Report No. UT-05.07

Annual Experimental Features Report

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Utah Department of Transportation
Research Division

June 2005

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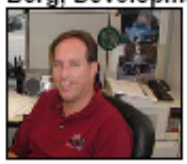

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Experimental Feature

Final Reports

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Lumimark Pavement Marking System

Final Report

Experimental Features X(00)02 & X(00)04

By: Dan Avila, P.E., Development Engineer (former)
Ken Berg, P.E., Development Engineer
Barry Sharp, Research Specialist

Utah Department of Transportation
Research Division

June 2005

INTRODUCTION

The Lumimark Traffic Marking System, an innovative durable pavement marking formerly manufactured by Master Builders Technologies (MBT), was introduced to the Utah Department of Transportation (UDOT) with the installation of two test sections in the summer of 2000. Lumimark is a polymer-modified cementitious portland cement concrete pavement striping system designed for white and yellow applications. Its claimed advantages include a stronger bond and thermal compatibility with the concrete pavement, durability and cost-effectiveness (compared to other high performance systems) and retro-reflectivity equal to or higher than that of other markings.

This interim report presents a brief description of each test site, including the exact location of each experimental feature and pavement marking performance results (retro-reflectivity and colorimeter readings).

BACKGROUND

This report presents information gathered during a manufacturer plant visit, where newly acquired production equipment was showcased and product preparation, apportioning and mixing was demonstrated. Also presented herein are the results of two field test sections that were installed and evaluated following the plant visit.

LOCATIONS

Region Two

A 156 m (511.8 ft) test section of the Lumimark Traffic Striping System is located near the Salt Lake International Airport. The test section was chosen based on several parameters including roadway condition and geometry, pavement age, traffic, and accessibility. The test section's exact location is on the westbound North Temple off-ramp to Airport/I-80 Westbound, between STA 1234+10 (by the *Airport Info: Tune Radio to 1200 AM* green sign) and STA 1238+00 (by the Surplus Canal bridge). This two lane portland cement concrete pavement road was built around 1987 and remains in excellent condition, showing no signs of faulting or rutting across traveled lanes and shoulders. Both lanes were restriped during test section installation, including the solid yellow shoulder line, the white skip line and the solid white shoulder line on the right hand side of the road.

Region Three

Another 152 m (498.7 ft) test section of the Lumimark Traffic Striping System is located along University Avenue, near 1200 South in Provo (UDOT Region Three). The test section was chosen based on several parameters including roadway condition, pavement age, traffic, and accessibility. This Experimental Feature is situated on Southbound University Avenue just before the 1200 South intersection in East Bay. Lumimark traffic markings were placed between STA 123+40 (by the parking area North

of Wendy's parking lot located on the West side of University Ave) and STA 118+33 (near the entrance to the car wash South of the old Shoney's parking lot). This two lane (plus median turnaround lane) PCCP road was built in 1994 and remains in excellent condition, showing no signs of faulting or rutting across either the traveled lanes or the shoulders. During the test section installation both lanes were restriped, including the solid yellow turnaround lane line, the inside and the outside white skip lines.

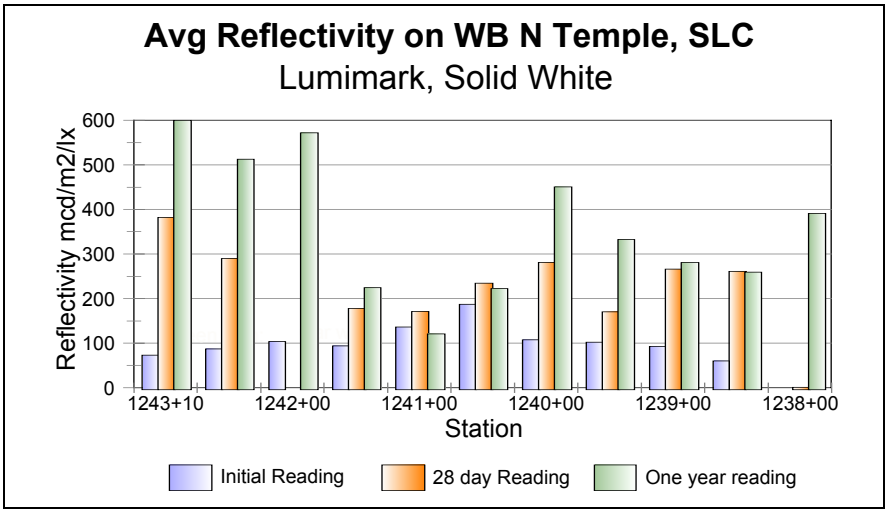
FIELD DATA

Region Two

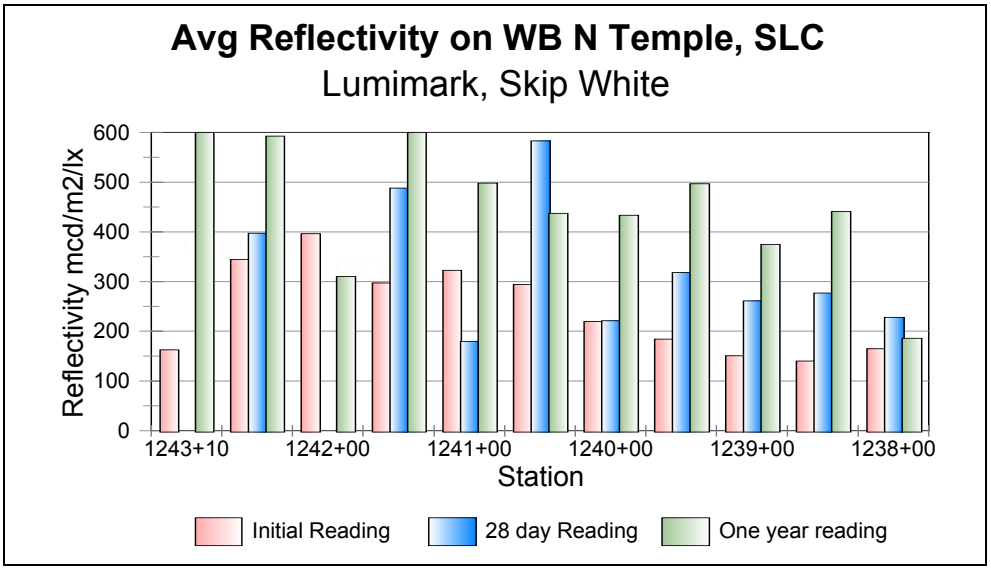
Retro-reflectivity

UDOT/MBT field data readings include retro-reflectivity (mcd/m^2/lux, using an LTL 2000 Retrometer, by Delta) and yellowness index (using a MiniScan Spectrocolorometer, by Hunter). As indicated in the graphs, retro-reflectivity readings after installation were not as high as what was observed in new installations of competing traffic markings. However, there has been a considerable increase in retro-reflectivity after the markings were placed. When comparing the average retro-reflectivity reading of the solid white line 28 days after installation (244 mcd/m^2/lux) to the average retro-reflectivity after one year of traffic exposure (367 mcd/m^2/lux), a net increase of 50% occurred. (see Graph 1).

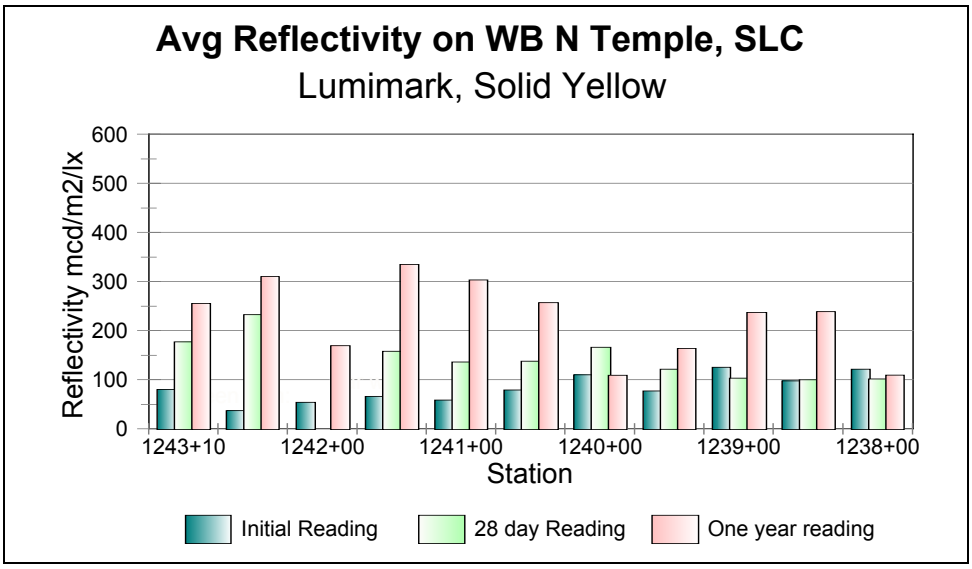
Similarly, the white skip line increased from 328 mcd/m^2/lux (28 days following installation), to 462 mcd/m^2/lux, just over a 40% increase in retro-reflectivity. (see Graph 2). The most significant change was observed on the solid yellow line, with a 58% increase in retro-reflectivity as shown in Graph 3 (from an average of 144 mcd/m^2/lux to 226 mcd/m^2/lux). This steady increase in retro-reflectivity can be attributed to normal wear of the marking surface by traffic and snow plowing operations, having a refreshing effect on the glass beads held within the material matrix.



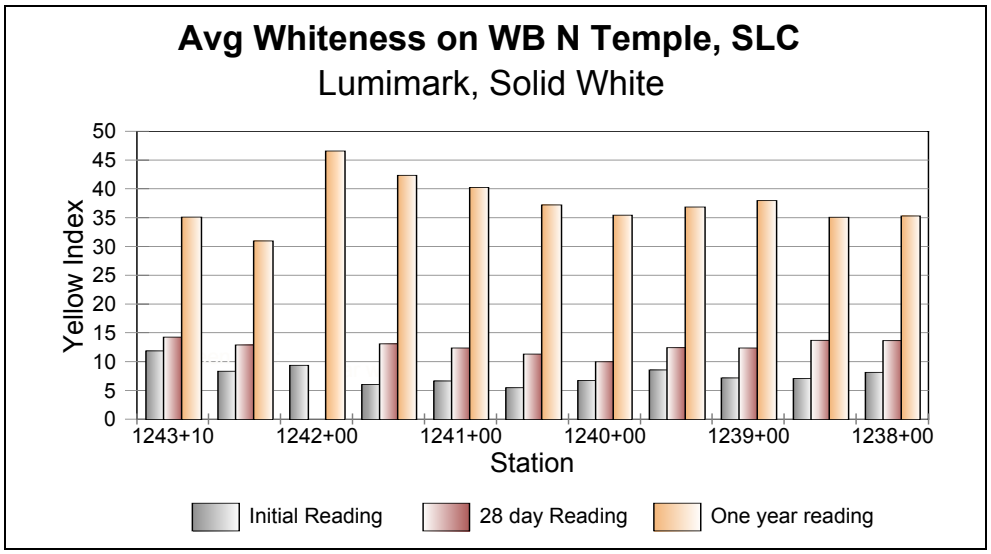
GRAPH 1. REGION TWO



GRAPH 2. REGION TWO



GRAPH 3.REGION TWO



GRAPH 4. REGION TWO

Observations

The preceding analysis was based on a quantitative approach, using retro-reflectivity data obtained during field evaluations. This section presents physical data gathered during empirical observations, in an effort to provide a more qualitative approach. A closer look at the Lumimark pavement marking material installed near the Salt Lake International Airport revealed the pavement markings remain in good condition, with no signs of delamination, spalling or debonding (See Figure 1). Radial cracking was present in some areas, typical of shrinkage effects during cure of a polymer-modified cementitious material. No indications, however, of structural damage.

Soundings using a chain revealed one air pocket (or void) where a hairline fissure was visible and under which a concrete crack appeared (small, isolated edge failure; see Figures 2 and 3). No other surface deficiencies were apparent. An evenly cut groove on the existing PCCP provided good material and substrate adhesion, evidenced in the clean profile shown in Figure 4. Small air intrusions were occasionally manifested as small surface flaws, having no detrimental effects on bonding and adhesion (Figures 5 and 6).

Despite high retro-reflectance values, certain areas exhibited an obvious difference in pavement marking visibility to the naked eye. Contrast, for example, the highly reflective surface shown in Figure 7 with the duller striping appearance depicted in Figure 8. Retro-reflectivity values in this zone were substantially lower than their counterparts throughout the test section (as shown in Graphs 2 and 3). Overall glass bead retention was good, with some open voids (craters) on the matrix towards the end of the test section, perhaps due to heavy plow action. This is also apparent from some scuffing and color variation at the surface of the marking, which left dark spots (of lower retro-reflectivance) where bead-refreshing action does not appear to have taken place. This dulling effect, however, should not be mistaken for surface discoloration (see Figures 9 and 10).

Figure 2. LUMIMARK PAVEMENT MARKING NEAR SALT LAKE INT'L. AIRPORT

Figure 1. HAIRLINE CRACK NEAR EDGE FAILURE CONTAINING AIR POCKET

Figure 3. HAIRLINE CRACK NEAR EDGE FAILURE CONTAINING AIR POCKET

Figure 4. CLEAN PROFILE DENOTES GOOD INSTALLATION TECHNIQUE

Figure 5. SMALL FLAW ON PAVEMENT MARKING SURFACE

Figure 6. SMALL FLAW ON PAVEMENT MARKIGN SURFACE

Figure 7. BRIGHT LUMIMARK PAVEMENT MARKING NEAR SALT LAKE INT'L. AIRPORT

Figure 8. DULLER LUMIMARK PAVEMENT MARKING NEAR SALT LAKE INT'L AIRPORT

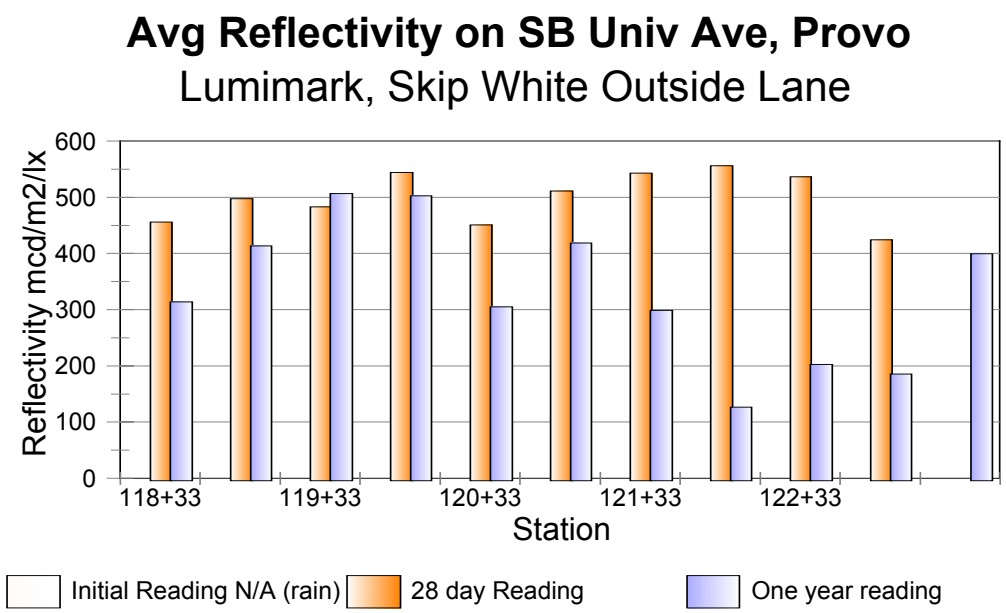
Figure 9. SNOW PLOW WEAR ON LUMIMARK PAVEMENT MARKING

Figure 10. SNOW PLOW WEAR ON LUMIMARK PAVEMENT MARKING

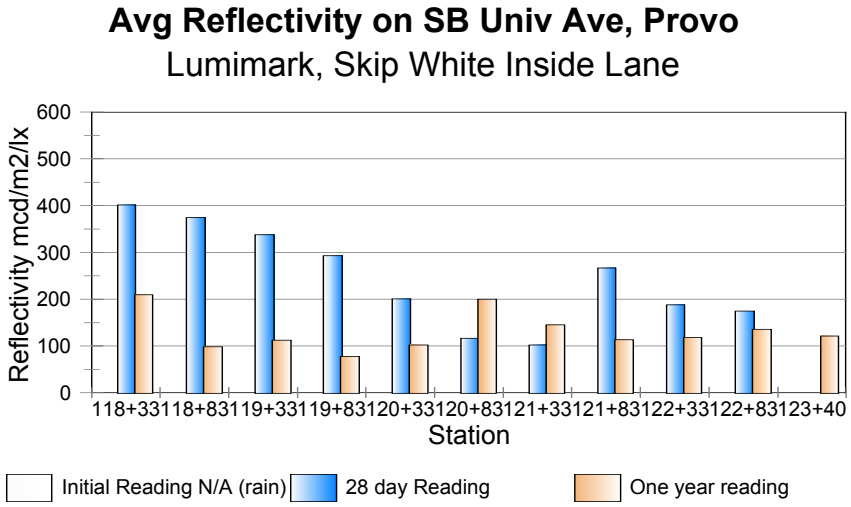
Region Three

Retro-reflectivity

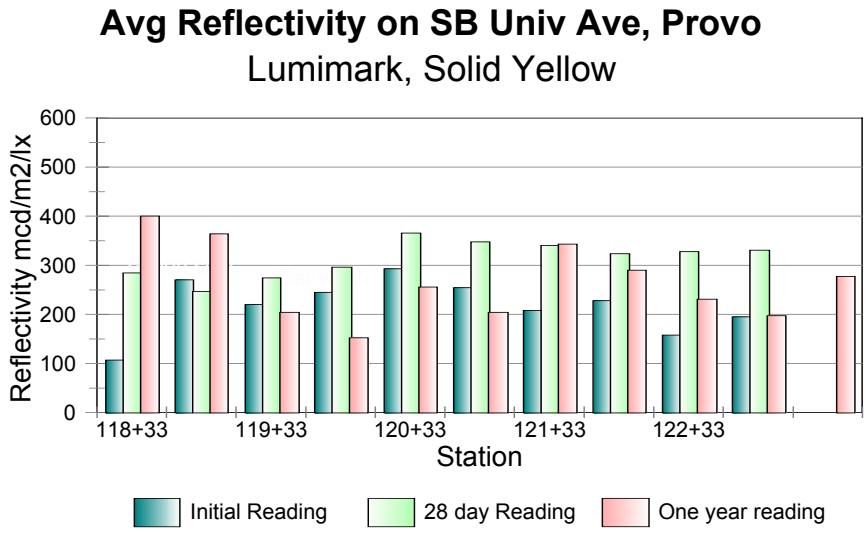
Production work in Region Three took place under rainy conditions (both skip white and solid white were installed during the second placement night, with rainy conditions throughout the night into the early morning. As a result of the prevailing weather, minor adjustments were made to the mix, pushing for a faster cure time. This made the material slightly less workable, leaving a finished product of rougher and duller appearance. Lingering rain did not allow for any retro-reflectivity readings immediately after cure of the white skip lines (as a wet surface greatly distorts the readings obtained by the instrument). However, comparing retro-reflectivity data gathered 28 days after installation and one year after installation, a decrease of about 27% (from 455 to 334 mcd/m^2/lux) is evident in the skip white outside lane markings (see Graph 5). Graph 6 displays an even higher reduction in the skip white inside lane line, with a decrease of just over 40% retro-reflectivity (from 222 to 129 mcd/m^2/lux). Even the solid yellow line shows a decrease in reflectivity, dropping from 285 to 265 mcd/m^2/lux (7 % reduction; see Graph 7).



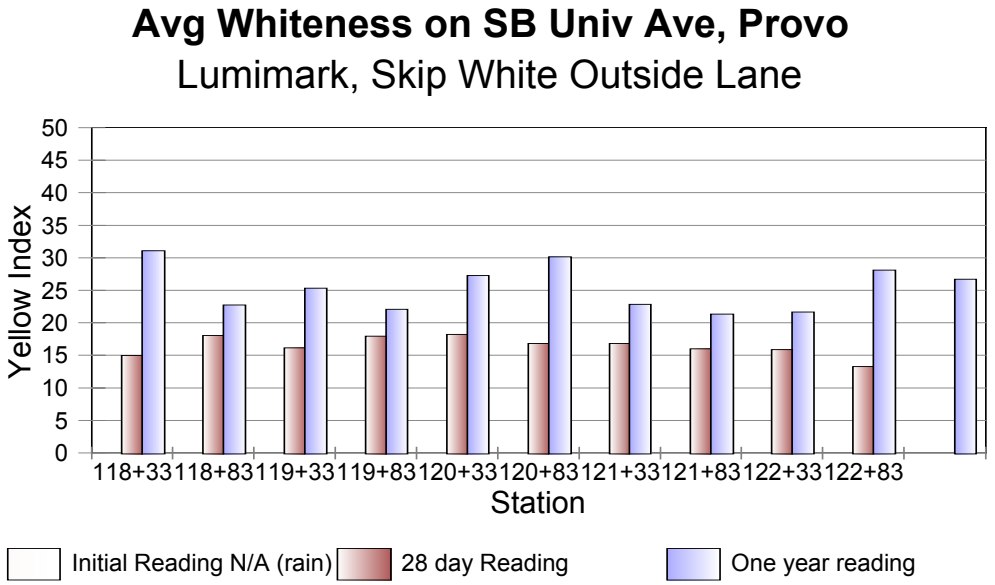
GRAPH 5. REGION THREE



GRAPH 6. REGION THREE



GRAPH 7. REGION THREE



GRAPH 8. REGION THREE

Observations

Pavement markings found in good condition, with no apparent signs of delamination, spalling or debonding. Only radial cracking found throughout the test section, typical of cementitious materials as a result of shrinkage during cure. Only one area showed spider cracks along the marking but no structural damage was apparent. Soundings made using a chain revealed no air pockets or voids in the markings. Bead retention was good, with minimal open voids (craters) on the matrix. Plowing effects apparent by some scuffing and color fading at the surface of the markings. Lower than typical retro-reflectivity values for this section can be mostly attributed to a rough, uneven marking surface and bead distribution due to an overly dry mix during damp weather installation.

CONCLUSIONS

The Lumimark Traffic Striping System was installed during the summer of 2000 in Regions Two and Three, using prototype walk-behind equipment. Lingering rain during the second installation night in Region Three caused some concern about product applicability, proper cure time before exposure to traffic, and final quality (reportedly, this being the first Lumimark product application in damp conditions). Despite the less-than-ideal weather conditions in Provo, both installations have shown good adhesion, with no signs of stress or delamination.

Data analysis reveals a divergence in reflectivity trends between the two test sections. While the Lumimark traffic markings in Region Two increased or maintained their retro-reflectivity over time, the opposite trend was seen in Region Three. This phenomenon can be attributed in part to product mixing and application inconsistencies under rainy

conditions in Provo, which ultimately affected the product's look, texture and ability to reflect light. Moreover, different plowing techniques, intervals and traffic conditions between test sections could lead to variations in traffic marking surface wear, thus reducing the refreshing effect of the glass beads held within the material matrix.

RECOMMENDATIONS

This product was reviewed in May 2005 for durability through visual inspection and there has been no significant wear or deterioration due to the inlay approach for this installation. Both the Provo Center Street and the Westbound North Temple installation were inspected and it is recommended that a new line should be applied over the test and this should maybe be done on the North Temple site also.

Reflective readings were performed using the LTL 2000 Reflectometer and the white solid line averaged 34 mcd/m squared/lux, the white skip lines averaged 69 mcd/m squared/lux and the yellow line averaged 34 mcd/m squared/lux all of there are well below the established minimum that may range from 100 to 125 readings.

Although the Lumimark Traffic Marking System is currently not available on the market, based on present performance, the Development Section feel this was a very good research project with a brand new durable application for traffic marking. However, the bead use requires more investigation and the cost must prove to be competitive with current UDOT traffic marking applications. If the product becomes available in the future, and the cost is more competitive, more evaluation is recommended.

FLY ASH USED IN PARKING LOTS FOR THE 2002 WINTER OLYMPICS

FINAL REPORT

Experimental Feature X(01)02 – New Products

By: **Barry Sharp, Research Specialist**
Robert Stewart, P.E., Development Engineer

Utah Department of Transportation
Research Division

June 2005

Introduction

The ski jumping events were held near Kimball's Junction (Winter Sports Park). This venue was built for the Olympics and post-Olympic parking requirements were relatively minor. However, during the Olympics there was a need to accommodate parking for the spectators. These parking lots had to be temporary since the demand was limited to two weeks.

In mid year of 1999, the Salt Lake Olympics Committee (SLOC) commissioned the Utah Department of Transportation, Research Division to develop a short term strategy for the parking lot at Kimball's Junction to accommodate the anticipated vast numbers of international winter sports enthusiasts. The existing soils at the selected site would not support any of the original strategies proposed. Soil samples were taken from the site and California Bearing Ratios (CBR's) run. The average was 3% of the standard, not enough to qualify as a passable sub-grade. This loamy material was three feet deep over the entire site of the proposed parking lot. The cost to remove, store and bring back this material proved prohibitive (300,000 yd^3 @ $ 4.00 per yields yd^3 $1,200,000.00)

Budgets for the Olympics were already tight and $1.2 million seemed wasteful since it was essentially digging a hole, filling it, and then re-digging the hole just to re-fill it. The Olympics Committee desired to build a temporary parking lot and remove the parking enhancers at a cost effective rate. Fly ash, a sub-grade enhancer, was deemed more cost-effective for this project.

Background Information

Enhancing soils using fly ash is not a new application and has been used occasionally for capping hazardous materials and where there is no suitable sub-grade.

Goal

The goal of this research was to find a cost-effective soil enhancer for temporary parking lots.

Objectives

The objectives of this project were:

1. Develop soil enhancement strategies.
2. Place and evaluate a test section for performance.
3. Recommend soil enhancement for entire parking lot.
4. Monitor the performance during Olympics.

5. Evaluate the return to natural conditions.

Results

Develop Soil Enhancement Strategies

Some strategies were developed in the laboratory to possibly enhance this marginal material and strengthen it. Based on CBR values three strategies resulted:

Strategy # 1 20% by weight of lime added to the existing material yielded 8.8% of Standard, not suitable for sub-grade.

Strategy # 2 20% by weight of fly-ash added to the existing material yielded 25.3% of Standard, more than suitable for sub-grade.

Strategy # 3 15% by weight of fly-ash to the existing material yielded 21% of Standard, more than suitable for sub-grade.

Place and Evaluate a Test Section for Performance

At the proposed site of the Winter Sports Park parking lot a 30,000 square foot test site was selected. The section was divided in half. For the first half, 15% fly ash (by weight) was mixed in-place with a roto-mill machine. The top 10 inches of native soil was milled with water and fly ash, then processed and rolled to maximum density. 4" of UTBC was then placed, finished and compacted.

The second half was processed in the exact same manner except that a geofabric was added. The goefabric chosen was BX 110, Tensar and was placed between the processed sub-grade and the 4" of compacted UTBC. Both of these strategies were evaluated for a season. Both strategies supported all types of heavy equipment traffic for a year and showed no signs of failure.

Recommend Soil Enhancement for Entire Parking Lot

Research recommended the use of 15% fly ash without the use of the geo-fabric. However, Sear Brown, the design consultants for the parking lots thought the geo-fabric added conservatism, which was justified due to the importance of success. Therefore, 15% fly ash plus the geofabric was used as the soil enhancement method on the entire project. Some locations differed from the test section in that 6 inches of UTBC and asphalt paving were used in the severe application areas (bus stops) for the Winter Sports Park Olympic parking lot.

Monitor the Performance During Olympics

There were no reported instances of failure during the Olympics. Cold temperatures probably helped since the ground remained frozen during the Olympics.

Figure 1-During Olympics

Figure 2-Just after Olympics

Evaluate the Return to Natural Conditions.

The return to natural conditions included removing the UTBC and the geofabric from the site. There were some problems removing the geofabric. The contractor found he could not simply pull up the fabric using equipment. The result was a bulldozer had to remove the UTBC and fabric together, and the geofabric was removed manually.

Figure 3-Pictures of Parking Lot after 1 Year (12/02)

Figure 4-Pictures of Parking Lot after 4 Years (6/05). Note the reestablished vegetation.

Once the UTBC and geofabric were removed, the soil was cultivated and the natural environment began taking over. As seen in Figure 4 (June 2005), four years after the event, the vegetation has been reestablished.

Conclusions

The Kimball's Junction parking lot performed as expected and the problems encountered in maintaining it were minimal. There was a slight problem in removing the geofabric however, the additional cost was not truly prohibitive and the strategy worked well.

Recommendations

The site consisted of 80 acres of poor soils and had to be graded and the section built to the satisfaction of the design team, owners and SLOC. The application of fly ash was a unique process that lent itself to restoring the complete site after the UTBC, geo-tech fabric and asphalt had been removed. All that had to be done was to lightly process the ground/soil by scarifying the 10" section of fly ash to finish grade. Fly ash is by nature a non-hazardous by product from coal-fired power plants and worst case may be a nuisance dust, however, properly handled there is no problem in using it for this or other similar applications.

Appendix

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Rapid Pavement Patch

Final Report

Experimental Feature X(01)03

By: Barry Sharp, Research Specialist
Ken Berg, P.E., Development Engineer

Utah Department of Transportation
Research Division

June 2005

SUMMARY

Early 2001 Ure-Fast PF 60, a concrete pavement patching material, was installed on two routes: SR 201 on a structure deck over 3200 West, and I-215 NB in various locations close to the 2100 South interchange. Region Two Maintenance funded this project and Central Maintenance was going to evaluate the installations.

During installation the material required a special applicator and consisted of a multi-flow material mixed in the tip that created a hot epoxy like product when it set. The applied material set quite rapidly and there was very little interruption in the traffic flow.

The first two years yielded remarkable success and there was very little degradation. The third year; however, the surrounding concrete began to fail and caused the Ure-Fast to fail also.

There are at least two schools of thought on why this happened but they are purely subjective.

Central Maintenance deemed the project a success but as yet has not proceeded to buy the $20,000 necessary application equipment.

Appendix

See Instruction block at bottom before starting to fill out form.

1. *Product Trade Name:* Ure-Fast PF-60 Date 5/1/2000

   Manufacturer/Co. Ure-Fast Industries Patented? ☐Yes ☐No ☐Appl

   Company Contact K.C. Sullivan Ph#: 800 201 9300 Fax # 206 575 3

   Street Address: P.O. Box 16782

   City Seattle State: WA Zip Code: 998116

2. Local Contact: Sullivan Supply Ph#: 800 201 9300 Fax # 206 575

   Local Address *(Distributor)* P. O Box 16782

   City Seattle State: Wash Zip Code: 998116

3. Background description of Company and its product:

4. Product Identification:

5. Recommended use of product: Product is a two part urethane pothole and spall repair process for concrete or asphalt

6. Outstanding Features or Advantages Claimed:

7. General Composition of Material: **(Attach laboratory report when applicable)**

8. When Introduced on Market? Alternate for what existing product(s)?

9. Approx. cost: $ $1.00 per POUND (unit). Delivery at site ____ days after receipt of order.

   If cost is "job-by-job" give typical price range to expect...$ ____ TO $ ____

10. Does your product meet requirements of the following specifications? Please write the specifical classification and type or subgroup when appropriate (i.e. AASHTO M 148, Type I D, Class A

AASHTO	UDOT Materials Test for Bond and Durability
ASTM	
FEDERAL	
UDOT	

Category: J.1 Horizontal

Sign Sheeting – Nippon Carbide

Final Report

Experimental Feature X(02)01 – New Products

By: Barry Sharp, Research Specialist
Ken Berg, P.E. Development Engineer

Utah Department of Transportation
Research Division

June 2005

SUMMARY

On Dec. 10, 2001, Robert Hull, P.E., Engineer for Traffic and Safety, queried the Research Division regarding a comparitive analysis of "Nikkalite" brand encapsulated retro-reflective sign sheeting manufactured by Nippon Carbide Industries, Inc., and high intensity sign sheeting manufactured by 3M Company. The following summarizes the response from the Research Division.

- The Nikkalite brand meets or exceeds the current UDOT, CSI Standard 02891, 2.1,E. This specification refers to the Federal Standards for Construction of Roads and Bridges on Federal Highway Projects, FP-85 and FP-92.

- UDOT has not conducted a comparative field test of the product with the 3M Company product. Test results are available, however, from other sources.

- The product is certified to meet the current criteria for NPEP and construction use and Nippon Carbide will match 3M's warranty with regard to the current procurement specification.

- Nippon has been furnished the construction criteria and has certified that the product meets the required reflectivity value. Warranty and customer service, etc. per procurement is according to criteria set by the Traffic & Safety Division.

- Nippon Carbide has completed our standard process for a new product. The product was approved in mid 2001 and accepted after letter of June 2001 was responded to with the required information regarding outside durability and certification.

Appendix

See Instruction block at bottom before starting to fill out form.

1. *Product Trade Name:* Nikkalite Encapsulated Lense Sheeting Date 6/1/2001

Manufacturer/Co. Nippon Carbide Industries (USA) Patented? ☐Yes ☐No ☐Appl

Company Contact James Hu Ph#: 310 632 7500 Fax #: 310 632

Street Address: 3136 E. Victoria Street

City Rancho Dominguez State: CA Zip Code: 90221

2. Local Contact: None Ph#: Fax #:

Local Address *(Distributor)*

City State: Zip Code:

3. Background description of Company and its product:

4. Product Identification:

5. Recommended use of product: Product is a high intensity, encapsulated lens retroreflective sign sheeting of three colo varity of adhesives.

6. Outstanding Features or Advantages Claimed:

7. General Composition of Material: **(Attach laboratory report when applicable)**

8. When Introduced on Market? Alternate for what existing product(s)?

9. Approx. cost: $ $2.50 per SQUARE FO (unit). Delivery at site days after receipt of order.

If cost is "job-by-job" give typical price range to expect....$ TO $

10. Does your product meet requirements of the following specifications? Please write the specificat classification and type or subgroup when appropriate (i.e. AASHTO M 148, Type I D, Class A

AASHTO
ASTM
FEDERAL
UDOT

UDOT 2002 Standard Specification 02891, Part 2.1 E

Category: X.1 Traffic Safety

Evaluate 3M Diamond Grade Sign Sheeting

Final Report

Experimental Feature X(02)02 – New Products

By: Barry Sharp, Research Specialist
Ken Berg, P.E., Development Engineer

Utah Department of Transportation
Research Division

June 2005

Summary

Early in 2002, 3M Company furnished the Traffic & Safety Sign Shop diamond grade sheeting to be placed on metal backing in the shape of directional arrows for installation in a location that exhibited the need for a more reflective back ground such as an unlighted roadway. The signs were installed on I-80 off ramp at Lake Point eastbound exit on a curve.

Visual inspection during nighttime conditions revealed the exceptional capabilities of this prismatic sheeting developed and marketed by 3M Company. When comparing high intensity encapsulated sign sheeting the difference was quite evident. The diamond grade sheeting, to the naked eye, created a much more suitable identity than what UDOT then used.

This small installation along with a white on green information sign installed on I-15 at MM 82 that showed “Paragonah” on the sign created ample support for further evaluation of the diamond grade and a viable improvement on our sigh background. In 2004, Traffic and Safety adopted the diamond grade as their sheeting of choice.

Appendix

Utah Department of Transportation
Research and Development Division

I.D. FILE # 04-041

PRELIMINARY INFORMATION FOR PRODUCT EVALUATION

Form R-52 (Rev. 2/04)

See Instruction block at bottom before starting to fill out form.

1. *Product Trade Name:* 3M™ HIGH INTENSITY GRADE PRISMATIC REFLECTIVE SHEETING SERIES 3930 Date: 6-21-04

   Manufacturer/Co.: 3M Patented? • Yes • No • Applied For

   Company Contact: ELLEN HARELSTAD Ph#: (651) 736-0166 Fax #: 651-733-6211

   Street Address: 3M CENTER, 235-3B-55

   City: ST. PAUL State: MN Zip Code: 55144

2. Local Contact: JUSTIN O'CONNOR Ph#: (970) 988-1481 Fax #: ___-___

   Local Address (~~Distributor~~): 3302 COURTE ALMADEN

   City: FORT COLLINS State: CO Zip Code: 80524

3. Background description of Company and its product: WORLD'S LEADING SUPPLIER OF REFLECTIVE PRODUCTS TO TRAFFIC SAFETY MARKETS.

4. Product Identification: 3930 (WHITE); 3931 (YELLOW); 3932 (RED); 3934 (ORANGE); 3935 (BLUE); 3937 (GREEN)

5. Recommended use of product: REFLECTORIZATION OF DURABLE TRAFFIC CONTROL SIGNS, WORK ZONE DEVICES AND DELINEATORS.

6. Outstanding Features or Advantages Claimed: LONG-TERM REFLECTIVITY AND DURABILITY.

7. General Composition of Material: (Attach laboratory report when applicable) CUBE CORNER OPTICS IN A TRANSPARENT RESIN, SEALED AND BACKED BY A PRESSURE SENSITIVE ADHESIVE, PROTECTED BY A LINER.

8. When Introduced on Market? 4/2004 Alternate for what existing product(s)? OTHER ASTM D4956/FP-96 TYPE III OR TYPE IV REFLECTIVE SHEETING.

9. Approx. cost: $_____ per _____ (unit). Delivery at site _____ days after receipt of order.
   PLEASE REFER TO JUSTIN O'CONNOR.
   If cost is "job-by-job" give typical price range to expect....$_____ TO $_____.

INSTRUCTIONS -- Answer ALL Questions. Use "X" to indicate choices.
Where a Question is Not Applicable, enter N/A.
Attach additional paper if needed and refer to Item No.

3M

High Intensity Grade Prismatic Reflective Sheeting

Series 3930 with Pressure Sensitive Adhesive

Market Test Product Bulletin 3930 **March 2004**

Description

3M™ High Intensity Grade Prismatic Reflective Sheeting Series 3930 is a non-metalized micro-prismatic lens reflective sheeting designed for production of reflective durable traffic control signs, work zone devices and delineators that are exposed vertically in service. Applied to properly prepared sign substrates, 3M high intensity grade prismatic sheeting provides long-term reflectivity and durability. Series 3930 sheeting is available in the following colors.

Color	Product Code
White	3930
Yellow	3931
Red	3932
Orange	3934
Blue	3935
Green	3937

Photometrics

Daytime Color (x,y,Y)

The chromaticity coordinates and total luminance factor of the retroreflective sheeting conform to Table A.

Color Test

Conformance to color requirements shall be determined by instrumental method in accordance with ASTM E-1164 on sheeting applied to aluminum test panels. The values shall be determined on a Hunter Color Flex 45/0 spectrophotometer. Computations shall be done in accordance with E-308 for the 2° observer.

Coefficients of Retroreflection (R_A)

The values in Table B are minimum coefficients of retroreflection expressed in candelas per lux per square meter (cd/lux/m²).

Table A - CIE Chromaticity Coordinate Limits* for new sheeting

Color	1		2		3		4		Limit Y (%)	
	x	y	x	y	x	y	x	y	Min.	Max
White	.305	.305	.355	.355	.335	.375	.285	.325	40	-
Yellow	.487	.423	.545	.454	.465	.534	.427	.483	24	45
Red	.690	.310	.595	.315	.569	.341	.655	.345	3	15
Orange	.550	.360	.630	.370	.581	.418	.516	.394	7	27
Blue	.078	.171	.150	.220	.210	.160	.137	.038	1	10
Green	.030	.398	.166	.364	.286	.446	.201	.794	3	9

* The four pairs of chromaticity coordinates deteremine the acceptable color in terms of the CIE 1931 standard colormetric system measured with standard illuminant D65.

Test for Coefficients of Retroreflection

Conformance to coefficient of retroreflection requirements shall be determined by instrumental method in accordance with ASTM E-810 "Test Method for Coefficient of Retroreflection of Retroreflective Sheeting" and per E-810 the values of 0° and 90° rotation are averaged to determine conformance to the R^A limits in Table B.

Table B - Minimum Coefficient of Retroreflection
R^A for new sheeting
(cd/lux/m²)

-4° Entrance Angle[2]

	Observation Angle[1]	
	0.2°	0.5°
White	360	150
Yellow	270	110
Red	65	27
Orange	145	60
Green	50	21
Blue	30	13

30° Entrance Angle[2]

	Observation Angle[1]	
	0.2°	0.5°
White	170	72
Yellow	135	54
Red	30	13
Orange	68	28
Green	25	10
Blue	14	6.0

[1]Observation (Divergence) Angle - The angle between the illumination axis and the observation axis.

[2]Entrance (Incidence) Angle - The angle from the illumination axis to the retroreflector axis. The retroreflector axis is an axis perpendicular to the retroreflective surface.

R_A for Screenprinted Colors and Overlay Films

For screenprinted transparent color areas on white sheeting, or white sheeting covered with 3M™ ElectroCut™ Film Series 1170 when processed according to 3M recommendations, the ratios of the R_A for the color to the R_A for the white shall be no less than 70% of the R_A listed for the integral color in Table B and the colors shall conform to Table A on page 1.

Adhesive

Series 3930 sheeting has a pressure-sensitive adhesive that is recommended for room temperature application. Room temperature application is defined as 65°F (18°C) or higher.

Test Methods of Adhesive and Film

Standard Test Panels

Unless otherwise specified, the reflective sheeting shall be applied according to the manufacturer's recommendations to smooth 0.063 inches (1.6mm) minimum thickness 6061-T6, 5052-H38 or equivalent aluminum panels that have been degreased and lightly acid etched. Lack of contamination of test panels must be confirmed by passing the water break test and tape snap test as described in 3M Information Folder 1.7.

Properties

Standard Conditioning: All mounted and unmounted test specimens shall be conditioned for 24 hours hours at 73°F +/- 2°F (23°C + 1°C) and 50% +/- 4% R.H. before testing.

1. Adhesion

Test Weight 1-3/4 lbs. (0.8 kg) Test Method - Apply 4" (10cm) of 1" x 6" (2.54x15cm) strip to panel and condition, face panel down and suspend test weight from free end. Requirement - Not more than 2" (5.0cm) of peel in 5 minutes.

2. Impact Resistance

Test Method - Apply sheeting to a standard panel 3" x 6" (7.6x15.2cm) and condition. Subject sheeting to a 50-inch pound (5.7Nm) impact in accordance with ASTM D-2794. Requirement - No separation from panel or cracking outside immediate impact area.

3. Shrinkage

Test Method - Following conditioning of 9" x 9" samples, remove liner, place specimen on flat surface with adhesive side up. Requirement - Shrinkage not greater than 1/32" (0.8mm) in 10 minutes or more than 1/8" (3.2mm) in 24 hours in any dimension.

