8	55.74	65.1		57.2	
I-70	Sect 8	337.9	338.1	E	Deer Trail - 8	ribbed	63.5	60.8	61.2	59.8	65.4	61.1	63.9	

Hwy	Site mp	From	To	Dir	Location	Tire	Skid Data 2004	2005	2006	2007	2008	2009	2010	2011
						smooth	63.1	60.9	61.7	60.1	28.8		63.6	
I-70	Sect 9	338.1	338.3	E	Deer Trail - 9	ribbed	62.6	60.7	63.3	63.6	60.9	63.3	65.9	
						smooth	62.2	59.7	61.4	59.4	61.8		65.6	
I-76	95	95	97	E	Brush - Atwood	ribbed	63.1	59.5	58.4	61.9	59.2	64.7		
						smooth	45.4	352.3	34.6	63.7	34.9	63.5		
I-76	181	176	184	E	State Line	ribbed	74	65	63.7	67.6		64.3		
						smooth	68.9	56.5	59.3	61.7		62.2		
SH-83	63	62.3	63.9	N	Parker north	ribbed	81.1	72.1	70	38.1		60.7	66.4	
						smooth	66.3	70.2	62.4	28.9	38.1	67.4	65.2	
SH-83	64	63.9	65.5	N	Parker north	ribbed	74	72.1	70	38.1		60.7	71.4	
						smooth	66.3	70.2	62.4	28.9	38.1	67.4	71.8	
SH-83	67.2	66.6	68.6	N	Parker north	ribbed	74.2	72.3	70.2	69.3		60.7	71.5	
						smooth	67.9	71.9	63.9	65.7	23.1	67.4	73.5	
US-85	19	188.3	189.6	N	Sedalia	ribbed	68.6	64.8	63.5	67.3	64.1	64.4	70.1	63.5
						smooth	65.3	65.6	48.7	52.8	50.2	62.4	57.7	52.3
US-160	186	182.9	186.3	W	South Fork	ribbed	59.1	55.8	54.6	58	55.2	64.4	60.7	55
						smooth	52	58.2	39.7	42	40	62.4	44	39.9
I-270	3.2	3.2	4.5	E	Denver	ribbed	41.3			68.6	55.2	64.4	62.9	
						smooth	50			66.1	45.7	62.4	56.1	
US-285	243	241.4	243.6	N	Turkey Creek	ribbed	53.6	50.6	53.4	50.1	50.1	54.5	55.1	
						smooth	47.5	51.6	48.2	36.1	36.5	44.9	40.2	
US-285	244	243.6	245.4	N	Turkey Creek	ribbed	55.3	52.2	51.4	45.2	50.9	51.2	43.6	
						smooth	43.2	44.3	34	33	33.2	34	34.9	
US-287	23	21.3	23.6	N	Springfield	ribbed	68.8	65	63.7	67.5	64.3	62.9		
						smooth	46.6	44.3	35.6	37.6	35.8	34.1		
US-287	88	86	95.2	N	n/o Wiley Jct.	ribbed	73.1	69	64.4	69.4	68.4	59	61.4	
						smooth	68.3	66	66.8	64.6	66.2	47.1	61.5	
US-287	Sect 1	325.8	326.1	S	Berthoud bypass	ribbed	58.7	75	67.2	63.5	61.7	66.4	59.6	
						smooth	57.3	71	62.8	58.4	49.3	49.6	58.4	

Hwy	Site mp	From	To	Dir	Location	Tire	Skid Data 2004	2005	2006	2007	2008	2009	2010	2011
US-287	Sect 2	326.1	326.3	S	Berthoud bypass	ribbed	66.1	67.2	70.2	62.3	60	67.2	62.7	
						smooth	59.5	62.8	61.2	63.9	47.1	62	60.5	
US-287	Sect 3	326.3	326.5	S	Berthoud bypass	ribbed	57.4	60.5	59.6	58.9	61.6	71.1	59.6	
						smooth	56.7	58.9	57.4	58.1	57.6	70.8	57.3	
US-287	Sect 4	326.5	326.7	S	Berthoud bypass	ribbed	73.2	72.1	74	69.5	57	68.4	54.8	
						smooth	71.7	68.1	72.1	57	50.2	68.4	44.7	
US-287	Sec 7t	326.7	327	S	Berthoud bypass	ribbed	74.2	72.3	70.2	69.3	61.8	61.4	63.5	
						smooth	67.9	71.9	63.9	61.6	58.1	54.1	55.7	
US-287	Sect 5	328.3	328.5	N	Berthoud bypass	ribbed	68.1	64.3	63	66.9	62.3	64.4	63.7	
						smooth	66.4	62.8	62	59	56.4	62.4	62.5	
US-287	Sect 6	328.5	328.7	N	Berthoud bypass	ribbed	72	72.1	70	69.1	65.4	65.2	52.8	
						smooth	66.3	70.2	62.4	57.3	57.7	67.4	43.2	

A.4. Accident and Traffic Data

Table 7. Accident and traffic count data.

