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RESEARCH UPDATE

U 2005-1

RECESSED AND SURFACE-APPLIED POLYUREA PAVEMENT MARKINGS

REFERENCES:

WP 2002-R-1

OBJECTIVE:

The objective of this project is to evaluate the performance of two pavement-marking application methods, surface applied and recessed. A proprietary 15 mil liquid polyurea pavement marking material placed on new bituminous concrete will be evaluated for durability and retroreflectivity in both application methods.

PRODUCT DESCRIPTION:

3M Stamark LPM Series 1200 is a polyurea marking material manufactured by 3M Corporation of St. Paul, Minnesota. This marking material contains proprietary reflective elements and glass beads for long term retroreflectivity. It is designed for long lines, edge lines, channelized lines, gore markings as well as symbols and legends.

OVERVIEW:

Polyurea markings were selected to be applied on I-189 in 2003 as part of the Burlington/South Burlington IM 189-3(36) project. The markings (all edge and skip lines) in the westbound (WB) lanes were to be recessed from MM 0.334 to MM 0.9 and surface applied from MM 0.9 to 1.443. The markings in the eastbound (EB) lanes were to be applied in a similar configuration, being recessed from MM 0.0 to MM 0.7 and surfaced applied from MM 0.7 to 1.492. Figure 1 shows this configuration below (with test sites noted).

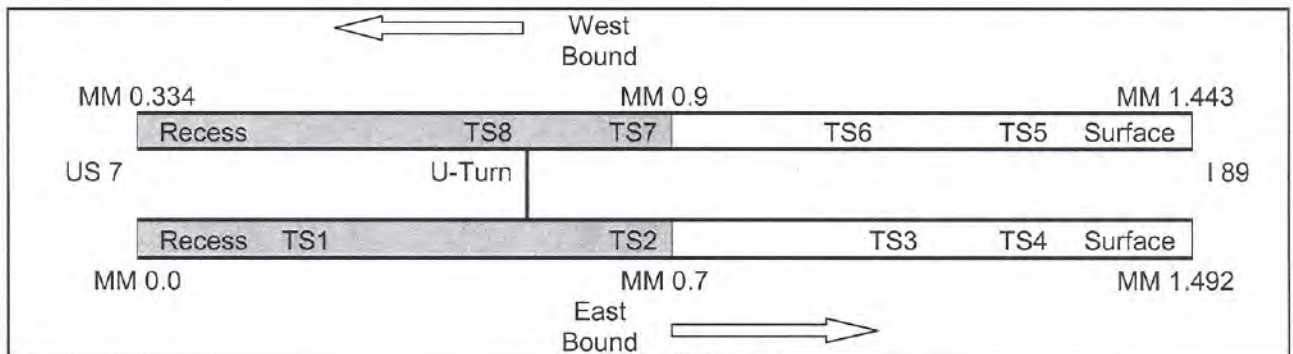


Figure 1 - I 189 LPM Test

MATERIAL APPLICATION:

On June 29th, 2003, L&D Safety Markings began to prepare the roadway for both the recessed and surface applications. This involved installing a groove for all long line markings (right edge, left edge and skip lines) 40 mils in depth (+/- 10 mils) in the areas chosen for recessing (Figure 2). All recess preparation was completed in one day but further production, including application of the markings, was curtailed due to heavy rain.

Application of the markings commenced in the evening of June 30, 2003. All markings were applied after evening rush hour due to high traffic volumes. Weather conditions were clear with temperatures ranging from 78°F at 6PM to 64°F at midnight. Installation of the yellow edge line began at 7:40 PM as the markings were applied in the WB lane from I-89 (MM 1.443) to the US- 7 interchange (MM 0.334), a distance of approximately 1.1 miles (See Figure 3). Immediately after placing the WB yellow edge line, the EB yellow edge line from the US-7 interchange (MM 0.0) to I-89 (MM 1.492) was completed. By 8:30 PM, the entire yellow line had been applied.

Retroreflectivity readings in the WB lane were taken at a point adjacent to the U-Turn at MM 0.55 averaged 822 mc/dl. Another set of retroreflectivity readings in the EB lane at MM 0.55 (at the same u-turn) averaged 925 mc/dl.