4. Flexibility

Test Method - Following conditioning of 1" x 6" sample, remove liner and dust adhesive with talc. At standard conditions, holding the ends of the sample, bend in one second around 1/8" (3.2mm) mandrel with adhesive side facing mandrel. Requirement - No cracking, peeling or delamination.

5. Gloss

Test Method - Test in accordance with ASTM D523 using an 85° glossmeter. Requirement - Rating not less than 50.

Sign Fabrication Methods

Application

3M high intensity grade prismatic sheeting series 3930 incorporates a pressure sensitive adhesive and should be applied to the sign substrate at room temperature 65°F (18°C) or higher by any of the following methods:

Mechanical squeeze roll applicator - Reference 3M Information Folder 1.4 (Room temperature application)

Hand squeeze roll applicator - Reference 3M Information Folder 1.6

Hand Application

Hand application is recommended for legend and copy only. Application of sheeting for complete signs or backgrounds must be done with a roll laminator, either mechanical or hand. See 3M Information Folder 1.5 for more details.

Hand applications will show some visual irregularities that are objectionable to aesthetically critical customers. These are more noticeable on darker colors. To obtain a close-up uniform appearance, a roll laminator must be used.

Splices

Series 3930 sheeting should be butt spliced when more than one piece of sheeting is used on one piece of substrate. The sheeting pieces should not touch each other at the splice and a gap of up to 1/16" is acceptable. This is to prevent buckling as the sheeting expands in extreme temperature/humidity exposure. If the visual appearance of the splice is important or a slight gap is undesirable, the following procedures must be followed:

1. Overlap the sheeting at least one inch, with or without the liner attached.
2. Using a straight edge and a sharp utility knife, cut through both layers of reflective sheeting.
3. Peel back and remove cut remnants. If liner was left on, remove and roll down remaining sheeting.
4. Seal edge with thinned 3M™ Process Color 880I Clear using a fine artist paintbrush.

Double Faced Signs - Series 3930 sheeting on the first side must be protected by damage from the steel bottom roll of squeeze roll applicators with FR-2 sponge rubber and SCW 568.

Substrates

For traffic sign use, product application is limited to properly prepared aluminum (see 3M Information Folder 1.7), with the exception that extrusions are to be trimmed rather than wrapped, and flat panel signs are to be carefully trimmed so that sheeting from adjacent panels do not touch on the assembled signs. Users are urged to carefully evaluate all other substrates for adhesion and sign durability. Series 3930 sheeting is designed primarily for application to flat substrates. Any use that requires a radius of curvature of less than five inches should also be supported by rivets or bolts. Plastic substrates are not recommended where cold shock performance is essential. Sign failures caused by the substrate or improper surface preparation are not the responsibility of 3M.

Screen Processing

Series 3930 sheeting may be screen processed into traffic signs before or after mounting on a sign substrate, using 3M™ Process Colors Series 880I (see Product Bulletin 880I). Series 880I process colors can be screen processed at 60 - 100°F (16-38°C) at relative humidity of 20-50%.

A PE 157 screen mesh with a fill pass is recommended. See 3M Information Folder 1.8 for details. Use of other process colors series is not recommended. 3M assumes no responsibility for failure of sign face legends or backgrounds that have been processed with non-3M process colors or 3M process colors other than those listed above.

Care should be taken to avoid flexing Series 3930 sheeting before and especially after screening to eliminate the possibility of cracking from improper handling techniques.

Cutting and Matching

The sheeting may be hand cut or die cut one sheet at a time, and band sawed or guillotined in stacks.

Series 3930 sheeting can be hand cut from either side with a razor blade or other sharp hand tool. Like all reflective sheetings, when two or more pieces are used side by side on a sign, they must be matched to assure uniform day color and night appearance.

Cutting equipment such as guillotines and metal shears, that have pressure plates on the sheeting when cutting, may damage the optics. Padding the pressure plate and easing it down onto the sheets being cut will significantly reduce damage.

Maximum stack height for cutting Series 3930 sheeting is 1-1/2" or 50 sheets. Details on cutting can be found in 3M Information Folder 1.10.

Multi-piece signs should have all panels or pieces oriented identically for uniform appearance under all viewing conditions (arrow and the seal pattern in the same direction).

Edge sealing Series 3930 sheeting is generally not required. Following extended exposure, airborne dust particles may become trapped within the row of cut cells along the sheeting edge. This should have no adverse effect on sign performance. If the user chooses to edge seal, series 8801 process color should be used.

Cleaning

Signs that require cleaning should be flushed with water, then washed with a detergent solution and bristle brush or sponge. Avoid pressure that may damage the sign face. Flush with water following washing. Do not use solvents to clean signs. See 3M Information Folder 1.10.

Storage and Packaging

Series 3930 sheeting should be stored in a cool, dry area, preferably at 65-75°F (18-24°C) and 30-50% relative humidity and should be applied within one year of purchase. Rolls should be stored horizontally in the shipping carton. Partially used rolls should be returned to the shipping carton or suspended horizontally from a rod or pipe through the core. Unprocessed sheets should be stored flat. Finished signs and applied blanks should be stored on edge. Screen processed signs must be protected with SCW 568 slipsheet paper. Place the glossy side of the slipsheeting against the sign face and pad the face with closed cell packaging foam. Double-faced signs must have the glossy side of the slipsheet against each face of the sign.

Unmounted screened faces must be stored flat and interleaved with SCW 568 slipsheet, glossy side against the sign face. Packages of finished sign faces must include sufficient nylon washers for mounting. Avoid banding, crating, or stacking signs. Package for shipment in accordance with commercially accepted standards to prevent movement and chafing. Store sign packages indoors on edge.

Panels or finished signs must remain dry during shipment and storage. If packaged signs become wet, unpack immediately and allow signs to dry.

See Information Folder 1.11 for instructions on packing for storage and shipment.

Installation

Nylon washers are recommended between the heads of all twist fasteners (such as screw heads, bolts, or nuts) and the sheeting to protect the sheeting from the twisting action of the bolt heads.

Health and Safety Information

Read all health hazard, precautionary and first aid statements found in the Material Safety Data Sheet, and/or product label of chemicals prior to handling or use.

General Performance Considerations

The durability of 3M high intensity grade prismatic reflective sheeting series 3930 will depend upon substrate selection and preparation, compliance with recommended application procedures, geographic area, exposure conditions, and maintenance.

Maximum durability of Series 3930 sheeting can be expected in applications subject to vertical exposure on stationary objects when processed and applied to properly prepared aluminum according to 3M recommendations provided in 3M Information Folder 1.7 on Sign Substrate Surface Preparation.

The user must determine the suitability of any nonmetallic sign backing for its intended use.

Applications to unprimed, excessively rough or non-weather-resistant surfaces, or exposure to severe or unusual conditions can shorten the performance of such applications. Signs in mountainous areas that are covered by snow for prolonged periods may also have reduced durability.

3M process colors, when used according to 3M recommendations, are generally expected to provide performance comparable to colored reflective sheeting, except for certain lighter colors, such as yellow, gold, or heavily toned colors or blends containing yellow or gold, whose durability depends on how much of each color is used.

Dilution of color and atmospheric conditions in certain geographic areas may result in reduced durability.

3M™ ElectroCut™ Film Series 1170 can be expected to perform satisfactorily for the life of the sign when direct applied to series 3930 sheeting.

Warranty

3M warrants that 3M™ High Intensity Grade Prismatic Reflective Sheeting Series 3930 sold by 3M to be used as components for traffic control and guidance signs in the United States and Canada will remain effective for its intended use and meet the stated minimum values for coefficient of retroreflection for ten years, subject to the following provisions in:

Table C
Percentage of Table B Initial R_A Minimums Guaranteed Over 10 Year Warranty Period (Colors: white, yellow, red, green and blue)

Warranty Period	Minimum Percentage R_A Retained
1-7 Years	80%
8-10 Years	70%

- R_A percentage retained above apply to all entrance and observation angles presented in Table B, and shall be measured per ASTM E 810.

- All measurements shall be made after cleaning according to 3M recommendations. If a high intensity grade prismatic sign surface is processed and applied to sign blank materials in accordance with all 3M application and fabrication procedures provided in 3M's product bulletins, information folders, and technical memos (which will be furnished to the agency upon request), including the exclusive use of 3M matched component systems, process colors, clear coatings, electronic cuttable films, protective overlay films, and recommended applications equipment; and

If the sign deteriorates due to natural causes to the extent that: 1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by a driver with normal vision, or 2) the coefficient of retroreflection after cleaning is less than the minimums specified in Table C, 3M's sole responsibility and purchaser's and user's exclusive remedy shall be:

If the failure occurs within the first 7 years from the date of fabrication, 3M will, at its expense, restore the sign surface to its original effectiveness. If the failure occurs within the 8th through the 10th year from the date of fabrication, 3M will furnish the necessary amount of high Intensity grade prismatic sheeting to restore the sign surface to its original effectiveness.

Conditions

Such failure must be solely the result of design or manufacturing defects in the high intensity grade prismatic reflective sheeting and not of outside causes such as: improper fabrication, handling, maintenance or installation; use of process colors, thinners, coatings, or overlay films and sheetings not made by 3M; use of application equipment not recommended by 3M; failure of sign substrate; exposure to chemicals, abrasion and other mechanical damage from fasteners used to mount the sign; sign burial; collisions, vandalism or malicious mischief.

3M reserves the right to determine the method of replacement. Replacement sheeting will carry the unexpired warranty of the sheeting it replaces. Claims made under this warranty will be honored only if the signs have been dated at the time of sheeting application, which constitutes the start of the warranty period. Claims made under this warranty will be honored only if 3M is notified of a failure within a reasonable time, reasonable information requested by 3M is provided, and 3M is permitted to verify the cause of the failure.

Limitation of Liability and Remedies

3M's liability under this warranty is limited to replacement or allowance as stated herein, and 3M assumes no liability for incidental or consequential damages such as lost profits, business or revenue in any way related to the product regardless of the legal theory on which the claim is based.

THIS WARRANTY IS MADE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OF FITNESS FOR A PARTICULAR PURPOSE, ANY IMPLIED WARRANTY ARISING OUT OF A COURSE OF DEALING OR OF PERFORMANCE, CUSTOM OR USAGE OF TRADE.

Literature Reference

IF 1.3 Instructions for Squeeze Roll Applicator
IF 1.5 Hand Application Instructions
IF 1.6 Instructions for Hand Squeeze Roll Applicator
IF 1.7 Sign Base Materials
IF 1.8 Color Application Instructions
IF 1.10 Cutting, Matching, Premasking, and Prespacing Instructions
IF 1.11 Storage Maintenance, and Removal Instructions

"Standard Highway Signs, As Specified in the Manual on Uniform Traffic Control Devices", U.S. Department of Transportation, Federal Highway Administration, 1979.

FOR INFORMATION OR ASSISTANCE CALL:
1-800-553-1380

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1-800-887-3238

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Axial 2000 Pavement Marking Equipment

Final Report

Experimental Feature X(02)03 – New Products

By: Barry Sharp, Research Specialist
Ken Berg, P.E., Development Engineer (current)

Utah Department of Transportation
Research Division

June 2005

Introduction

The Utah Department of Transportation (UDOT) is proactively involved in the development and implementation of a pavement marking management program that will ensure acceptable pavement marking performance on State roads, highways and bridges.

Background Information

Durability and retro-reflectivity of pavement markings present a continuous challenge for engineers and safety managers. At this time the engineers and safety managers currently lack the effective tools for pavement marking management. This problem will be exacerbated when upcoming FHWA rule concerning minimum retro-reflective standards for pavement markings becomes effective nationwide.

UDOT Central Maintenance, in partnership with Region 2 Operations and the Research Division, are prepared to evaluate a promising computerized roadway marking management system to help mitigate the problem presented above.

Goal

The goal of this experimental feature is to collect pavement-marking data in real-time (applied marking thickness, glass bead density, air temperature, component proportioning, rate of application, pavement surface condition, etc.) and begin populating a pavement marking database.

Cost

The total cost of the Axial 2000 Pavement Marking Equipment is $65,000, the total cost from Research is $20,000. The duration of the study will be one paint season.

The supplier of this equipment is Lignco Technologies, USA, Inc., 1790 Stoney Hill Drive, Suite B2, Hudson, Ohio 44326.

System installation data will be collected. Sensor verification will happen three times randomly throughout the paint season. System performance data will be

collected throughout the season. Opinion data will be collected at the end of the paint season.

Objectives

Evaluate system performance by:

Measuring amount of time each sensor is not functioning
Randomly verifying sensor data (air temperature, truck speed, application rate, etc.) if possible
Collect opinions of users (paint crews and Central Maintenance)
Analyzing truck modifications and installation problems
Applying paint using manual and automated controls and evaluating paint performance.

Results

Tom Quintana, Traffic Marking Foreman for Region 1 comments that the device has been working satisfactorily and number two above has not been a problem. UDOT, Operations is going to equip all waterborne traffic marking truck with this equipment because of the success of the first installation.

Conclusions and Recommendations

The system has subjectively been tested and is working as well as the applicators are able to understand and apply the techniques of this tool. Additional training is recommended on any future installations.

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COMAX Pavement Marking Removal and Preparation System

Final Report

Experimental Feature X(02)10

By: Richard Sharp, Research Specialist
Ken Berg, P.E., Development Engineer

Utah Department of Transportation
Research Division

June 2005

SUMMARY

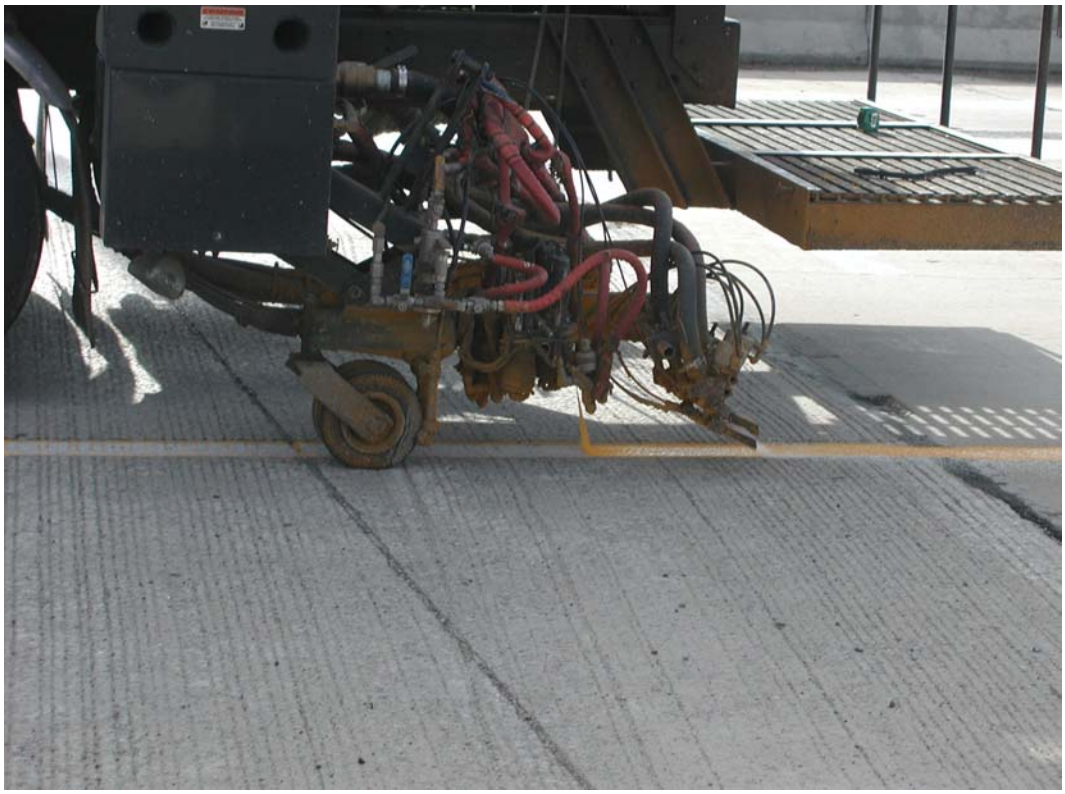
The traffic marking removal and preparation equipment is mounted on a large flat bed truck and the equipment consists of a vacuum designed to remove all dust and particles created by three diamond heads arranged in tandem. The cutting heads are set at 1/3 the prescribed depth. The width of the preparation is controlled by adding or removing diamond cutting blades. The depth of cut is automated and maintains a controlled cut to prepare the area for proposed traffic marking type, thermo plastic, epoxy, tape or poly urea for a durable traffic marking. The cuttings are contained and dust is no longer visible. With this type of operation the prepared sub-straight is clean and dust free thus increasing the potential success of the striping application.

This equipment also removes existing striping with minimal effect on the existing pavements. The equipment does compensate for the not so durable traffic marking; waterborne paint can be either inlaid at a price increase or placed on the surface. For performance of inlaid waterborne pavement markings see Experimental Feature X(04)01 Interim Report.

The contact for Comax:

Comax
8201 South State Street # 3A
Midvale, Utah 84047
Telephone: 801 565 0927
Web: Striperemoval.com
Email: Sales@Striperemoval.com

APPENDIX



Pavement Marking Protection

Final Report

Experimental Feature X(02)11 – New Products

By: Barry Sharp, Research Specialist
Ken Berg, P.E., Development Engineer

Utah Department of Transportation
Research Division

June 2005

SUMMARY

DESCRIPTION: Protect Existing Traffic Marking With a Protective Cover, Rejuvenate and Remove Protective Cover

Shana Lindsey, then Region Two Operations Engineer and Dan Betts, Region Two Striping Supervisor, initiated this study.

Utah Department of Transportation (UDOT) requires rejuvenation of asphalt pavements on a time basis and sometimes when rejuvenation is required there is still good traffic marking material that would just be covered up and then new traffic markings would be installed. This protective cover may be installed and removed to reduce the paint overs required otherwise.

The product used: 3M Company's Temporary Tape, SEPSM II

Manufacturer: 3M Company
1727 Hillside Drive
Fort Collins, Colorado 80524

This product was installed manually by Region Two pavement marking crew and when the rejuvenation was complete the tape was manually removed. Needless to say the removal was cumbersome and labor intensive but it did the job of protecting the existing markings. However it costs as much as new pavement markings.

Reflective reading were taken before and after the tape was installed. The LTL 2000 retro-reflectometer average readings were 79 before and 69 after. The information gleaned from this operation informed us of below minimum milli-candellas and not much else.

The tape was installed on I-80, westbound shoulder at Lambs Canyon plus or minus and was installed at no cost to UDOT.

This test was an exercise in futility for nothing was solved by covering the existing marking because there were no savings afforded to the Department.

Epoplex Polyurea (LS90)

Final Report

Experimental Feature X(02)14 – New Products

By: Barry Sharp, Research Specialist
Robert Stewart, P.E., Development Engineer (former)

Utah Department of Transportation
Research Division

June 2005

Introduction

This report describes the installation and performance of Epoplex's LS90 product. UDOT allowed Epoplex to demonstrate their polyurea product on 500 South between 300 and 400 West. The product was installed in September of 2002.

Background Information

Epoplex's product data sheet explains the product:

> "Epoplex LS90 is a two component, 100% solids polyurea coating designed as a fast setting highway marking coating that provides durability and abrasion resistance. Epoplex LS90 is formulated to provide a simple volumetric mixing ratio of two volumes of Component A (amine) to one volume of Component B (isocyanate)."

The location provides severe conditions for pavement markings. It is the entrance to the interstate system from downtown Salt Lake City. This location presents a high AADT, high occurrence of weaving, and high snowplow rate. There is also a business where many trucks turn in and out so a large portion of the yellow edgeline and one set of skips is exposed to scrubbing.

The price on poly urea ranges from $ 0.50 to $ 0.75 per linear foot. The beads that were used are Swarco Virgin and a double drop of small and large beads. (18-20 mesh large and 30-40 mesh small)

Construction Information

The material was placed over existing epoxy. Figure 1 shows the shadow of the epoxy. Figure 2 shows the markings after installation.

Figure 1- Polyurea over epoxy

Figure 2- Just after installation

Goal

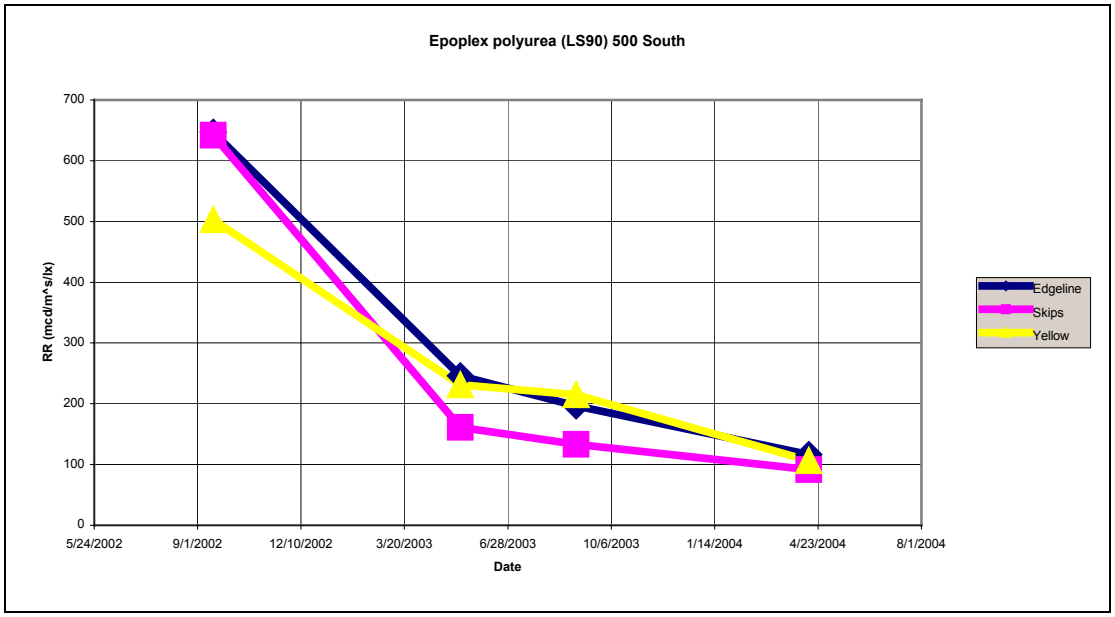
The goal of this study is to determine whether or not UDOT should use the LS90.

Objectives

1. Measure the retro-reflectivity over a period of 3 years.
2. Measure the life-cycle cost of this product at this location.

Preliminary Results

Two snowplow seasons yielded the following retro-reflectivity results:



	9/16/2002	5/13/2003	9/2/2003	4/14/2004
Edgeline	647	246	197	116
Skips	642	161	133	92
Yellow	503	231	215	107

Conclusions

The material has shown excessive wear, especially on the skip lines. However, at this location, the material has performed well. The material is at UDOT's trigger value for re-striping.

Recommendations

This material has shown its ability to provide good durability at a location where conditions for pavement markings are severe. UDOT should use this product in severe applications. The cost of the material is prohibitive, but may be cost-effective in such severe conditions as these.

There was no control set up at this location. Because of this, there can be no comparison, cost or otherwise, to UDOT's current material. For future test sections, the current practice should act as a control.

Appendix

Utah Department of Transportation
Research and Development Division

I.D. FILE # 02-082

PRELIMINARY INFORMATION FOR PRODUCT EVALUATION

Form R-52 (Rev. 10/00)

See Instruction block at bottom before starting to fill out form.

1. *Product Trade Name:* EPOPLEX LS90 **Date:** 9-11-02
   Manufacturer/Co.: EPOPLEX, Part of Stonbor Group, Inc. **Patented?** ☐Yes ☐No ☐Applied For
   Company Contact: KENT STOUGH, JR. **Ph#:** (856) 667-8399 **Fax #:** 856-321-7559
   Street Address: 1 PARK AVENUE
   City: MAPLE SHADE **State:** NJ **Zip Code:** 08052
2. Local Contact: ROBERT CASEY **Ph#:** (801) 619-1442 **Fax #:** 801-619-1443
   Local Address (~~Distributor~~): 2505 E. MAPLE CREEK LANE
   City: SANDY **State:** UT **Zip Code:** 84092
3. Background description of Company and its product:
4. Product Identification: 2 TO 1 RATIO POLYUREA PAVEMENT MARKING
5. Recommended use of product: LONG LINES, CROSSWALKS, ARROWS, STOP BARS, CROSS HATCHING
6. Outstanding Features or Advantages Claimed: 100% LIGHT UV STABLE, FAST DRY TIMES
7. General Composition of Material: (Attach laboratory report when applicable) POLYUREA
8. When Introduced on Market? NEW Alternate for what existing product(s)? THERMOPLASTIC, TAPE, EPOXY
9. Approx. cost: $65.00 per GALLON (unit). Delivery at site 10 days after receipt of order.
   If cost is "job-by-job" give typical price range to expect....$1.00/foot TO $1.50/foot depending on PREPARATION COSTS

INSTRUCTIONS -- Answer ALL Questions. Use "X" to indicate choices.
Where a Question is Not Applicable, enter N/A.
Attach additional paper if needed and refer to Item No.

10. Does your product meet requirements of the following specifications? Please write the specification number, classification and type or subgroup when appropriate (i.e. AASHTO M 148, Type I D, Class A)

AASHTO _____
ASTM _____ (SEE ATTACHED PRODUCT DATA SHEET) _____
FEDERAL _____
UDOT _____

11. Is product approved for use by other highway authorities or agencies?
(Indicate by whom used and whether use is routine or experimental only) NO - UNDER TESTING AT THIS TIME

12. Who recommended that the Department be contacted? _____

13. Has another office of UDOT been contacted ☐Y ☒N If YES, Whom? _____

Please answer the following questions by placing an X in the appropriate box:

YES	NO	
☒	☐	Can a demonstration be provided?
☐	☒	Are ☐ videos or ☐ educational training courses available?
☐	☒	Can ☐ plans, ☐ drawings, or ☐ pictures be furnished by manufacturer? If Yes, ☐ Copy attached ☐ To be mailed.
☒	☐	Are instructions or directions for installation, application or use available?
☐	☒	Is availability seasonal?
☒	☐	Can samples be provided ☒ free or ☐ at cost for laboratory/field testing?

Approximate cost for samples? $_____

Signature _____ 9/11/02
(Needed for follow up correspondence.)

☞ *Please attach trade literature, test results, testimonials, specifications, MSDS sheets, instructions, warranty, samples, etc.* ☜

Please submit this form to:

UDOT -- Research & Development
Attn: Barry Sharp
4501 South 2700 West
Salt Lake City, UT 84114-8410
UDOT Box # 148410

or fax to : (801) 965-4564

For your questions or comments our engineering staff is available M-Th from 7am to 5pm (MST),

Kenneth H. Berg, P.E.	Don Avila, P.E.	R. Barry Sharp
Development/Implementation Program Manager	Development Engineer	Research Specialist
(801) 965-4321	(801) 965-3890	(801) 965-4314

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EPOPLEX LS90

PRODUCT DATA

EPOPLEX

PRODUCT DESCRIPTION:
EPOPLEX LS90 is a two-component, 100% solids polyurea coating designed as a fast setting highway marking coating that provides durability and abrasion resistance. EPOPLEX LS90 is formulated to provide a simple volumetric mixing ratio of two volumes of Component A (amine) to one volume of Component B (isocyanate).

USES, APPLICATIONS:
EPOPLEX LS90 may be applied to both cementitious and asphalt highway surfaces as a long-lasting striping material for both edging and center line markings, as well as all intersection markings.

PRODUCT ADVANTAGES
- 100% solids chemistry
- Low viscosity suitable for spray application
- Long-term abrasion and corrosion resistance
- Excellent bond strength assures good adhesion to a variety of substrates
- Special formulation chemistry for fast set at a wide range of temperatures
- 100% ultraviolet light stability
- High reflective qualities

PACKAGING
Component A: Amine and Pigmentation

Component B: Isocyanate

Both components are available in 55 gallon drums and 250 gallon returnable totes.

PHYSICAL CHARACTERISTICS

Percent Solids	100%
Yellowness Indexing (ASTM D-1925)	Max. before QUV 5 Max. after 72 hrs QUV 5 Max. after 500 hrs QUV 5 Max. after 1000 hrs QUV 5
Drying Time @ 77°F/25°C (ASTM D-711)	7-10 min. (with glass beads)
Adhesion (ACI Method 503)	> 300 psi (100% concrete failure)
Hardness (ASTM D-2240)	> 75 Shore D
Abrasion Resistance (ASTM D-4060)	< 120 mg weight loss
Tensile Strength (ASTM D-638)	> 3,500 psi
Theoretical Coverage	122 sq. ft. per gallon @ 15 mils

STORAGE CONDITIONS
Store both components of EPOPLEX LS90 in a dry area. Avoid excessive heat and do not freeze. The shelf life is two years in the original unopened container.

COLOR
EPOPLEX LS90 is available in highway white, yellow and black. Custom colors are available upon request.

Note: See reverse side for Viscosity vs. Temperature Chart.

3M LPM 1500 Polyurea Stop Bars & Cross Walks

Final Report

Experimental Feature X(02)15

By: Barry Sharp, Research Specialist
Robert Stewart, P. E., Development Engineer (former)
Michelle Page, P.E., Program Manager

Utah Department of Transportation
Research Division

June 2005

Introduction

Transverse pavement markings are subject to more shear forces (tires and plows) than longitudinal lines. Because of this, stop bars and crosswalks often wear faster than longitudinal lines. 3M developed their Liquid Pavement Marking (LPM) 1500 especially for these markings.

LPM 1500 is a poly-urea that uses standard beads. Retro-reflectivity is not measured on these markings and UDOT considers durability only for the markings.

Construction Information

The project is located on Bangerter Highway (SR-154) at 5400, 4700 and 3500 South intersections. The total square footage installed was 6,500 square feet. The surface was prepared by grinding the existing markings from the roadway surface. The marking was applied 20 mils thick by Peck Striping on October 13 & 14, 2002.

Goal

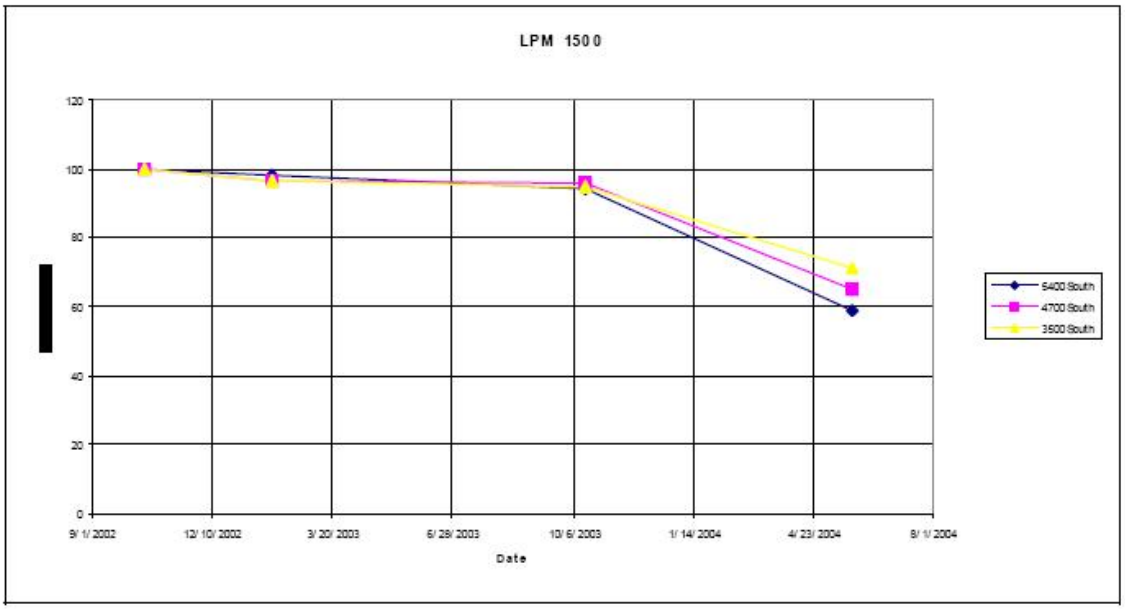
Determine whether or not the LPM 1500 poly-urea traffic marking is cost effective used as a stop bar and cross walk marking.

Objectives

Measure durability
Measure life cycle cost of this product at the three locations

Final Results

Two plow seasons yielded the following results:



The third season was visually evaluated according to the ASTM Method D913 for durability and the stop bars and crosswalks were about 70% no need to be repainted.

The total cost for this product was $ 2.00 per square foot, 50% for paint and 50% for preparation. The product lasted three seasons that represent $ 0.66 per square foot.

Conclusions

The material performed very well for the given severe conditions. The AADT for this area is about 50,000 and the paint experiences a lot of wear from turning, braking and accelerating. The price is high, but may be justified because most other markings would probably not make it through a season.

Recommendations

There was no control on this project. It is recommended this product be installed next to the product that would typically be used for these locations. This is the only way to determine whether or not this product is more cost-effective than the current practice.

PolyUrea is extremely sensitive to contamination. The only premature failures that were experienced with this project were in the “oil drip” path. Even though the surface was ground it is apparent the material was not able to adhere to the concrete at these locations. It is also recommended this product not be used in

a location where it would be difficult to reach non-contaminated concrete through surface preparation.

3M LPM 1500 PolyUrea is recommended for use as a durable crosswalk and stop bar traffic marking in sever conditions where previous markings have failed to withstand a season of exposure.

Delineator Mounted Work Zone Signing

Final Report

Experimental Feature X(02)16 – New Products

By: Barry Sharp, Research Specialist
Ken Berg, P.E., Development Engineer

Utah Department of Transportation
Research Division

June 2005

Introduction

Portable sign stands used in temporary work zone settings have a tendency to be affected adversely by the traffic backlash and wind in general. This new and improved sign standard is not affected by the traffic backlash or wind because it is mounted over an existing traffic delineator and is very stable.

Background Information

The Maintenance Sheds have occasion to set up temporary traffic in work zones where shoulder work, pavement repair, or traffic marking is being performed and the temporary traffic signing is seriously effected by the traffic backlash and winds and blown down or shifted. Region Four Maintenance, driven by a need, designed a special mount for existing traffic marking delineators. In order to be defined as acceptable this mount must be crash tested by an authorized National Testing Facility.

The Research Division, Traffic & Safety and Central Maintenance will share the cost of the crash test.

Goal

Crash test the newly designed sign mount attached to a standard delineator post to meet the NCHRP 350, Test Level 3.

Objective

Justify using the temporary sign brackets by having them tested to meet the National criterion.

Final Results

Two testing laboratories in California were contacted and offered formal quotes to allow a purchase order of this magnitude. The quotes were $12,500 each but the lab selected, Karco Engineering offered a savings if the tests went well. Ultimately Karco Engineering performed the crash tests and the cost was $9,968.56. The sign brackets did pass the tests and are now used Region wide and will probably become the best approach for temporary construction zone signing.

Recommendations

The sign mounting brackets passed national testing regulations and are currently being used throughout the department.

Appendix

ONE LANE
ROAD
AHEAD

ONE LANE
ROAD
AHEAD

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18” Nyloplast PVC Inlets

Final Report

Experimental Feature X(02)17 – New Products

By: Barry Sharp, Research Specialist
Robert Stewart, P. E., Development Engineer

Utah Department of Transportation
Research Division

June 2005

Introduction

The Utah Department of Transportation (UDOT) historically, in the construction process, has installed concrete inlets, either prefabricated or cast in place. The concrete boxes are very expensive, sometimes as much as $ 4,000 per cubic yard per box. Nyloplast, a division of Advanced Drainage Systems, Inc. has developed a prefabricated polyvinyl chloride (PVC) inlet box that involves considerably less cost to manufacture and install. At this time UDOT has allowed only concrete boxes per their Standard Drawings, CB 1 through CB 10C. UDOT Research in concert with Central Hydraulics/Structures has proposed that the PVC inlets be installed and field-tested to determine if they may be a viable alternative to the concrete inlets.

Objectives

1. Install four inlets furnished by Nyloplast at no charge
2. Evaluate the price and ease to install PVC inlets
3. Evaluate the performance over time

Results

Attempts to install one PVC box at a point of the mountain gravel pit for severe application was not successful and only two of the PVC boxes were installed on the project located at 12300 South and I-15, East and West. One of the boxes was installed on I-15 mainline, (Southbound and the other on a radius adjacent I-15 Mainline). These installations have been monitored and evaluated for over 18 months. At this time they are performing as expected. All installations were performed in Salt Lake County.

Conclusions

The New Products Evaluation Panel and the Central Hydraulics/Structures division have conditionally accepted PVC Storm Drain Inlets. A UDOT Special Provision will be in place for potential use by contractors. This decision was based upon the performance review conducted by Research and Hydraulics. Product will be placed in the Performance Data Products Listing until such time as further successful reviews support the decision that has been made.

Recommendations

The performance of PVC inlets during this 18 month evaluation period seem to be equivalent to concrete. Further evaluation for at least 4 to 5 years is recommended to more accurately predict long-term performance relative to concrete inlets. Preconstruction units should be notified of this study and where UDOT stands in an attempt to reduce the overall construction costs. Michael Fazio, Hydraulics Engineer has a Utah Department of Transportation, Special Provision.

Appendix

Utah Department of Transportation
Research and Development Division

I.D. FILE # 02-079

PRELIMINARY INFORMATION FOR PRODUCT EVALUATION

Form R-52 (Rev. 10/00)

See Instruction block at bottom before starting to fill out form.

1. *Product Trade Name:* Nyloplast Storm Drainage Structures Date: 08/28/02
   Manufacturer/Co.: Nyloplast, a Division of ADS Patented? ☐Yes ☑No ☐Applied For
   Company Contact: Corey Welch Ph#: (801) 558 - 7445 Fax #: 801 294-6874
   Street Address: 207 Valley View Drive
   City: North Salt Lake State: UT Zip Code: 84054
2. Local Contact: Jeff Smith, ADS District Manager Ph#: (801)943 -8058 Fax #: 801 943-8818
   Local Address *(Distributor)*: 2048 E. New Horizon Drive
   City: Sandy State: UT Zip Code: 84093
3. Background description of Company and its product: Nyloplast has been producing and installing drainage structures in the U.S. market since 1992. Our primary market is storm drainage applications.
4. Product Identification: Nyloplast Drain Basins, Nyloplast Curb-Inlet Structures, Nyloplast Road & Highway Structures, Nyloplast Inline Drains, Nyloplast Drop-In Grates
5. Recommended use of product: Nyloplast is recommended for use in both site and off-site drainage applications, for both new and improvement/upgrade drainage projects.
6. Outstanding Features or Advantages Claimed: Watertight Gasketted Joints, Corrosion-Free PVC Structure, High Strength Ductile Iron Grates (H-25), Custom made for project requirements, easy handling, economical and flexible installation. Provides EPA Best Management Practice Pre/Post Construction.
7. General Composition of Material: (Attach laboratory report when applicable) Ductile Iron, PVC
8. When Introduced on Market? 1992 Alternate for what existing product(s)? Pre-Cast Concrete Structures, Cast-in Place Structures, Cast iron and Steel Grates.
9. Approx. cost: $ Per Size per See attached (unit). Delivery at site 5-9 days after receipt of order.
   If cost is "job-by-job" give typical price range to expect....$ See attach TO $ _____.

INSTRUCTIONS -- Answer ALL Questions. Use "X" to indicate choices.
Where a Question is Not Applicable, enter N/A.
Attach additional paper if needed and refer to Item No.

10. Does your product meet requirements of the following specifications? Please write the specification number, classification and type or subgroup when appropriate (i.e. AASHTO M 148, Type I D, Class A)

AASHTO					
ASTM	1336-01	D3034,D1784	D3212-96a	F-477	A536
FEDERAL					
UDOT					

11. Is product approved for use by other highway authorities or agencies?
(Indicate by whom used and whether use is routine or experimental only) See attached approvals, letters, and testimonials.

12. Who recommended that the Department be contacted? Customers, Civil Engineers, Contractors

13. Has another office of UDOT been contacted ☐Y ☒N If YES, Whom?

Please answer the following questions by placing an X in the appropriate box:

YES	NO	
☒	☐	Can a demonstration be provided?
☒	☐	Are ☐ videos or ☒ educational training courses available?
☒	☐	Can ☐ plans, ☒ drawings, or ☒ pictures be furnished by manufacturer? If Yes, ☒ Copy attached ☐ To be mailed.
☒	☐	Are instructions or directions for installation, application or use available?
☐	☒	Is availability seasonal?
☒	☐	Can samples be provided ☒ free or ☐ at cost for laboratory/field testing?

Approximate cost for samples? $ No Cost

Signature _____
(Needed for follow up correspondence.)

• • Please attach trade literature, test results, testimonials, specifications, MSDS sheets, instructions, warranty, samples, etc. • •

Please submit this form to:

UDOT -- Research & Development
Attn: Barry Sharp
4501 South 2700 West
Salt Lake City, UT 84114-8410
UDOT Box # 148410

or fax to : (801) 965-4564

For your questions or comments our engineering staff is available M-Th from 7am to 5pm (MST),

Kenneth H. Berg, P.E. Development/Implementation Program Manager (801) 965-4321	Dan Avila, P.E. Development Engineer (801) 965-3890	R. Barry Sharp Research Specialist (801) 965-4314

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ADVANCING TECHNOLOGY PROMOTES

Stormwater Drainage

The system's offset design taps into the larger drainage pipe 90 degrees perpendicular to the trunk line, eliminating the need to oversize the drainage structures.

All across the country, public works officials are discovering performance and economic improvements by utilizing advanced technology in drainage systems. Engineered plastics can play a key role in design and installation in both drainage pipe and structures for new and reconstruction projects alike.

FIRST IMPRESSIONS

Tom Sanders, the director of community development for Moberly, a northeast Missouri town of about 12,000, was in charge of widening the sections of Park Avenue and Beuth Road that wind through the hills of a residential section from 22 ft to 30 ft. He also had to install curbs and gutters where only drainage ditches existed before. In fact, in the 30-plus years since the roads had been paved, about six in. of asphalt had been applied to the roadway surface with no storm sewers in sight.

"I sat down with an engineering firm to discuss our drainage system options," Sanders said. "We weighed the costs and benefits of different methods and based on that criteria, we decided to try something new to us."

That something new was Nyloplast® (a division of Advanced Drainage Systems [ADS], Buford, Georgia), engineered drainage structures including curb inlets and drain basins, along with high-density polyethylene pipe from ADS (Hilliard, Ohio). The savings in time and money over alternative materials was significant, according to engineers.

"This was the first time we had specified this system in Moberly," said Lyn Heying, senior project manager for Meco Engineering (Hannibal, Missouri). "The lighter weight of the pipe, catch basins, and curb inlets meant we needed a much smaller construction crew. One man for the backhoe, and one or two to place the pipe in the trench. That's it."

The system's inline drains and drain basins are made of corrosion resistant PVC and are built to connect with HDPE pipe to form a watertight joint.