Hwy	Site mp	From	To	Dir	Location	Accident Count (2003 - 2010) Dry Road	Wet Road	Total	Avg AADT (2003 - 2010)
US-40	429.53	422.2	429.4	W	Wild Horse	11	3	14	2381
US-40	429.75	429.4	429.7	W	Wild Horse	0	0	0	2501
US-40	430.05	429.7	431.7	W	Wild Horse	2	0	2	2501
I-70	94	86.5	94	E	Rifle east	147	77	224	17846
I-70	95.75	95	96.2	E	Rifle east	25	5	30	19349
I-70	Sect 1	335.3	335.8	E	Deer Trail - 1	4	1	5	10877
I-70	Sect 2	335.8	336.3	E	Deer Trail - 2	3	2	5	10877
I-70	Sec 3t	336.3	336.7	E	Deer Trail - 3	3	0	3	10877
I-70	Sect 4	336.7	337	E	Deer Trail - 4	2	0	2	10877
I-70	Sect 5	337	337.2	E	Deer Trail - 5	2	0	2	10877
I-70	Sect 6	337.2	337.7	E	Deer Trail - 6	1	0	1	10877
I-70	Sect 7	337.7	337.9	E	Deer Trail - 7	1	0	1	10877
I-70	Sect 8	337.9	338.1	E	Deer Trail - 8	2	0	2	10877
I-70	Sect 9	338.1	338.3	E	Deer Trail - 9	2	0	2	10877
I-76	95	95	97	E	Brush - Atwood				
I-76	181	176	184	E	State Line				
SH-83	63	62.3	63.9	N	Parker north	52	15	67	40094
SH-83	64	63.9	65.5	N	Parker north	175	41	216	44140
SH-83	67.2	66.6	68.6	N	Parker north	129	43	172	42957
US-85	19	188.3	189.6	N	Sedalia	13	2	15	16277

Hwy	Site mp	From	To	Dir	Location	Accident Count (2003 - 2010) Dry Road	Wet Road	Total	Avg AADT (2003 - 2010)
US-160	186	182.9	186.3	W	South Fork	11	10	21	3402
I-270	3.2	3.2	4.5	E	Denver	37	14	51	70890
US-285	243	241.4	243.6	N	Turkey Creek	60	10	70	23351
US-285	244	243.6	245.4	N	Turkey Creek	57	27	84	23351
US-287	23	21.3	23.6	N	Springfield	5	3	8	2389
US-287	88	86	95.2	N	n/o Wiley Jct.	12	9	21	2639
US-287	Sect 1	325.8	326.1	S	Berthoud bypass				
US-287	Sect 2	326.1	326.3	S	Berthoud bypass				
US-287	Sect 3	326.3	326.5	S	Berthoud bypass				
US-287	Sect 4	326.5	326.7	S	Berthoud bypass				
US-287	Sec 7t	326.7	327	S	Berthoud bypass				
US-287	Sect 5	328.3	328.5	N	Berthoud bypass				
US-287	Sect 6	328.5	328.7	N	Berthoud bypass				

A.5. Tire-Pavement Noise Data

Table 8. Tire-pavement noise data.