Figure 2- Recess for Yellow Edge Line



**Figure 3- Yellow Edge line being applied
(MM 0.55 WB)**



Figure 4- White line being applied

Following the yellow edge line application, at approximately 10:00 PM, installation of the white edge lines was begun (See Figure 4). Research and Development staff observed the placement of the EB white edge line until approximately 10:15 PM. White line retroreflectivity readings were not taken on June 30, 2003. All markings were completed before daybreak on July 1.

PERFORMANCE:

White Edge Lines

Eight test sites were placed randomly along the project in both recessed and non-recessed areas to evaluate retroreflectivity. Each test site contains five test areas marked out at 10 foot intervals on the white and yellow edge lines. In addition, the white skip line was tested within the test sites by establishing five test areas. The first full set of readings on the test sites was taken on July 9, 2003, ten days following installation. The data recorded on this date varied little from the recessed to the non recessed areas. (See Appendices A, B, C, & D for all data collected) The average of the values collected for the recessed and surface applied white edge lines was 924 and 925 mcdl, respectively. The lines had a durability rating of 10 for both, as measured according to ASTM D913, 'Standard Method for Evaluating the Degree of Resistance to Wear of Traffic'. **For purposes of this report, only edge line data will be presented in order to eliminate any interpretive interference by adding the skip line data to the analysis.**



Figure 5- Surface Markings, July 9, 2003

Figure 6- Recessed Markings, Nov 6, 2003

Date	# of Readings	Jul-03	Nov-03	Apr-04	May-04	Aug-04	Oct-04	May-05	Jul-05	Sep-05
EB Surface White	10	995	840	135	132	147	140	87	77	83
EB Recess White	10	911	700	327	243	517	377	209	211	247
WB Surface White	10	855	704	127	131	126	111	66	53	59
WB Recess White	10	937	777	264	274	266	252	115	40	96
Average WB and EB Surface and Recessed Lines										
WB & EB Surface White	20	925	772	131	131	137	125	77	65	71
WB & EB Recess White	20	924	739	296	259	391	314	162	126	172

Table 1 – Average Readings for White Lines

The second set of readings was taken on November 6th 2003, four months after the first data collection. The average remained high, however a 20 percent drop in the values (from 924 mcdl to 739mcdl) was observed on the recessed lines with a 16.5 percent drop on the surface lines (from 925 to 772 mcdl). This drop may have been due to the loss of excess beads over the four months of service. The durability rating remained at a value of 10.

Retroreflectivity readings have been taken periodically from 2003 up to the present time. Of particular note is how the markings compared with each other after one winter maintenance season, when the April 2004 data was analyzed. The readings sampled on the surface applied markings were 120 mcdl while the recessed markings were 295 mcdl. Durability ratings were down for both recessed and surface applied lines from a rating of 10 in November 2004 to a rating of 8 in April 2005.

During the spring and summer of 2004 the surface applied white polyurea markings remained steady in terms of retroreflectivity. The readings obtained on the recessed markings remaining above an average value of 250 mcdl and the surface applied remaining at 130 mcdl.



Figure 7- Recessed Markings, May 5, 2005

Figure 8- Surface Markings, July 19, 2005

The most recent readings were taken on September 21, 2005. Averages are indicated in Table 1 with a complete set of readings in Appendix A. The results show that after two winter maintenance seasons, the average readings for the recessed white lines had reached 171.5 mcdl while the surface-applied lines were 71.1 mcdl. The durability ratings had dropped to 7 for the recessed lines and 5 for the surface-applied lines. This trend is similar for most pavement marking systems tested by VTrans and is evident in the graph in Figure 9.