The contractor on the Moberly job was Larry Sapp, project foreman for Emory Sapp and Sons, (Columbia, Missouri). Like his colleagues, he had no experience with plastic drainage structures before he was hired to improve Park Avenue and Beuth Road.

"The best thing about using these

Above: Installation of curb inlet structures can easily be done with minimum manpower and equipment. At right: Structurally designed HDPE corrugated pipe and PVC structures are lightweight and watertight.

structures is that once the inlets go in the ground, you're done. There's nothing else to do," Sapp said. "You're in the ground in 30 minutes and you're finished."

Drain basins are used as a collection point where two or more drain lines converge. The Nyloplast basins are custom made to provide a transition between different sizes and type of pipe, and also change the elevation or direction of the pipe. Because the drain basins are connected with corrugated N-12® pipe, a watertight system can be achieved with no extra effort.

"Just like any project, I'll inspect the site periodically to see how everything is working," Sapp mentioned. "This project is draining just fine. Both the structures and the pipe are performing as we expected."

COMMON SENSE SOLUTIONS

Jim Gilmore, P.E., is a 67-year old senior project manager for R.P. Industries in Franklin, Tennessee, a city of 42,000 people. Forty-five years in the trenches have taught him that common sense beats being set in your ways every time.

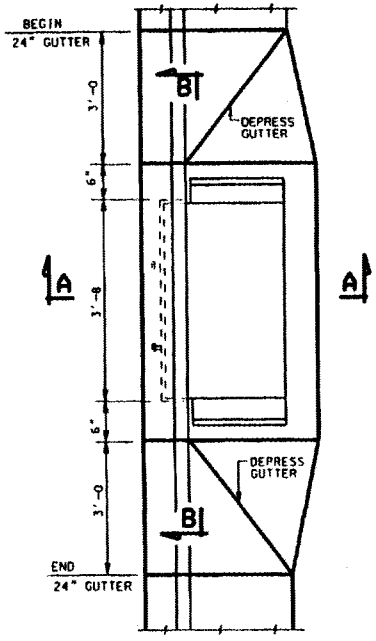
"We saw the benefit of using these structures almost immediately. They are lightweight yet exceptionally well built for these applications," Gilmore said. "If you're putting in these catch basins and drain pipes the old way, you might as well be living in Julius Caesar's time. I wish we had these structures 20 years ago. I must have saved a thousand problems with these."

According to Gilmore, he saved about $25,000 on a single project alone. Nyloplast offset structure design (OSD) curb inlet basins were used at the Thoroughbred Village Shopping Center in the Cool Springs area of Franklin. The significant dollar savings were achieved by replacing 48-in. and 60-in. diameter drainage structures with the new curb inlets.

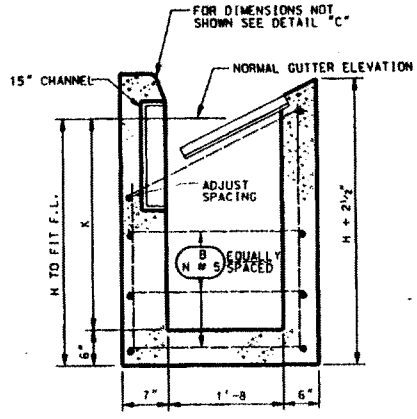
Offset curb designs tap into the larger drainage pipe 90 degrees perpendicular to the main pipe run. This novel design means the drain basins can all be buried at the same shallow grade while only the pipe is gradually sloped. Thus, the inlets are designed to capture the prescribed surface water runoff and connect to large diameter mains for maximum drainage flow, allowing for a larger trunk line without the need to oversize the drainage structure.

Field adjustment of the ductile iron hood and grate also provides

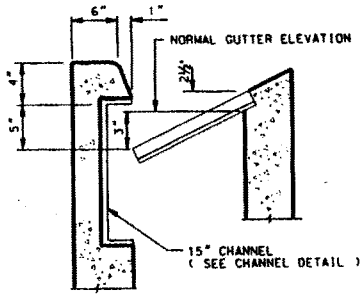
Because the drain basins were connected with corrugated N-12 WT™ pipe, a watertight system was achieved.



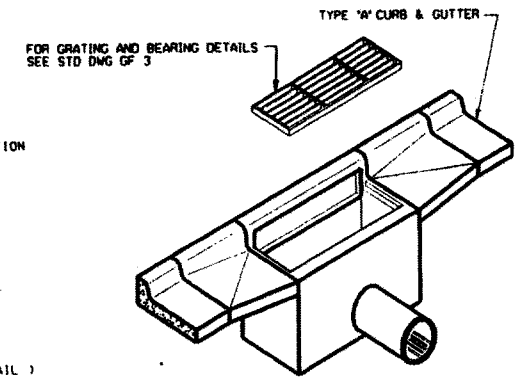
PLAN

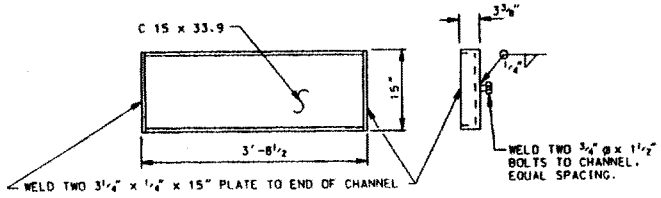


SECTION A-A

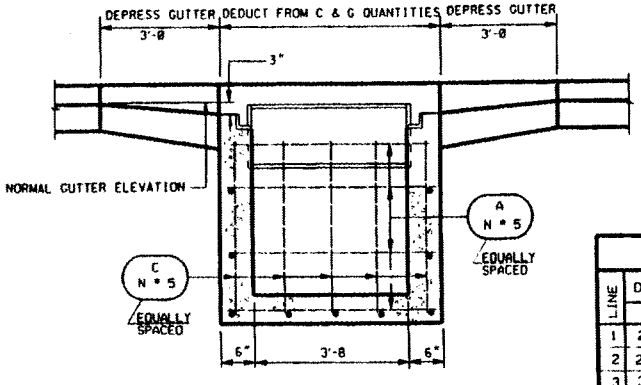


DETAIL "C"





CHANNEL DETAIL



SECTION B-B

TABLE "A"			
R.C.P.		C.M.P.	
DIA.	CU. YDS.	DIA.	CU. YDS.
12"	.024	12"	.015
15"	.036	15"	.023
		18"	.033

NOTE: QUANTITIES IN TABLE "A" ARE FOR PIPE THROUGH 6" WALL.

SCHEDULE OF INSTALLATION													
LINE	DIMENSIONS		MAXIMUM PIPE DIA.		REINFORCING STEEL						REIN. STEEL	CONC.
					A		B		C			
	H	K	RCP	CMP	N	LENGTH	N	LENGTH	N	LENGTH	LBS.	CU. YDS
1	2'-0	1'-0	—	15"	7	4'-4	9	2'-5	12	1'-9	76.2	0.63
2	2'-6	2'-0	12"	18"	9	4'-4	11	2'-5	12	2'-3	96.6	0.75
3	3'-0	2'-6	15"	↓	9	4'-4	11	2'-5	12	2'-9	102.8	0.88
4	3'-6	3'-0	↓	↓	11	4'-4	13	2'-5	12	3'-3	123.2	1.00
5	4'-0	3'-6	↓	↓	11	4'-4	13	2'-5	12	3'-9	129.4	1.13
6	4'-6	4'-0	↓	↓	13	4'-4	15	2'-5	12	4'-3	149.8	1.25
7	5'-0	4'-6	15"	18"	13	4'-4	15	2'-5	12	4'-9	156.0	1.38

NOTES:

1. USE COATED DEFORMED BILLET REINFORCING STEEL BARS CONFORMING TO AASHTO M-284 OR M 111 AND M 31 GRADE 60 RESPECTIVELY.
2. USE STRUCTURAL STEEL CONFORMING TO AASHTO M 270 GRADE 36 EXCEPT WHERE NOTED OTHERWISE.
3. HOT-DIP GALVANIZE THE CHANNEL AND END PLATES AFTER FABRICATION IN ACCORDANCE WITH AASHTO DESIGNATION M 111
4. CHAMFER ALL EXPOSED CONCRETE CORNERS ¾" EXCEPT WHERE NOTED OTHERWISE.
5. PROVIDE 2" CONCRETE COVER TO REINFORCING STEEL EXCEPT WHERE NOTED OTHERWISE.
6. USE CLASS AA(AE) CAST-IN-PLACE CONCRETE EXCEPT WHERE SPECIFIED OTHERWISE.
7. TYPE II CEMENT (LOW ALKALI) REQUIRED.
8. INCLUDE CONCRETE QUANTITIES FOR CURB AND GUTTER IN ROADWAY QUANTITIES
9. FOR LOCATION AND SIZE OF PIPE(S) SEE ROADWAY PLANS.
10. CUT AND/OR BEND REINFORCING STEEL AS NECESSARY TO CLEAR PIPES AND MAINTAIN 2" CLEARANCE.
11. DEDUCT CONCRETE DISPLACED BY PIPES (TABLE "A") FROM CONCRETE QUANTITIES GIVEN IN SCHEDULE OF INSTALLATION.
12. QUANTITIES IN TABLE "A" ARE FOR PIPE THROUGH 6" WALL THICKNESS.

DESIGN DATA

HS 20-44 OR INTERSTATE ALTERNATE MILITARY LOADING IN ACCORDANCE WITH CURRENT AASHTO AND INTERIM SPECIFICATIONS.

STRUCTURAL STEEL: Fs = 20,000 psi

STRUCTURAL CONCRETE: Fc = 1400 psi
Fs = 24,000 psi
N = 8

QUANTITIES

SEE SCHEDULE OF INSTALLATION

NO.	DATE	APPR.	REMARKS

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
STANDARD DRAWINGS FOR ROAD AND BRIDGE CONSTRUCTION
SALT LAKE CITY, UTAH

RECOMMENDED FOR APPROVAL — DATE 7-02-02
CHAIRMAN STANDARDS COMMITTEE
APPROVED — DATE 7/1/02
DEPUTY DIRECTOR

CURB INLET CATCH BASIN

STD DWG
CB 2

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Evaluate Canvas Fabric as a Viable Containment for Cement Grout

Final Report

Experimental Feature X(03)01 – New Products

By: Barry Sharp, Research Specialist
Ken Berg, P.E., Development Engineer

Utah Department of Transportation
Research Division

June 2005

Summary

The Utah Department of Transportation, Hydraulics Section has a need for fabric covered grout bags to serve as erosion control riprap in areas that are subject to scouring. The bags would be one solution to preventing scouring if they do not contaminate the running water in the streambed.

CMT Engineering Laboratories, North Salt Lake, was selected to conduct the leaching tests on the canvas containers of grout. The results of possible leaching were a visible evaluation and then a ph of the water outside the bag would be tested.

CMT set up an evaluation process and was about to begin evaluation and the Hydraulics Section placed a stop on the testing for they decided that this probably was doomed for failure from the start.

The testing and evaluation were discontinued March 15, 2003.

Work Zone Speed Limit Study

Final Report

Experimental Feature X(03)02 – New Products

By: **Dan Avila, P.E., D&I Engineer (former)**
Barry Sharp, Research Specialist
Robert Stewart, P.E., Development Engineer (former)

Utah Department of Transportation
Research Division

June 2005

Introduction

UDOT typically reduces the speed limit in a work zone by 10 mph as a standard. The MUTCD states in section 6C.01 “Reduced speed zoning (lowering the regulatory speed limit) should be avoided as much as practical because drivers will reduce their speeds only if they clearly perceive a need to do so.” The purpose of this study was to see if the 85th percentile speed was reduced after the reduced posted speed in two work zones in Utah.

Background Information

The first work zone studied was on I-215 at the south end of the Salt Lake City valley. I-215 is a 3-lane freeway that was under construction in order to widen the alignment, place constant-slope barrier in the median, place soundwalls, and crack-and-seat the badly deteriorated concrete pavement. The work zone was approximately 3 miles long, with about 4 miles of reduced speed limit (from 65 mph to 55 mph). The work zone did not necessarily reduce the amount of lanes through the area (with the exception of small areas near off-ramps and on-ramps), however, the lane width did not meet the 12-ft standard of UDOT freeways.

The second work zone was on I-15 from about 11800 South thru 13000 South (approximately 1.5 miles) with about 3 miles of reduced speed limit (65 mph to 55 mph). The work zone was necessary to replace a structure at 12600 South where the cross street was being widened. The work zone created a lane shift, and a lane-width reduction, but did not require a reduction in the number of lanes.

Goal

The purpose of this study was to determine if further research should be conducted into the UDOT practice of lowering speed limits in work zones by 10 mph.

Objectives

1. Conduct a basic literature search.
2. Gather speed data at work zones.

Results

1. A report produced by Migletz et. al. for the NCHRP provides a process for deciding when and where to use a speed reduction. The report, “Effectiveness and Implementability of Procedures for Setting Work Zone Speed Limits” [3-41(2)] and its developed procedure are confirmed as viable by Migletz et. al. in a

TRB report “Work Zone Speed Limit Procedure” (Paper No. 99-0920 in report 1657).

Also presented in these reports was the fact that speed variance, not necessarily speed, was the major factor in work zone crashes, “The relationship between accident rate and deviation from the mean speed implies that speed variance is an important parameter because the percentage of vehicles traveling at speeds substantially above or below the mean speed increases as the speed variance increases.” (Migletz et. al. Paper 99-0920 pp. 24).

A report just completed by Brigham Young University for UDOT showed a reduction of 2-4 mph in the work zones studied by posting a 10 mph reduction.

2. The results for the speed studies showed similar results to the BYU study. Traffic slowed for the reduced speed limit anywhere from 2-5 mph. At the I-215 construction site (EB & WB), the variance in traffic speed increased after the posted speed limit. At the I-15 site, the variance in traffic speed decreased.

		Before WZ	After Posted	In Construction	After Trailer
I-215 EB	Speed*	73	71		63
	Avg. Speed	67	64		58
	Variance	**20**	**23**		**15**
I-15	Speed*	75	71	65	
	Avg. Speed	71	66	61	
	Variance	**28**	**27**	**24**	
I-215 WB	Speed*	75	71	69	65
	Avg. Speed	70	65	64	62
	Variance	**29**	**36**	**18**	**21**

*85th Percentile
All speeds in mph

Conclusions and Recommendations

The literature review resulted in a conclusion that the current UDOT practice should be revised. First, the speed limit should not be reduced ½ mile before the work zone, which is currently done. Second, the process developed by NCHRP to determine if a reduction is warranted should be implemented at UDOT. Third, the speed limit should never be reduced more than 10 mph for any work zone. The traffic control should be modified if it warrants a speed reduction of more than 10 mph.

One conclusion that can be drawn from the speed studies is that the I-15 site required the posted speed reduction. This conclusion arises from the reduction in variance at that site. This construction site, according to the NCHRP process, required a reduction in speed limit, so the procedure is validated. At the I-215 site, the posted speed limit should not have been reduced. This is evident

because the variance in speed increased after the posted speed limit. Again, according to the NCHRP process, this construction site did not require a speed reduction, validating the process.

The reduction in variance on the I-215 WB in the construction can probably be attributed to the roughness of the existing road. This section of I-215 was in extremely poor condition with potholes and extreme bumps. The speed trailers seemed to cause a reduction in both speed and variance. These results match those found by Brigham Young University.

Thermal Mapping Concept Study for UDOT

Final Report

Experimental Feature X(03)03 – New Products

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Utah Department of Transportation
Research Division

June 2005

Introduction

Anti-icing in transportation is preventing the bond of snow and ice to pavement. Snow-fighters do this by applying an anti-icing agent to the pavement (i.e. salt water) before a storm occurs or before the temperature reaches the freezing point of a liquid on the pavement. One tool they use to anticipate when anti-icing is necessary is a Road Weather Information System (RWIS). RWIS stations measure pavement temperature and other meteorological and climatological conditions (wind, humidity, precipitation, etc.). A snow-fighter will monitor conditions and decide whether or not to send anti-icing crews to apply chemical to the roads.

A problem with RWIS is the stations can only be set at discrete points and are spaced at great distances. A snow-fighter has to make educated guesses as to whether or not the RWIS station is representative of the entire road between it and another station. One tool that has been developed to aid in this educated guess is thermal mapping.

Thermal mapping involves gathering pavement temperature data with spatial location. The data will show where hot and cool spots occur in a given road segment. If the RWIS station happens to show a temperature of 32 degrees, the snow-fighter could make a decision to only apply chemical where the thermal map data suggests it is cooler than 32 degrees and therefore is susceptible to ice.

The goal of this project was to prove that UDOT could perform thermal mapping with existing personnel and equipment.

Objectives

The objectives of this project were to:

- Equip a UDOT vehicle with thermal sensing equipment.
- Gather pavement temperature data in all 6 lanes of Interstate 80 from Mile Marker 30 to Mile Marker 40.
- Map this data in a GIS.

Objective 1: Equip a UDOT vehicle with temperature sensing equipment

A UDOT vehicle needed to be equipped with pavement temperature sensing equipment. Central Maintenance provided a vehicle, bought the hardware and software, and installed the equipment. The vehicle that was available was a Ford F-350 Power Stroke diesel. A thermal sensor was placed underneath the truck approximately under the bench seat of the truck. An air sensor was mounted on the exterior of the truck. Both of these sensors were wired to a display that was powered with DC from the cigarette lighter. The display shows the pavement temperature and the air temperature to an accuracy of within 1 decimal place.

The display had a RS-232 connection output that was connected with a laptop. The laptop was loaded with software that collected the air and temperature data and also included an input from a Distance Measuring Instrument (DMI) to measure distance along the road. The data was collected into a Microsoft Access database.

A problem came up with the DMI. It was unable to communicate with the software probably due to the electronic noise that is created by the diesel engine. Distance measurement a critical component of thermal mapping and could not be excluded. The software allows manual input of text that can be stored along side the data. Therefore, the Mile Marker # was inputted as text manually as the truck passed it. However, this required two people to perform the data collection, which creates waste. In the future, configuring the DMI differently will permanently solve the distance problem, or adding GPS coordinates to the data input.

Objective 2: Gather pavement temperature data in all 6 lanes of Interstate 80 from Mile Marker 30 to Mile Marker 40.

The temperature gathering went rather smoothly. The data was collected on February 27, 2003 from about 4:45 A.M. till 6:00 A.M. The air temperature at the summit was about 20°F, the skies were mostly clear, and the wind was calm. These were ideal conditions to capture the maximum differences in pavement temperature. Wind and cloudy skies will tend to dampen the differences in pavement temperature because wind will distribute temperature, and clouds will re-reflect radiation back to the earth's surface.

The software polled the data at a rate of about 1 reading per second. The cruise control was set at 65 mph, therefore, there were a little less than 60 readings taken every mile.

Objective 3: Map the data in GIS
This proved to be the most difficult part of this project. The reason for this is the complications in distance measurement described in Objective 1. As stated, the location of each Mile Marker was manually inputted as text into the database. The first problem arose because the text data was not stored in the same table as the temperature data. The text data was stored in another table by the software and was labeled with time. All of the data was taken from the Access database and placed into an Excel spreadsheet. In the Excel spreadsheet, each Mile Marker was manually entered into a new column by matching the time with the time column from the pavement temperature data.

This procedure gave a reference point to only one point of pavement temperature data. All of the data between the Mile Markers did not have a location. To solve this problem, linear interpolation was used in between Mile Markers. Although

this method is not the most accurate, it is the only way to tie the data to a location. The data was then exported to a Dbase file for future conversion. Once every pavement temperature data point was connected with a location, the data now had to be plotted onto a map. The geographical location of each physical Mile Marker is known. However, it would have been too laborious to enter the latitude and longitude of every Mile Marker and then interpolate between Mile Markers (as was done earlier). Instead, UDOT has a shapefile that contains all of the roads in the State. Using ArcView 3.1, the pavement temperature data was tied to the roads shapefile using dynamic segmentation. It was easier to use ArcView 3.1 instead of ArcGIS 8.2 because ArcGIS requires the route that events will be tied to be an M type. The routes in the UDOT road shapefiles are not M type and therefore would have had to be converted to M type before dynamic segmentation could be performed.

Once the dynamic segmentation had been performed, the road shapefile, the pavement temperature dbase file (now tied to the road shapefile), and AGRC quad photos were brought into ArcMap 8.2 as themes. The entire roadway length (10 miles) was too long to be seen with any detail with the screen and printer resolution. Therefore, the length was broken into 9 different maps so that each segment could be zoomed. The maps are given in the Appendix.

Results

The resulting maps were analyzed for hot and cold spots. From the maps, it could be seen that the bridge decks were cold (common knowledge) and there were certain spots not previously known that were 5 degrees cooler than the surrounding road.

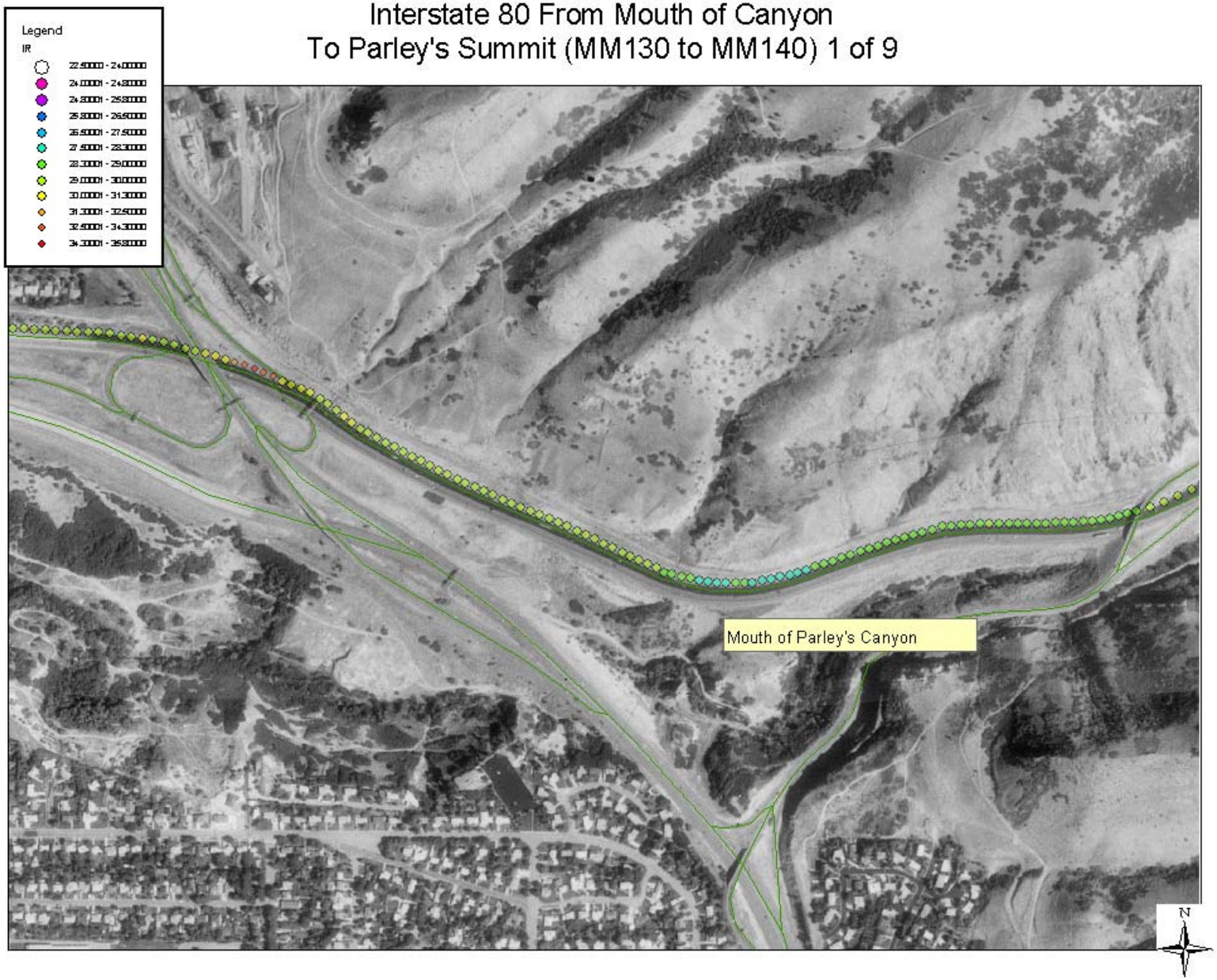
Conclusions

The purpose of this project was to prove that thermal mapping is possible with the resources available at UDOT. The objectives were to equip a UDOT vehicle with sensors, gather thermal data, and map it in a GIS. All three of these objectives were met with this project. Therefore, thermal mapping is possible with current UDOT resources.

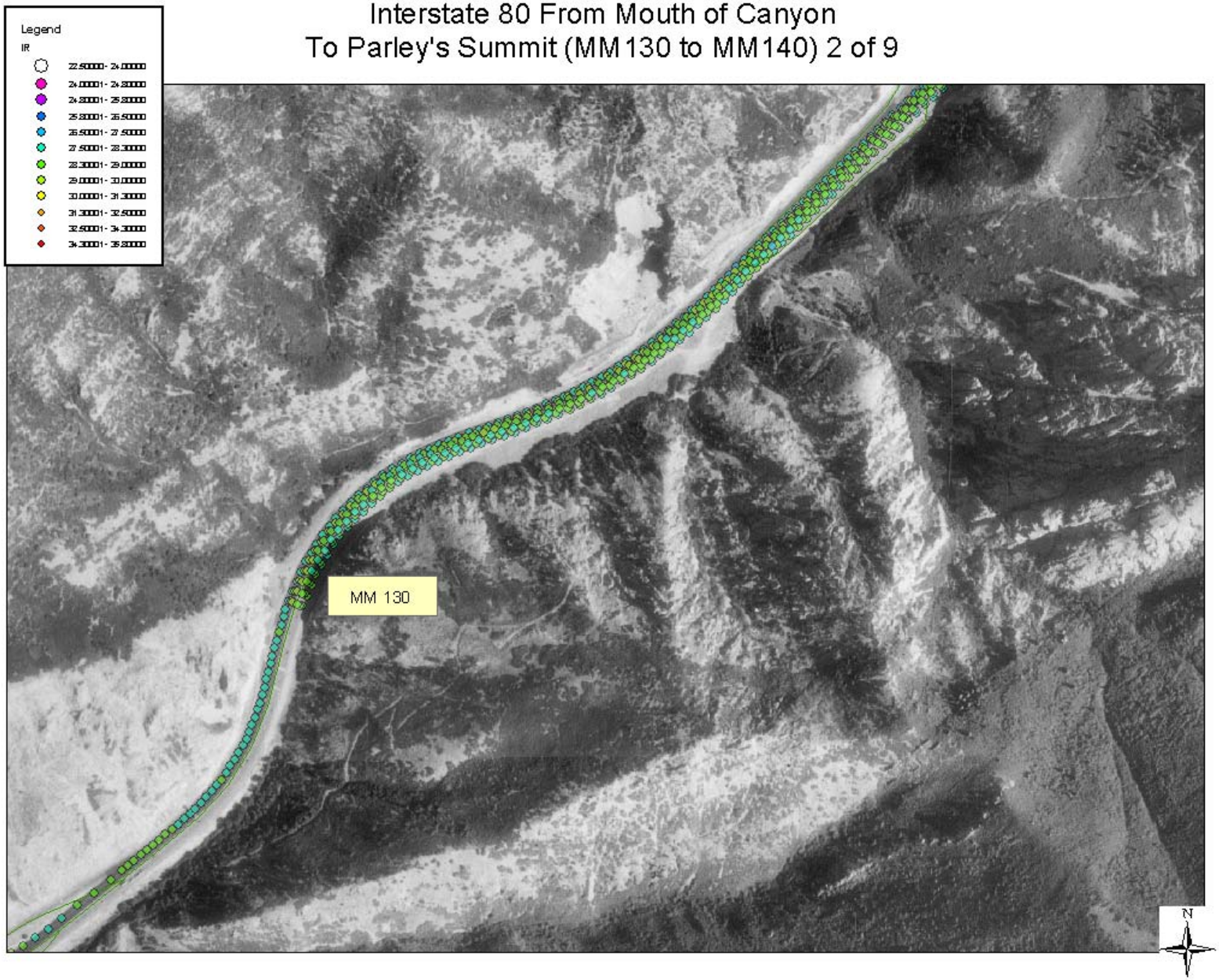
Recommendations

Thermal mapping can be a powerful tool for snow-fighters. The total time spent on this project was significant, but can be reduced with more experience. With the addition of a working DMI, most of the time spent on database manipulation can be reduced, which took about ¼ of all time spent on this project. More thermal maps should be made in the future especially in areas with frequent fatal accident occurrences.

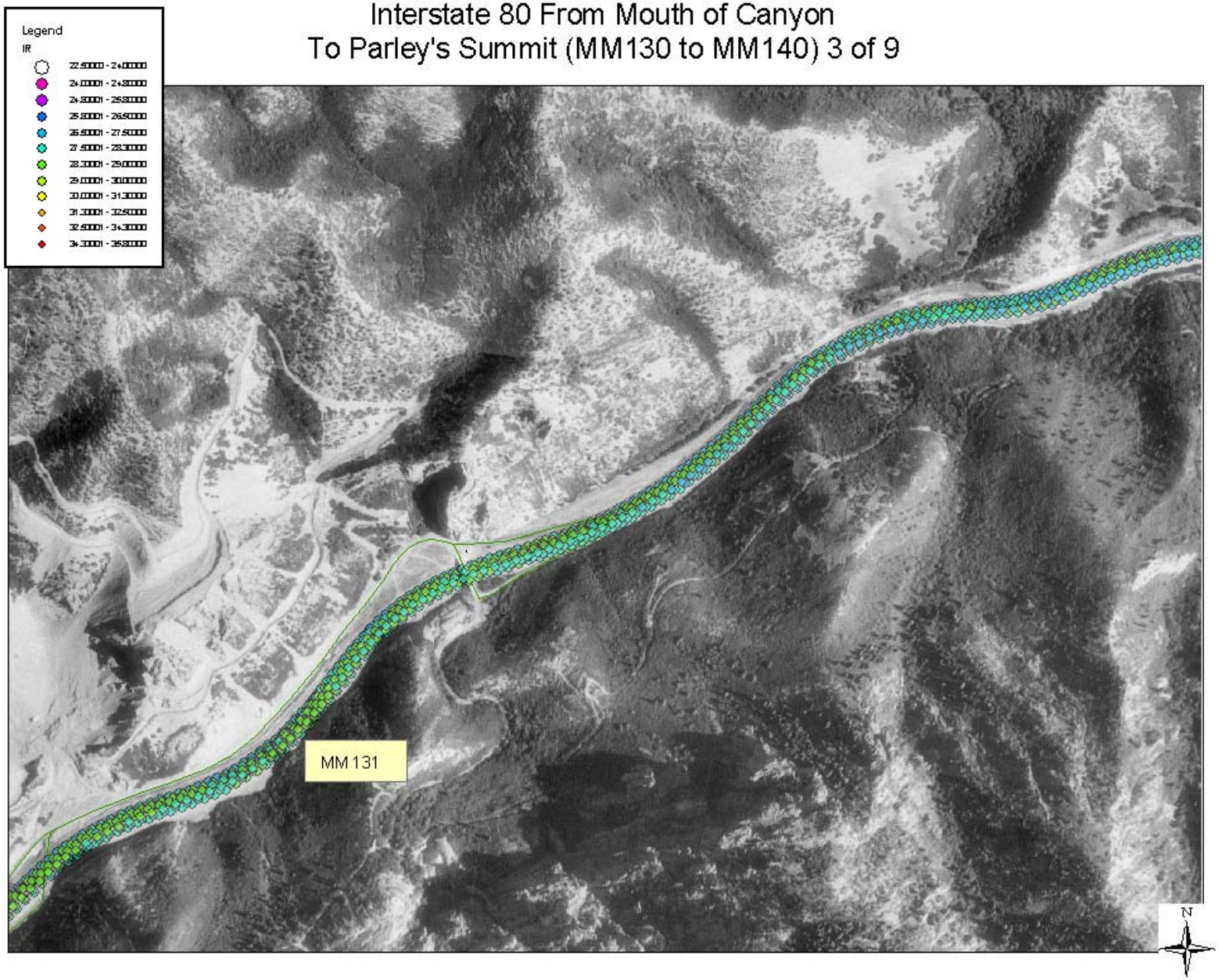
Pavement Temperature Data
Interstate 80 From Mouth of Canyon
To Parley's Summit (MM130 to MM140) 1 of 9



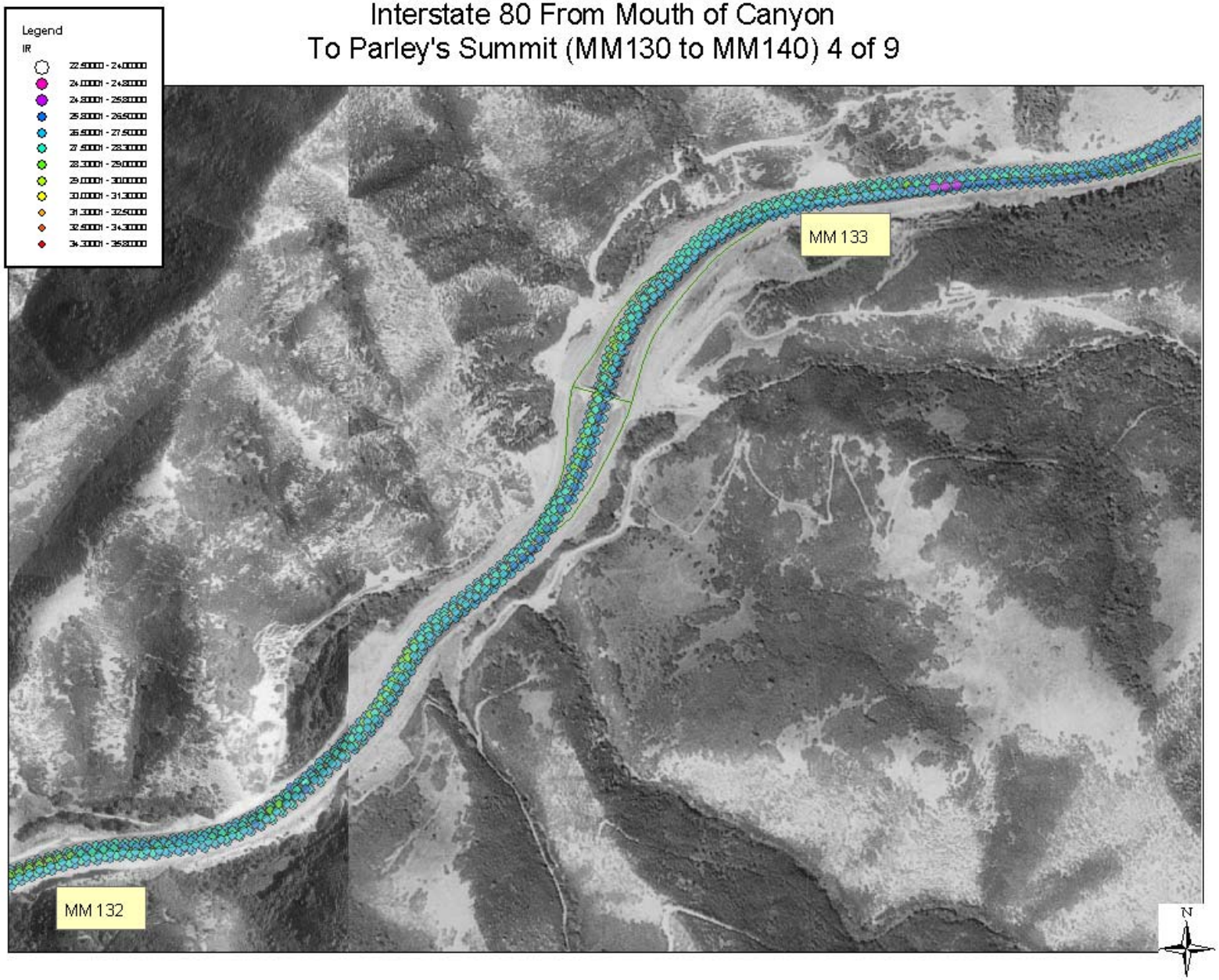
Pavement Temperature Data
Interstate 80 From Mouth of Canyon
To Parley's Summit (MM130 to MM140) 2 of 9



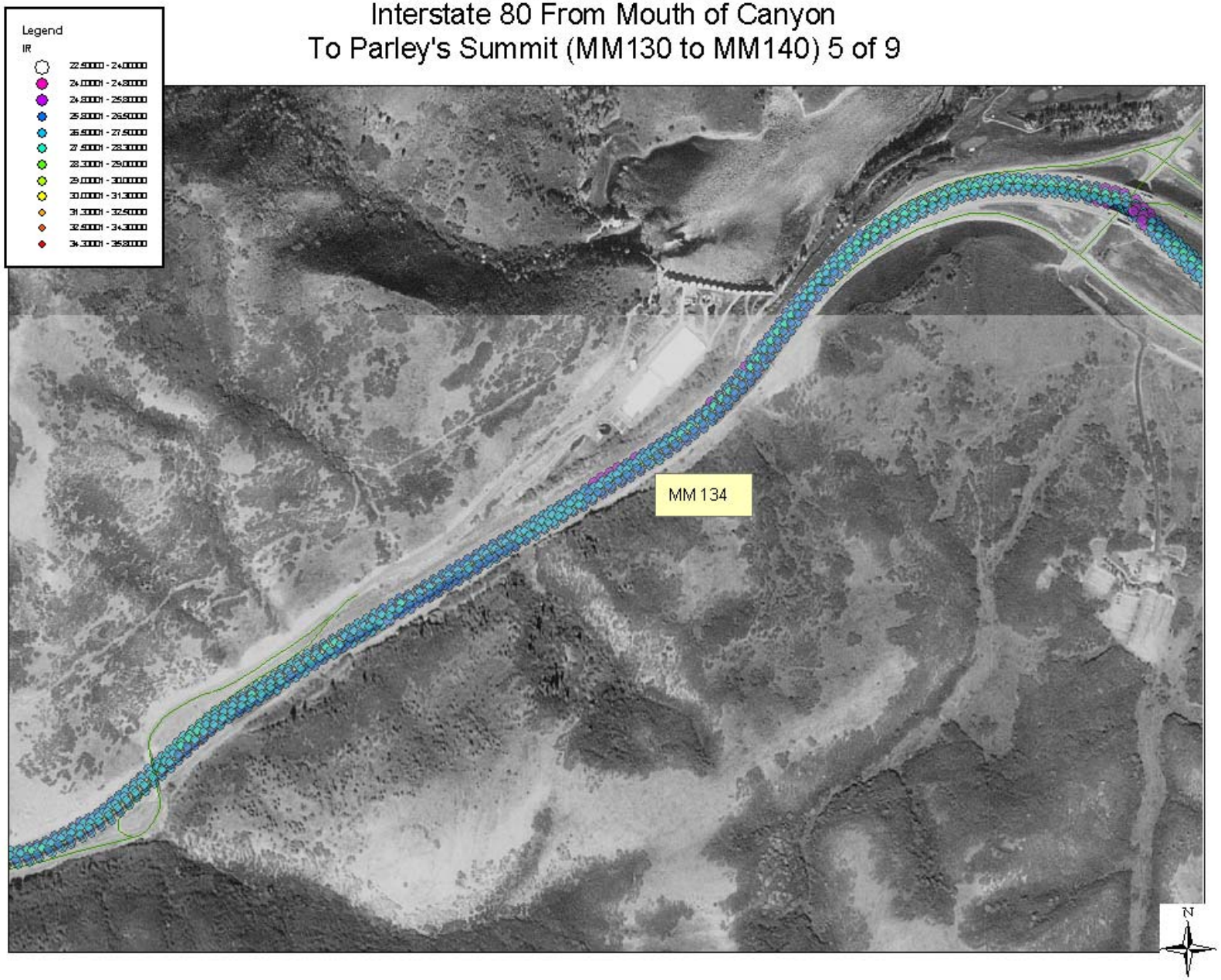
Pavement Temperature Data
Interstate 80 From Mouth of Canyon
To Parley's Summit (MM130 to MM140) 3 of 9



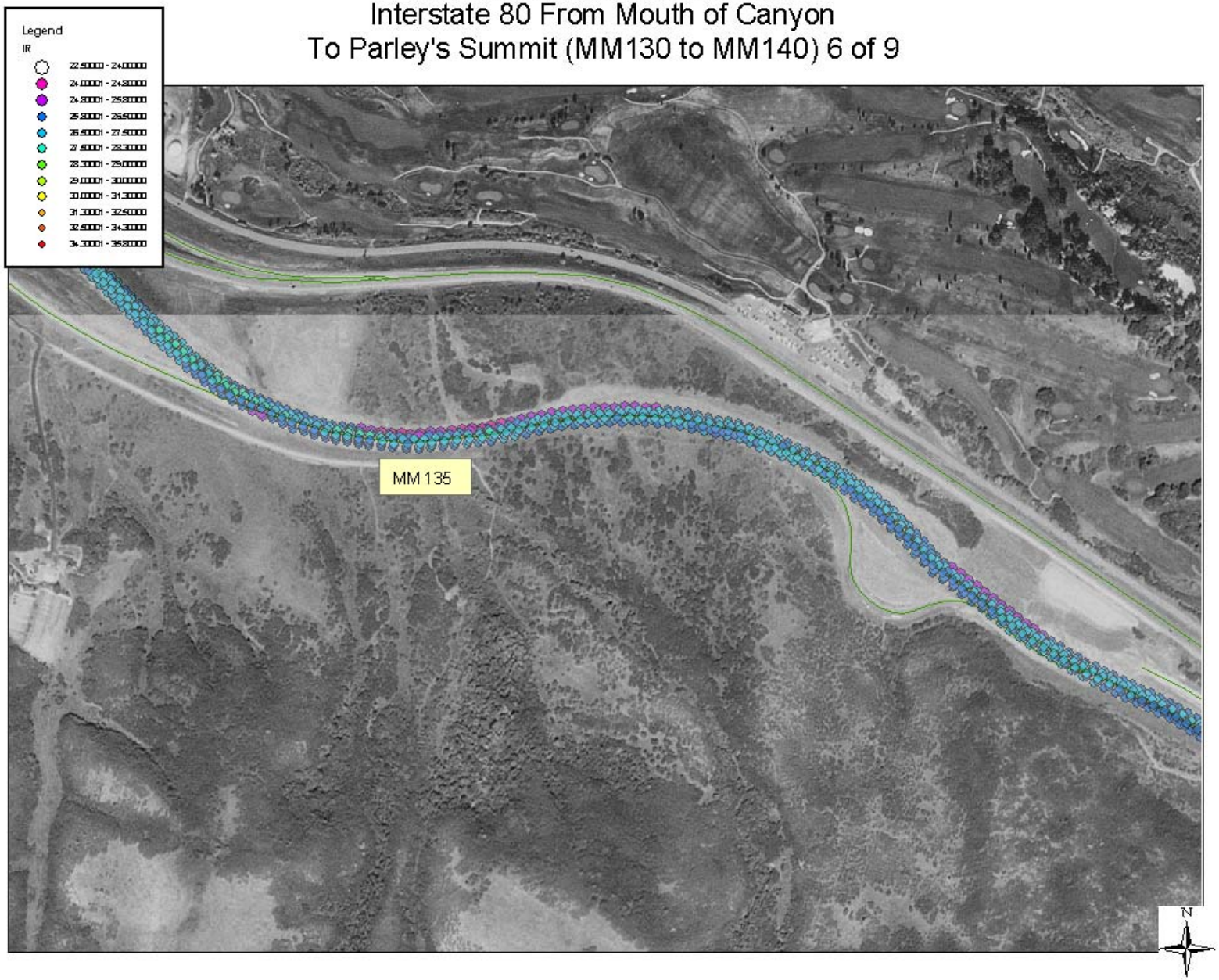
Pavement Temperature Data
Interstate 80 From Mouth of Canyon
To Parley's Summit (MM130 to MM140) 4 of 9