Hwy	Site mp	From	To	Dir	Location	Surface Texture	Note	OBSI Level (dBA) 2005	2006	2007	2009	2011
US-40	430.05	429.7	431.7	W	Wild Horse	Tines Only			101.9	102.1	101.3	101.6
I-70	94	86.5	94	E	Rifle east	Ground	1		101.6	103.5	103.6	105.1
US-85	19	188.3	189.6	N	Sedalia	No Tines	2		102.4	102.8	102.5	103.0
US-285	243	241.4	243.6	N	Turkey Creek	Longitudinal Tines			104.3	104.8	105.1	105.3
US-285	244	243.6	245.4	N	Turkey Creek	Transverse Tines			104.5	104.7	104.5	105.1
US-287	Sect 1	325.8	326.1	S	Berthoud bypass	Random Longitudinal Tines		101.4			102.2	
US-287	Sect 2	326.1	326.3	S	Berthoud bypass	Meandering Longitudinal Tines		104.1		103.6	102.9	
US-287	Sect 3	326.3	326.5	S	Berthoud bypass	¾” Tines – no Astro-Turf Drag		103.7		102.8	102.2	
US-287	Sect 4	326.5	326.7	S	Berthoud bypass	Heavy Astro-Turf Drag and No Tines		101.2		102.0	102.4	
US-287	Sec 7t	326.7	327	S	Berthoud bypass	¾” longitudinal tine (CO std)		103.0		102.9	102.7	
US-287	Sect 5	328.3	328.5	N	Berthoud bypass	Longitudinal Sawing		102.2				
US-287	Sect 6	328.5	328.7	N	Berthoud bypass	Longitudinal Ground		100.8		100.1	100.4	

Notes: 1. Direction for the tire-pavement noise is west bound.

2. Section for the tire-pavement noise is adjacent to the north end of the section defined in the From-To columns.

APPENDIX B. DRAFT REVISIONS OF SECTION 106 AND 412

Sections 106 and 412, Surface Texture of Portland Cement Concrete Pavement, of the Standard Specifications are hereby revised for this project as follows:

Subsection 106.06 (a) shall include the following:

> The Contractor shall submit the proposed method of PCCP texturing at the Pre-Construction conference for approval by the Engineer. The Contractor shall perform process control (PC) testing for the pavement surface texture depth in accordance with CP 77 Method B. All PC results for surface texture depth measurements shall be included in the Contractor's QC notebook. The start of PC testing for texturing depth shall be completed within 24 hours after the first 500 linear feet of textured pavement is placed for each lane. Paving shall not proceed until results are accepted by the Engineer.
>
> Surface texture will be considered acceptable when the texture depth is greater than 0.05 inch. When the texture depth is less than 0.05 inches, the contractor shall determine the area represented by this test. The area shall be determined by taking additional tests at 15 foot intervals parallel to the centerline in each direction from the affected location until two consecutive tests are found to be within the specified limits. Any surface with unacceptable texturing exceeding 25 linear feet in any lane or shoulder greater than 8 feet wide shall be diamond ground full width of the lane. Upon the second unacceptable test result, the Contractor shall notify the Engineer, in writing, the action taken to provide an acceptable surface texture.

Subsection 106.06 (b) shall include the following

> The Department will perform surface texture acceptance testing in accordance with CP 77 Method B. The Department will determine the panel locations where acceptance test measurements are to be taken. One stratified random acceptance test per 2,500 linear feet

or fraction thereof in each lane and shoulder wider than 8 feet shall be taken with a minimum of one test per day when the Contractor is paving.

When the Department locates areas of surface texture that do not meet the minimum texture depth, the Contractor shall be notified and the Contractor shall be responsible for identifying the limits. After the Engineer approves the limits, the Contractor shall correct the deficient surface texture by diamond grinding full lane width at no additional cost to the project. Correcting surface texture deficiencies shall occur prior to pavement smoothness testing and pavement thickness determinations. Upon the project's third unacceptable test result from the Department, the Engineer will notify the Contractor, in writing, and the pay estimate will be withheld until diamond grinding is completed to provide an acceptable surface texture.

In subsection 106.06, delete the Tining Depth element from Tables 106-2 and 106-3 and replace with the following Element:

Table 106-2

Element	**Minimum Testing Frequency Contractor's Quality Control**
Surface Texture Depth	1 per 528 linear feet in each lane and shoulder wider than 8 feet.

Table 106-3

Element	**Minimum Testing Frequency Contractor's Quality Control**
Surface Texture Depth	1 per 528 linear feet in each lane and shoulder wider than 8 feet.

Delete Subsection 412.12 (c) and (d) and replace with the following:

c) *Final Finish and Stationing*. The final surface of the pavement shall be uniformly textured with a broom, burlap drag, artificial turf or diamond ground in order to obtain the specified texture depth. Surface imperfections resulting from the texturing operation shall be corrected by the Contractor at no additional cost.