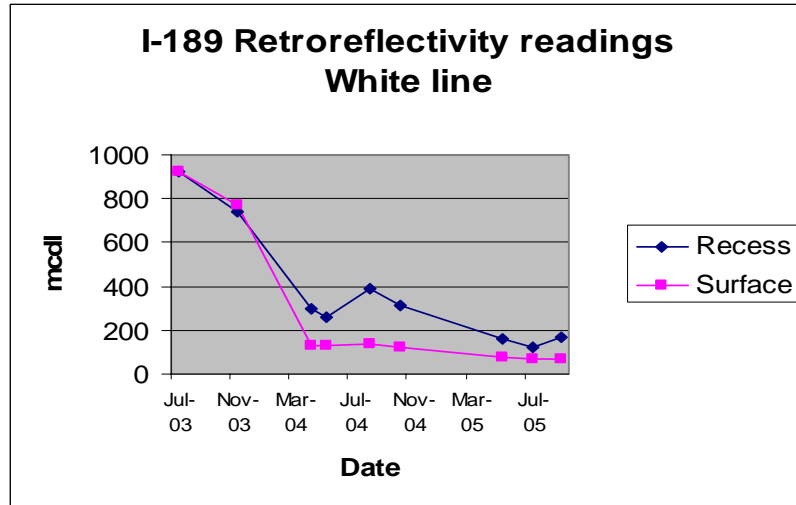


Figure 9 – Average Reading for White Line

Yellow Edge Lines

The recessed yellow edge lines follow a somewhat different pattern than the white lines. Initial readings taken on July 9, 2003 obtained averages values of 833 mcdl for the surface applied markings and 782 mcdl for those that were recessed. Additional readings were taken in concert with the white edge with the most recent readings being obtained on September 21, 2005. At this point the average value for surface-applied readings had dropped to 110 mcdl, while the recess average remained much higher at 493 mcdl. These are shown graphically in Figure 10 as well as in Table 2 below.

Dates	# of Readings	Jul-03	Nov-03	Apr-04	May-04	Aug-04	Oct-04	May-05	Jul-05	Sep-05
EB Surface Yellow	10	849	600	136	93	129	115	103	91	90
EB Recess Yellow	10	797	580	328	520	369	377	278	285	358
WB Surface Yellow	10	818	601	166	143	167	169	134	130	129
WB Recess Yellow	10	766	715	574	607	702	725	562	556	628
Average WB and EB Surface and Recessed Lines										
WB & EB Surface Yellow	20	833	601	151	118	148	142	118	111	110
WB & EB Recess Yellow	20	782	647	451	563	536	551	420	421	493

Table 2 – Average Readings for Yellow Edge Lines

After two winters, the typical retroreflectivity readings obtained on the recessed yellow lines have remained above 400 mcdl, while the surface applied yellow lines have dropped from 800 to 200 mcdl (see Appendices for all data). This may be attributed to snowplow and traffic patterns. Durability of

these lines performed similar to the white edge edges with initial ratings of 10, and dropping to 7 for the recessed lines and 5 for the surface applied lines for the September 21, 2005 inspection.

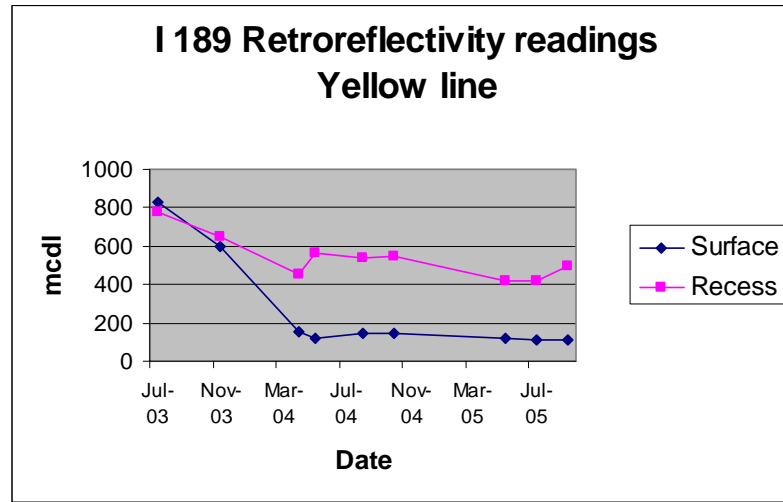


Figure 10 – Average Reading for Yellow Edge Line

OTHER OBSERVATIONS

It has been observed that the range of the readings is larger in the recess area as compared to surface-applied areas. This is illustrated by looking at two sets of readings. In May 2005, the retroreflectivity values obtained for the recessed white edge lines ranged from 56 to 350 mcdl while the readings obtained in the surface-applied area had a tighter range (51 to 115 mcdl). This pattern was similar in September 2005 with the surface-applied readings ranging from 33 to 103 mcdl, and the recessed markings having much more varied values between 46 and 430 mcdl (Table 3).