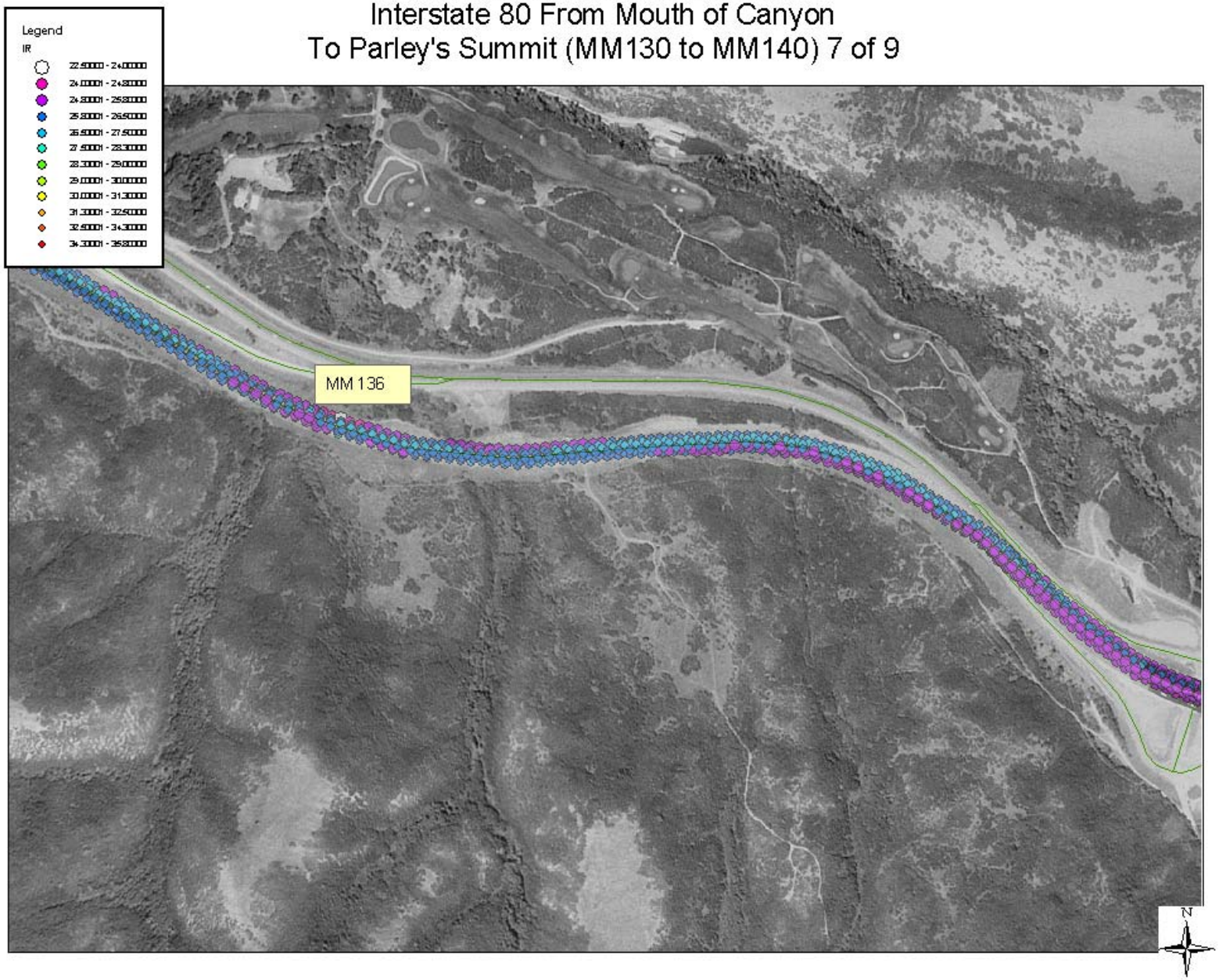
Pavement Temperature Data
Interstate 80 From Mouth of Canyon
To Parley's Summit (MM130 to MM140) 5 of 9



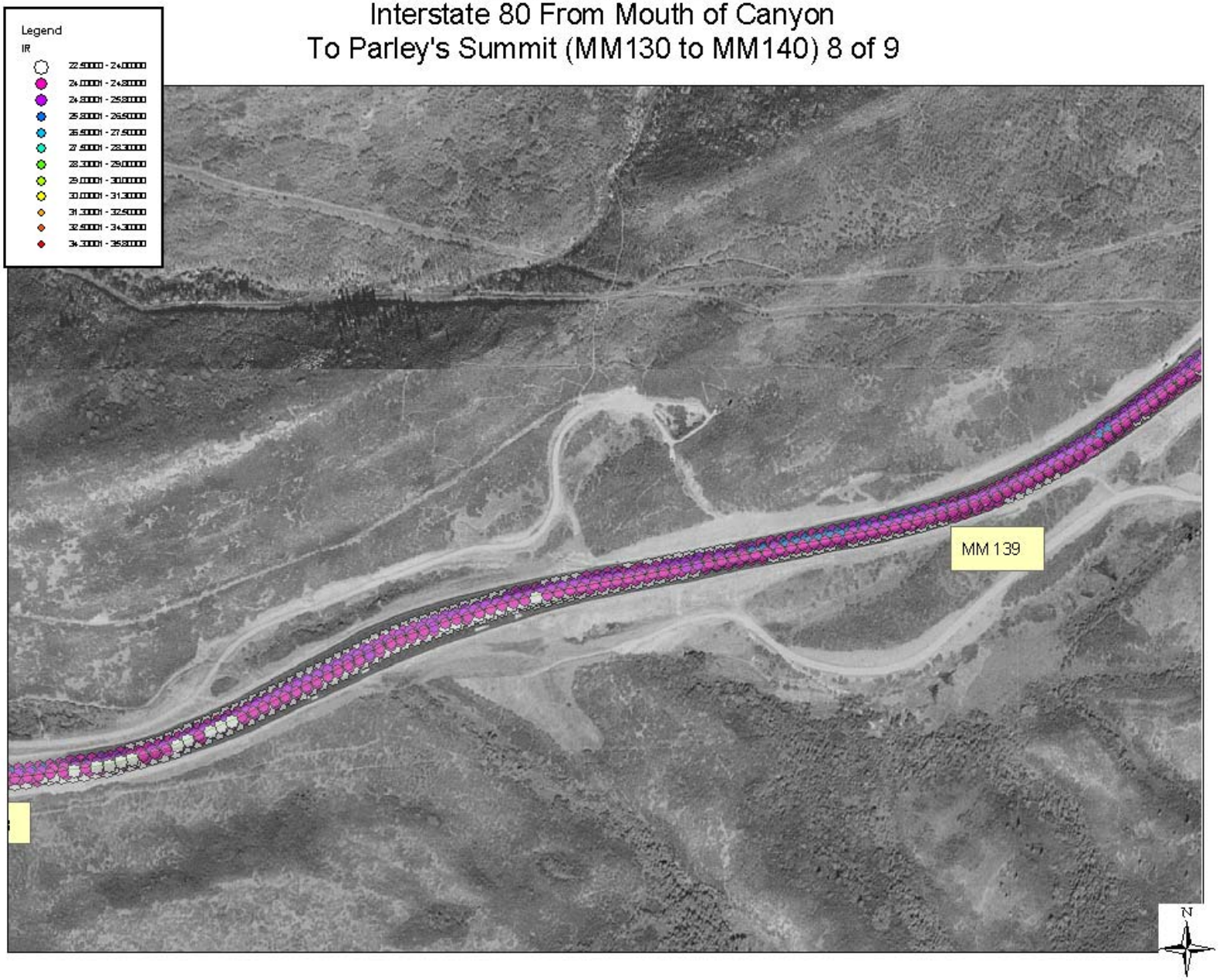
Pavement Temperature Data
Interstate 80 From Mouth of Canyon
To Parley's Summit (MM130 to MM140) 6 of 9



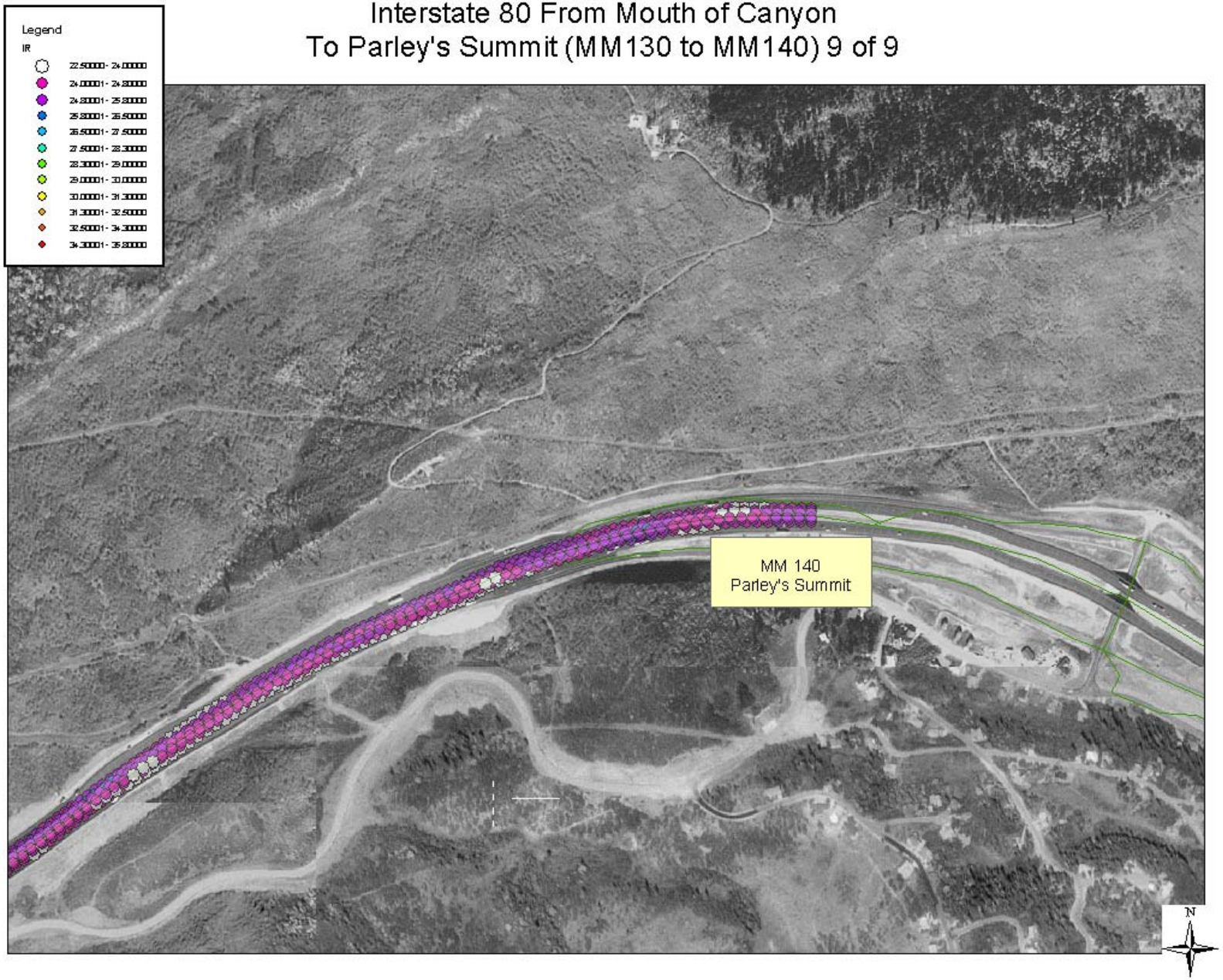
Pavement Temperature Data
Interstate 80 From Mouth of Canyon
To Parley's Summit (MM130 to MM140) 7 of 9



Pavement Temperature Data
Interstate 80 From Mouth of Canyon
To Parley's Summit (MM130 to MM140) 8 of 9



Pavement Temperature Data
Interstate 80 From Mouth of Canyon
To Parley's Summit (MM130 to MM140) 9 of 9



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‘Your Speed’ Signs for School Zones

Final Report

Experimental Feature X(03)04

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Utah Department of Transportation
Research Division

June 2005

SUMMARY

This study was originally planned to evaluate the effectiveness of permanently mounted “Your Speed” display signs in reducing the average speed through school zones. The plan was to collect baseline speed data both before and after the signs were installed, and then evaluate any changes in the speed data.

A number of urban and rural school zones were identified in each region, and the task of collecting baseline speeds in each of the locations was planned to be shared by both Research and Traffic & Safety Divisions. Speed data was collected in some of the school zones, but when difficulties arose in procuring the correct sign size, data gathering was put on hold.

The Traffic & Safety Division worked with the sign vendor to eventually get the correct size sign delivered. The signs were installed, however, before the baseline speed data collection could be updated and completed. Therefore the effectiveness of the signs could not be evaluated.

High-Tension Cable Median Barrier (Brifen & Trinity) at UDOT

Final Report

Experimental Feature X(03)05,06 – New Products

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Utah Department of Transportation
Research Division

June 2005

Introduction

Crossover crashes are considered one of the most fatal crash types due to the relatively high chance of a head-on collision. Solutions to these crashes traditionally have included, among others, extended-width medians and cast-in-place concrete barrier.

High-tension cable median barrier is a relatively new concept in the United States. UDOT investigated the benefits of two systems that were installed in 2002, Wire Rope Safety Fence (WRSF) system by Brifen*USA, Inc. and the Cable Safety System (CASS™) by Trinity Industries, Inc. Previous studies showed the Brifen WRSF to be an initial lower cost solution to crossover crashes than concrete barrier.

UDOT decided to install and study a 1.7-mile section of the Brifen system in 2003 on I-15 from SR-92 to 1200 West in Lehi. Since the installation, other companies have begun manufacturing high-tension systems. In 2004 Trinity Industries was selected to install a 14.7-mile section extending south from 1200 West in Lehi to the S-curves.

The following photos illustrate some installation elements of the two systems:

Brifen Wire Rope Safety Fence (WRSF)

Trinity Cable Safety System (CASS)

In this 16.4-mile stretch on I-15, prior to the installation of the first of these two systems, there had been a total of 203 serious injuries and 41 fatalities related to median cross over crashes from 1996 to 2003.
Both systems have been successful at preventing head-on collisions, but UDOT wanted to evaluate, among other elements, the maintainability and cost per hit of each system. This report presents the results. The vendor literature and Preliminary Information for Product Evaluation Form (R-52) for each system are included in the Appendix.

Background

Cable barrier is not a new technology in the United States. The US 3-wire system is similar to the studied systems except the cables are only subject to low tension. These systems have proven successful in reducing the number of crossover fatalities where installed. However, problems arose with these systems due to their maintainability. Cars often became tangled in the cable requiring the cable to be cut and spliced. Also, the entire system would go down after the 1st crash leaving the median exposed to potential crossover crashes until maintenance crews could repair the barrier. This has proven extremely difficult, especially in winter when crews are busy with winter operations, and where winter conditions, also, heighten the crossover potential.

Oklahoma DOT researched possible alternatives in a location where they were experiencing a high number of crossover fatalities. The conclusion from this research was to experiment with the Brifen WRSF system, citing good results at a fraction of the cost of concrete barrier along with aesthetic and maintenance concerns. A 1000' section was installed after FHWA approval. The success of the system was so great, OK-DOT moved to the second phase of the project which was to install another 7 miles of the system.

Goal

The goal of the study was to collect information for future installations of these systems.

Objectives

The objectives identified to accomplish the study goal were:

1. Collect crash data to determine the effectiveness of these systems.
2. Collect maintenance input to determine the maintainability of each system.
3. Collect the approximate cost per hit of each system.
4. Collect lessons learned from construction and maintenance.

Construction Information

The installations of each of these two systems were similar. The first step was to determine the desired location of the system in the median. After the location was determined, the installation procedure for each system was, basically, the same.

Postholes were drilled, sockets were placed in fresh concrete, posts were placed in the sockets, the end sections were installed, and the cable was placed and tensioned. The construction progress on the Brifen system and part of the CASS system was slow, initially, however, the contractor was soon able to increase the pace.

Results

Crash Data

As of May 2004 there had been at least 18 crashes on the two systems; 6 on the Brifen and 12 on the CASS. However, there had been no crossover fatalities, but two cars were able to penetrate the Brifen system. One was caused by the placement of the system and the other was due to a near 90^0 hit, which the system isn't designed to prevent. In both cases there was no damage any other vehicle. Both systems have been hit before a previous hit could be fixed and both systems were successful in preventing the second hit from penetrating. In fact, there was an instance where 4 successive cars hit the CASS system and each car, although allowing more deflection, was redirected.

As of June 2005, crash data provided by UDOT Traffic and Safety Division, for both systems shows significant decreases in the number of serious injuries and the number of fatalities resulting from median related crashes. The average number of serious injuries per year decreased by 92 % from 27.4 to 2.1. The average number of fatalities decreased by 100% from 5.9 to 0. The Crash Data Summary table is shown in the Appendix.

Maintenance Input

From conversations with both maintenance supervisors who have been asked to maintain these, both systems are not difficult to maintain. One of the reasons for this is a maintenance crew does not need to fix the system immediately after impact. The systems seem to be able to withstand multiple hits without a compromising service. The CASS system was even hit during construction where the ends of the cables had yet to be secured; the car still did not penetrate the system.

Cost Per Hit of Each System

The two systems are similar in maintenance costs. The labor has proven to be about 1 man-hour for each hit, which is negligible. The major cost comes from post and accessories, which is about $500 for a typical hit of 4-5 posts. Fourteen months of maintenance cost data shows a total of $14, 517 incurred to repair 43 hits. The Maintenance Cost Data Summary table is shown in the Appendix.

Lessons Learned

On March 24, 2005 a meeting was held in UDOT Region 3 to discuss and document the lessons learned. Representatives from industry (Brifen and Trinity) were there along with UDOT personnel from Region 2, Region 3, Research Division, Traffic & Safety Division and the FHWA. The resulting documented lessons learned have

been summarized and categorized into Preconstruction, Construction and Maintenance as shown below.

Preconstruction Lessons Learned

Median Placement -The system should be placed on the high side of the median slope and not in the ditch. The geometry of a cut median lends itself to the possibility of a car bumper going underneath the cables. Performance of the barrier in preventing vehicle penetration seems to be better if the cable is installed on the slope, away from the ditch flow line. Also, the wetter soil in the flow line increases the possibility of post and anchor foundations becoming loose. The preferred alignment is just outside the clear zone in a location that is as flat as possible. Interstate installations will always have at least 24 feet of clear zone to the system. Maintenance sees the advantage in the speed; if traffic control is needed then the advantages drop.

Post & Anchor Foundations -The top of post and anchor foundations should match the finished grade of the slope. One crash into the Brifen system resulted in a post foundation failure. The only conclusion reached was the car (most likely the axle or frame) was able to hit a lip of concrete of the foundation. The foundation then sheared off at the bottom of the socket and flew across 3 lanes of traffic. Fortunately no one was injured. Concrete post foundations need to be flush with the surrounding terrain so that vehicles cannot snag or hook the top of the foundation or the sleeve. Also, soil compaction requirements and details around the anchor foundations should be clarified in specifications and standard drawings and enforced in construction. Several of the deadman anchors have rotated out of place and required the contractor to come back and enlarge the foundation. Trinity felt that this might be due to less than required compaction around the foundation or over tensioning the cables. The soil conditions should be verified and compaction requirements should be clarified in the specifications. Existing soft soils should be modified or removed.

The increased cost of concrete socketed foundations seems justified for long-term installations because they are easier to maintain. Direct drive sockets would be cheaper for transition installations (concrete seems a waste for a short anticipated system use life).

Shoulder applications need a couple of feet of good material behind the line posts on all systems similar to what is required for other devices (like guardrail).

Post Color - Posts can be powder coated in any color desired.

Median Grades - Fill the median to as flat as possible before placing the system. Even though both systems claim to be able to be suited for a slope of 6:1 or less, this recommendation has two effects: 1) An approaching vehicle will have a greater probability of striking the system as designed. 2) The driver of an approaching vehicle will have better control of a vehicle which increases the chance of avoiding

the collision altogether. Prepping the grade prior to installation of the cable system also provides a more aesthetically pleasing installation. In order to provide a smoother finish grade, some projects have varied the thickness of the untreated base course rather than maintaining exactly four inches.

With the median being as flat as possible, the grades around the system installations need to be carefully designed to provide adequate drainage. The Initial survey data probably needs to be much better than previously used.

***Median Landscaping* -** If landscaping is designed for the median, an "adequate" buffer zone around the system should be provided. A minimum of two feet was discussed but a closer look should be taken to determine the definition of "adequate". If landscaping is not going to be in the median, the ground should be sterilized prior to installation.

Cable Anchors -The existing conditions around the location where the terminal anchor is placed need to carefully assessed. There is the concern of losing the anchor and then losing the system if a vehicle turning around in the median accidentally hits it. If the location of the anchor falls close to a median turn-around, gaps around the NCHRP 350 compliant anchors need to be eliminated to discourage improper turn-arounds. A detail also needs to be added in the non-NCHRP drawing. Other possible anchorage protection schemes should be investigated.

***Quantities* -** Cable and anchor quantities should be estimated as closely as possible. The manufacturers provide the runs in the exact lengths needed and modifications are expensive and time consuming.

***Erosion Control* -** Review the location and size of existing check dams and other erosion control devices in the median. They may need to be adjusted or repositioned if cable barrier system performance may be compromised.

New Test Sections -Any new products need to have spare parts contracts set up with the initial installation (including test sections).

***Community & Media Relations* -** For future installation projects it is recommended that a media marketing initiative begin in the design phase or early in the construction phase. This would help educate the public as to how the systems work and what performance is like in other places until local performance history is established.

Emergency Services - Coordination with and training of local emergency services is also something to start early on. They do not want to have to cut these systems.

Concrete Sleeves - A contactor in another state that was installing the Trinity system had an experience with pre-cast concrete sleeves that were failing on impact due to voids in the concrete. Pre-cast concrete sleeves that are called out in the Trinity drawings now require four pieces of rebar. Brifen has seen good performance with pre-pounded holes filled with pre-cast concrete post anchors.

Narrow Medians - Narrow median applications need further review by UDOT but other agencies have had successful projects with little room available for deflection. Impact angles are typically shallower than what is tested for in the NCHRP tests

Training - Training to the designers by the manufacturer's representative is encouraged.

Construction Lessons Learned

Boring Holes-A guardrail-drilling rig should be used to bore the holes.
This is one trick the contractor found to speed the drilling and also better control the alignment. Installation goes fairly well unless a very hard subsurface exists (slag). Some equipment was underpowered for installation in slag

Paved Medians - For applications in asphalt paved medians, it is possible to auger right through thick asphalt. Others have cored the asphalt and then capped the hole with concrete.

Training -Training by the manufacturer's representative to the construction personnel should be required.

Maintenance Lessons Learned

System Tension-A periodic review of the tension in the systems needs to be logged. Either every six months or every thirty hits (needs to be developed) so that we can show that the system is regularly checked for accident claims. Retensioning the Brifen system took four hours for a 1.8 mile section. Tension was not rechecked after fourteen days as is now required by spec. The time between tensioning needs to be sufficient to allow a new system to settle in.
Trinity had an anchor hit in Washington (5300' long run) where tension was released. It took about three to four hours to re-stand the anchor and re-tension the system.

There have been impacts with untensioned cable where the cable has still performed as intended.

System Repair –The cable should be picked up with a Handyman Jack instead of by hand. A vice grip pliers works best to hold the cable in place in the nearest undamaged post. In the case where a cable on a curve has been knocked out of position and is taking the short route across the curve, it works best to use a winch or come-a-long mounted in the receiver hitch to pull the cable back in position.

A custom built spacer is used to keep the cables in proper order.

Public Reaction to Repair Costs-Motorists involved in crashes with these systems have not balked at the costs involved with damages to State equipment as they have done with safety devices that are more expensive to repair. Insurance companies have not been objecting either.

Training- Training by the manufacturer's representative to the maintenance personnel should be required

Eyewitness Accounts

The following are comments received from people who were involved in, or were eye witnesses to, vehicles hitting the systems:

Scott Andrus, UDOT Region Three

"I didn't hit the system, but witnessed another vehicle hitting it. In my opinion, if the cable barrier hadn't been there that car would have passed through the median and hit me. I was very impressed with the barriers performance after witnessing the impact, the car stayed in contact with the barrier almost as if it were "held" and though there was damage to the vehicle the driver was fine and talking on her cell phone within minutes of the accident, standing outside the car."

Conclusions

During the relatively short time these systems have been in place, they have both proven to be effective in significantly reducing the average number of serious injuries and fatalities per year. UDOT maintenance personnel consider both systems to be relatively easy to maintain. The time and cost of repairs have been less than $500 per hit on average. Several lessons have been learned and documented which will improve the design, construction and maintenance of these systems.

Recommendations

Both systems performed well and, from a Research perspective, are recommended in locations where the initial cost of concrete barrier is cost-prohibitive or in other areas as identified by, and in coordination with, UDOT Traffic & Safety Division. Systems that are installed should have pre-stressed cables. Non-stressed cables would require more maintenance due to the need to re-tension after a hit and are not recommended at this time.

Status

Specification

- As of the date of this report, a special provision specification, “Sec. 02845S, High Tension Cable Barrier”, is available from UDOT Traffic & Safety Division and is included in the Appendix.

Drawings

- Detailed drawings have also been completed and were included in a project bid package. The drawings are currently before UDOT Standards Committee for review.

Media

- A newspaper article entitled “New Barriers - A Safety Boon” written by Zack Van Eyck, was published in the Deseret News and is included in the Appendix.
- A feature news story entitled “Cable Barriers” was aired on KSL television 10:00 Evening News and is available from UDOT Research.

Follow-up

The following items were also identified in the meeting held in Region 3 and will be addressed in a follow-up report.

- Research will contact the insurance industry to determine their opinions about the systems, and if there is a documented decrease in repair and injury claim costs due to the cable barrier systems.
- Document the accounts of drivers who have hit the systems as documented by IMT and/or UHP personnel

Acknowledgements

Special thanks are hereby expressed to the following for their contributions to this study:

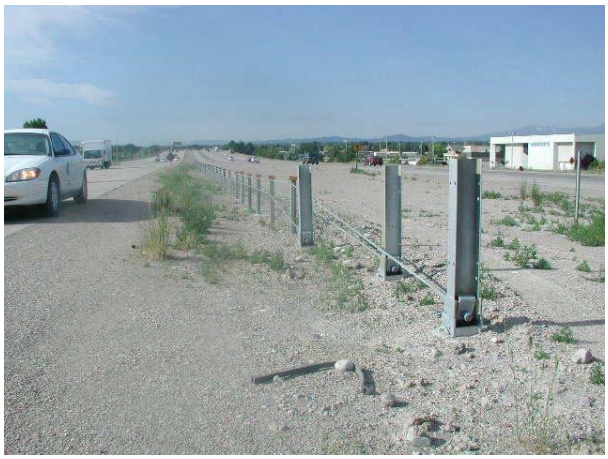
UDOT Region 3 Operations and Preconstruction
UDOT Region 2 Operations
UDOT Traffic and Safety Division
UDOT Research Division
Brifen*USA, Inc.
Trinity Industries, Inc

Appendix

The tire tracks show that the vehicle path was diverted by the cable barrier, preventing what would have been an almost certain crossover collision.

350 Anchor

W-Beam Anchor



350 Anchor

W Beam Anchor

Deadman Anchor

W Beam Anchor

W Beam Anchor

BRIFEN★USA INC.

WIRE ROPE SAFETY FENCE

TL-4 APPROVED

NCHRP 350 APPROVED

Proven Design, Years of Real World Performance

Because You Only Want The Very Best

Utah Department of Transportation
Research and Development Division

I.D. FILE # 03-016

PRELIMINARY INFORMATION FOR PRODUCT EVALUATION

Form R-52 (Rev. 6/00)

See Instruction block at bottom before starting to fill out form.

1. *Product Trade Name:* BRIFEN WIRE ROPE SAFETY FENCE (WRSF) Date: 02/11/03

   Manufacturer/Co.: BRIFEN*USA, INC. Patented? ☒Yes ☐No ☐Applied For

   Company Contact: JERRY EMERSON Ph#: (405) 793 - 9500 Fax #: 799 - 3808

   Street Address: P.O. BOX 94220, OKLAHOMA CITY, OK. 73143
   ~~9215 S. SHIELDS BLVD., OKLAHOMA CITY, OK 73160~~

   City: State: Zip Code:

2. Local Contact: SAME AS ABOVE Ph#: ( ) - Fax #: -

   Local Address (*Distributor*):

   City: State: Zip Code:

3. Background description of Company and its product: BRIFEN WRSF IS MANUFACTURED IN OKLAHOMA CITY PLANT BY BRIFEN*USA, INC.

4. Product Identification: A 4-CABLE ROADSIDE OR MEDIAN BARRIER. THE CABLES (WIRE ROPE) ARE PRE-STRETCHED AND HIGHLY TENSIONED, ON WEAK STEEL POSTS.

5. Recommended use of product: MEDIAN OR ROADSIDE BARRIERS, SECURITY FENCES AROUND IMPORTANT FACILITIES.

6. Outstanding Features or Advantages Claimed: AS A BARRIER, THE WRSF HAS MUCH LESS DEFLECTION THAN TYPICAL 3-CABLE U.S. CABLE BARRIER: STAYS UP AFTER A HIT AND CAN HANDLE SUBSEQUENT HITS BEFORE REPAIRED: QUICK REPAIR TIME (30 MINUTES).

7. General Composition of Material: (Attach laboratory report when applicable) STEEL POSTS AND WIRE ROPES (4), ALL GALVANIZED TO ASTM A-123. ROPES 19MM ASTM A-741-90 MODIFIED TO BRIFEN SPECIFICATIONS.

8. When Introduced on Market? 2000 IN U.S. Alternate for what existing product(s)? CAN BE USED IN PLACE OF STRONG OR WEAK POST W-BEAM, CONCRETE BARRIER, 3-CABLE TRADITIONAL SYSTEM.

9. Approx. cost: $ 8-9.00 per LIN. FOOT (unit). Delivery at site 30 days after receipt of order.

   If cost is "job-by-job" give typical price range to expect....$ 8.00 TO $ 10.00 PER LINEAR FOOT

INSTRUCTIONS -- Answer ALL Questions. Use "X" to indicate choices.
Where a Question is Not Applicable, enter N/A.
Attach additional paper if needed and refer to Item No.

10. Does your product meet requirements of the following specifications? Please write the specification number, classification and type or subgroup when appropriate (i.e. AASHTO M 148, Type I D, Class A)

AASHTO					
ASTM	A-741-90	A-123	A-36		
FEDERAL	NCHRP-350 (TL-3)				
UDOT					

11. Is product approved for use by other highway authorities or agencies? (Indicate by whom used and whether use is routine or experimental only) USED WORLDWIDE IN OVER 30 COUNTRIES.

12. Who recommended that the Department be contacted? DANIEL AVILA

13. Has another office of UDOT been contacted ☒Y ☐N If YES, Whom? GLENN SCHULTE

Please answer the following questions by placing an X in the appropriate box:

YES	NO	
☒	☐	Can a demonstration be provided?
☒	☐	Are ☐ videos or ☐ educational training courses available?
☒	☐	Can ☐ plans, ☐ drawings, or ☐ pictures be furnished by manufacturer? If Yes, ☐ Copy attached ☐ To be mailed.
☒	☐	Are instructions or directions for installation, application or use available?
☐	☒	Is availability seasonal?
☒	☐	Can samples be provided ☒ free or ☐ at cost for laboratory/field testing?

Approximate cost for samples? $_____

Signature _____
(Needed for follow up correspondence.)

☞ *Please attach trade literature, test results, testimonials, specifications, MSDS sheets, instructions, warranty, samples, etc.* ☜

Please submit this form to:

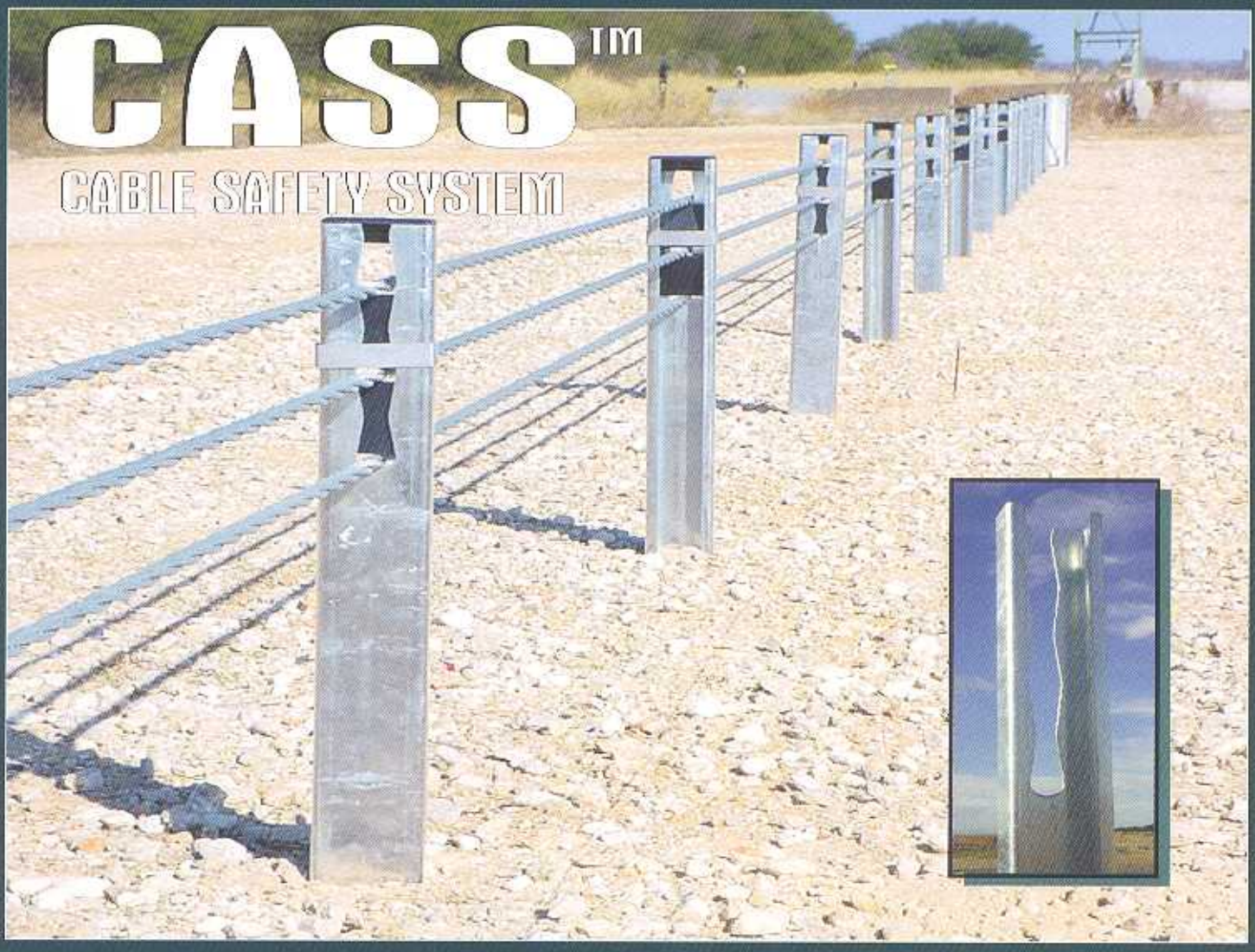
UDOT -- Research & Development
Attn: Barry Sharp
4501 South 2700 West
Salt Lake City, UT 84114-8410
UDOT Box # 148410

or fax to : (801) 965-4796

For your questions or comments our engineering staff is available M-Th from 7am to 5pm (MST).

Kenneth H. Berg, P.E. Development/Implementation Program Manager (801) 965-4321	Dan Avila, P.E. Development Engineer (801) 965-3890	R. Barry Sharp Research Specialist (801) 965-4314

filename: qpl\c52.fm



CASS™
CABLE SAFETY SYSTEM

CASS has been tested to EN 1317-1,2, containment level N2 and NCHRP 350 Test Level 3.

CASS addresses the weaknesses of existing systems by using new technology and innovative solutions. CASS is a complete system that provides:

Increased safety from the softened shape of the post and widened spread of the cables.

Increased flexibility by way of designable deflections and complete solutions for practically any situation.

Increased value from maintenance-free service and quick repair after impact.

CASS™ Offers Specifiers, Installers and Users All These Advantages:

- Designable deflections.
- Maintenance-free service (no periodic retensioning)
- Posts can be driven in soil or installed in steel sleeves set in asphalt or in concrete post foundations
- Posts have no sharp edges or hooks.
- Patented shape of the slot keeps the cables in position during impact, resulting in noticeably lower deflections.
- Each of the three 19 mm pre-stretched cables has a minimum breaking load of 16.7 metric tons.
- Personal Training Seminars by Our Highway Safety Experts are available to Installers and User Groups.

Trinity Industries, Inc.
Tel: +1 214 589 8140
Fax: +1 214 589 8423
Email: product.info@.trin.net
Website: www.highwayguardrail.com

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01/03

Utah Department of Transportation
Research and Development Division

I.D. FILE # 03-088

PRELIMINARY INFORMATION FOR PRODUCT EVALUATION

Form R-52 (Rev.6/00)

See Instruction block at bottom before starting to fill out form

1. Product Trade Name: **CABLE SAFETY SYSTEM (CASS)** Date: **Septermber 26, 2003**

   Manufacturer/Co.: **TRINITY INDUSTRIES, INC.** Patented? **Yes** No Applies For

   Company Contact: **Don Gripne** Ph#**(360) 943-9559** Fax # **(360) 943-9559**
   Street Address: **5216 Brassifield Dr.**
   City: **Olympia** State **WA** Zip Code: **98501**

2 Local Contact: **Trinity Industries, Inc.** Ph#**(800) 772-7976** Fax # **(801) 292-9138**
   Local Address (Distributor):
   City: **Centerville** State: **UT** Zip Code: **84014**

3. Background description of Company and its products: **Trinity Industries, Inc supplies highway safety products such as guardrail, guardrail end treatments, impact attenuators, truck mounted attenuators, and the Dent Breakaway Bolt. This cable system stays in line with providing roadway safety products.**

4. Product Identification: **CASS**

5. Recommended use of product: **The system can be used where a cable barrier would be required.**

6. Outstanding Features or Advantages Claimed: **The cable system is prestreched and tensioned which reduces the amount of deflection and the maintenance before and after impacts. The system requires anchors every 10,000 feet, and it has a NCHRP approved terminal.**

7. General Composition of material: (Attach Laboratory report when applicable) **A-36 steel and galvanizing.**

8. When Introduced on Market? **2003** Alternate for what existing product(s)? **Any cable system on the market.**

9. Approx. cost: **$8 to $12 per foot** (unit). Delivery at site 7 days after receipt of order.
   If cost is "job-by-job give typical price range to expect...**$B TO $ 12 per foot.**

INSTRUCTIONS - - Answer ALL Questions. Use "X" to indicate choices.
Where a Question is Not Applicable, enter N/A.
Attach additional paper if needed and refer to Item No.

10. Does your product meet requirements of the following specifications? Please write the specification number, classification and type or subgroup when appropriate (i.e. AASHTO M 148, Type 1D, Class A)

AASHTO	
ASTM	**A36; A153**
FEDERAL	**NCHRP 350**
UDOT	**NCHRP 350**

11. Is Product approved for use by other highway authorities or agencies?
(Indicate by whom used and whether use is routine or experimental only)
New product on the market. Currently being submitted to all states.

12. Who recommended that the Department be contacted? **Standard procedure with a new roadway safety product.**

13. Has another office of UDOT been Contacted Y N **X** If YES, Whom?

Please answer the following questions by placing an X in the appropriate box:

YES	NO	
X		Can a demonstration be provided?
X		Are videos or educational training courses available?
X		Can plans, drawings, pictures be furnished by manufacturer?
X		Are instructions or directions for installation, application or use available?
	X	Is Availability seasonal?
X		Can samples be provided free or **X** at cost for laboratory/field testing?
		Approximate cost for samples?

Signature _____
(needed for follow up correspondence.)

Please attach trade literature, test results, testimonials, specifications, MSDS sheets instructions, warranty, samples, etc.