Diamond grinding shall be performed using diamond blades mounted on a self-propelled machine designed for diamond grinding and texturing concrete pavement. The equipment shall have a positive means of vacuuming the grinding residue from the pavement surface, leaving the surface in a clean, near-dry condition. Diamond grinding shall not occur until the concrete has attained strength of at least 2,500 psi.

The diamond grinding process shall produce a pavement surface that is true to grade and uniform in appearance. The grooves shall be evenly spaced. Any ridges on the outside edge next to the shoulder, auxiliary, or ramp lanes greater than 3/16 inch high shall be feathered out to the satisfaction of the Engineer in a separate, feather pass operation.

The pavement surface after diamond grinding shall have no depressions or misalignment of slope in the longitudinal direction exceeding 1/8 inch in 12 feet when measured with a 12 foot straightedge placed parallel to the centerline. All areas of deviation shall be reground at no additional cost.

Traffic shall not be allowed on the pavement until after the surface texture has been accepted.

Stationing shall be stamped into the outside edge of the pavement, as shown on the plans.

APPENDIX C. DRAFT PROCEDURE 77 METHOD B

Colorado Procedure 77 Method B

Standard Procedure for

Determination of Macrotexture Depth for Portland Cement Concrete Pavements

1.0 SCOPE

1.1 This test method describes the means to evaluate the macrotexture depth of a Portland cement concrete pavement (PCCP) surface.

1.2 This Colorado Procedure (CP) may involve hazardous materials, operations, and equipment. This CP does not purport to address all of the safety problems associated with its use. It is the main responsibility of the user to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2.0 REFERENCE

2.1 AASHTO Standards

M 247-11, Type 1 Glass Beads Used In Traffic Paints

2.2 ASTM Standards

E 1094-04 Pharmaceutical Glass Graduates or ISO Standard 6706 Plastic Laboratory Ware - Graduated Measuring Cylinders

2.3 CP Standards

Appendix L Random Sampling

3.0 TERMINOLOGY

Terms and abbreviations shall be in accordance with the Department’s Standard Specifications, and Field Materials Manual.

4.0 SIGNIFICANCE AND USE

This CP is used to evaluate the macrotexture of a PCCP surface.

5.0 APPARATUS

5.1 Filler: Type 1 glass beads in accordance with AASHTO M 247-11.

5.2 Spreader: A flat, stiff hard disk with a thickness of 1.0 ± 0.5 in., diameter of 4 ± 2 in.

5.3 Graduate**:** A conical or cylindrical shape graduate, Type 1, Class B or better, 250 ml capacity conforming to the volume and accuracy requirements of ASTM E 1094-04 or ISO Standard 6706 used to measure the volume of filler for the test.

5.4 Brushes: A stiff wire brush and a soft bristle brush used to clean the pavement.

5.5 Container: A small container with a secure and easily removable cover used to store 50 ml of filler.

5.6 Screen: A shield used to protect the test area from air turbulence created from wind or traffic.

6.0 LABORATORY PREPARATION

6.1 Prepare one container for each sample location.

6.2 Fill the graduate with 25 ± 2 ml of filler.

6.3 Gently tap the side of the graduate to level the surface of the filler.

6.4 Place the measured volume of filler in the container.

6.5 Label the container with type and quantity of filler.

7.0 PROCEDURE

7.1 Randomly determine a sample panel on the PCCP to test the macrotexture.

7.2 Gently clean an area of about 1 foot by 1 foot for the sample location using the stiff wire brush to remove any, residue, debris or loosely bonded material. Be careful not to dislodge bonded material. After using the stiff wire brush, gently brush the sample location with the soft bristle brush to remove any remaining debris.

7.3 Place the screen on the PCCP surface to protect the sample location from air turbulence.

7.4 Hold the container with filler above the pavement at the sample location at a height not greater than 4 inches.

7.5 Pour the measured volume of filler from the container onto the pavement surface into a conical pile.

7.6 Place the spreader lightly on top of the conical pile of filler being careful not to compact the filler.

7.9 Move the spreader in a slow, circular motion to disperse the filler in a circular area and to create a defined crest around the perimeter.

7.7 Continue spreading the filler until it is well dispersed and the spreader rides on top of the high points of the pavement surface.

7.8 Measure and record the diameter of the circular area four times, at intervals of 45º and to the nearest 0.1 in., as shown below.