Date	I 189 White Lines			I 189 Yellow Lines		
	Ave	Min	Max	Ave	Min	Max
Recessed May-05	162	56	350	420	154	691
Surface May-05	77	51	115	118	25	322
Recessed Sep-05	172	46	430	493	186	712
Surface Sep-05	71	33	103	110	18	331

Table 3 – Marking Variability

This pattern is not as apparent with the yellow markings. In May 2005, the surface-applied lines retroreflectivity readings ranged from 42mcdl to 213 mcdl, while those obtained on the recess markings ranged from 183 mcdl to 738 mcdl (see Table 3). Similar ranges exist in the data from September 2005 (Appendices C and D) However, even though the surface-applied yellow lines are not as normally distributed as the white lines, it can be seen that the yellow recessed lines have readings that are much more varied than the surface-applied yellow lines. It is unclear why this range difference

takes place, though the wide range of values may be affected by the discontinuity of the surface from grinding of the recessed area itself. This range difference will be investigated in future reports.

COST

The cost of the recessed LPM 1200 on this project was \$1.67 per linear foot; while the surface-applied LPM 1200 was \$1.16. Standard Vermont applications of thermoplastic markings are typically bid at \$0.425 per linear foot.

SUMMARY

The two year old recessed white and yellow markings have performed better than the surface applied material to this point. The retroreflectivity values for the majority of the recessed lines remain quite high. The lower results obtained on the surface applied lines do not differ much from similar durable marking materials applied on Vermont's highways. Over this same time period the recess markings exhibit durability ratings averaging 7 compared with an average of 5 for the surface applied markings. It is interesting to note that the surface applied material (both yellow and white) has a wider range in their readings than that which is recessed. This difference may be due to varying depths of the recesses in the test area or other factors unknown at this time. Generally it can be stated that recessing pavement markings can be considered beneficial for extending the performance of the product. Additional readings will be taken to confirm or refute these findings and to better describe the performance of the markings.

Disclaimer

“The information contained in this report was compiled for the use of the Vermont Agency of Transportation. Conclusions and recommendations contained herein are based upon the research data obtained and the expertise of the researchers, and are not necessarily to be construed as Agency policy. This report does not constitute a standard, specification, or regulation. The Vermont Agency of Transportation assumes no liability for its contents or the use thereof.”

**Recessed White Polyurea - Retroreflectivity Readings
Installed July 2003**

	Jul-03	Nov-03	Apr-04	May-04	Aug-04	Oct-04	May-05	Jul-05	Sep-05
TS1	899	890	463	266	769	446	297	365	337
	958	853	308	288	729	572	350	377	353
	987	947	467	214	840	635	317	253	398
	761	832	447	263	795	521	282	326	396
	939	887	476	321	780	546	243	293	430
TS2	1018	514	277	292	355	240	161	126	152
	828	565	251	238	285	246	115	96	117
	894	521	203	195	237	196	128	106	99
	1004	488	215	183	206	172	89	85	85
	823	507	166	172	173	193	111	86	102
TS7	908	704	164	147	195	168	76	44	56
	916	671	134	136	115	114	64	37	50
	998	668	142	139	124	115	59	37	47
	974	568	159	149	118	124	58	30	46
	665	607	159	157	139	123	56	31	49
TS8	1001	825	234	357	367	301	156	60	115
	983	919	444	478	423	428	176	44	154
	1006	844	329	366	351	361	148	46	134
	1063	981	464	414	441	410	177	36	146
	858	984	408	398	382	377	184	34	164

Ave	924.15	738.75	295.50	258.65	391.20	314.40	162.35	125.60	171.50
Median	948.50	764.50	264.00	250.50	353.00	273.50	152.00	72.50	125.50
Std Dev	98.22	174.99	129.67	103.28	253.50	169.30	91.95	122.17	131.74

**APPENDIX A- RETROREFLECTIVITY VALUES – I-189, SOUTH BURLINGTON
RECESSED WHITE EDGE LINES**

**Surface-Applied White Polyurea - Retroreflectivity Readings
Installed July 2003**

	Jul-03	Nov-03	Apr-04	May-04	Aug-04	Oct-04	May-05	Jul-05	Sep-05
TS3	1091	915	149	132	142	150	83	78	73
	1020	809	174	168	186	166	111	95	102
	915	733	190	181	202	212	113	97	97
	1033	816	211	189	203	208	115	96	100
	954	761	186	154	172	144	85	80	72
TS4	790	654	145	142	157	131	95	92	103
	1038	874	75	101	119	105	79	71	86
	1063	920	60	72	101	96	70	75	77
	1020	971	75	98	98	97	59	52	66
	1023	947	80	83	88	90	58	37	58
TS5	641	904	147	170	174	145	81	68	78
	746	715	138	133	147	133	73	70	71
	650	738	137	170	152	135	70	67	68
	774	826	110	110	117	112	70	64	64
	940	980	139	139	149	129	93	62	102
TS6	977	513	109	119	104	97	56	43	44
	924	558	98	106	98	82	57	42	46
	981	584	131	139	116	99	62	47	47
	930	649	*30	87	87	73	51	36	33
	983	571	141	136	120	105	51	35	35