Please submit this form to:
UDOT -- Research & Development
Attn: Barry Sharp
4501 South 2700 West
Salt Lake City, UT 84114-8410
UDOT Box # 148410
or fax to : (801)965-4796

==========

For your questions or comments our engineering staff is available M-Th from 7am to 5pm (MST)

Kenneth H. Berg, P.E. Development/Implemanetaion Program Manager (801) 965-4321	Dan Avila, P.E. Development Engineer (801) 965-3890	R. Barry Sharp Research Specialist (801) 965-4314

CABLE BARRIER CRASH HISTORY SUMMARY
1996 TO 5/10/05

SYSTEM	I-15 LOCATION DESCRIPTION	BEFORE/AFTER INSTALLATION	YEARS OF DATA	MEDIAN CRASH DATA (ave./yr.)		
				# CRASHES	# SERIOUS INJURIES	# FATALITIES
CASS	Segment: S-Curves to Pleasant Grove Interchange Length: 7.6 miles Install date: Jan. 2004	BEFORE	7	52.4	13.3	3.3
		AFTER	1.4	48.6	1.4	0
	Segment: Pleasant Grove Interchange to 1200 W. Lehi Length: 7.6 Install date: Jan. 2005	BEFORE	8	53.4	11.6	2.6
		AFTER	0.4	?	0	0
Brifen	Segment: 1200 W. Lehi to SR-92 Length: 1.7 miles Install date: Oct. 2003	BEFORE	6.8	8.5	2.5	0
		AFTER	1.5	6	0.7	0
		Total Before		114.3	27.4	5.9
		Total After		54.6	2.1	0
		% DECREASE			***92%***	***100%***

UDOT REG. 3 CABLE BARRIER REPAIR COST SUMMARY
1/5/04-3/2/05

Repair No.	Maint. Sta.	I-15 MP	Date	Costs			Total
				Labor	Equip.	Materials	
1	3448	285	1/5/2004	622.6	56.98	122.3	801.88
2	3423	283.8	3/9/2004	56.6	2.1	31.35	90.05
3	3427	269	4/13/2004	90.29	3.85		94.14
4	3427	269	4/18/2004	56.59	3	0	59.59
5	3427	271	5/1/2004	150.2	6	246	402.2
6	3427	270	5/18/2004	120.16	6	81.4	207.56
7	3427	270	5/19/2004	84.9	4.8	122.1	211.8
8	3423	273.5	5/29/2004	166.55	6		172.55
9	3423	284	5/31/2004	3	28.7	56.6	88.3
10	3423	283	6/11/2004	226.4	11.94	242.49	480.83
11	3427	270	6/20/2004	120.16	6	81.4	207.56
12	3427	268	6/24/2004	142.26	6		148.26
13	3427	269	6/30/2004	45.06	3	123	171.06
14	3427	267	6/30/2004	120.16	6	162.8	288.96
15	3427	272	7/3/2004	897.83	66	272.3	1236.13
16	3423	283.7	7/8/2004	180.24	6	67.8	254.04
17	3427	269	7/12/2004	56.59	3	0	59.59
18	3427	269	7/15/2004	300.4	14.8	871.44	1186.64
19	3427	271	7/16/2004	90.12	4.62	123	217.74
20	3427	271	7/22/2004	90.12	4.44	123	217.56
21	3427	269	7/27/2004	45.06	3	123	171.06
22	3423	274.9	8/3/2004	60.08	2.1	104	166.18
23	3427	268	8/16/2004	150.2	6	369	525.2
24	3427	271	8/22/2004	150.2	6	205	361.2
25	3423	283.2	8/25/2004	60.08	2.1	149.6	211.78
26	3427	269	8/29/2004	120.16	6	123	249.16
27	3427	271	9/8/2004	$0.00	6	123	129
28	3427	272.5	9/8/2004	$240.32	6	369	615.32
29	3423	273.7	9/24/2004	$180.24	6	164	350.24
30	3423	274.4	9/25/2004	$360.48	12	902	1274.48
31	3423	273.9	11/1/2004	$147.63	9	0	156.63
32	3423	274.8	11/4/2004	$101.55	6	0	107.55
33	3444	286	11/13/2004	$21.54	11.98	77.4	110.92
34	3427	271	11/13/2004	$90.12	3.33	123	216.45
35	3427	273	11/14/2004	$45.06	3	123	171.06
36	3427	272	12/9/2004	$135.18	9	205	349.18
37	3427	269	12/22/2004	$45.06	3	123	171.06
38	3427	270	12/22/2004	$45.06	3	123	171.06
39	3427	269	12/22/2004	$45.06	3	123	171.06
40	3427	272	1/1/2005	$120.16	6	246	372.16
41	3423	282.7	1/12/2005	$180.24	6	114.15	300.39
42	3427	268	1/27/2005	$240.32	12	937.29	1189.61
43	3427	269	3/2/2005	$90.12	3	287	380.12
					$382.74	$7,840.42	$14,517.31

43 Repairs
$14517.31 Total Repair Cost
AVE. $337.61 per repair

April 14, 2005

Special Provision

SECTION 02845 S

HIGH TENSION CABLE BARRIER

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Cable barrier materials and installation procedures.

1.2 RELATED SECTIONS

A. Section 02317: Structural Excavation

B. Section 03055: Portland Cement Concrete

C. Section 02324: Compaction

D. Section 02841: W-Beam Guardrail

1.3 REFERENCES

A. AASHTO M 30: Zinc coated Steel Wire Rope and Fittings for Highway Guardrail

B. AASHTO M 268: Retroreflective sheeting for Traffic Control

C. ASTM A-36: Standard Specification for Carbon Structural Steel

D. ASTM A500: Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

E. ASTM A1011: Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

F. ASTM A-123 Standard Specifications for Zinc-Coated (Hot Dip Galvanized) Coatings on Iron and Steel Products

G. ASTM A741-98 (2003) Standard Specifications for Zinc-Coated Wire Rope and Fittings for Highway Guardrail

H. AWS D1.1: Structural Welding Code

I. NCHPR-350: Recommended Procedures for the Evaluation of Highway Features

PART 2 PRODUCTS

2.1 GENERAL

A. Provide cable barrier system with the following requirements:

1. Capable of roadside or median mounting
2. System meeting NCHRP-350 Test Level 3 on a 6H:1V or flatter slope.
3. Maximum deflection of 8 feet under NCHRP 350 TL-3 conditions.
4. NCHRP 350 approved terminals and transitions.
5. Non-NCHRP-350 anchor.

B. Provide a socketed (pre-cast or cast-in-place concrete foundations) line post option or a driven sleeve line post option.

C. Provide all hardware and miscellaneous items associated with cable barrier system.

D. Receive pre-qualification prior to bidding system. Provide manufacturer's FHWA Letter of Acceptance(s).

E. Have system parts available within 48 hours of request.

F. Conduct manufacturer-supplied training, prior to the installation of the system.

2.2 MATERIALS

A. Wire Rope: Galvanized wire rope ¾ inch 3 x 7 construction meeting AASHTO M 30/ASTM A741-98 Type I Class A coating except Table 1 Type 1: Breaking Strength Minimum = 39,000 pounds.

1. Wire rope is to manufacturer's specifications: pre-stretched ¾ inch 3 x 7. Pre-stretch wire rope during manufacturing to exhibit a minimum modulus of elasticity of 11,805,000-pounds/sq. in. after pre-stretching.

   a. If the wire rope is an out-sourced product of the cable barrier system manufacturer supply a separate certification from the wire rope manufacturer stating it meets the cable barrier manufacturer's requirements.

B. Hardware and miscellaneous items:

1. Meet manufacturer's requirements for all hardware and miscellaneous items as outlined in the manufacturer's specifications for the installation of the cable barrier system. Items to include but not limited to the following:
   a. Anchor and terminal fittings
   b. Turnbuckles and rigging screws
   c. Post caps and sleeve caps
   d. Parts used to separate and hold cable barrier at designed height.

C. Line post, sleeve sockets and direct drive sleeve:
1. Size as shown in manufacturer's specifications.
   a. Line posts.
      1) Meet all manufacturer's specifications.
      2) Posts as per ASTM A1011 or ASTM A-36.
      3) Galvanized to ASTM A-123, after fabrication.
      4) Post has a means of holding the wire ropes at the design height.
   b. Line post sleeve.
      1) Meet all manufacturer's sleeve specifications for the selected post foundation option.
      2) Sleeves as per ASTM A500.
      3) Welds as per Certified Welders to AWS D1.1.
      4) Galvanized to ASTM A-123, after fabrication.
2. Line post foundations, cast in place with sleeve, precast concrete with cast in sleeve or direct driven sleeves.
   a. Cast in place post foundation option will require the complete filling of each excavated hole with concrete.
      1) Reinforcing steel as required by manufacturer.
      2) Do not use a tubular concrete form for casting of foundation.
   b. Pre-cast post foundations as per manufacturer's specifications.

1) Excavated holes will require the area around the excavation to meet Standard Specification Section 02324 for compaction.

c. Direct drive post sleeves with an industry standard approved method for driving post sleeve.

3. Line Post delineation.

a. Delineation using AASHTO M 268 Type III or greater retroreflective sheeting.

1) Sheeting color: White or yellow, color to correspond with the adjacent edge line.

2) Minimum size: 7 sq. in. per side (2" x 3½")

3) Delineation required on both sides of post as per this section, 3.6, D.

D. Cable Barrier Terminals, Cable Barrier Transitions and Cable Barrier End Anchor:

1. Cable Barrier Terminals, Cable Barrier Transitions and Cable Barrier End Anchor will be of the size and shape required by the manufacturer and meet manufacturer's specifications.

a. Cable Barrier Terminal: NCHRP-350 Approved

1) Approved terminal using Cable Release Posts (CRP) (commonly referred to as the TTI Cable Anchor).

2) Cable Barrier Terminal line posts with sleeve

3) Object marker delineation using AASHTO M 268 Type III or greater retroreflective sheeting.

b. Cable Barrier Approach Transition using w-beam.

1) Approved w-beam guardrail to cable barrier transition.

2) Meet Section 02841 for w-beam, post, blocks and hardware.

(a) Meet manufacturer's requirements for w-beam, post, blocks and hardware when items required to

meet approach transition design needs exceed UDOT requirements.

3) Delineation using AASHTO M 268 Type III or greater retroreflective sheeting for terminal ends as per Standard Drawing CC-1.

c. Cable Barrier Departure Transition using w-beam, thrie beam or a combination of:

1) Approved departure transition from w-beam to cable barrier.

2) Meet Section 02841 for w-beam, post, blocks and hardware.

(a) Meet manufacturer's requirements for guardrail elements, post, blocks and hardware when items required to meet departure transition design needs exceed UDOT requirements.

3) Delineate using AASHTO M 268 Type III or greater retroreflective sheeting for terminal ends as per Standard Drawings CC-1 and GW-9 .

d. Non-NCHRP-350 Cable Anchor (dead-man anchor)

1) Barrier protection for this end anchor is required when placed within 1.2 times the clear zone.

(a) See plan set for offsets and required external barrier protection.

2. Terminals not described above must meet NCHRP-350 testing requirements and have FHWA Acceptance Letter issued. Obtain prior approval from the Division of Traffic & Safety before bidding terminal

E. Shop drawings, 4 sets, for the installation of the following:

1. Cable Barrier Terminal (NCHRP-350 approved)
2. Cable Barrier Approach Transition (NCHRP-350 approved)
3. Cable Barrier Departure Transition (NCHRP-350 approved)

4. Cable Barrier anchor terminal (non-NCHRP-350)
5. Typical installation of line posts and cable.

F. Training Materials
1. Installation manuals
2. Maintenance manuals
3. Materials deemed necessary to conduct training for proper installation and maintenance of cable barrier system.

PART 3 EXECUTION

3.1 TRAINING AND LITERATURE

A. Provide all training materials in hard copy and electronically in PDF format.

B. Notify and provide installation and maintenance training and certification.
1. Training conducted by the supplying manufacturer.
a. Provide one training session prior to construction to the following:
1) Contractor (Prime)
2) Installation Contractor (Sub)
3) Resident Engineer and/or designee.
b. Provide one training session prior to UDOT accepting project and invite the following:
1) Region Maintenance Engineer and/or designee
2) Region Operations Engineer and/or designee
3) District Engineer and/or designee
4) Area Supervisor and/or designee
5) Local Maintenance Station personnel
6) Engineer for Maintenance (Complex) and/or designee
7) Representative from the Division of Traffic and Safety
8) FHWA-Utah Division representative
2. Provide 4 sets of shop drawings as stated in this section 2.2, F.
a. Distribution
1) Resident Engineer

2) Prime Contractor

3) Installation Contractor (sub)

4) Local Maintenance Station

3.2 PREPARATION

A. Site considerations:

1. Complete all grading to final grade requirements as per plan prior to installing cable barrier post foundations, terminals, transitions or anchor system.

2. Apply a bare ground treatment 2 feet on each side of the cable system using Sahara Bare Ground Herbicide.

a. Apply after cable barrier foundations have been installed and the excess material has been removed or graded into surrounding area.

b. Follow product-labeling requirements for selected product.

c. Apply herbicide at a rate of 10 pounds per acre.

d. Have a license issued by the Utah Department of Agriculture for Right of Way application.

3.3 CONCRETE FOUNDATIONS AND DIRECT DRIVE REQUIREMENTS

A. Line posts

1. Precast post foundation

a. Supply as per manufacturer's specification.

b. Install precast foundation as per manufacturer's specification.

c. Install precast foundation to a point that the top of foundation is at final grade level.

d. Excavate holes and backfill with excavated material. Compact material around the precast foundations to a minimum of 95 percent of maximum laboratory density refer to Section 02324. Dispose of excess material by removal or grade into surrounding area.

1) Other methods of installing foundation will require approval from the Resident Engineer.

2. Cast in place post foundation

a. Excavate hole to diameter and depths as per manufacturer's specification.
   1) Do not over excavate hole.
   2) Install required reinforcing steel.
   3) Install post sleeve ½ to 1 inch above finished grade.
   4) Fill the excavated hole with concrete, dome concrete down from top of post sleeve to flush with finished grade.
      (a) Do not use a tubular concrete form for casting of foundation.

b. Use AA(AE) concrete, refer to Section 3055.

c. Allow concrete to cure a minimum of seven (7) days and to achieve 4000 psi before installing any other elements of the barrier system.

3. Direct drive line post sleeve.

a. Use an industry standard approved method for driving post sleeve.
   1) Do not excavating hole for post sleeve.

b. Drive sleeve to a point ½ inch or less above finished grade.
   1) Do not drive sleeve below finished grade.

B. Terminal, Anchor and Transitions

1. Supply and install cast in place NCHRP-350 approved terminal using Cable Release Posts (CRP) (commonly referred to as the TTI Cable Anchor), and terminal line post.

a. Excavate Cable Release Posts (CRP) holes and terminal line posts to diameter and depths as per cable manufacturer's specification.
   1) Do not over excavate hole.
   2) Install required reinforcing steel as per manufacturer's specifications.
   3) Install Cable Release Post (CRP)
      (a) Place bottom section of post in such a manner that top section of post can be attached and the bottom of the hinged portion is at finished grade level.

(b) Fill the excavated hole with concrete, ensure top of concrete is flush with final grade.

(c) Do not use a tubular concrete form for casting of foundation.

(c) Use AA(AE) concrete, refer to Section 3055.

(d) Allow concrete to cure a minimum of seven (7) days and to achieve 4000 psi before installing any other elements of terminal or barrier system.

4) Terminal line post

(a) Use post sleeve as per manufacturer's specification.

(b) Follow same installation procedure, and use same concrete material and allow same curing time as required in this Section, 3.3, A, 2.

C. Precast anchor (deadman anchor)

1. Supply and install precast anchor block as per manufacturer's specification.

a. Excavate hole and install anchor block, backfill with excavated material. Compact material around the precast anchor block to a minimum of 95 percent of maximum laboratory density refer to Section 02324. Dispose of excess material by removal or grade into surrounding area.

1) The top of the anchor block will be at the same grade and elevation as the three consecutive posts foundations approaching the anchor block.

2) Anchor block will not move more than 3 inches toward the opposite cable anchor or terminal during or after tensioning has been completed. If anchor block moves more than 3 inches it will be either removed and replaced with larger block or secured such that no more decrease of cable tension occurs.

2. Supply and install anchor line posts with sleeves as required for anchor system to manufacturer's specification.
   a. Use post sleeve as per manufacturer's specification.
   b. Install required reinforcing steel as per manufacturer's specifications.
   c. Follow same installation procedure, and use same concrete material and allow same curing time as required in this Section, 3.3, A, 2.

C. Cast in place anchor (deadman anchor)

1. Install as per manufacturer's specification.
   a. Excavate hole and form and cast in place anchor.
      1) Use AA(AE) concrete for anchor system, refer to Section 03055.
      2) Install reinforcing steel per cable manufacturer's requirements.
      3) Install hardware as per cable manufacturer's requirements for the attachment of cable.
      4) The top of the anchor block will be at the same grade and elevation as the three consecutive posts foundations approaching the anchor block.
   b. Allow concrete to cure a minimum of seven (7) days and to achieve 4000 psi before installing any other elements of the barrier system.
   c. Backfill with excavated material. Compact material around the cast in place anchor block to a minimum of 95 percent of maximum laboratory density refer to Section 02324. Dispose of excess material by removal or grade into surrounding area.
      1) Anchor block will not move more than 3 inches toward the opposite cable anchor or terminal during tensioning or after tensioning has been completed. If anchor block moves more than 3 inches it will be either removed and replaced

with larger block or secured such that no more decrease of cable tension occurs.

2. Install anchor line posts with sleeves and hardware for the attachment of cable as required for anchor system as per manufacturer's specification.
   a. Install foundations with post sleeves for anchor posts as per manufacturer's requirements.
      1) Follow same installation procedure, and use same concrete material and allow same curing time as required in this Section, 3.3, A, 2.

3.4 CABLE BARRIER TO GUARDRAIL TRANSITIONS

A. Cable Barrier Approach Transition using w-beam guardrail.
   1. Supply and install all components of cable barrier to w-beam approach transition to UDOT'S and manufacturer's specifications.
      a. W-beam guardrail elements will meet the standards and specifications of Section 02841 W-Beam Guardrail and be installed as per Standard Drawings BA 4 series. Use guardrail elements that the manufacturer of the cable barrier system requires to be greater than those specified under standard specification Section 02841 W-Beam Guardrail.

B. Cable Barrier Departure Transition
   1. Supply and install all components of approved cable barrier departure transition to UDOT'S and manufacturer's specifications.
      a. Guardrail elements will meet the standards and specifications of Section 02841 W-Beam Guardrail and be installed as per Standard Drawings BA 4 series. Use guardrail elements that the manufacturer of the cable barrier system requires to be greater than those specified under standard specification Section 02841 W-Beam Guardrail.

3.5 POST AND CABLE INSTALLATION

A. Install posts per manufacturer's requirements to insure proper cable height.

1. Install sleeve cover.
2. Install post caps.

B. Install cable per manufacturer's requirements.

C. Tension immediately after initial installation to manufacturer's requirements.

1. Recheck and adjust tension five (5) days, ten (10) days and fifteen (15) days after initial tensioning.
2. Maintain tension log showing time, date, location, ambient temperature, and final tension reading, signed by the person performing the tension reading.
3. Give log to the Engineer after work is completed.
   a. Include manufacturer's recommended tension chart.

3.6 DELINEATION

A. Cable Release Posts Terminal (CRP) (commonly referred to as the TTI Cable Anchor).

1. Install appropriate object marker sheet on all cable release posts in such a manner it is visible to approaching traffic.
   a. Use a minimum 120 sq. inches (5" x 24") per post.
   b. Install delineation on post # 6 of the terminal line posts as per this Section, 3.6, D.

B. Cable Barrier Approach Transition

1. Install appropriate object marker sheet on terminal end as per Standard Drawing CC-1.
2. Install delineation on rail elements as per Standard Drawing GW 9.
   a. Sheeting color: White or yellow, color to correspond with the adjacent edge line.

C. Cable Barrier Departure Transition

1. Install delineation on transition as per Standard Drawing GW-9.

D. Line Posts

1. Install appropriate sheeting on the first and last line post and every fourth post of barrier system.
   a. Sheeting color: White or yellow, color to correspond with the adjacent edge line.
   b. Place on both sides of post.
   c. Use a minimum 7 sq. inches (2” x 3½”) per side of post.

3.7 PART AND CONTACTS

1. Manufacturer of system will supply the following to the Maintenance Division of the Department no later than 5 days after projects acceptance
   a. Installation details and parts list of system. (4 sets)
      1) Distribution to Central Maintenance, Region/District Maintenance Engineer, Maintenance Area Supervisor, and Maintenance Station Foreman
2. List of suppliers of repair parts, with contact information.
3. Supply parts directly to the Maintenance Division within 48 hours of notification of need.
4. List of Utah based, manufacturer trained installers.

END OF SECTION

New barriers a safety boon

By Zack Van Eyck
Deseret Morning News

WEST VALLEY CITY — When you drive past them, they don't exactly make you feel secure.

Not like concrete barriers would.

But the new cable barriers now used to separate northbound and southbound traffic on two Utah freeways have proven to be more effective than concrete at preventing wayward cars from crossing into the oncoming lanes.

And that should make all motorists feel more secure.

Safety engineers and administrators at the Utah Department of Transportation have been impressed by the performance of the cable barriers, installed on I-215 near the E Center and at two locations on I-15 in Utah County.

As a result of the pilot program's success, UDOT plans to add more cable barriers on Utah interstates and highways to help prevent traffic fatalities and injuries.

Utah motorists simply will have to get used to the fact that the cable barriers — a grouping of three cables held aloft by small posts and looking only slightly stronger than the electric fences used to contain cattle — are more effective than they appear.

"It has the ability to stop the vehicle from crossing over but without imposing a serious impact to that vehicle," said UDOT safety programs engineer Rob Clayton. "If you hit a concrete barrier, there is significant damage to the vehicle. With the cable barrier, while it does damage the vehicle, the impact is less for the vehicle and the driver."

And that can be the difference between life and death.

Cable barriers have been in place for eight months in the median of an eight-mile stretch of I-15 in Utah County, from Provo to Pleasant Grove. Those barriers have been hit 35 times and, Clayton happily reported, "In all of those hits, none of the drivers crossed over into oncoming traffic. And there has been only one serious injury, which we believe was sustained in a related accident that occurred in a collision before they hit the barrier."

Of those 35 barrier hits, at least 15 were at high speed — 55 mph or greater — and those vehicles likely would have crossed over into the oncoming lanes if a concrete barrier had been in place, Clayton said.

"Of course, we don't know what would have happened if they had crossed over," he said. "But we know, based on history, that doesn't end well when that happens."

Prior to the cable barriers, that stretch of freeway averaged 2.5 fatalities and 12 serious injuries per year. In eight months with cable barriers, there have been no fatalities and just the one serious injury, according to UDOT.

The cable barriers on I-215, which stretch for about a mile north of the 3500 South interchange, have only been in place about five months. They have been struck once with no injury reported.

The third segment of cable barriers extends for about a mile-and-a-half on I-15 between the Point of the Mountain and Lehi. That was the first test zone, with barriers in place for about a year now. In that time, there have been six barrier strikes with no injuries.

Near Provo, Clayton said, there was an accident on July 15 in which a Canadian man fell asleep while traveling 80 mph and struck the cable barriers three separate times. At each location, the vehicle wiped out 10 of the posts used to keep the barriers upright, but

the cables prevented the vehicle from crossing into oncoming traffic. And the man was unhurt.

"It doesn't look as sturdy as a concrete barrier, but it actually has the same effect as a rubber band — not that severe, but when a car runs into it, the cable barrier brings them back into the shoulder," said UDOT spokesman Nile Easton.

Not only are they more successful than concrete, but cable barriers also are less expensive than concrete barriers — about a third of the cost. Cable barriers cost $12.85 per foot, fully installed, while concrete barriers cost about $38 per foot.

UDOT is poised to invest about $12 million over the next four years to place more cable barriers along Utah interstates and highways.

So far, another 19 miles worth of cable barriers are scheduled to be installed in the median of I-15, in the following areas: Cedar City, Beaver, from Spanish Fork to Springville, between Pleasant Grove and Lehi, and a three-mile segment in Ogden. Those barriers should be in place within the next year or so, Clayton said.

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Techrete Concrete Pavement Patching on I-15, South of Beaver

Final Report

Experimental Feature X(03)07

By: Richard Sharp, Research Specialist
Ken Berg, P.E., Development Engineer

Utah Department of Transportation
Research Division

June 2005

Introduction

The Utah Department of Transportation (UDOT) is continually searching for a viable concrete spall repair product for concrete pavements that produce a shorter turn around than wet concrete and this product fits the profile of a fast set concrete repair material even though it is a hot polymer that has durability and tenacity.

Objectives

Install a patch quickly in a concrete pavement and be traffic ready in 40 minutes.

Results

Techcrete is a hot applied polymer concrete pavement, fast setting, repair material and was installed on I-15 just south of Beaver at MM 101 +/-. This product was installed September 25, 2003 and has been monitored by Beaver Maintenance forces. Techcrete has performed well under the heavy traffic on the right wheel path, outside lane, and evidences no deterioration and rutting after one winter and two summers. The success of this installation prompted Region One, to write a contract for spall repair on I-15, Hot Springs to Perry, MM 156 to MM 166 +/-. Bill Gooch is the Region One contact and after the installation it appears to be working well as a concrete pavement spall repair.

Conclusions

This field installation and evaluation was to be evaluated for rutting, and durability and was successful in meeting the criteria for acceptance of the product on a job by job and application by application basis. Product will be placed in the Performance Data Products Listing as acceptable based upon performance in the field.

Recommendations

Techcrete has been reviewed and evaluated and dependent upon the application may be used in concrete spall repair under fast track conditions.

Appendix

See Instruction block at bottom before starting to fill out form.

1. *Product Trade Name:* TechCrete Date 9/1/2003

Manufacturer/Co. Crafco, Inc. Patented? ☐Yes ☐No ☐Appl

Company Contact First Name Last Name Ph#: (602) 276-0406 Fax # (480) 940

Street Address: 420 North Roosevelt Avenue

City Chandler State AR Zip Code 85226

2. Local Contact: Cate Equipment Ph#: (801) 973-2900 Fax # (801) 97

Local Address *(Distributor)* 2055 South Pioneer Road

City Salt Lake City State: UT Zip Code 84127

3. Background description of Company and its product:

4. Product Identification:

5. Recommended use of product: A crack repair, for cracks, spalls, pop-outs, failed joints and most types of defects in co surfaces up to a maximum depth of eight inches

6. Outstanding Features or Advantages Claimed:

7. General Composition of Material: **(Attach laboratory report when applicable)**

8. When Introduced on Market? Alternate for what existing product(s)?

9. Approx. cost: $ $216.00 per CF (unit). Delivery at site days after receipt of order.

If cost is "job-by-job" give typical price range to expect...$ TO $

10. Does your product meet requirements of the following specifications? Please write the specificat classification and type or subgroup when appropriate (i.e. AASHTO M 148, Type I D, Class A

AASHTO UDOT 2002, CSI Standard Specifications, Section 03152

ASTM

FEDERAL

UDOT

Category: H. JOINT SEALERS/FILLERS

Evaluate LED Raised Pavement Markers

Final Report

Experimental Feature X(03)10 – New Products

By: Barry Sharp, Research Specialist
Ken Berg, P.E. Development Engineer

Utah Department of Transportation
Research Division

June 2005

SUMMARY

Raised pavement markers have been controversial for a number of reasons, such as the impact on the snow plow blades and requiring sheeting replacement at least semi annually because of the dirt that settles in the reflective areas of the marker.

Lynn Bernhard in Central Maintenance was approached by a vendor that manufactured a pavement marker that is solar powered and self cleans better and would be a viable product to test.

Next, Lynn and the vendor selected a site on I-15 north of Beaver at MM 140 plus or minus. The installation was on the northbound, inside shoulder adjacent to a 6-foot median barrier on curved section of the highway.

The vendor installed 30 devices and the first time a snowplow came by plowing it clipped the markers and destroyed them all.

Hence, the project was discontinued.

Pipe Culvert End Section on I-215

Final Report

Experimental Feature X(03)11

By: Ken Berg, P.E., Development Engineer
Barry Sharp, Research Specialist

Utah Department of Transportation
Research Division

June 2005

Summary

An experimental pipe culvert end section was installed in conjunction with a construction project on the east side of I-215 sometime in the last 18 months. There has been no work plan or product information found to date. If more information about the installation is discovered it will be included in a subsequent report.

8” Wide Waterborne Traffic Marking Project Number IM-NH-15-3(26)121

Final Report

Experimental Feature X(04)05 – New Products

By: Michelle Page, P. E., Development Engineer
Barry Sharp, Research Specialist

Utah Department of Transportation
Research Division

June 2005

Introduction

The State of Arizona and Nevada have decided to go with wider traffic markings on highways for no other reason than it has the appearance of better distance vision and better delineation. This study is an attempt to quantify the utility of a wide traffic marking line and determine a cost benefit relationship of 8” verses 4” line.

Background Information

Nighttime reflection of traffic markings using 4” wide lines fail to adequately capture the attention of the total driving audience, particularly the aging driver. At night, the wider lines appear to extend the night distance about three times the distance when compared to the 4” lines.

Construction Information

The 8” wide traffic marking was installed November 11, 2004 on I-15 Northbound lanes at MM 120 to MM 126. Interstate Barricade was the contractor who painted the wider lines and also the rest of the 8 to 10 project.

8” wide traffic marking was installed using the rationale to cover some old lines and old removal damage. 6” lines would be the recommended change in UDOT practices on the condition that there really is a cost benefit relationship. Going from a 4” protocol to an 8” involved recalibrating the machine for bead drop and paint volume. Visual inspection revealed some early bead loss and maybe some beads just not placed because of the major change in application. The 8” line has a glaring difference from the 4” line and the delineation in the daytime is amazing.

Goal

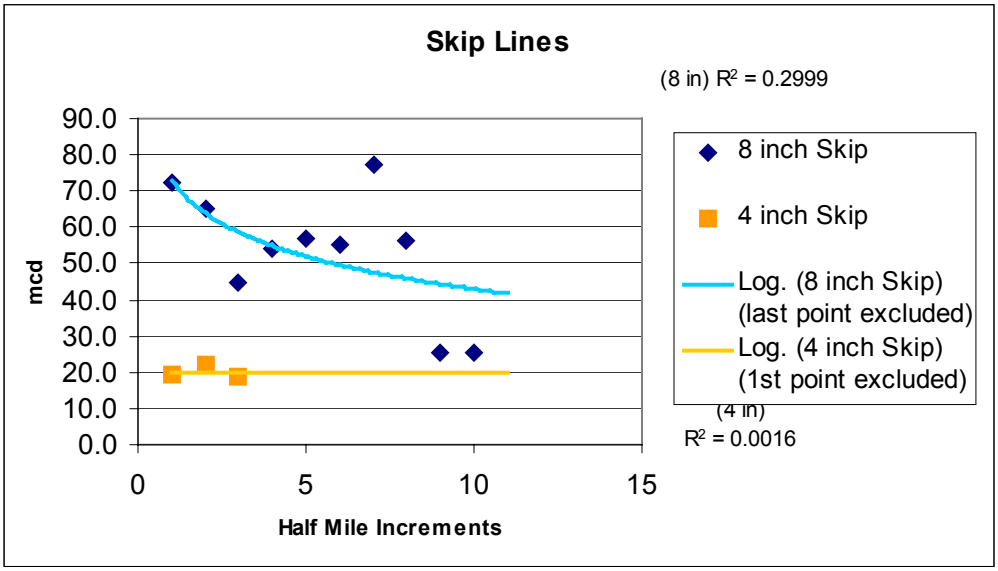
Determine if there is a cost savings through improved safety and vision using the wide traffic marking.

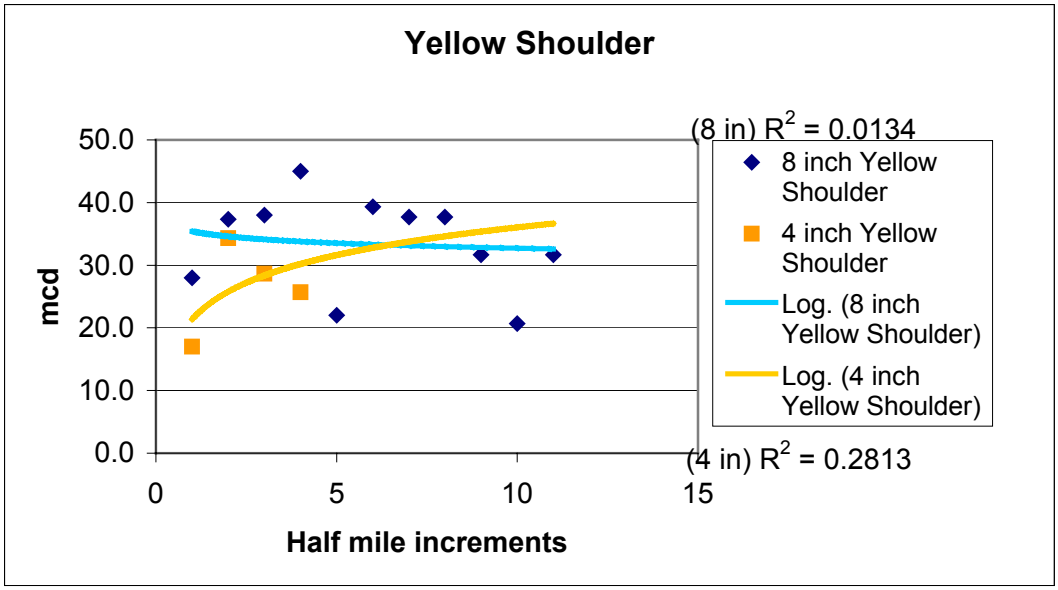
Objectives

Compare retro-reflective capabilities of 4” and 8” wide lines
Visually check for degradation
Obtain a cost effective number for the wider line verses the narrow one

Results

White Shoulders
100.0
80.0
60.0
40.0
20.0
0.0
mcd
0
2
4
6
8
10
12
Half Mile Increments
(8 in) R2 = 0.0315
(4 in) R2 = 6E-05
8 inch White Shoulder
4 Inch White Shoulder
Expon. (8 inch White Shoulder)
Linear (4 Inch White Shoulder)


Skip Lines
(8 in) R2 = 0.2999
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
mcd
0
5
10
15
Half Mile Increments
8 inch Skip
4 inch Skip
Log. (8 inch Skip)
(last point excluded)
Log. (4 inch Skip)
(1st point excluded)
(4 in)
R2 = 0.0016



The above reflective results are by no means enough data to justify making a judgment regarding the cost effectiveness of wide verses not so wide. The information may indicate the there is little more durability and reflectivity but not enough to justify a legitimate cost effective analysis at this time.

Conclusions

One winter for this particular application, 4” and 8”, is just about all you may get to maintain a quality traffic marking. Portions of each are almost indistinguishable because of the snow plowing and traffic on this section of freeway. Waterborne traffic markings are not durable by years but by seasons and plans should be made to paint at least twice a year, fall and spring, to obtain a safe, visible line.

Recommendations

Another site utilizing the 4” and 6” line should be sought and further studied as supported by UDOT Traffic & Safety.

Experimental Feature

Interim Reports

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3M 820 Wet-Reflective Tape on SR-6 & I-215

Interim Report

Experimental Feature X(02)12 – New Products

By: **Barry Sharp, Research Specialist**
Robert Stewart, P.E., Development Engineer

Utah Department of Transportation
Research Division

June 2005

Introduction

Pavement markings continue to be a developing field in transportation. The most challenging property of pavement marking is its ability to provide delineation during wet-night conditions. Although Utah is the second driest State in the Union, wet-night reflectivity can be a concern. UDOT's Traffic and Safety Division identified 2 such locations; US-6 near Soldier Summit and I-215 (300 East to 1300 East).

UDOT's Traffic and Safety Division along with the local maintenance division decided to install 3M's wet-reflective tape on these two locations. The section on US-6 was installed in August 2003 and the section on I-215 was installed in September 2003. UDOT's Research Division has been asked to monitor these sections for durability, retro-reflectivity, and wet-night retro-reflectivity. This study will last three years and interim reports will be written each fall and spring.

Background Information

This 8-mile stretch of US-6 is primarily a three-lane (two EB, one WB) highway (see Figure 1), however it constricts to a two-lane highway at the beginning and end of the section.

Figure 1-Typcial Section of US-6 (Heading WB)

Interstate 215 is the belt route of Salt Lake City. At the test section location, the road is a six-lane divided interstate (see Figure 2).

Figure 2-Typical I-215 section

Table 1 gives the properties of each section of this Experimental Feature.

Table 1		
	US-6	**I-215**
AADT	6,855	116,251 - 58,000 Each Direction
Material	PG Asphalt	PCCP
Elevation	1,900m - 2,250 m	1,300 m

Construction Information

Both installations required the product to be placed below the profile of the road. For the US-6 project this was accomplished in two ways. First, a chip seal was

placed over the existing asphalt surface, but the oil sprayers were turned off over the tape location. This allowed the excess chips to be swept away and a trough was left where the tape was going to be placed. Then, a Roadpro asphalt grinder was used to increase the depth of the inlay and to make a more precise groove. The surface was then sprayed with the 3M primer, the paper backing removed, and the product placed. Compacting rollers were not used on this job; instead, a car wheel and a truck wheel were driven over the product to press it. Figure 3 shows the end product.

The SR-6 project included only the edgeline of the two-lane rural road. The I-215 project included both white edgeline, yellow edgeline, and skip lines.

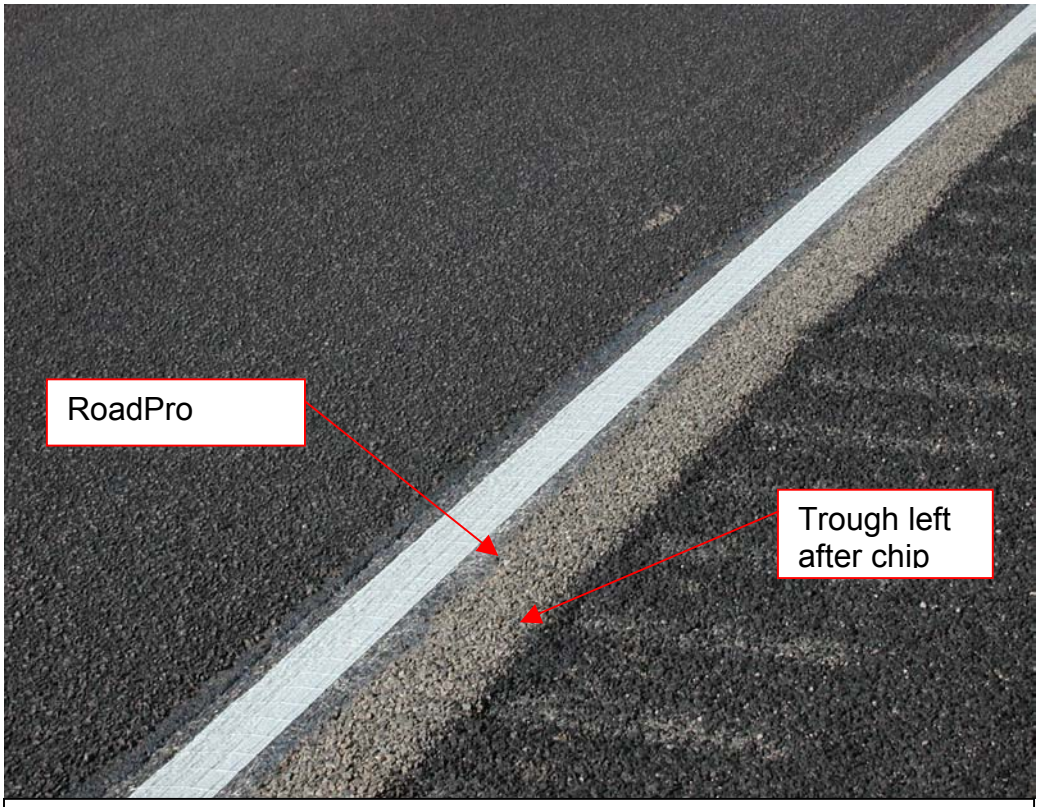


Figure 3-Installed tape on US-6

Goal

The goal of this project was to determine the effectiveness of this tape.

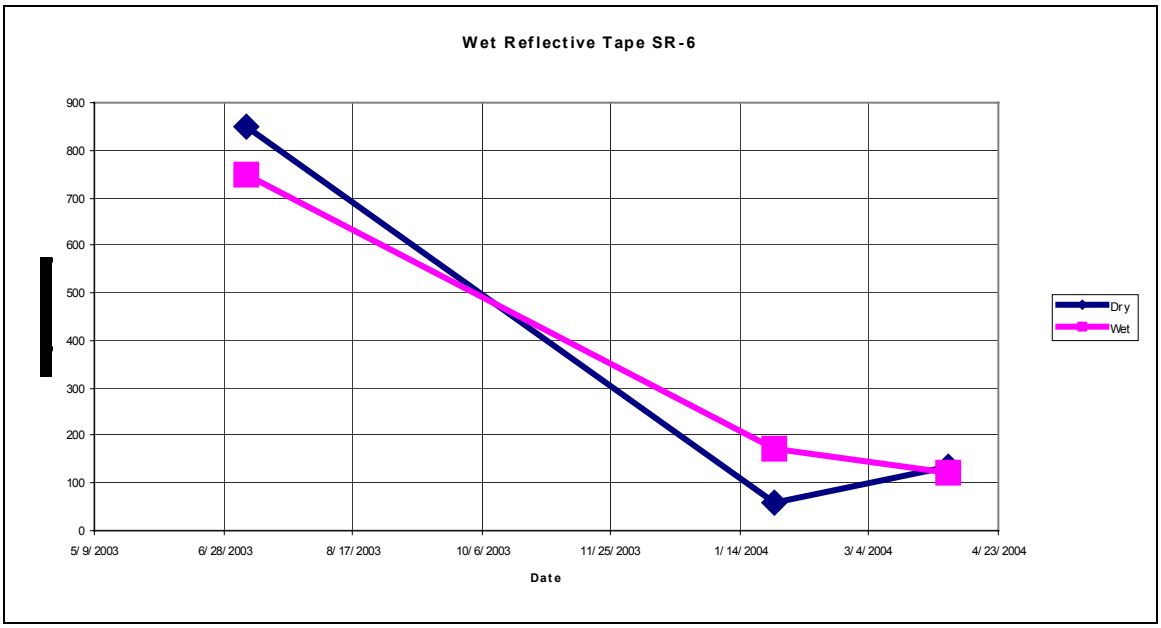
Objectives

The objectives are:

1. Evaluate the retro-reflectivity over time (mcd/m^2/lx).
2. Evaluate the durability over time.

Results (U.S. 6)

1. The initial retro-reflectivity was very good. However, there was a large standard deviation in the data. The data shows a dramatic decline in the RR over the first season. The wet-night retro-reflectivity was measured using the LTL 2000 and showed good results.



The chart shows the dramatic decline. Interestingly, the values doubled or sometimes tripled if the retro-reflectivity was measured against the flow of traffic. This hasn't been explained, but may indicate the product is more sensitive to snow plow abrasion than other markings.

Retro-reflectivity readings have recently been taken on I-215 but had not yet been compiled and analyzed as of the writing of this report.

2. There was a major problem with the durability. In both locations there were major portions that came up. The total loss amounted to about 10% of the total project. The reason for the loss isn't yet known. Warranty work will be done to replace the failed tape.

3. Warranty work was performed by 3M and because the redo involved significant replacement at both sites the study was discontinued. Evaluating old and new is not practical and yields mixed results.

Results (I-215)

The third set of retro-reflectivity readings have recently (July 2005) been taken on I-215 but had not yet been compiled and analyzed as of the writing of this report. The previous two sets of readings proved inconclusive as the failure curve could not be generated. However, the visual inspection shows good visibility under both wet and dry conditions.

Conclusions (U.S. 6)

The tape on U.S. 6 lost its much of its RR after the first season. The product also suffered heavy loss in durability after the first season. However, subjective descriptions of the product during wet-night conditions were extremely positive indicating the product works under the conditions for which it is designed.