7.9 Calculate the average diameter of the circular area covered by the filler.

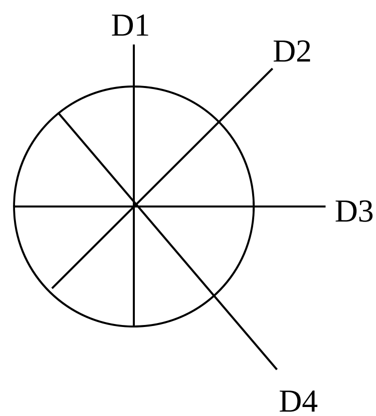
7.10 Determine the macrotexture depth of the PCCP surface by using the cross reference table on the bottom of the Macrotexture Report form. Report the result to three decimal places.

7.11 Repeat steps 7.2 through 7.11 two more times on areas within the selected PCCP panel.

7.12 Remove the filler material and properly dispose of the material.

8.0 CALCULATIONS. Calculate the average diameter and area of the filler.

Da = (D1 + D2 + D3 + D4) / 4



Where:

Da = Average diameter of the filler area, in.

D1, D2, D3, D4 = Diameters of the filler area, in.

Area (in^2) = π Da^2 /4

Calculate the volume of filler in cubic inches (in^3):

V (in^3) = V (ml) / 16.387 ml/ in^3

Calculate Macrotexture Depth (in):

Volume of filler (in^3) divided by area of filler (in^2).

Example:

Da = 8 in.

Volume of filler = 25 ml (convert to in^3) V (in^3) = 25 / 16.387 = 1.525 $in.^3$

Area = π Da^2 /4 ➔ π 8^2 /4 = 50.265 $in.^2$

Thickness = 1.525 $in.^3$/50.265 $in.^2$ = 0.030 in.

8.0 REPORT. Report the following information.

Date of test	Name of prime contractor
Project number	Diameter of filler area, D1, D2, D3, D4
Contract ID	Average diameter of filler area, in.
Station or Milepost of sample location	Macrotexture Thickness
Offset of sample location	Name of PCCP contractor

MACROTEXTURE REPORT

Project No: ___________________________________ Contract ID: ___________________________

PCCP Contractor: ______________________________ Prime Contractor: ______________________________

Test #	Date	Station	Offset	Dia. D1 (in.)	Dia. D2 (in.)	Dia. D3 (in.)	Dia. D4 (in.)	Average Dia. (in.)	Macro Texture Depth(in.)
								Average =	

Test #	Date	Station	Offset	Dia. D1 (in.)	Dia. D2 (in.)	Dia. D3 (in.)	Dia. D4 (in.)	Average Dia. (in.)	Macro Texture Depth(in.)
								Average =	

Test #	Date	Station	Offset	Dia. D1 (in.)	Dia. D2 (in.)	Dia. D3 (in.)	Dia. D4 (in.)	Average Dia. (in.)	Macro Texture Depth(in.)
								Average =	

MACROTEXTURE DEPTH BASED ON 25 ML OF FILLER AND AVERAGE DIAMETER

Average Diameter (Inch)	Macrotexture Depth (Inch)	Average Diameter (Inch)	Macrotexture Depth (Inch)	Average Diameter (Inch)	Macrotexture Depth (Inch)	Average Diameter (Inch)	Macrotexture Depth (Inch)
5	0.078	6.5	0.046	8	0.030	9.5	0.022
5.1	0.075	6.6	0.045	8.1	0.030	9.6	0.021
5.2	0.072	6.7	0.043	8.2	0.029	9.7	0.021
5.3	0.069	6.8	0.042	8.3	0.028	9.8	0.020
5.4	0.067	6.9	0.041	8.4	0.028	9.9	0.020
5.5	0.064	7	0.040	8.5	0.027	10	0.019
5.6	0.062	7.1	0.039	8.6	0.026	10.1	0.019
5.7	0.060	7.2	0.037	8.7	0.026	10.2	0.019
5.8	0.058	7.3	0.036	8.8	0.025	10.3	0.018
5.9	0.056	7.4	0.035	8.9	0.025	10.4	0.018
6	0.054	7.5	0.035	9	0.024	10.5	0.018
6.1	0.052	7.6	0.034	9.1	0.023	10.6	0.017
6.2	0.050	7.7	0.033	9.2	0.023	10.7	0.017
6.3	0.049	7.8	0.032	9.3	0.022	10.8	0.017
6.4	0.047	7.9	0.031	9.4	0.022	10.9	0.016