Ave	924.65	771.90	131.32	131.45	136.60	125.45	76.60	65.35	71.10
Median	965.50	785.00	138.00	134.50	131.00	120.50	71.50	67.50	71.50
Std Dev	133.46	147.54	41.97	34.03	37.17	38.09	20.34	20.80	22.59

**APPENDIX B- RETROREFLECTIVITY VALUES – I-189, SOUTH BURLINGTON
SURFACE-APPLIED WHITE EDGE LINES**

**Recessed Yellow Polyurea - Retroreflectivity Readings
Installed July 2003**

	Jul-03	Nov-03	Apr-04	May-04	Aug-04	Oct-04	May-05	Jul-05	Sep-05
TS1	862	598	285	670	352	310	247	279	322
	868	424	385	710	395	403	175	282	338
	770	395	264	712	267	459	355	412	502
	641	450	246	732	304	360	245	209	309
	841	456	439	667	366	369	262	288	423
TS2	758	651	316	284	335	280	246	198	225
	789	724	132	183	210	180	154	178	186
	826	693	257	295	349	369	259	292	339
	834	687	456	462	460	529	433	458	484
	784	722	502	485	654	509	404	258	447
TS7	807	688	505	403	603	772	537	505	703
	696	730	447	541	714	730	504	654	678
	756	707	590	634	760	806	646	647	712
	687	747	488	509	732	750	477	538	582
	782	607	472	512	673	611	479	456	656
TS8	786	818	567	686	654	701	563	506	575
	838	744	649	643	726	745	581	520	525
	796	687	699	714	754	723	542	486	556
	783	703	635	688	642	692	599	601	633
	731	717	690	738	760	717	691	644	661

Ave	781.75	647.40	451.20	563.40	535.50	550.75	419.95	420.55	492.80
Median	785.00	690.50	464.00	638.50	622.50	570.00	455.00	457.00	513.50
Std Dev	59.05	121.02	161.98	167.36	193.67	196.12	165.82	159.98	162.93

**APPENDIX C- RETROREFLECTIVITY VALUES – I-189, SOUTH BURLINGTON
RECESSED YELLOW EDGE LINES**

**Surface-Applied Yellow Polyurea - Retroreflectivity Readings
Installed July 2003**

	Jul-03	Nov-03	Apr-04	May-04	Aug-04	Oct-04	May-05	Jul-05	Sep-05
TS3	933	665	242	161	195	227	183	175	194
	857	681	229	121	210	163	163	154	139
	774	681	231	129	219	179	199	190	162
	842	694	196	112	188	145	120	101	144
	867	673	229	152	216	211	213	180	149
TS4	731	597	60	69	70	62	38	32	33
	804	494	47	58	57	47	31	25	23
	933	553	40	45	48	46	28	21	22
	881	484	38	44	50	32	25	17	18
	863	477	48	42	41	37	27	19	20
TS5	861	596	138	121	147	151	77	74	85
	827	456	144	129	141	166	86	93	100
	877	455	178	155	167	149	93	107	114
	791	529	142	141	186	175	108	100	100
	775	417	142	101	141	145	86	86	71
TS6	807	696	253	213	261	258	322	303	331
	786	713	194	175	196	200	152	170	126
	792	768	167	146	166	152	164	147	150
	830	735	134	115	121	154	103	97	92
	830	646	164	135	139	144	144	121	123

Ave	833.05	600.50	150.80	118.20	147.95	142.15	118.10	110.60	109.80
Median	830.00	621.50	154.00	125.00	156.50	151.50	105.50	100.50	107.00
Std Dev	52.42	108.68	71.73	46.69	65.23	65.07	76.46	72.72	74.21

**APPENDIX D- RETROREFLECTIVITY VALUES – I-189, SOUTH BURLINGTON
SURFACE-APPLIED YELLOW EDGE LINES**