Conclusions (I-215)

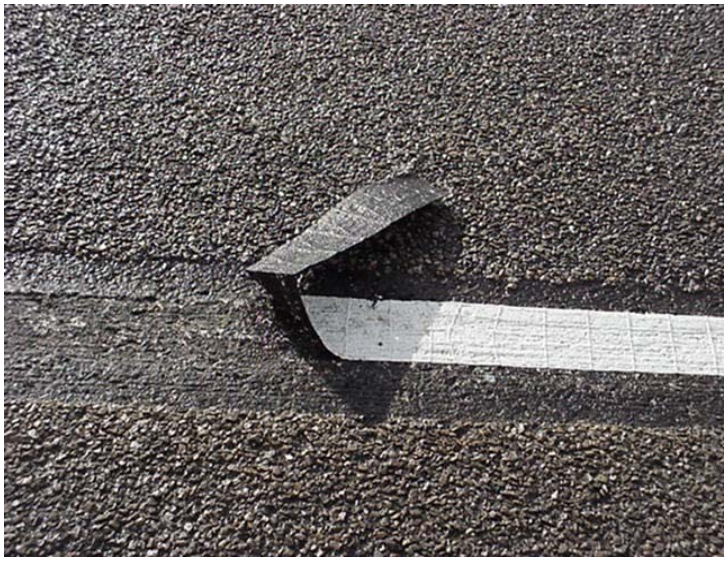
The tape on I-215 still is in place. The product will continue to be evaluated.

Recommendations

At this time, the Research Division does not recommend using a foil backed wet reflective tape as it has yet to prove durable. 3M is currently working on a 380 series wet reflective tape which will be tested in Region Two in the Fall of 2005. Currently Materials, Central Maintenance, Traffic & Safety, Research and the Regions are working together to determine effective pavement markings for given conditions.

Appendix

US 6 Photographs:



Failed tape on SR-6

Failed tape on SR-6

Failed tape on SR-6

90% typical tape on SR-6

I-215 Photographs:

Wet reflective median and skip lines under wet conditions.

Newly installed white wet reflective tape by the side of existing stripe.

3M Company's Polyurea Traffic Marking (LPM 1200 and 1201)

Interim Report

Experimental Feature X(02)13 – New Products

By: **Michelle Page, P. E., Program Manager**
Barry Sharp, Research Specialist
Robert Stewart, P.E.

Utah Department of Transportation
Research Division

June 2005

Introduction

This report describes the installation and evaluation of 3M Company's 1200 Polyurea traffic marking. Utah Department of Transportation allowed 3M Company to install this product on Bangerter Highway from SR 201 to 3500 South, all lane marking.

Background

Durability, retro-reflectivity and curing time of fluid pavement markings present a continuous challenge for engineers and safety managers. The Utah Department of Transportation (UDOT) is proactively involved in the development and implementation of a pavement marking management program that will ensure acceptable pavement marking performance on State highways. New products are continually being developed which have the potential to improve that program. A particularly promising new product is a polyurea paint striping material produced by 3M Company, LPM 1200. UDOT currently has no polyurea lane line striping on its state highway system.

3M's LPM 1200 polyurea striping material claims several potential advantages over traditional epoxy and water-based paint products. Among them are:

- The polyurea binder material cures to a hardness that enhances the ability of the material to retain the reflective beads, a common problem with traditional paints
- The curing time is only 3 to 6 minutes, depending on the thickness of application (compared to an hour or more with epoxy and water-based paint)
- Polyurea cures to a hardness that enhances durability over epoxy and water-based paints
- Polyurea can be applied at surface temperatures as low as 40 degrees (compared to 50 degrees or more for the other)
- Polyurea has increased visibility in wet night conditions
- Polyurea is more resistant to UV degradation.

If these claims are valid, polyurea would become a valuable tool to UDOT, for the reasons listed above, to be used in conjunction with existing methods of marking lane lines. UDOT Traffic & Safety is championing and funding this Experimental Feature. UDOT Region Two Operations has accepted hosting this Experimental Feature.

Project Responsibilities

Responsibilities on the project are as follows:

UDOT Traffic & Safety Division

Research Champion
Construction Manager
Source of Funding
Assisting with the product evaluation
Assisting with preparation of recommendations for future applications
Implementation

UDOT Research Division

Preparing the work plan
Administering the contract
Identifying performance measures
Technology evaluation
Recommendations for future applications
Implementation

UDOT Region Two Operations

Project site selection
Assisting with the product evaluation
Assisting with preparation of recommendations for future applications
Implementation

Construction Information

UDOT Region Two Operations selected the segment of SR 154, Bangerter Highway, between SR 201 and 3500 South (NB & SB) to use as the test section for this project. This section of Bangerter Highway experiences a high traffic volume and will provide an effective test of durability. The section is in need of pavement marking replacement. All of the existing lines have been removed per UDOT Standard Specification 02765 and replaced with 3M LPM 1200 polyurea product described earlier.

There are three different applications of this product on this project. The three applications are 4” yellow solid lines, 4” white solid lines and 4” white skip lines, two each direction. Research will take retro-reflectivity measurements at 21 random locations along the test section.

The results of this reflective testing will be compiled every 6 months and an electronic copy will be distributed to interested parties and will be updated on the

UDOT Research web-page. UDOT will publish interim reports and a final report when UDOT Traffic & Safety determines to end this study.

Pavement markings are very dependent upon proper preparation and installation. 3M recommended the contractor they use in this area to do the installation:

United Rentals
4533 Andrews Street
North Las Vegas, Nevada 89301.

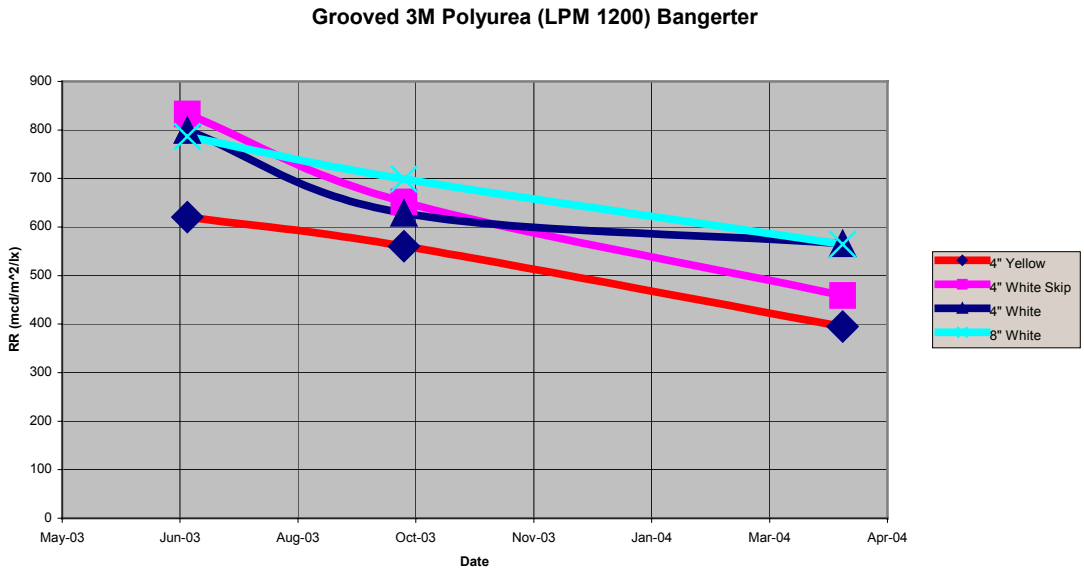
Total cost of this installation was $76,000 which includes removal, preparation and installation.

Objectives

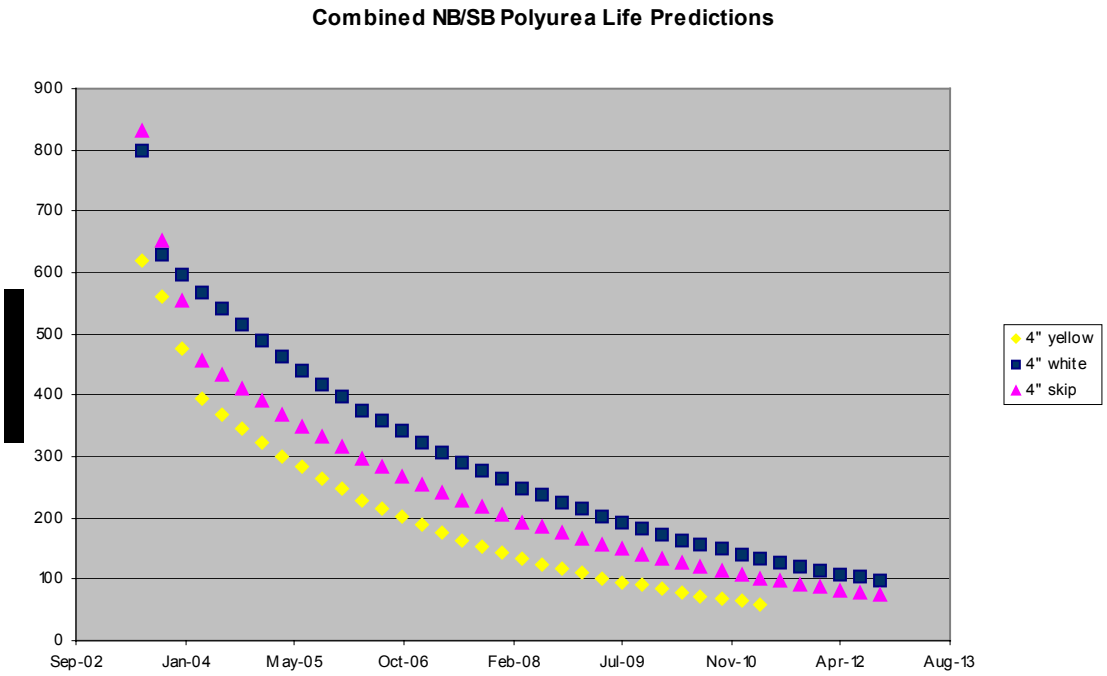
Measure the retro-reflectivity until failure
Measure life cycle cost for this project
Measure durability

Interim Results

Product was installed and the results of three years of reflective readings is below:



Product has been evaluated and the projected life of the product is as follows:



Conclusions

The material has shown very good durability and as you may note in the above graphs it is doing very well on the Bangerter Highway. There is little evidence of bead loss and that is one of the benefits the polyurea lays its claim to fame.

Recommendations

UDOT should be thinking about using this product for a durable marking. The average cost per linear foot for this product is under $ 2.00 and the life expectancy base of the graph above allows failure in 2009. A six year life yields a life cycle cost of $ 0.35 a linear foot for this product. You do the math regarding traffic control and interrupted flow of traffic and you will see this is a product to use based on the information we have at this time.

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Trinidad Lake Asphalt (TLA) Two Experimental Applications On I-80 from Echo to Castle Rock

Interim Report

Experimental Feature X(02)18 – New Products

By: Tim Biel, P.E., Engineer for Materials
Barry Sharp, Research Specialist
Robert Stewart, P.E, Development Engineer (former)
Michelle Page, P.E., Program Manager

Utah Department of Transportation
Research Division

June 2005

Project Location

There are three different locations for this project. The first is a control section on I-80 from Coalville to Echo (approximately 4 miles). This asphalt section is a standard 8” PG 64-32 HMA. This is a typical pavement section that UDOT designs for this application.

The second section is on I-80 from Echo to Emory (approximately 8 miles). The design of this section is 3” TLA over 3” Zero-Void asphalt. The Zero-Void asphalt is designed to add fatigue resistance to the TLA (which enhances durability properties).

The third section is on I-80 from Emory to Castle Rock (approximately 8 miles). The design of this section is different depending on the lane (two lanes each direction). The left most lane is constructed with 5” of standard HMA and the right most lane is constructed with 5” of TLA.

Scope

The scope of these test sections is to give quantifiable results of the performance of different TLA applications. The results need not be statistically significant since resources are limited on this project. Every effort was made to provide results that are professionally respectable.

Evaluation Method

Both laboratory and field tests are necessary on this project. The laboratory tests for the asphalt pavement are:

Asphalt Pavement Analyzer (APA) Rut Test
APA Fatigue Test
Hamburg Wheel Tracker
Corelok (Bulk Specific Gravity)
Resilient modulus

Each of these tests will be performed on each of the different pavement sections present in this project. The schedule of collection will vary depending on the workload of the Materials division. The target is to do each of these tests at least once every year.

The field tests to be performed are:

FWD

PCI Calculation

Skid Resistance

Each of these tests will be performed on each of the three sections at each milepost. The schedule of the FWD and Skid Resistance tests will vary depending upon the workload of the Pavement Management division. The target is to complete each of these tests at least once per year. PCI will be collected at least once a year.

Preliminary Results

March 18, 2005 eight 12" cores were obtained from the three sections of I-80 and were delivered to the Central Materials laboratory for preparing and running the Hamburg Wheel Tracker to test for durability and stripping. The results will be reported when the test results are available.
June 20, 2005 a visual inspection of the test site was performed by Research Division, Michelle Page and Barry Sharp. The asphalt pavement in all test sections appeared to be in good condition; in regards to the potential for rutting and the longitudinal joint that has failed; it has been treated with our asphalt crack sealer and this has virtually stopped any further fatigue in this regard. Pictures were taken at the core sites and reveal very little, if any, real failure of the pavement. The only condition that was noted was the chip seal that remains has been pounded into the HMA and has smoothed considerable. This condition is further reinforced by 2004 skid tests that tend to show a need to address the shiny surface appearance.

The FWD readings are forthcoming and will be reported when received.

Conclusions/Recommendations

Until such time as all data has been compiled and evaluated this product remains experimental and all users should involve Central Materials.

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Gilsonite in Asphalt

Interim Report

Experimental Feature X(03)09 – New Products

By: **Dan Avila, P.E., D&I Engineer**
Barry Sharp, Research Specialist
Robert Stewart, P.E., Development Engineer (former)

Utah Department of Transportation Research Division

June 2005

INTRODUCTION

The Utah Department of Transportation, Region Three Construction sponsored a limited application of an old product, powdered gilsonite with melting reducing polymers to be used as an anti-stripping agent in Hot Mix Asphalt (HMA). The Utah Department of Transportation (UDOT) currently specifies a slurried, hydrated lime. The success of this application will offer two rather than one type of anti-strip agent used in HMA. Competition should produce economies in the price paid for HMA. The goal in this application is to make available another anti-stripping product.

TEST SECTION AND PRODUCT INSTALLATION

Location

The project is located on Southbound US 40 from MM 149.77 to MM 151.1. A 2" overlay using gilsonite was installed. The overlay was 24' wide on the outside traveled way heading southbound the full length of the project. The 2" overlay of HMA with gilsonite was placed on 2" HMA with lime.

Installation-October 21, 2003

The powdered gilsonite was introduced in the asphalt mix at the plant at a 1% by weight rate. The gilsonite was introduced into the counterflow continuous mix asphalt plant where the recyled asphalt is usually added. There was little problem with this application and the mix was not changed. The gilsonite people asked for a little hotter mixing temperature, about 335 degrees Fahrenheit. According to the plant operator he estimated the capacity was increased at least 10% and this does not include the BTU consumption of the heater/dryer that has decreased. The HMA was delivered to the jobsite and placed with normal paving procedures. Paving equipment consisted of shuttle buggy, paving machine and two vibrating rollers. Paving conditions mirrored that of lime slurry treated HMA.

Figure 1-Tacked HMA/Lime

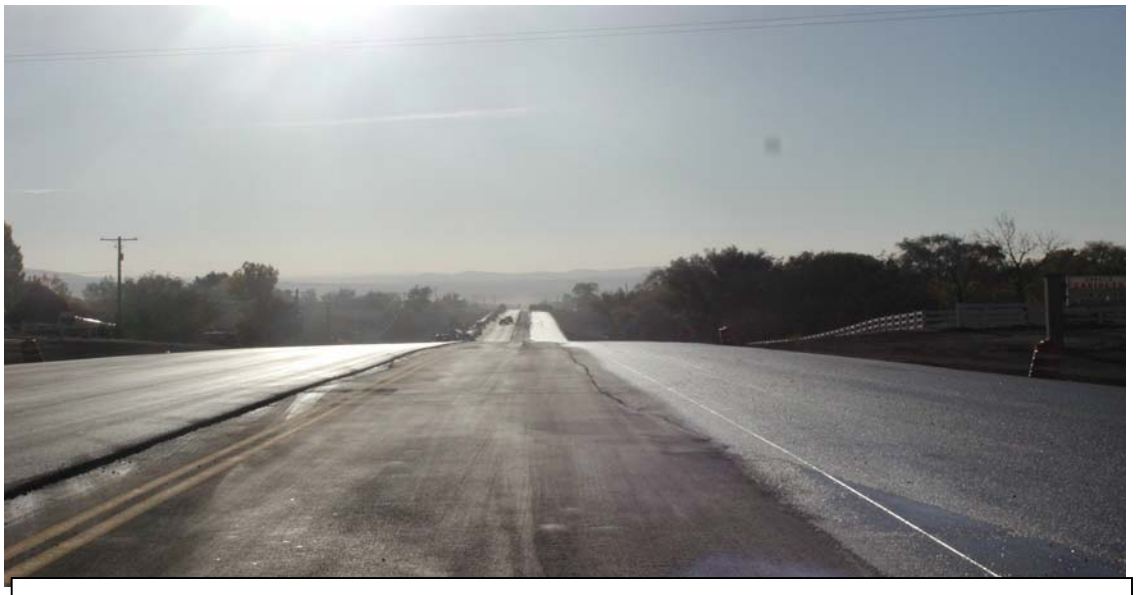


Figure 2-Southbound US 40 Prepped

Figure 3-HMA Mat

Figure 4-Aggcoat Feed Process

FIELD AND LABORATORY TESTING

Nuclear density testing was performed by QA/QC testing laboratory.
UDOT Materials-Central performed sample testing for gradation, VMA, Voids, VFA, Hamburg, Rut and Fatigue.
UDOT Central Materials will obtain roadway samples and conduct the test for stripping-Hamburg Test.
FWD, Structural Adequacy, Rut Depth, Road Profile and IRI, Pavement roughness will not be performed as stated in the work plan because there is no full depth HMA that includes gilsonite on the project. The HMA with gilsonite is a 2" overlay on HMA with lime for anti-stripping. Tests obtained each year for the Hamburg Wheel will only result in how this 2" gilsonite treated overlay works placed on 2" of lime treated HMA.

INTERIM RESULTS

Six cores were cut from the roadway, three in the hot mix asphalt that used lime as an anti-stripping agent and three cores where the gilsonite was used as an anti-strip. The following result of the Hamburg rut test indicates that there is very little difference after a year in place.

The Hamburg rut test of November 2004, all tests passed the criterion allowed and except for the Core # 1 and #1A, they are almost a mirror of each other. The comparison between lime and gilsonite appear after one physical test to perform equally.

CONCLUSIONS/RECOMMENDATIONS

The test results are inconclusive at this time. This study will last for another three years to develop some comparison curves with more than one point.

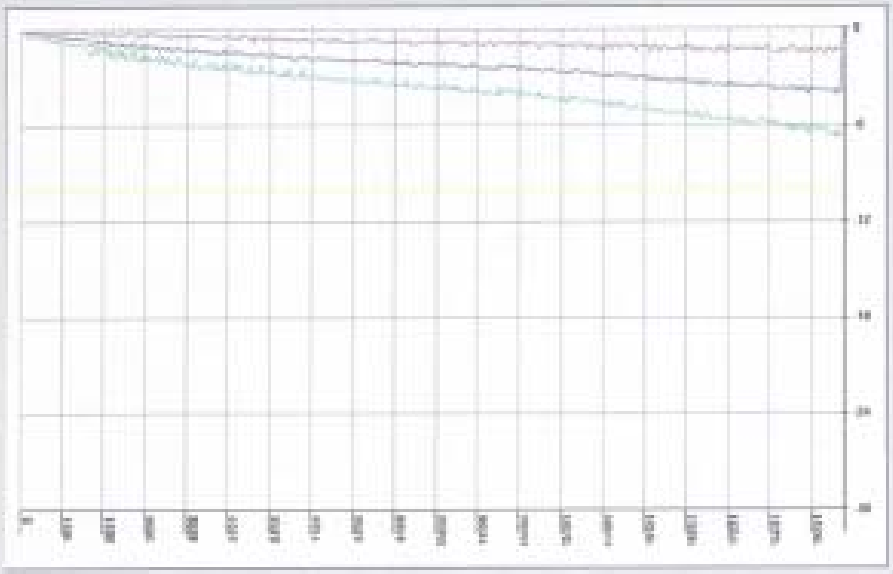
UTAH DEPARTMENT OF TRANSPORTATION
REGION THREE LAB OREM UTAH
(1 M.P. 149.970 18' RT CL 0" to 1 5/8" (1-A M.P. 149.970 18' RT OF CL 2 5/8" to 4 1/4")

Project Name:	US-40 NAPLES 1 MILE EASTE	Date:	11/16/2004
Project Number:	NO NUMBER	Date Sampled:	11/16/2004
Job Number:		Lab Number:	
Project Engineer:		Mix Type:	
Submitted By:		Asphalt Grade:	????
		Pit Source:	

	Layer Below Aggregate Core #1-A	Aggregate Core #1	
	Right	Left	Average
Maximum Impressions:	-7.76 mm	-2.70 mm	-5.23 mm
	Pass #: 19951	Pass #: 19001	

Failure Depth: 10 mm PASSED

PMW WheelTracking Test



20:

MARK WHITE

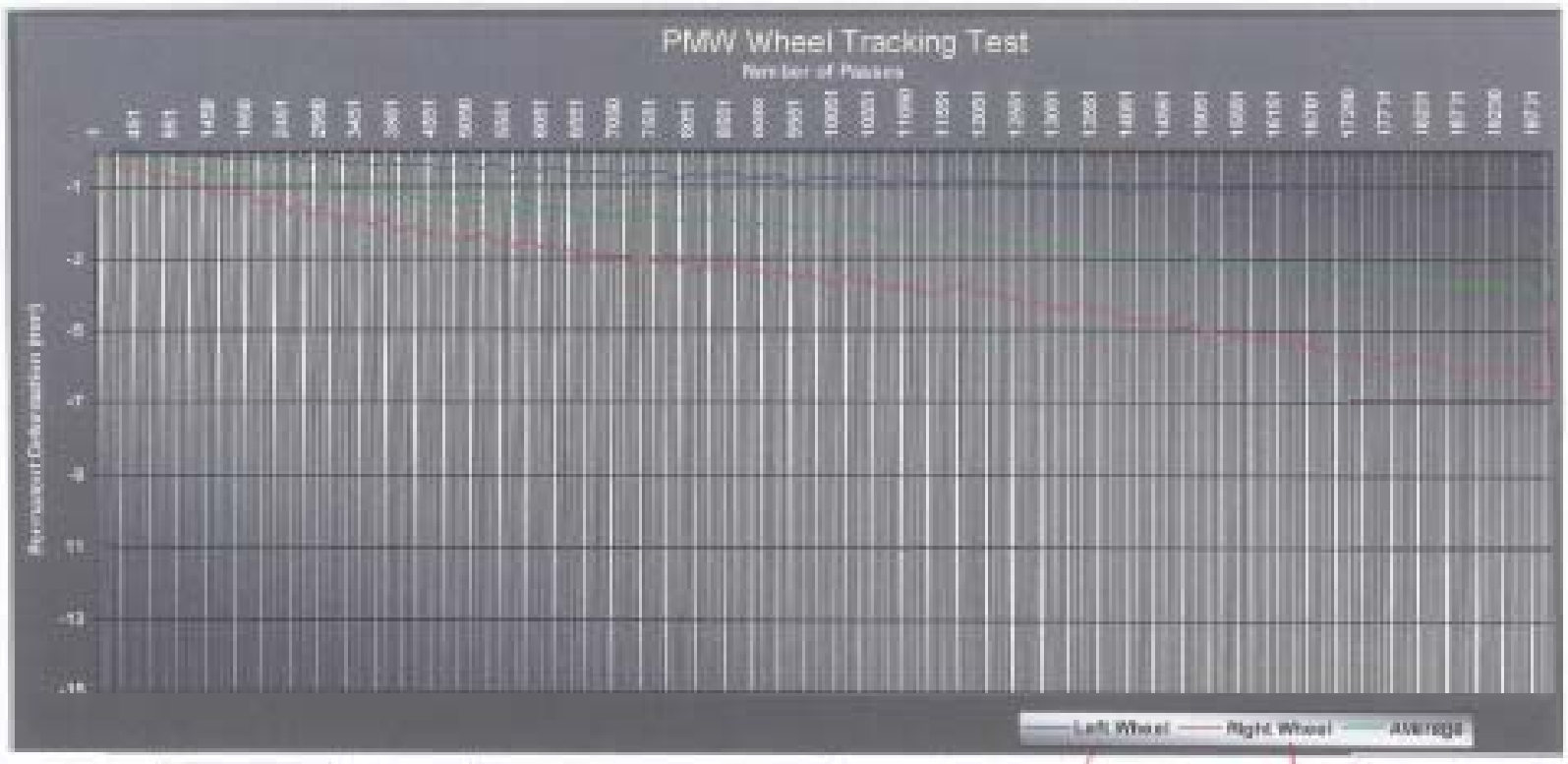
PMW Wheel Tracking Test

Speed: 52

Max Pass #: 20,000

Project Name: US-41 NAPLES 1 MILE EASTE

11/15/2004 4:46:54 PM



Raleigh as: BILL

Customer: REGION THR

Asphalt: ????

Aggregate: ????

CORE #1

CORE #1-A

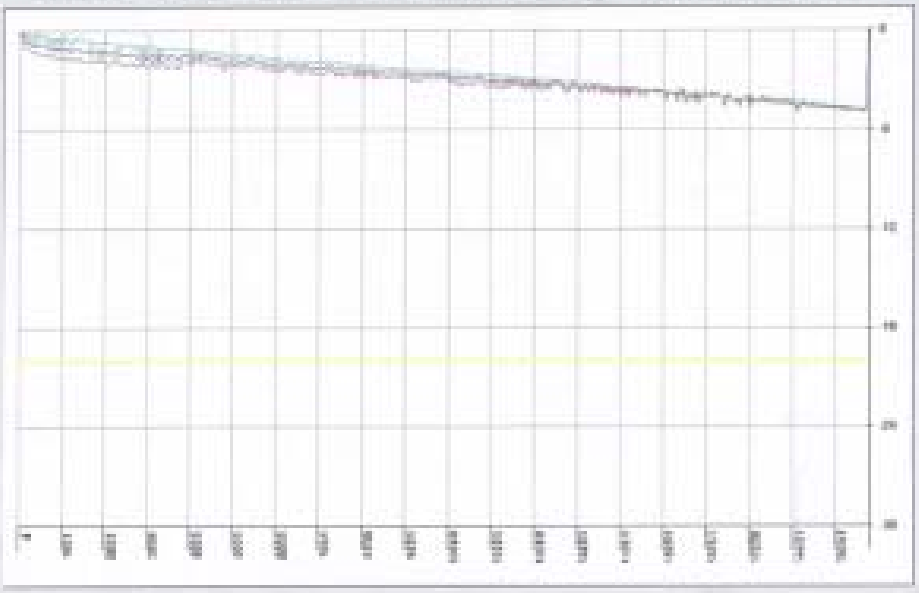
UTAH DEPARTMENT OF TRANSPORTATION
REGION THREE LAB OREM, UTAH
M.P. 149.970(CORE 2 0" TO 1 5/8" 9' Rt C.)(CORE 2-A 2 5/8" TO 3 1/4" 9' Rt CL)

Project Name:	US-40 NAPLES 1 MILE EASTE	Date:	11/23/2004
Project Number:	NO NUMBER	Date Sampled:	11/23/2004
Job Number:		Lab Number:	
Project Engineer:		Mix Type:	
Submitted By:		Asphalt Grade:	????
		Pit Source:	

	Layer Below Aggcrete CORE # 2A	Aggcrete CORE # 2	
	Right	Left	Average
Maximum Impressions:	-6.43 mm	-5.82 mm	-6.03 mm
	Pass #: 19900	Pass #: 19950	

Failure Depth: 20 mm PASSED

PMW WheelTracking Test



DG:

WILLIAM LAPSON

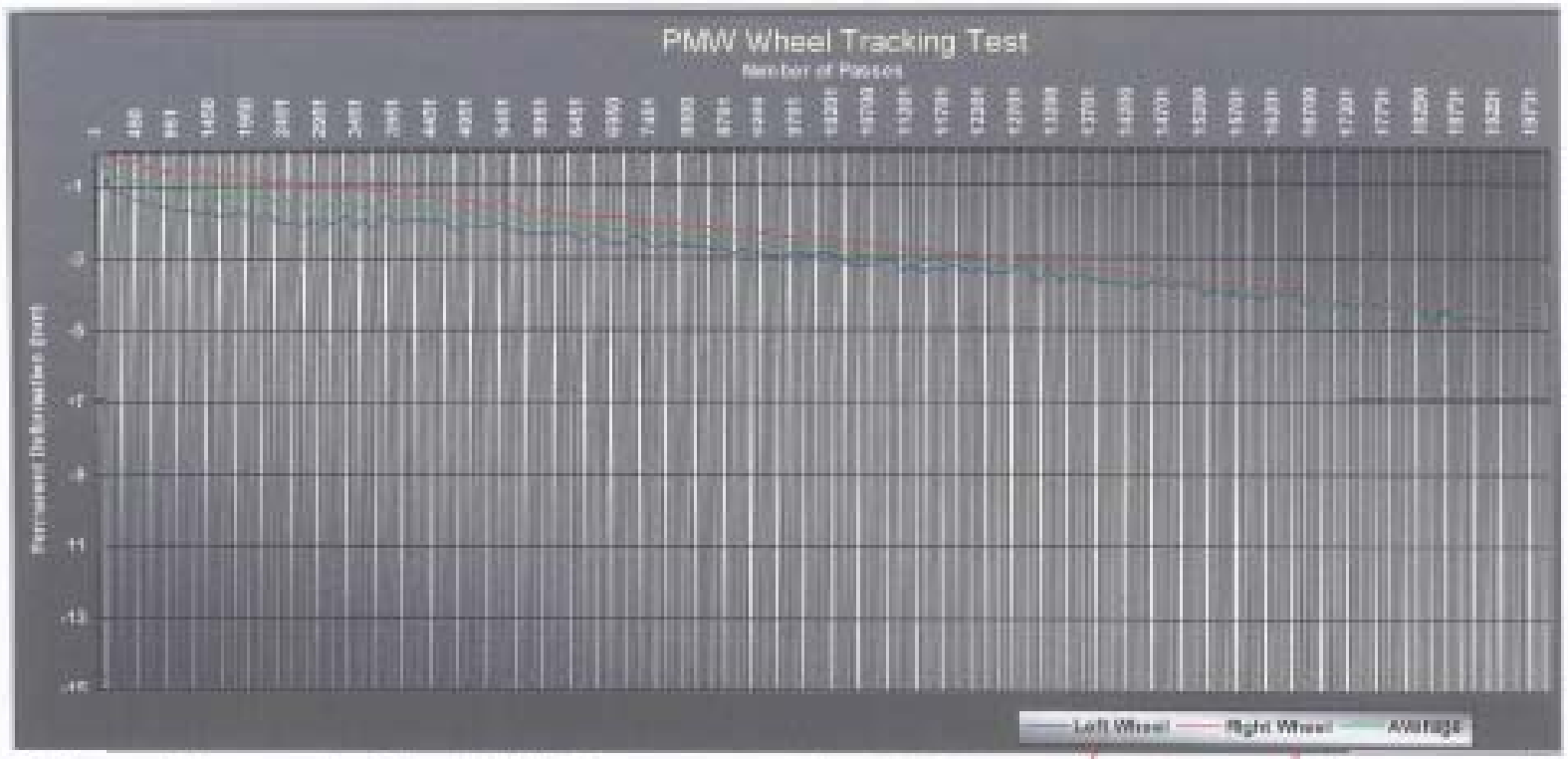
PMW Wheel Tracking Test

Speed: 60

Max Pass #: 20,000

Project Name: US-41 NAPLES 1 MILE EASTE

11/23/2004 4:32:31 PM



Salesman: BILL

Customer: REGION THR

Asphalt: ????

Aggregate: ????

CORE #2

CORE #2A

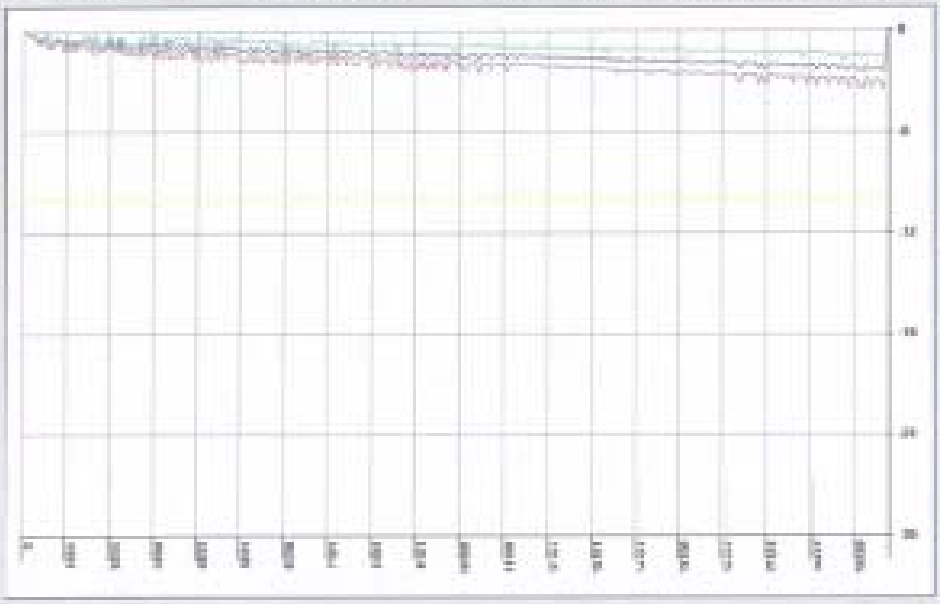
UTAH DEPARTMENT OF TRANSPORTATION
REGION THREE LAB OREM UTAH
(CORE #3 M.P. 150.134.16' RT CL)(CORE #4 M.P. 158.154.8' RT CL)

Project Name:	US-40 NAPLES 1 MILE EASTE	Date:	11/15/2004
Project Number:	NO NUMBER	Date Sampled:	11/15/2004
Job Number:		Lab Number:	
Project Engineer:		Mix Type:	?????
Submitted By:	MACK HALL	Asphalt Grade:	????
		Pit Source:	??????

	Aggcoate CORE #4	Aggcoate CORE #3	
	Right	Left	Average
Maximum Impressions:	-2.58 mm	-4.44 mm	-3.51 mm
	Pass #: 20001	Pass #: 19651	

Failure Depth: 10 mm PASSED

PMW WheelTracking Test



cc:

WILLIAM LARSON

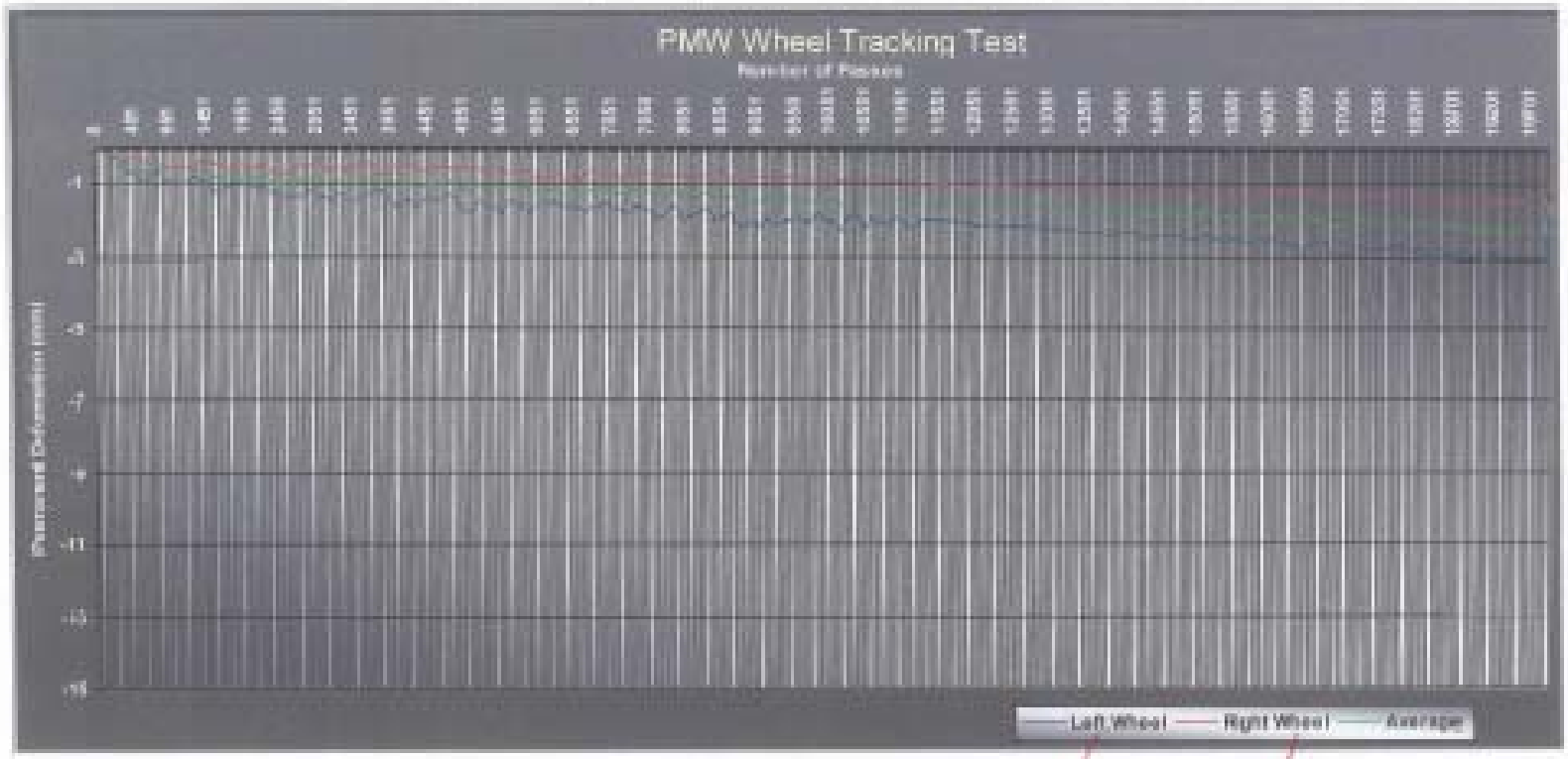
PMW Wheel Tracking Test

Speed: 52

Max Passes #: 20,000

Project Name: US-40 NAPLES 1 MILE EAST E

11/13/2009 0:43:00 PM



Salesman: BILL

Customer: REGION THR

Asphalt: ????

Aggregate: ????

CORE # 3

CORE # 4

cores 3 & 4

Left Right

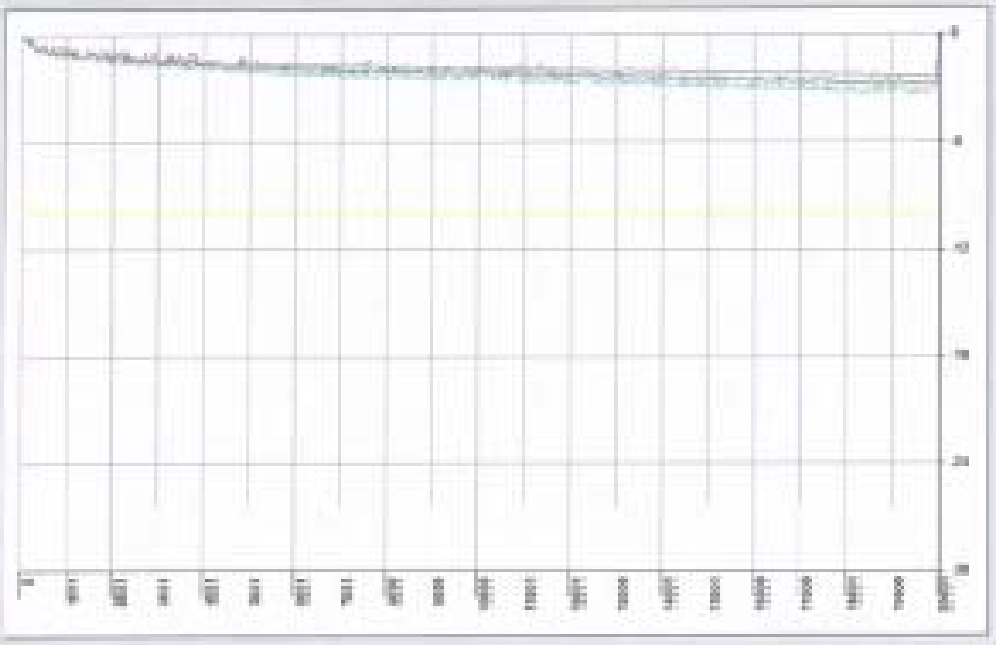
DEPARTMENT OF TRANSPORTATION
REGION THREE LAB OREM UTAH
M.P. 160.412(CORE 5'0" to 1 5/8" 18" RT CL)(CORE 6'0" to 1 5/8" 9' RT CL)

Project Name:	US-40 NAPLES 1 MILE EASTE	Date:	11/17/2004
Project Number:	NO NUMBER	Date Sampled:	11/17/2004
Job Number:		Lab Number:	
Project Engineer:		Mix Type:	
Submitted By:		Asphalt Grade:	????
		Pit Source:	

	Agg Coate Core #6	Aggcoate Core #5	
	Right	Left	Average
Maximum Impressions:	-3.77 mm	-2.73 mm	-3.25 mm
	Pass #: 20001	Pass #: 19851	

Failure Depth: 10 mm PASSED

PMW WheelTracking Test



Willam Lascn

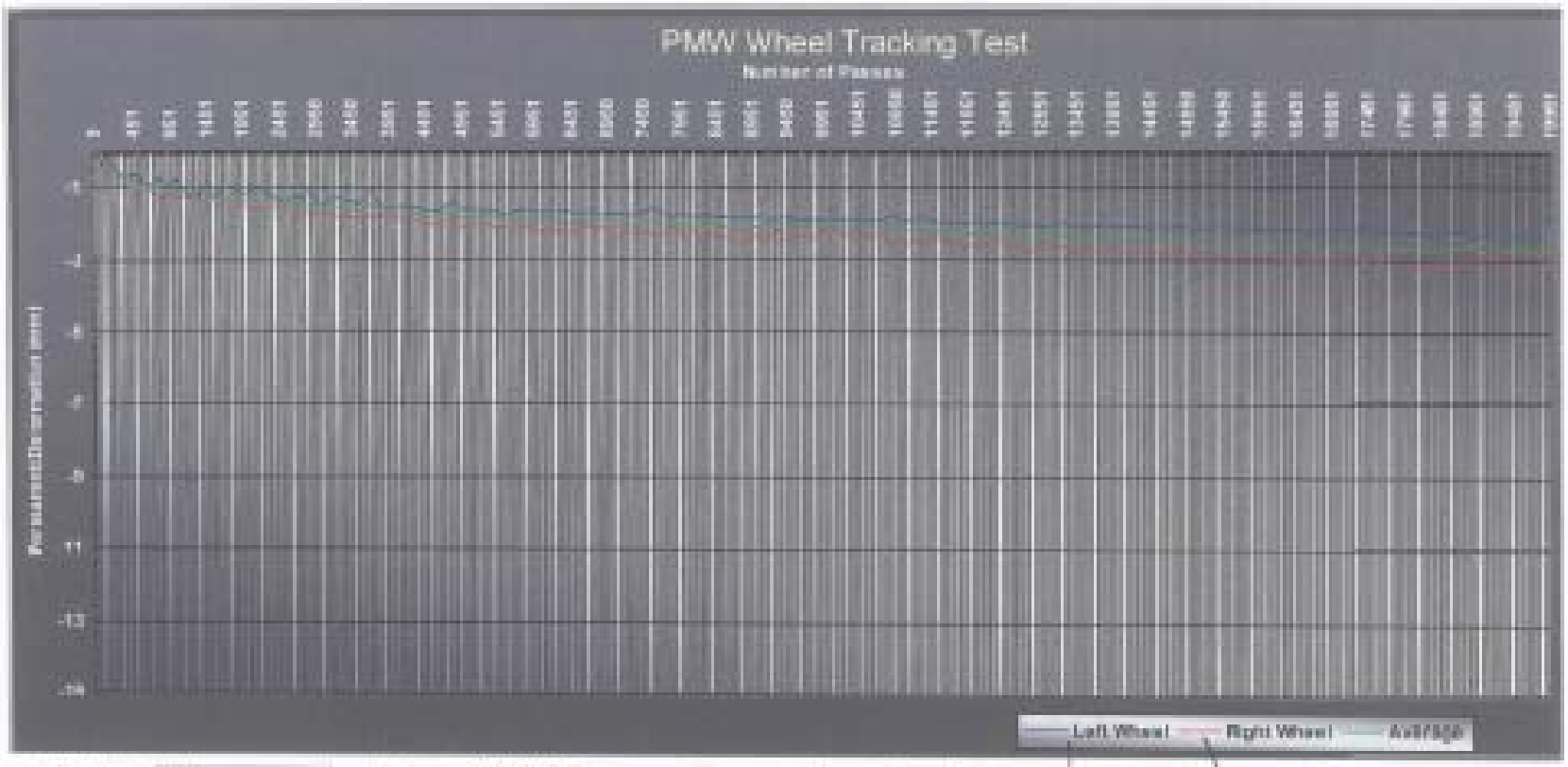
PMW Wheel Tracking Test

Speed: 52

Max Pass #: 20,000

Project Name: US-40/NAPLES 1 MILE EAST

11/17/2004 4:43:49 PM



Salesman: BILL

Customer: REGION THR

Asphalt: ????

Aggregate: ????

Core #5

Core #6

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I-215 Rigid Pavement, High-Volume Pavement Marking System

Interim Report

Experimental Feature X(04)01

By: Michelle Page, P. E., Program Manager
Barry Sharp, Research Specialist
Andrew Stromness, Intern

Utah Department of Transportation
Research Division

June 2005

Introduction

This is an interim report for an experimental feature conducted by the Utah Department of Transportation on the various types and applications of pavement markings. This experiment included the participation of six pavement marking vendors and five marking materials.

The test section is located on the west side of I-215 between 700 North and the Davis County Line, in both traveling directions. The materials were placed in July – September 2004. All solid longitudinal lines were removed using a diamond blade, then the concrete was grooved 20 – 120 mils for the placement of the material.

Background Information

UDOT is continually looking for a pavement marking material that will provide a long life with a low life cycle cost. UDOT also requires a material that is able to withstand the extreme winter conditions in Utah. In general UDOT uses epoxy and waterborne paint, and 3M tape. Prior research has not yet defined the most cost effective and efficient pavement marking materials.

Generally, the accepted philosophy is that placing a material in a groove where the snowplows will ride on the surface rather than the traffic marking material will improve the life and durability of this material. However grooving costs too much, makes a material dirty (due to sand and dust settling in the groove), ruins wet-night reflectivity (a wet film obtusely reflects headlights), and locks lane alignment. Management has typically deterred from grooving-in pavement markings. However, on high-volume roads, anything that can enhance durability should be considered.

Five different materials and 10 total products were selected for evaluation on this project: 2 preformed tapes, 1 epoxy, 2 methyl methacrylates (MMA), 1 thermoplastic, and 2 waterbornes. Poly-urea, a durable marking, was not selected for this study because UDOT is evaluating a grooved in section on concrete.

Each material was applied in ½ mile sections. The NB section was grooved to a depth that is equal to the material thickness. The SB section will have a 100% removal of the existing lines. Each material was applied for a total of one mile, solid yellow and solid white, there were no skips. The tape is the only exception; it was installed in ½-grooved section.

Construction Information

TMT Pathway and Swarco decided not to participate in the project. Therefore, there was only one methyl methacrylate and three tapes installed.

Construction was set to take place over the weekend of July 16-19, 2004. This began with line removal and grooving for one day, two nights. During their removal there was a heavy rainstorm that halted removal for several hours. When removal did resume the pavement still contained some moisture causing the dust from removal to stick to the pavement. This was a concern during the placement of the project because it caused the freshly placed markings to not adhere properly.

Initial construction plans included the removal and replacement of all longitudinal lines, including skips. During the removal process it was discovered that the majority of the skips were tape or thermoplastic paint, which could not be removed by the diamond saw blade. In order to remove these materials a carbide blade would have been required. The decision was made to only do removal and replace the longitudinal solid lines, where the existing paint was epoxy and waterborne and could easily be removed with the diamond blade.

Markings were placed on July 17-18. Polycarb, placing epoxy, was the only vendor to place markings on the 17th. Twenty mils of epoxy were applied into a 30-mil inlay. The pavement temperature during the placement was 101.7 °.

On July 18 two waterborne paints were placed, one by Pervo, and one by Ennis. Both waterborne paints were applied at a thickness of 20 mils, inlaid 30 mils. Pervo placed their material when the pavement temperature was 77 °, and Ennis placed their material when the pavement temperature was 82 °.

Methyl Methacrylate (MMA), provided by Ennis, was placed on July 18. The placement of the MMA was postponed until early evening due to high pavement temperatures during the day. MMA cannot be placed when pavement temperatures exceed 105 °. The MMA was placed 90 mils thick, and was inlaid 120 mils. The pavement temperature during placement was 91°. Due to problems with the application equipment, the MMA yellow solid line was not installed.

Thermoplastic tape, also provided by Ennis, was placed the same day at a thickness of 90 mils, and inlaid 120 mils. Thermoplastic must be heated to 400 °+ for application. Heating the material to this temperature was time consuming and took several hours.

All three vendors that were supplying tape require a 24-hour window after precipitation before placement of their materials. Due to this restriction and the

storm on the night of July 17, UDOT was unable to have the tape products placed during the initial freeway closure.

The night of July 29, single lanes were closed for the placement of tape. 3M placed 70-mil thick tape, inlaid 90 mils. The other two vendors, Briteline and ATM, placed 60-mil thick tape, inlaid 70 mils. The pavement temperatures ranged from 77 ° - 82° during the installation. The products provided by ATM and Briteline required the placement of primer prior to the tape installation, while the 3M products did not.

The skip lines were able to be removed on the stretch of freeway where the tape was being installed. Due to time constrictions during the night closure none of the vendors were able to place any skips on July 29.

All three tape vendors returned to place contrast tape in the skips in their respective areas at a later date. ATM placed their contrast tape on August 22, and the other two vendors placed their tape on September 12.

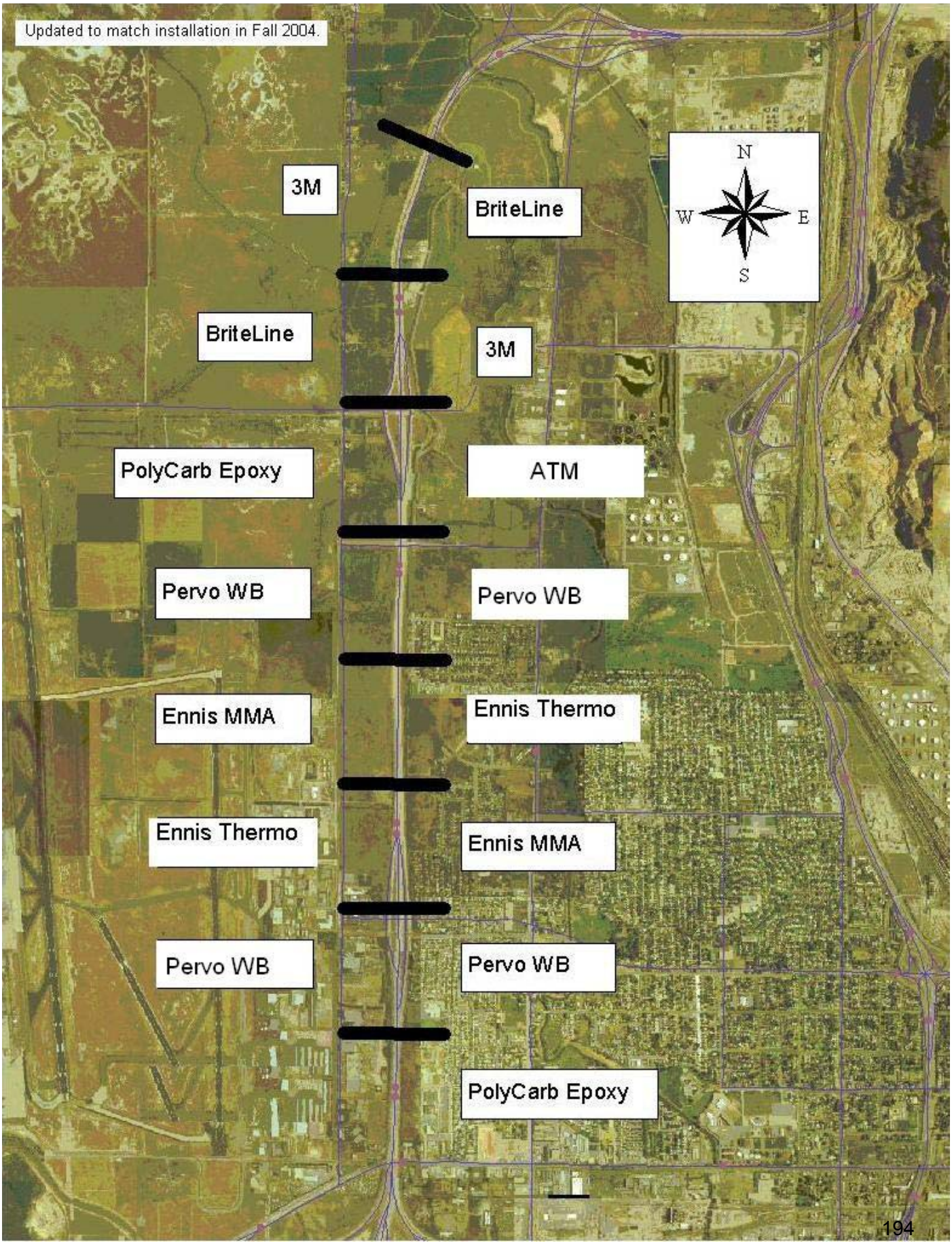
Grooved-in Markings (NB + Tape)

Material	Location Begin North	Location End North	Location Begin West	Location End West	MM	Pav. Temp	Air Temp	Rel Humid	Wind Speed/Dir.	Mil Thickness	Groove Depth
Epoxy	40.48.338	40.48.770	111.56.963	111.56.972	23.12	101.8	84	33	0	20	30
WB 1 (Pervo)	40.47.905	40.48.338	111.56.979	111.56.963	23.621	90.9	77	28	0	20	30
MMA (Ennis)	40.47.465	40.47.905	111.56.989	111.56.979	24.101	126.5	91	13	0	90	120
Thermo (Ennis)	40.47.028	40.47.465	111.56.962	111.56.969	24.616	125.2	92	13	0	90	120
WB 2 (Ennis)		40.47.028		111.56.962	25.112	97.5	82	19	0	20	30
Tape 2 (ATM)	40.48.767	40.49.202	111.59.939	111.56.950	25.591	85.3	82	17	0	60	70
Tape 1 (3M) White	40.49.202	40.49.622	111.56.950	111.56.835	26.082	80.6	77	23	0	70	90
Tape 3 (BL)	40.48.770		111.56.972		26.145	80.6	77	23	0	60	70
Tape 1 (3M) Yellow		40.49.634		111.56.862	26.572	84.9	80	21	0	70	90

Surface Prep Markings (SB)

Material	MM	Pav.Temp	Air Temp	Rel Humid	Wind Speed/Dir.	Mil Thickness
Epoxy	25.562	101.8	84	33	0	30
WB 1	25.076	90.9	77	28	0	20
MMA	24.576	126.5	91	13	0	90
Thermo	24.068	125.2	92	13	0	90
WB 2	23.564	97.5	82	19	0	20

Note: An aerial map showing the installation locations of each product in the test section is shown on the following page.


Updated to match installation in Fall 2004.
3M
BriteLine
BriteLine
3M
PolyCarb Epoxy
ATM
Pervo WB
Pervo WB
Ennis MMA
Ennis Thermo
Ennis Thermo
Ennis MMA
Pervo WB
Pervo WB
PolyCarb Epoxy
N
W
E
S

The following chart contains the handheld retroreflectivity readings for the test section for Fall 2004 and Spring 2005. These readings do not contain any information regarding the skip reflectivity, as the roadway was not closed for readings.

I-215 Direction	Location	Vendor/Product	8/19/2004 8/22/2004 Readings Handheld	5/18/2005 5/19/2005 Handheld Readings
NB	Outside Shoulder	PolyCarb Epoxy	465	191
	(White)	Pervo WB	327	130
		Ennis MMA	241	128
		Ennis Thermo	382	276
		Ennis WB	287	167
		ATM	569	196
		3M	808	713
		BriteLine	--	--
	Inside Shoulder	PolyCarb Epoxy	382	206
	(Yellow)	Pervo WB	303	171
		Ennis WB	--	100
		Ennis Thermo	182	221
		Ennis WB	141	139
		ATM	479	268
		3M	--	--
		3M	--	
SB	Outside Shoulder	3M	--	--
	(White)	BriteLine	608	149
		PolyCarb Epoxy	288	299
		Pervo WB	359	229
		Ennis MMA	226	154
		Ennis Thermo	320	297
		Ennis WB	266	140
	Inside Shoulder	3M	451	387
	(Yellow)	BriteLine	391	190
		PolyCarb Epoxy	224	211
		Pervo WB	248	153
		Ennis WB	--	--
		Ennis Thermo	160	194
		Ennis WB	172	136

Recommendations

Currently, the Research Division in coordination with Maintenance, Traffic & Safety, Central Materials and the regions are evaluating all pavement marking data on a Statewide basis to provide recommendations as to what products perform best under specific conditions and at what cost/benefit to the department.

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Techrete Concrete Pavement Patching on I-215

Interim Report

Experimental Feature X(04)02

By: Ken Berg, P.E., Development Engineer
Michelle Page, P.E., Program Manager

Utah Department of Transportation
Research Division

June 2005

Introduction

UDOT highway bridge decks are subject to constant dynamic loading and freeze/thaw cycles over their lives. These and other factors can cause the concrete decks to spall. A new product, Techcrete by Crafco, a hot pour rapid set polymeric material, had performed well on I-15 concrete pavement as documented in Experimental Feature No. X(03)07 of this report. It was, therefore, decided to install and evaluate it as a potential bridge deck spall repair product. UDOT bridges C-699 and C-701 on NB I-215 over I-80 and I-15 off-ramps were selected for the evaluation.

Objectives

The objective of the test was to evaluate the speed and ease of product installation and to observe the durability of the product over two or three years.

Larry Limberis, Maintenance Station #230 Supervisor and Ron Hall, Maintenance Station #230 agreed to monitor the material throughout the winter as they snowplow and keep UDOT Research up to date on its performance.

Construction & Cost

The product was installed in August of 2004. Those attending the installation were:

- Larry Limberis, Maintenance Station Supervisor #230
- Ron Hall, Maintenance Station #230
- 2 Installers from CRAFCO (in the fluorescent vests)
- Prison Crew
- Michelle Page, UDOT Development Engineer
- Richard “Barry” Sharp, UDOT Research Specialist
- DaveEixenberger, UDOT Structures, Operations Engineer
- Mike Ellis, UDOT Structures, Bridge Inspector

Area covered with this first installation: (Potholes were approximately 2 inches deep.)

- Large Pothole = 12 ft x 14 ft
- Two Small Potholes = 3 ft x 2 ft & 1 ft x 1 ft

Materials used:

- 2750 lbs polymer
- 5 gallons of primer
- 6 bags of gravel

CRAFCO representative quoted the materials at $1.25 per pound.

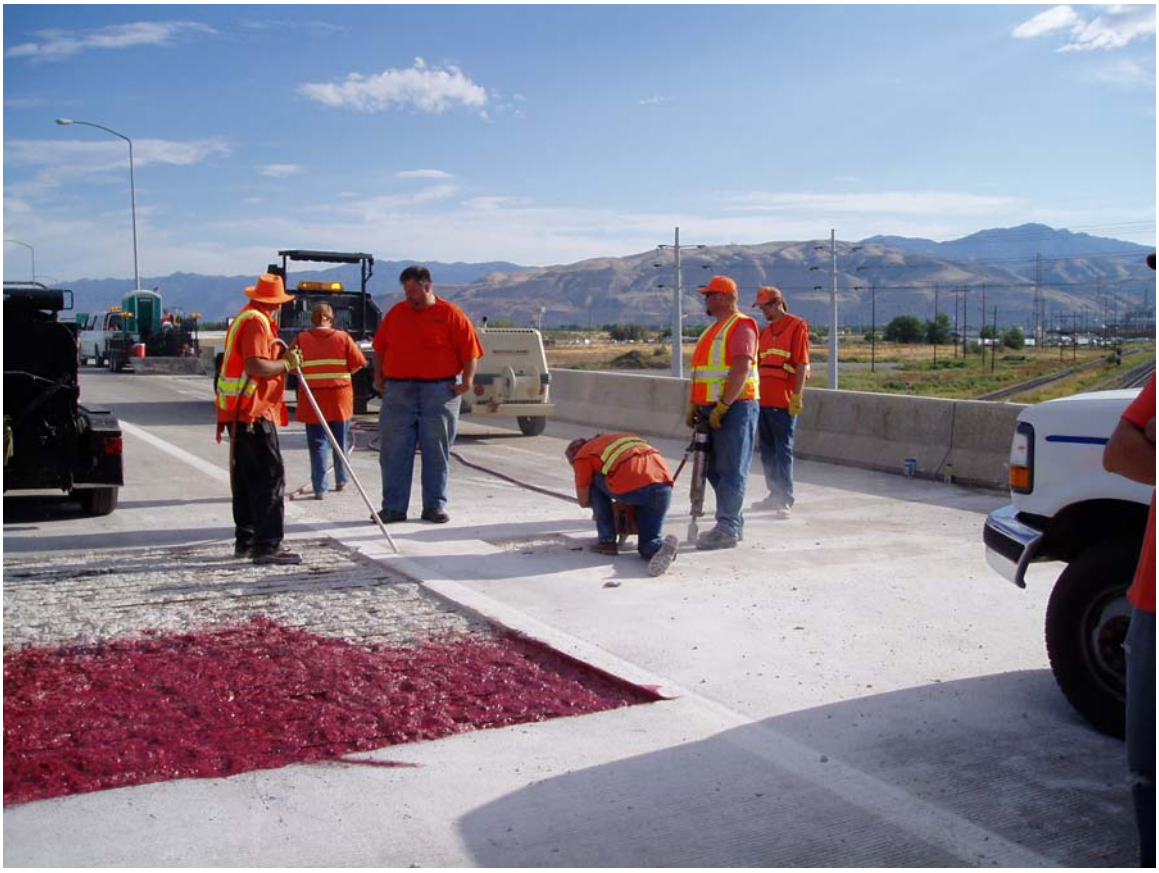
The following photos illustrate elements of the installation:

Prep work consisted of saw cutting edges and hammering out the delaminated concrete.

Concrete was heated prior to application of the primer.

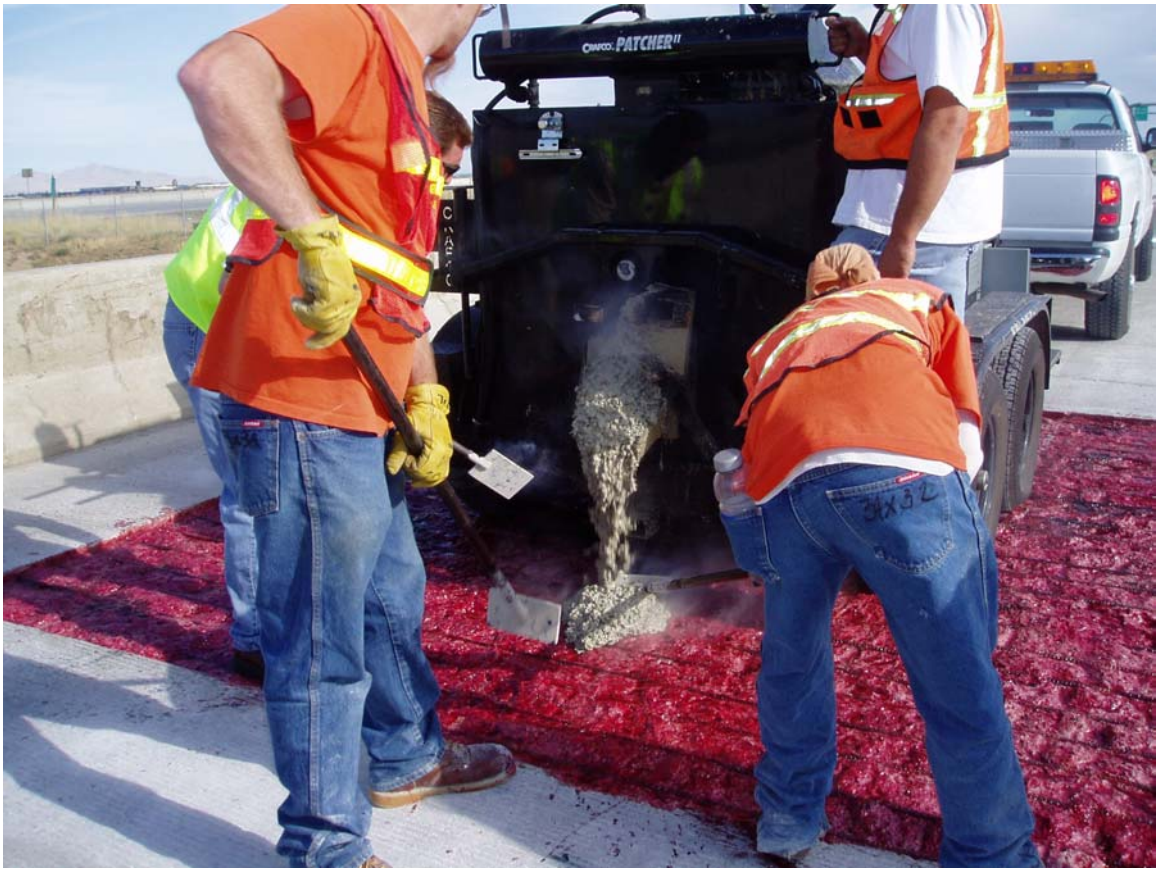
Primer was splashed on, then broomed and brushed in until it fully coated the exposed concrete and reinforcing steel.

CRAFCO

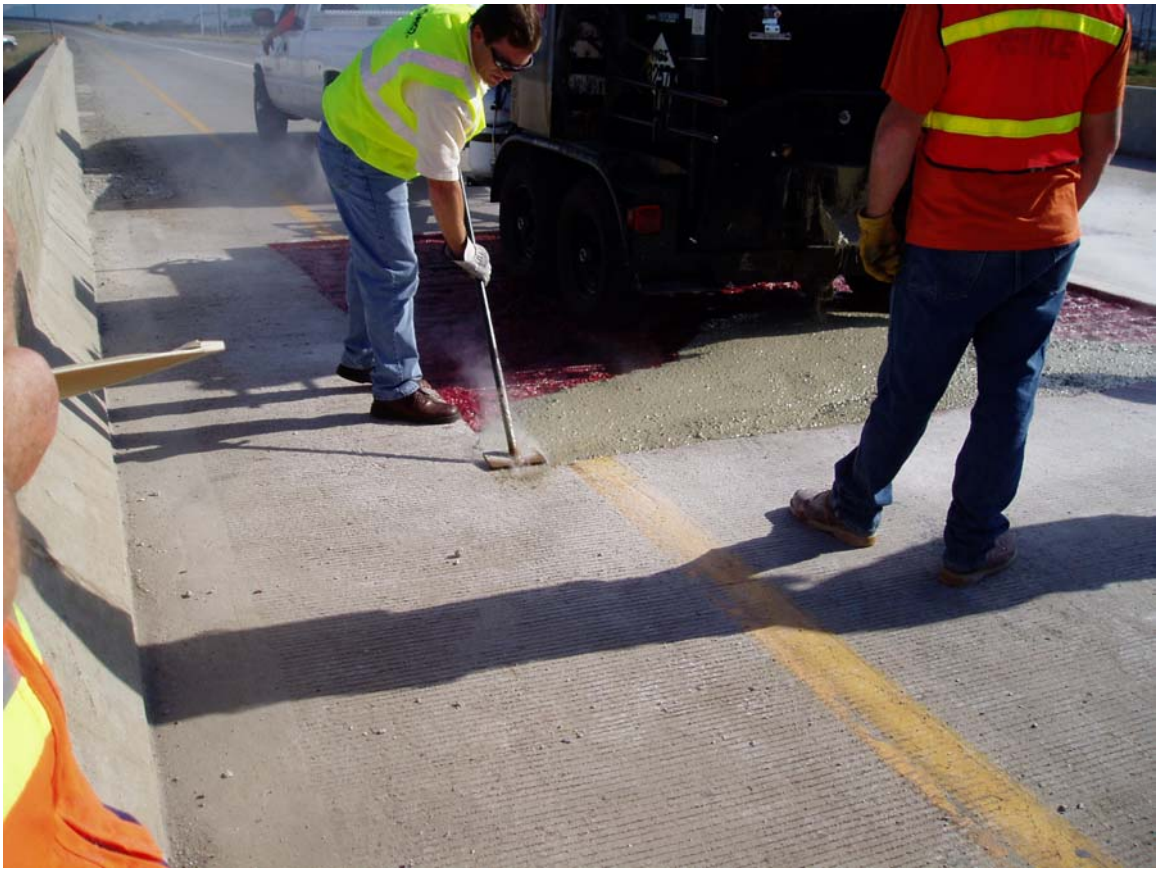


All edges of the patch area were also covered with the primer.

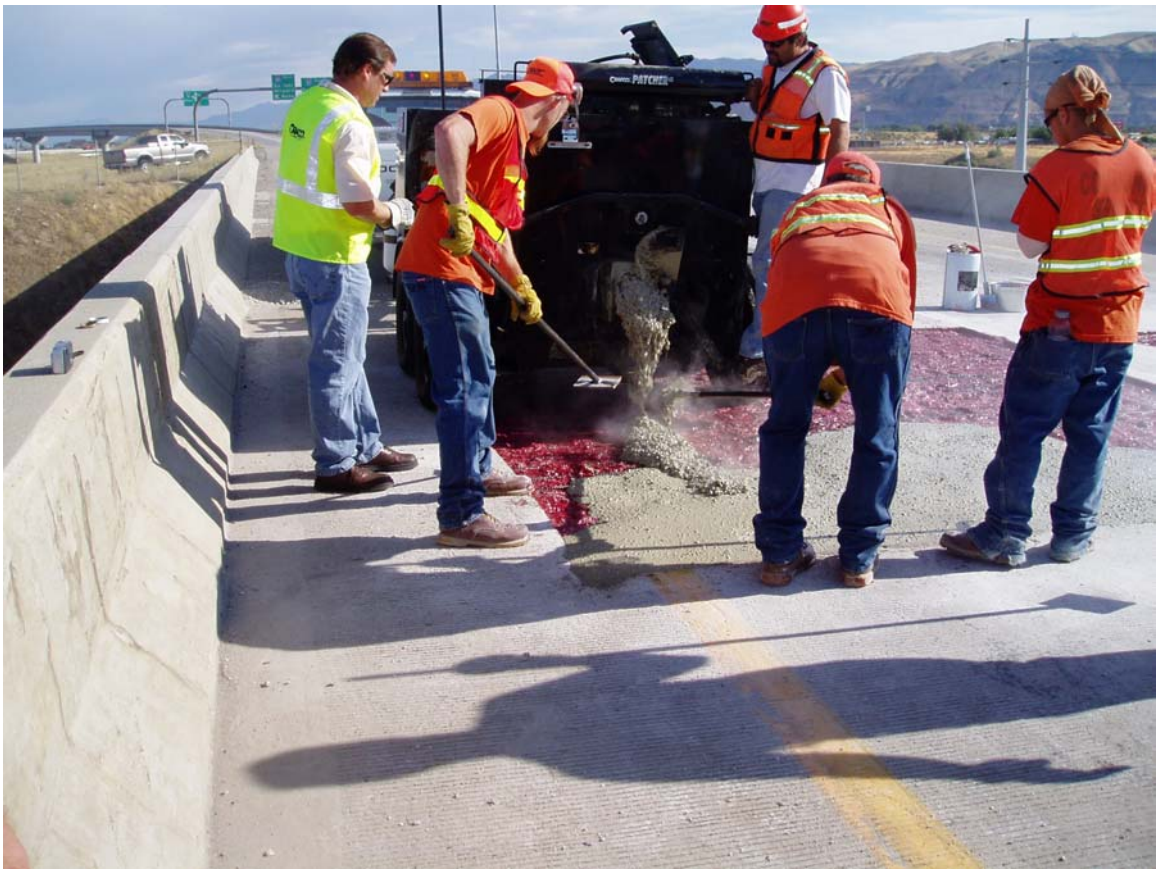
The initial “plug” was emptied into a bucket and dumped back into the mixer to be reheated.



Heated spreaders were used to push the polymer into place where it began self-leveling.



The corners of the patch area were worked into place.



DODGE

DODGE

DODGE

The polymer “sets” quickly as it cools. This makes it difficult to push into place over a large area.

The polymer was reheated for greater workability.

Bubbles were present in the hot polymer.

“Sanding” of the polymer could not begin until all the bubbles had popped.

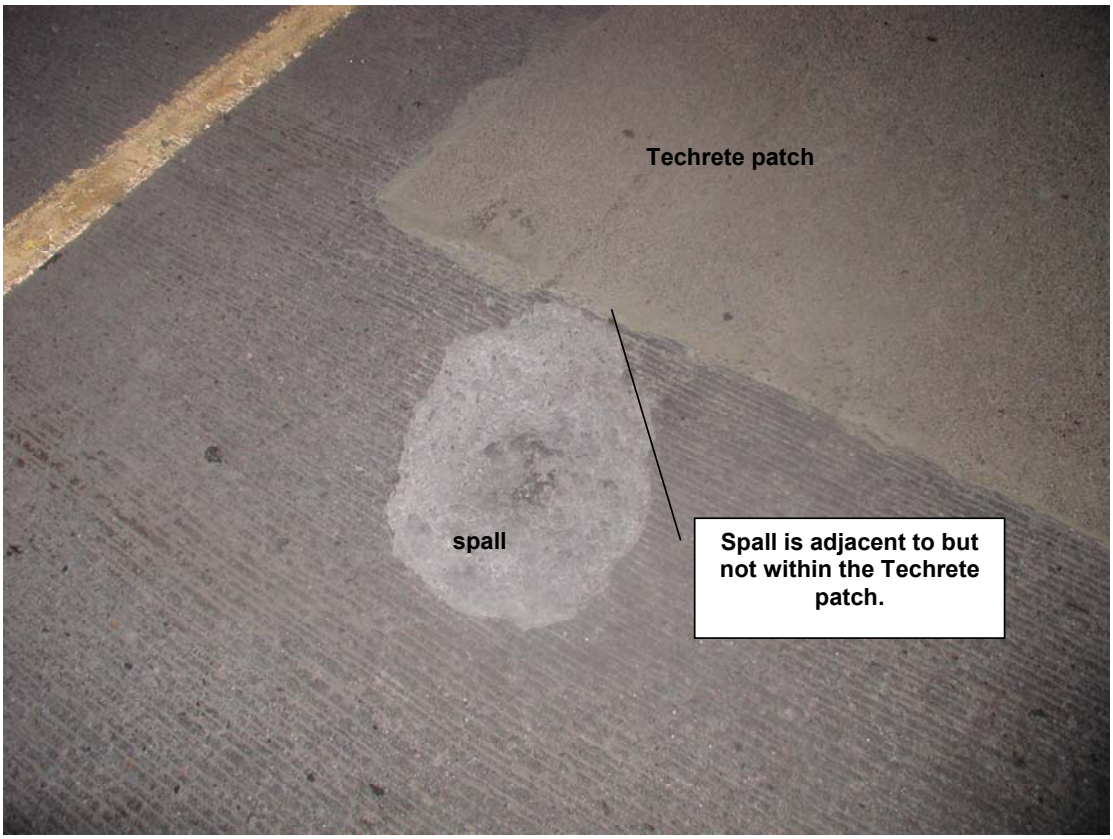
The polymer was heated to help the last bubbles pop and warm the surface for the application of the sand.

The sand was patted into place to assure bonding.

Interim Results

The following photos taken in the spring of 2005 show that the patch seems to be intact.

Techrete patch appears to be intact with no evidence of degradation



Conclusions

Athough the product performance seems good after one winter, overall performance is still inconclusive. The product will continue to be monitored over the next two years.

Recommendations

Recommendations are pending further monitoring.

Hot In-Place Recycled Asphalt Pavement

Interim Report

Experimental Feature X(04)03 – New Products

By: Michelle Page, P.E., Program Manager
Barry Sharp, Research Specialist
Ken Berg, P.E., Development Engineer

Utah Department of Transportation
Research Division

June 2005

Indroduction

Old asphalt pavements tend to become cracked and rough riding resulting in a less than “pretty” appearance, even though they are still showing no structural impairments. A process to redeem the ride and aesthetics has been initiated whereby the existing pavement is heated with a radiant process and scarified to a depth of 2”. Next it is windrowed in the process, picked up, relayed with a conventional asphalt paving machine and compacted.

Background Information

Paveover Inc. is the contractor that specializes in this type of rejuvenation process. The recycling train consists of a pre-heater that preheats the asphalt pavement to remove excessive moisture prior to the main heating and milling process. The pre-heater unit is towed behind a 1500 gallon capacity propane supply 5 ton truck. The truck is equipped with two 80/40 propane vaporizers. The pre-heater utilizes high airflow burners fired horizontally, one foot above the pavement, into an insulated steel enclosure designed to dissipate the moisture while heating the entire lane width. Four hydraulic cylinders are utilized to raise and lower the burner system as required. Rubber tired wheels used for towing are replaced by steel wheels for operation. Emissions are naturally aspirated through exhaust stack into an emissions combustion chamber where unburned hydrocarbons are incinerated prior to discharge.

Paveover Inc.
P. O. Box 92195
Albuquerque, New Mexico 87199
Phone: 505 839 1000
Contact: Mr. Ron Welch

Goal

This process was an attempt to eliminate the surface cracking caused by the aging process and produce a finished product that would be visually acceptable and functional.

Objectives

Heat and remix the top 2” of old asphalt pavement by heating and remixing to eliminate roughness and aging.
Extend the life of the pavement for a few years.

Construction Information

The work was performed in September 2004 and the visual inspection of both projects was very promising with good results anticipated.

There were two sites selected for this process, US 89 at MM 250 +/- SR 25 (Fish Lake Road). Both projects were about 6 miles in length.

The US 89 project design called for adding heated chips to utilize anticipated excess asphalt. The finished mat look just like new asphalt paving.

The Fish Lake project was something different because of the variety of materials in the 2" that were rejuvenated making it difficult for the contractor to obtain a constant yield for the finished surface. The operation broke through the pavement section many times.

The cost to perform the heater recyling was $ 3.50/yd$^{2.}$

Results

A visual evaluation was performed in May 2005 on US 89 and the old cracks that were to be eliminated had already radiated through the 2" of heater recycle in just eight months. In June 2005, the Fish Lake Project was visited to see if the same thing had occurred. Again, extensive cracking was evident.

Conclusion

At this time and based upon the visual inspection in 2005, it is apparent that the recycling did not slow down the old surface appearance for very long as the cracks in the new pavement were reflecting through and matching the old surface appearance.

Now the project is being chip sealed to improve the skid characteristics. If the chips last for 5 years then maybe the project was a success. Only time will tell how the reflective cracking affects the overall condition.

The purpose of using this type of rejuvenation was determined based upon the technology advancements in the past decade, better and more consistent heat and milling action and handling processes.

The following photos show the difference between the old pavement and the recycled material. Note that the light gray is the old pavement and the dark is the recycled material at eight months.

Recommendations

The process had cracks reflect up though 2” of repave in eight months and this is not the time frame that was hoped for. The chip seal applied in the next season is something that should be evaluated for a few years to see if there is any early failure that may be caused by the heater repave process.

Pavement Engineers should look really closely at the use of this process and make sure the design is for the end product desired.

Redwood Road & I-215 3M Contrast Tape Pavement Marking System Interim Report

Experimental Feature X(04)04

By: Brandon Squire, P.E., Resident Engineer
Michelle Page, P.E., Program Manager
Barry Sharp, Research Specialist
Andrew Stromness, Intern

Utah Department of Transportation
Research Division

June 2005

Redwood Road (9000 South to 10600 South) & I-215 (4700 South to Redwood Road)

Introduction

As part of the Reconstruction of Redwood Road, it was suggested that a grooved-in 3M Contrast Tape be tested for durability and reflectivity.

As part of the Reconstruction of I-215, it was suggested by the Region Director, that a 3M Contrast Tape be tested for durability and reflectivity. Previous test sections of this product include Redwood Road (90th to 104th South) and I-215 West (700 North to the Davis County Line). The I-215 West section is included in its own report as several products were placed in one test section; this report is available under Experimental Feature X(04)01. The purpose of these two test sections is to find a cost-effective material for high-volume rigid pavements in Utah.

Project Responsibilities

Responsibilities on the projects are as follows:

UDOT Central Maintenance

- Record LaserLux readings and submit to the Research Division.

UDOT Research Division

- Identify performance measures,
- Documentation,
- Technology evaluation,
- Recommendations for future application and,
- Implementation.

UDOT Region 2 Construction

- Prepare the work plan,
- Contact vendors
- Source of funding in coordination with FHWA,
- Project site selection,
- Traffic control,
- Administer contract for surface preparation/grooving and
- Implementation.

Project Locations

On Redwood Road the grooved-in contrast tape extends the length of the project from 9000 South to 10600 South. This road is a principal arterial.

A section of I-215 on the south end of the valley was selected between 4700 South and Redwood Road as part of the reconstruction efforts. The location has enough traffic to make it high-volume, but isn't as busy as I-15.

Scope

It is believed that placing a pavement marking material in a grooved recess will prolong the life of the material since the snowplows will ride on the surface rather than the material. Redwood Road will allow a principal arterial to be evaluated while the I-215 section is a high volume freeway where the life cycle cost of the grooved material and whether the grooving makes a material dirty (due to sand and dust settling in the groove) and ruins wet-night reflectivity (a wet film refracts headlights) can be evaluated for both roadway classifications. Since this is a newly widened roadway, locking the lane alignment was not considered a problem.

Peck Striping installed 3M's pavement marking contrast tape. Comax Industries grooved the recess for the tape since they have a dry dustless grooving process. The cost for this experimental feature will be a change order into the federally funded reconstruction project.

Goals/Objectives/Tasks

In summary, here are the goals, objectives and tasks of these two projects:

***GOAL*:** The goal of these two projects is to determine if grooved tape is a cost-effective pavement marking system (material and surface prep) for high-volume rigid pavements or principal arterials at UDOT.

Objectives/Tasks:

1. Produce failure curves for these pavement marking systems.

    a. Measure durability.
    b. Measure retro-reflectivity.

2. Implement findings.

    a. Give results to Regions.
    b. Meet with each Region to discuss results.

3. Place results on AASHTO's APEL website for other states' information.

Preliminary Results

To date the following tabulated information has been gathered for the I-215 and Redwood Road test sections. Any future recommendations or conclusions will be based on the performance of this product over the next several evaluation periods. Currently, a Pavement Marking QIT is looking at statewide methods, applications and guidelines. Over the course of the next six months to a year recommendations for the Regions will come from this QIT. Members representing Central Maintenance, Materials, Traffic & Safety, Research and the regions are working to coordinate all efforts regarding pavement markings.

Summary of Redwood Rd. Tape Test Readings		
	Avg. 2/4/2005	**Avg. 7/7/2005**
NB Skip	442.7	399.4
SB Skip	363.3	353.9
Combined	403.0	376.6
	Avg. 2/4/2005	**Avg. 7/12/2005**
NB Yellow	209.4	260.9
SB Yellow	217.7	251.5
Combined	213.6	256.2

Summary of 215 (47th to Redwood) Tape Readings		
	Avg. 2/4/2005	**Avg. 7/12/2005**
NB 1st Skip	529.3	523.5
NB 2nd Skip	551.8	532.4
NB 3rd Skip	520.0	
SB 1st Skip	545.8	387.3
SB 2nd Skip	509.4	515.5
Combined Skip	531.3	489.7
	Avg. 2/4/2005	**Avg. 7/7/2005**
NB Yellow	196.6	207.7
SB Yellow	243.6	257.9
Comb. Yellow	220.1	232.8

Special Studies

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Bridge Corrosion Monitoring System in Ogden, UT

Interim Report

Special Study S(05)07

By: Michelle Page, P.E., Program Manager
Ken Berg, P.E., Development Engineer

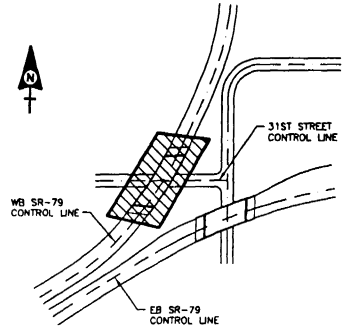
Utah Department of Transportation
Research Division

June 2005

SUMMARY

Bridge corrosion monitoring systems were installed on bridge structures in Ogden, UT by Corrosion Service Co. Ltd. The installation locations were SR-79 EB over Reeves Avenue and SR-79 WB over 31st Street. The installation detailed drawings are shown in the Appendix.
Training has been scheduled for Research Division to take the responsibility of monitoring and gathering data at the sites for the next 10 to 15 years. More information will be included in subsequent reports.

Appendix



LOCATION PLAN

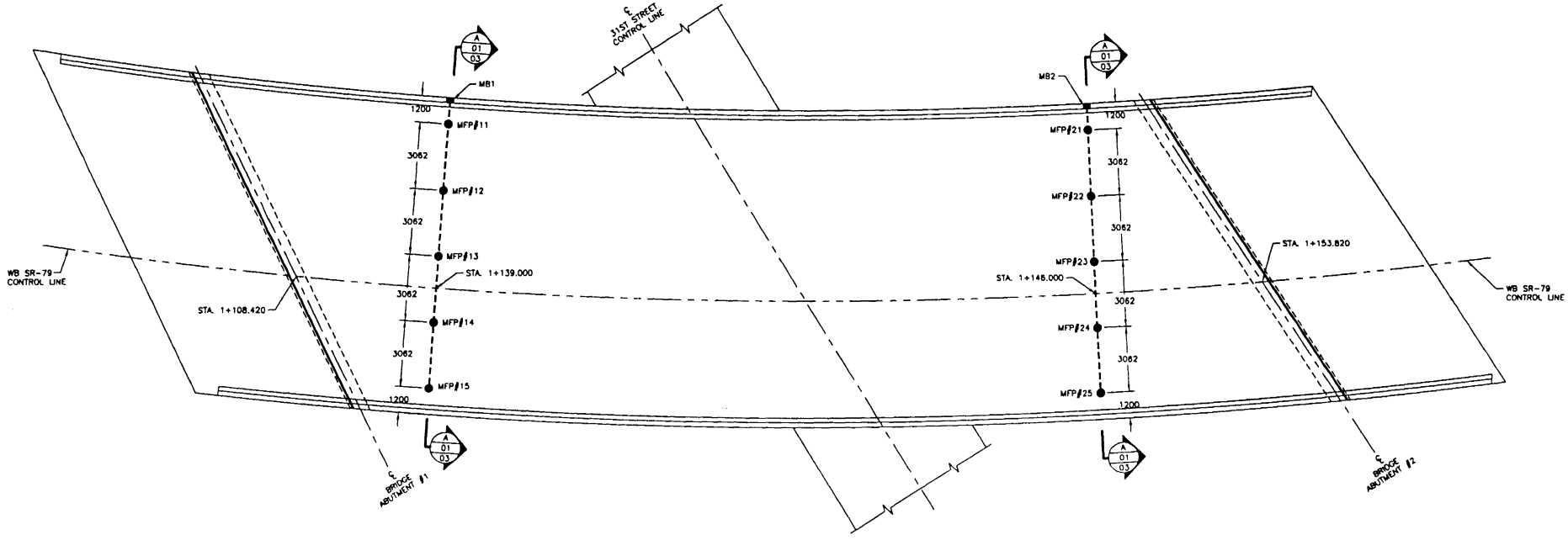
N.T.S.

INSTALLATION NOTES

1. FINAL LOCATION OF CORROSION MONITORING EQUIPMENT TO BE SITE DETERMINED.
2. MONITORING BOXES SHALL BE LOCATED NOT LESS THAN 1.5m FROM LIGHT STANDARDS, 1.2m FROM LIGHTING JUNCTION BOXES, OR 750mm FROM JOINTS IN BARRIERS.
3. PROBE LINE SHALL BE A MINIMUM OF 1.2m FROM JOINT BETWEEN POURS.
4. THE PROTECTIVE CAP ON THE CENTER ELEMENT OF THE MULTI-FUNCTION PROBE MUST BE REMOVED PRIOR TO CONCRETE INSTALLATION.
5. ALL REINFORCEMENT STEEL SHALL BE COATED BILLET-STEEL BARS CONFORMING TO AASHTO M 284 OR M 111 AND M 31M GRADE 400, RESPECTIVELY.
6. ALL DIMENSIONS GIVEN IN MILLIMETRES UNLESS NOTED OTHERWISE.

BILL OF MATERIALS

ITEM	CODE	DESCRIPTION	QUANTITY
1	MB#	FLANGED BOX WITH FIBRE-REINFORCED SAFETY TREAD COVER, 'PEX' PART # H664, CODE 77685, c/w TERMINAL STRIPS	2 pcs
2	MFP#11, MFP#12 MFP#13, MFP#21 MFP#22, MFP#23	'CORROSION SERVICE COMPANY LIMITED' MULTI-FUNCTION PROBE PART # CMP3E6C c/w 10m OF CONNECTION CABLE	6 pcs
3	MFP#14, MFP#15 MFP#24, MFP#25	'CORROSION SERVICE COMPANY LIMITED' MULTI-FUNCTION PROBE PART # CMP3E6C c/w 20m OF CONNECTION CABLE	4 pcs
4	-	'CADWELD' CA-15 CARTRIDGES	15 pcs
5	-	'CADWELD' MOULD	1 pcs
6	-	FRP MOUNTING RODS	AS REQ'D
7	-	MISCELLANEOUS EQUIPMENT	AS REQ'D



PLAN

1:100

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Professional Engineers : Corrosion Specialists

Sarnia : Toronto : Montreal : Halifax

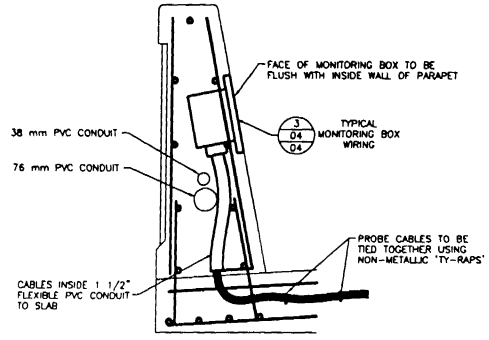
UTAH DEPARTMENT OF TRANSPORTATION

WALL, 30TH AND 31ST IN OGDEN

WB SR-79 OVER 31ST STREET

CORROSION MONITORING SYSTEM LAYOUT

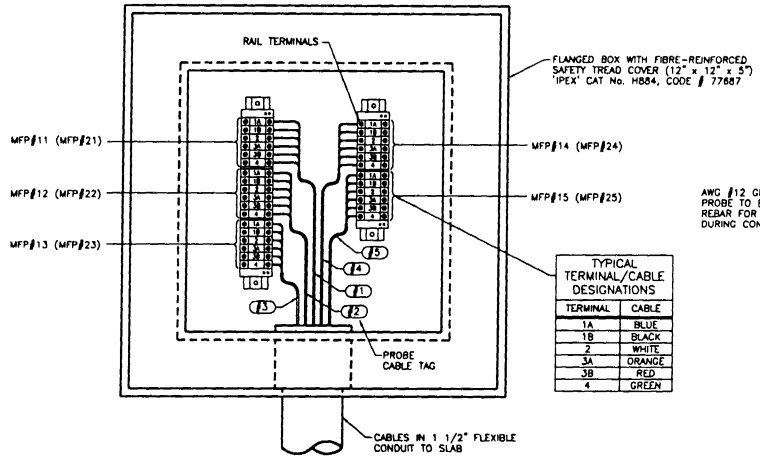
C.I: DE-01-8810-U-0	DESIGNED: S. SEGALL
SCALE: AS INDICATED	DRAWN: B. STEFFLER
DATE: 7 AUGUST 2001	CHECKED: P. BAGAT.
DWG. No. D-4258-01	STATUS D1



DETAIL 1/03/04 TYPICAL MONITORING BOX INSTALLATION

1:10

NOTE: SIZE, SPACING, AND LOCATIONS OF REINFORCING STEEL ARE APPROXIMATE AND ARE SHOWN FOR ORIENTATION PURPOSES ONLY.



TYPICAL TERMINAL/CABLE DESIGNATIONS

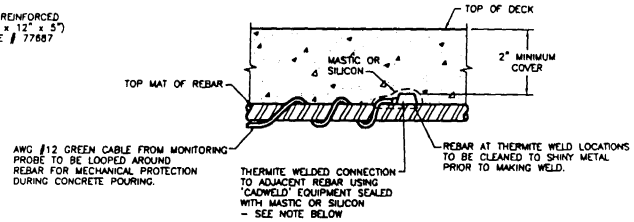
TERMINAL	CABLE
1A	BLUE
1B	BLACK
2	WHITE
3A	ORANGE
3B	RED
4	GREEN

INSTALLATION NOTES

1. INSTALL FLANGED BOX COVER FLUSH WITH INSIDE FACE OF PARAPET.
2. OFFSET REBARS, AS REQUIRED, TO FIT MONITORING BOX.
3. ALL PROBE CABLES TO BE TAGGED INSIDE MONITORING BOX.

DETAIL 3/04/04 TYPICAL MONITORING BOX WIRING

SCALE: 1/2



CABLE TO REBAR CONNECTIONS:

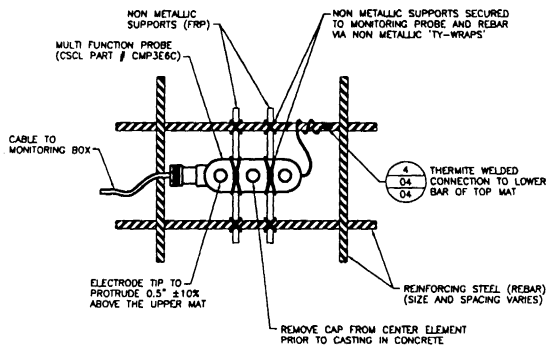
AWG #12 STRANDED CABLES ARE TO BE CONNECTED TO THE STEEL REINFORCING RODS WITH EXOTHERMIC WELDED CONNECTIONS. THE EQUIPMENT TO BE UTILIZED SHOULD BE 'CADWELD' EQUIPMENT AS MANUFACTURED BY 'ERICO INC.' OR EQUIVALENT AS FOLLOWS:

WELDER PART NUMBER.....CAHAA-1GA
WELD METAL NUMBER.....CA-15
WIRE SLEEVE NUMBER.....CAB-133-1H
MOLD SEALING MATERIAL.....CAT-403

THE INSTRUCTIONS SUPPLIED WITH THE MATERIAL MUST BE CONSULTED FOR SAFE AND PROPER USAGE.

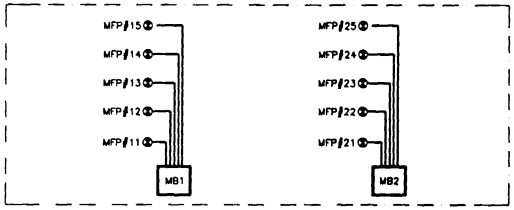
DETAIL 4/04/04 THERMITE WELDED CONNECTION

SCALE: 1/2



DETAIL 2/03/04 INSTALLATION OF MULTI-FUNCTION PROBE

SCALE: 1/4



TYPICAL SYSTEM SCHEMATIC

(TYPICAL ARRANGEMENT PER OVERPASS)

229

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Sarnia : Toronto : Montreal : Halifax

UTAH DEPARTMENT OF TRANSPORTATION

WALL, 30TH AND 31ST AT OGDEN
W.B. SR-79 AND E.B. SR-79

CORROSION MONITORING SYSTEM INSTALLATION DETAILS AND SYSTEM SCHEMATIC

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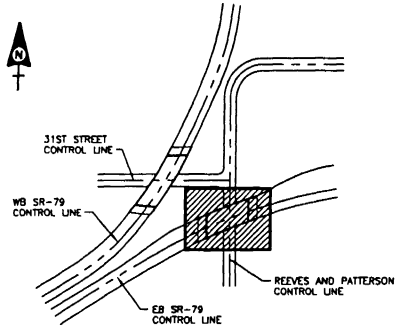

LOCATION PLAN

N.T.S.

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6. ALL DIMENSIONS GIVEN IN MILLIMETRES UNLESS NOTED OTHERWISE.

BILL OF MATERIALS

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3	MFP#14, MFP#15 MFP#24, MFP#25	'CORROSION SERVICE COMPANY LIMITED' MULTI-FUNCTION PROBE PART # CMP3E6C c/w 20m OF CONNECTION CABLE	4 pcs
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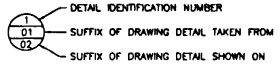
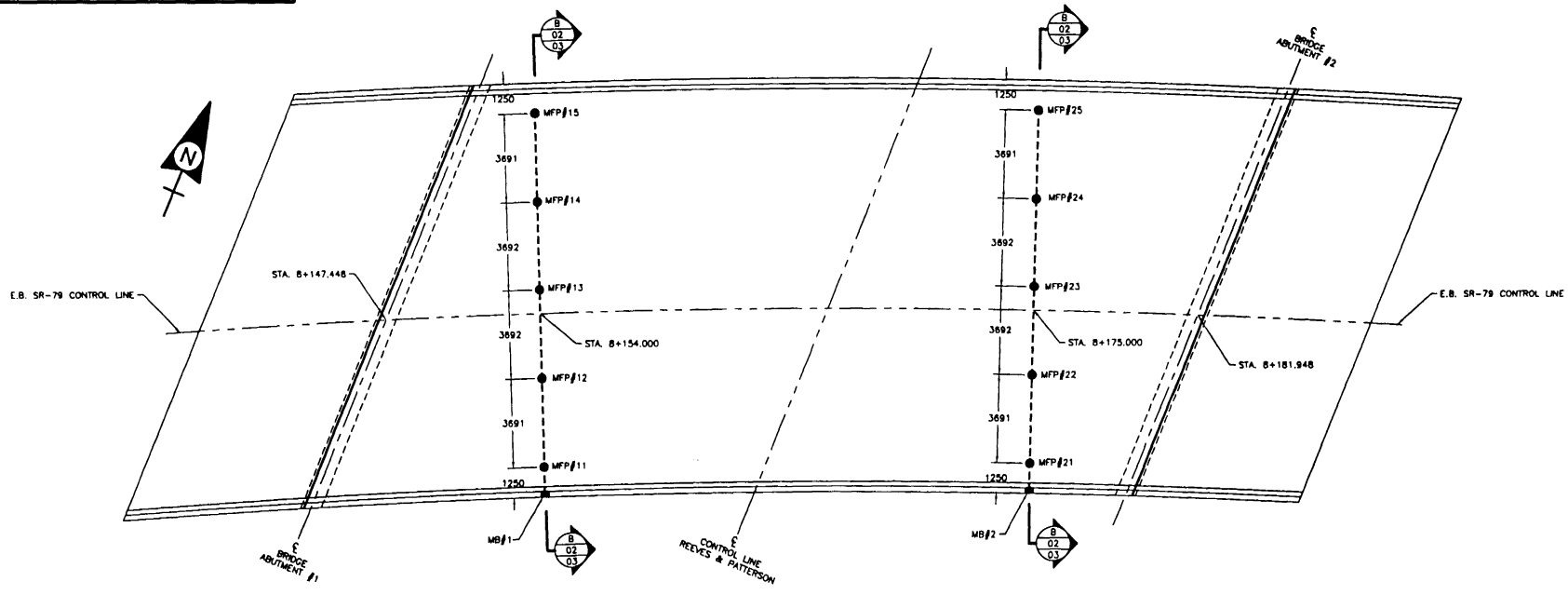
5	-	'CADWELD' MOULD	1 pcs
6	-	FRP MOUNTING RODS	AS REQ'D
7	-	MISCELLANEOUS EQUIPMENT	AS REQ'D

DETAIL SYMBOL EXPLANATION





PLAN

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WALL, 30TH AND 31ST IN OGDEN
E.B. SR-79 OVER REEVES AVENUE

CORROSION MONITORING SYSTEM LAYOUT

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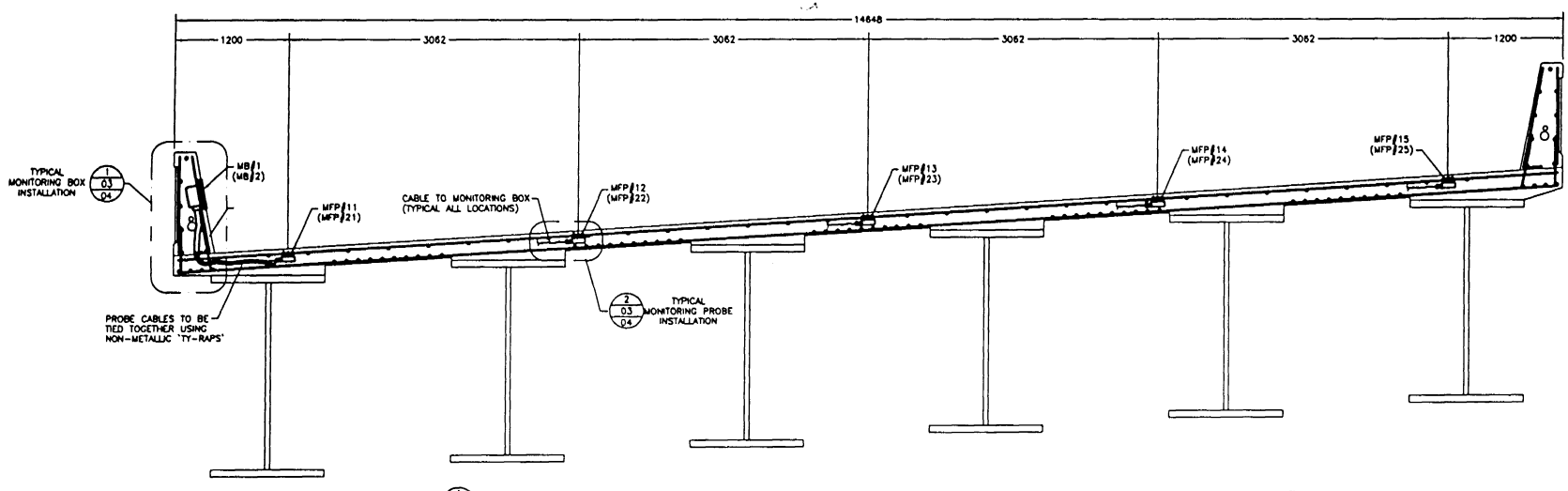
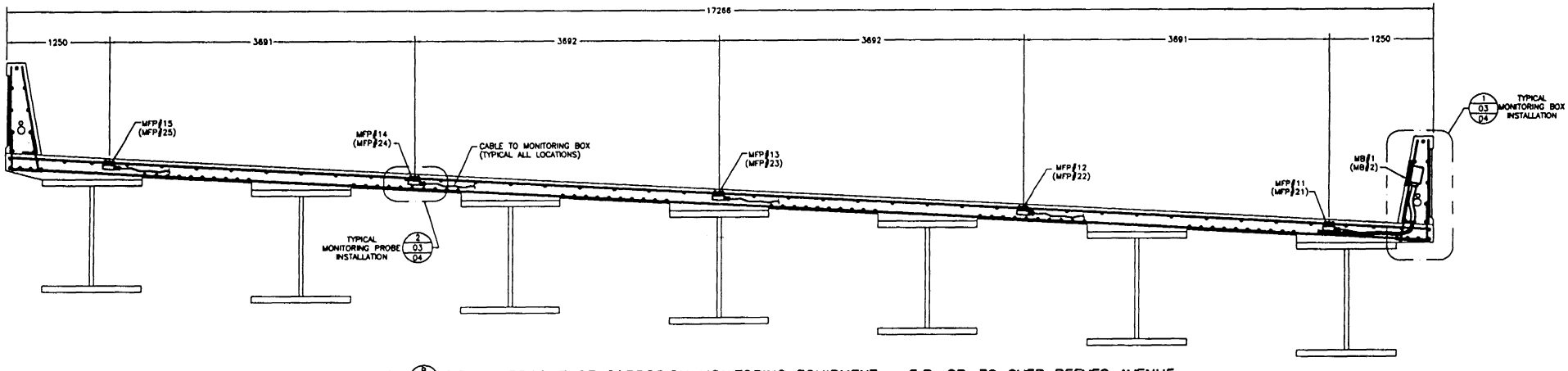


SECTION A 01 03 TYPICAL PROFILE OF CORROSION MONITORING EQUIPMENT – W.B. SR-79 OVER 31ST STREET
1:25

NOTE: SIZE, SPACING, AND LOCATION OF REINFORCING STEEL ARE APROXIMATE, AND ARE SHOWN FOR ORIENTATION PURPOSES ONLY.



SECTION B 01 03 TYPICAL PROFILE OF CORROSION MONITORING EQUIPMENT – E.B. SR-79 OVER REEVES AVENUE
1:25

NOTE: SIZE, SPACING, AND LOCATION OF REINFORCING STEEL ARE APROXIMATE, AND ARE SHOWN FOR ORIENTATION PURPOSES ONLY.

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CORROSION SERVICE COMPANY LIMITED
Professional Engineers : Corrosion Specialists
Sarnia : Toronto : Montreal : Halifax

UTAH DEPARTMENT OF TRANSPORTATION
WALL, 30TH AND 31ST IN OGDEN
W.B. SR-79 AND E.B. SR-79

CORROSION MONITORING SYSTEM SECTIONS

C.J: DEO-01-8810-U-0	DESIGNED: S. SEGALL
SCALE: 1:25	DRAWN: B. STEFFLER
DATE: 3 AUGUST 2001	CHECKED: P. BAGAT.
DWG. No. D-4258-03	STATUS D1

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Right-of-Way Lessons Learned From the 12300/12600 South Design/Build Project

(DM #19828)

Also identified/known as the following:

12300 South; Bangerter Highway to 700 East Project
(12300/12600 South Project)

Federal Project No. *HPP-STP-0071(12)0
FINET Project No. 50817
PIN 3516

State Project No. SP-0071(12)1
FINET Project No. 78078
PIN 3219

Prepared by:

Michelle Page, P.E.
UDOT Research
Program Manager

Ken Berg, P.E.
UDOT Research
Development Engineer

April 2005

Introduction

The 12300/12600 South Reconstruction project was the first Design/Build (D/B) project in which the Utah Department of Transportation (UDOT) included full Right-of-Way (ROW) acquisition services as part of the D/B Contractor's responsibility. The scope of the contract included negotiation with at least 360 different property owners on over 1000 parcels located along the corridor and within the central business districts of both Riverton City and Draper City. Additionally, the Contractor/Consultant was required to clear all ROW within a 2-year period while concurrently designing and constructing the project. During the course of the project, the Contractor encountered many challenges in processing the ROW acquisition activities. The Contractor requested, and was granted, the assistance of UDOT's Central ROW staff with acquisition activities in order to keep the project on schedule. The following report documents the lessons learned as a result of this innovative approach to acquiring ROW.

Purpose of Research

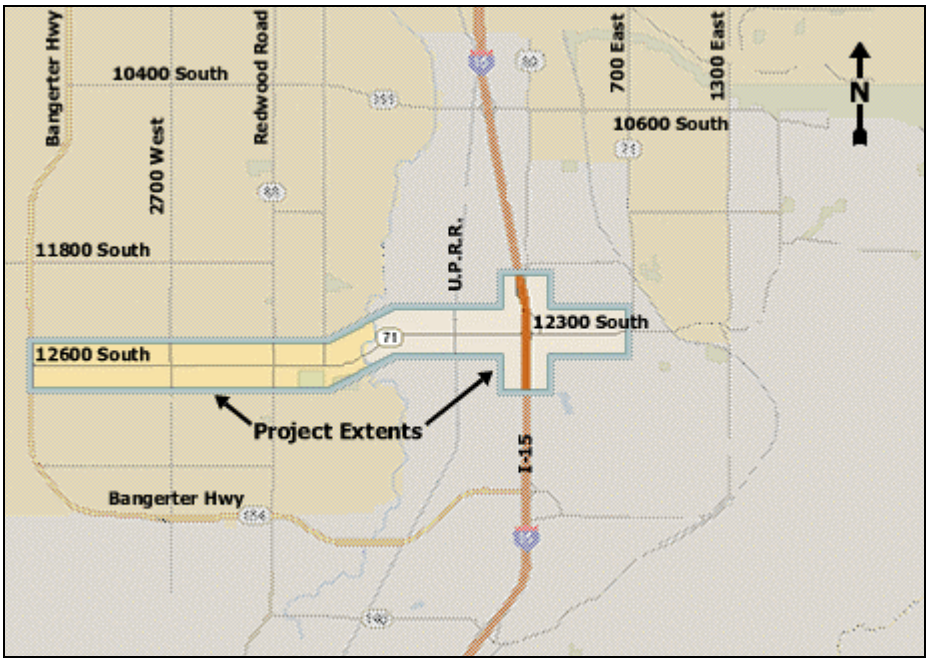
The purpose of this report, as requested by Lyle McMillan, Director UDOT ROW, is to summarize the key elements related to the ROW acquisition challenges, and to document the lessons learned. The information reflected herein was compiled from conversations with key project personnel. Their responses are shown in the Appendix.

Project Background

Originally the 12300/12600 South Project(s) was programmed and conceptualized to be a traditional design/bid/build project to be built in four segments over the course of several years between 700 East in Draper and the Bangerter Highway intersection in Riverton. The Environmental Assessment report based on that approach was approved on September 15th, 2001 and identified the four segments upon which the overall corridor would be reconstructed. Due to the events of September 11th, 2001 the project was identified as an "economic stimulus" which, conceptually, would have the potential to boost Utah's economy; especially the communities of Draper and Riverton.

Additionally, the UDOT was under an EPA "air conformity" deadline date of July 10, 2002 that affected the 12300/12600 South Project(s) and all other UDOT projects that were intended to add capacity. For these reasons late in 2001 UDOT decided to change the project(s) to a Design/Build Contract beginning at 700 East and extending to Bangerter Highway. The project's extents map is shown below.

In July of 2002 UDOT awarded the contract and issued a Notice to Proceed (NTP) to Geneva Rock/Ralph L. Wadsworth Construction/W.W. Clyde known as GRW Design/Builders.



Identification of Key ROW Issues

As the project progressed the following key ROW issues were identified:

- ✓ R/W Acquisition Schedule
- ✓ Increased UDOT ROW Involvement
- ✓ Data Input into ePM
- ✓ Parcel Payout Costs
- ✓ Administrative Settlements
- ✓ Utility Parcels

The following are the contractual/planned vs. actual elements related to the key ROW issues for the 12300/12600 South Design/Build Project:

R/W Acquisition Schedule

Contractual/Planned

The ROW acquisition schedule became critical to the project completion date, which was noted in the project schedule that was submitted shortly after the Notice to Proceed (NTP). The schedule indicated a ROW acquisition completion date of Sept. 23, 2003. The Design/Build contract called for the Contractor to initiate ROW acquisitions immediately after the NTP, to submit groups of approximately 20 parcels every two weeks, to allow UDOT 10 Working Days per 25 appraisal reports or acquisition packages for review, and to assume responsibility for any delays to the project schedule that resulted from submittal of inadequate or incomplete appraisal reports or acquisition packages.

The contract also required the Contractor to "remain open to all reasonable settlement requests from property owners that are feasible, comply with the regulations as outlined herein, and help expedite the ROW acquisition process. Note that the Department encourages all positive and creative solutions that both satisfy the property owner and promote the success of the Project."

Actual

As of this report the ROW acquisition process has not been completed in its entirety. However, the key element of the contract for the 12300/12600 South Design/Build Project was to complete construction by December 4, 2004; that has occurred. Therefore, time of completion was not effected.

Increased UDOT ROW Involvement

Contractual/Planned

HW Lochner, Inc., had contractual responsibility to act as an agent for UDOT in performing all activities necessary for final ROW acquisition, subject to UDOT review and approval, for 360+ ownerships with 1000+ parcels requiring ROW or easement work. UDOT's planned ROW oversight involvement, for document review and approval, was 30% of one FTE over a period of approximately six months or in other words 288 hours. The planned hours were a best guess due to the Design/Build aspect of the project. An undertaking of this amount of ROW by a Consultant had never been done before. In the past, UDOT had always maintained control of the process and taken responsibility for any delays to the Contractor. This change shifted the risk and ultimately led to some adjustments by UDOT.

Actual

Due to the ROW acquisitions affect on the critical path of the project, UDOT Central ROW Division was asked by the UDOT Project Manager to help Lochner expedite the ROW acquisition process; resulting in increased UDOT involvement. This was not wholly unanticipated due to the pioneering effort of a Consultant run ROW acquisition process.

The table below summarizes actual hours charged to the project as of 12/3/2004 by UDOT ROW staff.

MGT. UNIT	NAME	R/W ACTIVITY ACTUAL HOURS							TOTALS
		MGT	55P	60P	65P	67P	19D	MISC	
9102	L. Mabey	50	132	1280		10			1472
	R. Jones			1048		497			1545
	A. Dearden			15					15
	S. Nelson	4		24					28
	W. Cook		13						13
9103	K. Stein			13	165			9	187
	T. Butcher			11					11
	A. Dearden			5					5
	E. Lyon		13						13
9104	C. Fox			2					2
9105	J. Baird			5		129			134
	J. Plumhoff		9	4		92			105
	J. Rico					27			27
	D. Parker						4		4
	TOTALS	**54**	**167**	**2407**	**165**	**755**	**4**	**3**	**3561**

The table below summarizes the comparison between the planned hours for UDOT oversight activities and the actual hours charged to the project as of 12/3/2004 by UDOT ROW staff. The values in the "ACTUAL HRS." column come from the above table. Note, only UDOT prepares resolutions for condemned ROW. Therefore, this activity was not billed to the Contractor/Consultant.

ACTIVITY	DESCRIPTION	PLANNED HRS.*	ACTUAL HRS.	+/-
MGT	MANAGEMENT	288	54	-234
55P	MAKE R/W APPRAISALS	0	167	167
60P	ACQUIRE R/W	0	2407	2407
65P	RELOCATE OCCUPANTS	0	165	165
67P	CONDEMN R/W	0	755	755
19D	DEVELOP R/W PLANS	0	4	4
MISC	MISCELLANEOUS	0	9	9
	TOTALS	**288**	**3561**	**3273**

From the above table it is apparent that the actual hours charged to the project were 3273 hours over and above the planned hours.

Data Input into ePM

Contractual/Planned

UDOT's "planned" 288 hours for oversight were intended to include the time necessary to input data into ePM. These hours were the default values that ePM calculated and were not adjusted manually as historic data was not available to assist with this portion of the Project Manager's estimate.

Actual

The time that UDOT ROW staff spent inputting project data into ePM was more than anticipated. However, the actual time associated with ePM data input was not tracked therefore a specific number of those hours are not available. Future projects would definitely benefit from the ability to assign multiple rights of access to enter activity hours into ePM.

Parcel Payout Costs

Contractual/Planned

The estimated parcel payout costs shown on the shotgun estimate were $23.4M.

Actual

Overall, parcel payout costs were $2,493,819 higher than the estimate of $23,400,000 as of November 2004. This value is roughly ten percent of the estimate which is generally within acceptable limits. Most likely, this difference was a result of combining the Engineer's Estimates from the four separate projects into one estimate and changing from a Design/Bid/Build process to a Design/Build process. However, these "overages" did not exceed the overall anticipated ROW costs for the project. At the time this project was assembled there was a rush to accommodate legislative requests in a timely manner. This is one area that could have been refined had there been more time available up front when preparing the contract.

Administrative Settlements

Contractual/Planned

Lyle McMillan had maintained a log of historical ROW acquisition data for two years prior to the 12300/12600 South Design/Build contract being let in 2002. Based on that data the anticipated percentages of volume and cost of administrative settlements were 17.4% and 6.4% respectively. See table below.

R/W Acquisitions for all UDOT Projects FY01 & FY02*					
Parcel Volumes			Parcel Costs		
Total	Adm. Settlements	%	Total	Adm. Settlements	%
683	119	17.4%	$54,752,270	$3,479,454	6.4%

*Historical data summarized from Lyle's Acquisition Log, July 2000 to June 2002

Actual

The percentage of actual administrative settlements is about twice that of the historical average of 17.4%. Note, however, that the percent for administrative settlements is essentially the same. Parcel data as of November 2004 is shown below:

R/W Acquisitions for UDOT's 12300/12600 South Design/Build Project**					
Parcel Volumes			Parcel Costs		
Total	Adm. Settlements	%	Total	Adm. Settlements	%
293	101	34.5%	$25,893,819	$1,723,741	6.7%

** Historical data summarized from Lyle's Acquisition Log, July 2002 to Nov 2004.

Utility Parcels

Contractual/Planned

It was anticipated the utility parcels would become critical and would be expedited as quickly as possible; although, explicit language to that extent was not included in the contract. The intent was that no parcel would be delayed in the ROW acquisition process.

Actual

Delayed parcels were mostly those where the property acquisition process and compensation process were unclear, such as the railroad parcels. The problems have been identified and UDOT Central ROW is working on the new process for acquiring these types of properties. These types of acquisition problems are not unique to Design/Build projects.

Key Lessons Learned

The conclusions and recommendations in this report come from many visits with project personnel. The responses from those visits are included in detail in the Appendix. The following are the main lessons learned regarding the ROW Acquisition Process for the 12300/12600 South Design/Build Project:

1) The success of this Design/Build project reflects the partnering efforts made by UDOT staff as well as the Consultant/Contractor's personnel. The results of this effort indicate that future Design/Build projects will also rely on this level of partnering until such time as the Consultant/Contractor's personnel fully develop the external resources to manage all ROW activities.

2) At least one full time employee should be dedicated to any Design/Build project of this size for ROW Oversight. Ideally, 2-3 employees with different areas of expertise spending approximately 30-40% of their time may work best.

3) When a project incorporates more than one local government, such as this one, additional coordination time should be included in the contract.

4) UDOT needs to be flexible in its ROW approach when the Contractor/Consultant is dealing with a wide variety of utility companies. (This project involved such utilities as the railroad, four canal companies, South Valley Sewer District, etc.)

5) A clear and realistic ROW date needs to be established in the Design/Build Contract.

6) The Request for Proposals (RFP) should contain detailed qualification requirements for the ROW Acquisition Team.

7) ROW Negotiators need to have the signature deeds prior to meeting with the property owner.

8) Project Level Budgeting – Knowing what work qualifies for each activity and billing it accordingly.

9) When changing a project from a Design/Bid/Build to a Design/Build adjust the cost estimate in such a way as to account for the greater risk placed on the Contractor/Consultant.

10) The use of Rights of Occupancy worked very well on this project; especially on the east side of I-15.

11) UDOT did not have time to do an in-depth review of every single parcel. A spot check method was used to monitor the work of the Contractor/Consultant. This worked well for a project of this size.

12) A higher than average number of parcels were administratively settled rather than allowed to go through the condemnation process. The feeling from the Project Management side was that in general the administrative settlements were less costly and timely to the Department, resulting in better public support of the project. In addition, ROW being negotiated without a 100% design resulted in subsequent design changes that forced renegotiations resulting in higher parcel costs and more administrative settlements.

13) The Contractor/Consultant worked on taking the minimum amount of property. GRW Design/Builders were reasonable and conscientious in selecting how much land they needed for constructing the project. Another consultant may not have been so considerate.

14) One significant benefit of contracting ROW is that it eliminated delays/costs to the public and UDOT. The contract built this risk into the Design/Build and the Contractor absorbed it. UDOT's responsibility was to be flexible to the Design/Builder's needs and help out wherever possible.

APPENDIX

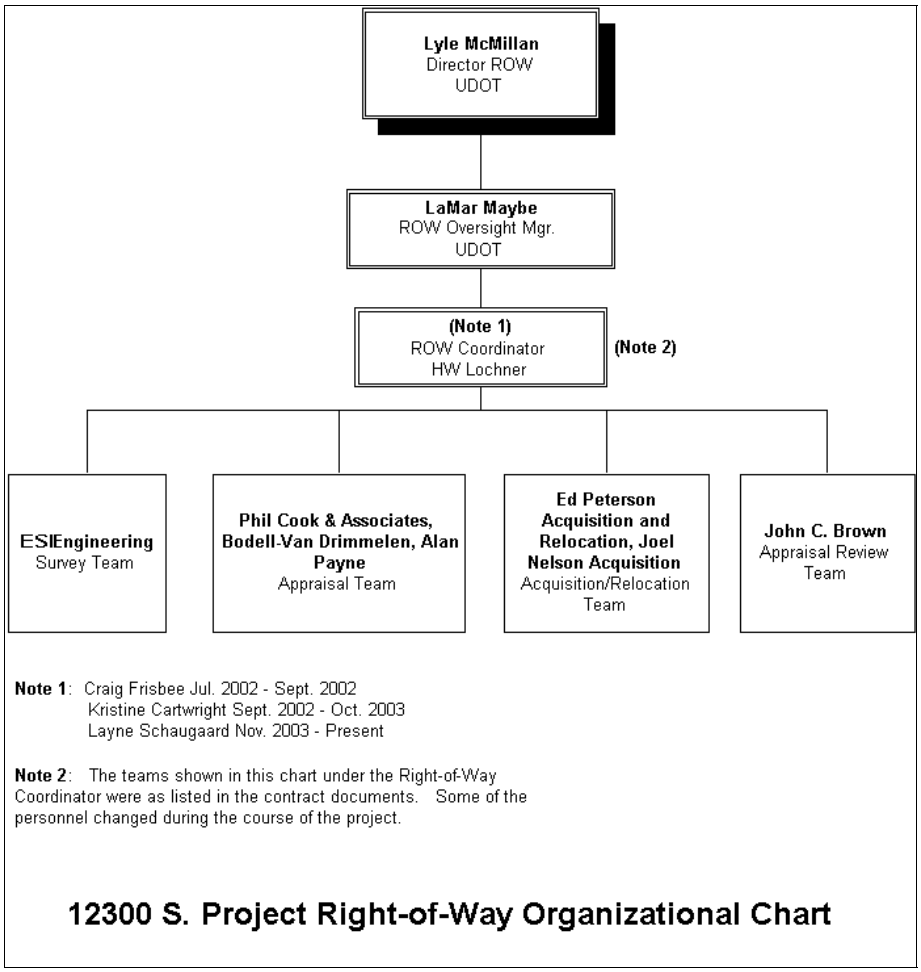
Additional Project Information:

The major elements of the overall project were identified in the contract as the following:

- Widen the corridor (6.2 miles) to a consistent cross section of two travel lanes in each direction with a center median, bicycle lanes, shoulders, curb and gutter, park strips; and sidewalks
- Replace the Jordan River Bridge
- Replace the at-grade Union Pacific Railroad crossing with a grade separation structure
- Reconstruct existing diamond interchange on I-15 at 12300 South to provide a more efficient SPUI interchange with increased capacity

The key UDOT personnel that had responsibility over the entire project were Steve Poulsen, Project Manager (Preconstruction), and Kris Peterson, Resident Engineer (Construction). LaMar Mabey (Right-of-Way) was assigned to be the ROW Oversight Manager.

GRW sub-consulted the ROW acquisition services to H. W. Lochner, Inc. The organizational chart below shows the ROW lines of communication. Craig Frisbee, HW Lochner, was initially identified as the ROW Coordinator but was replaced after a few months. An organizational chart showing proposed key ROW personnel and their coordination and communication relationships is shown below.



Survey Responses:

Following are the Lesson's Learned Survey results:

Kristine Cartwright - Kristine E. Cartwright Associates
Successes:
Turnkey ROW programs work.
Despite a bumpy start, this first turn key Design/Build ROW program was successful.
ROW working directly with the contractor on schedule and progression of work facilitates the acquisition process.
Problems that arise with ROW can be resolved more quickly as the Contractor is directly involved in the day to day operations.
UDOT stepped outside of their typical role and acted as facilitator and provided innovative ideas which resulted in minimized condemnations and delayed acquisitions.

Failures:
Better, timely system in place for payment of right of way subcontractors.
Unclear expectations with a couple right of way functions, for example the title work.
Miscommunication of progress of right of way program.

Given everything, K. Cartwright Associates would be a part of this first turn key Design/Build program.

Layne Schaugaard - H.W. Lochner
1- Conflict of Interest - To avoid any potential conflict of interest on future projects, we at Lochner have incorporated a statement into our sub-consultant agreements to eliminate any misunderstanding as to allowable conduct when dealing with property owners. The statement reads as follows:
Conflict of Interest. The Consultant and its Sub-consultants, if any, along with their officers, employees, and agents, are prohibited from acquiring any interest, including purchase options, in property within or adjacent to work locations that are reasonably anticipated to be impacted by the Project. The Consultant and its Sub-consultants, along with their officers, employees, and agents, are also prohibited from receiving any real estate fees, compensation, or benefits associated with the sale of a replacement dwelling to a person displaced by this Project or from any other real estate acquisition activity related to this Project. The Consultant shall include these prohibitions in all of its subcontracts. Any such acquisition of property interest or receipt of fees, compensation, or benefits will be considered by Lochner to constitute a material breach of contract and may result in the termination of the Agreement by Lochner.

2- Make sure that the signature deeds remain in the files until given to the negotiator. The negotiator should have the signature deeds when presenting the offer so that if agreement can be reached, the transaction can be finalized at that time. Many times a property owner will have "seller's remorse" or change their mind if the documents are not available to sign at the time. Their signature on a deed tends to finalize the transaction.

3- Make sure that all interests are considered in the contract. If tenant occupied, be sure to investigate leasehold interest. Where indicated, all parties with a legitimate interest in the property should be included on the check for payment to avoid additional claims for compensable interests.

4- Make sure that elevation differences are taken into consideration in the appraisal for properties with remainders. This will avoid additional claims after the improvements are installed.

5- If agreement cannot be reached, begin a "friendly condemnation" 35 days after the offer has been tendered. Notify the property owner that this is necessary to comply with the schedule for Design/Build projects. Frequently, owners will want time to check out data in the appraisal, and then if they disagree with the findings, will hold out for more money. It may appear that they are going to settle, but you can't take that chance and not file if the schedule is to be met. If agreement can be reached later, the condemnation process can be stopped. If such is the case, immediately notify the Attorney General's office to save wasted effort.

6- The project lead agent for the consultant should work closely with UDOT's Right-of-Way oversight and UDOT's project manager. Coordination and communication is key to effectively acquire the right-of-way needed for the project. Although the consultant is responsible for the day to day activities, input from UDOT is essential to provide direction and advice and to work out complications that invariably arise. To be successful for both sides, right-of-way acquisition is a team effort.

Gale Padgett - H.W. Lochner
I have read Layne's response and concur with all that he has mentioned. In addition, I would like to add:

1. Make sure the team that has initial contact with a property owner is well informed as to how the Initiation of Negotiations, the Housing Study and the 90 Day Notice are related, so that property owners are not misinformed and upset as to when they will be required to move.

2. Make sure the acquisition agents are disclosing that moving prior to Initiation of Negotiations could jeopardize the Relocation Benefits.

Craig Fox-UDOT Central R/W - Property Management
1. Agree on what improvements are to be demolished - prior to work being started. Contractor needs to contact ROW for agreement on any changes.

2. ROW should be involved and approve any leases on property being acquired whether it be extensions or new leases.
Contractor needs to make sure all properties are secure and keep ROW informed on all Security issues - such as vandalism, fires, etc. on UDOT owned properties.

James Baird-UDOT Central R/W - Property Management
The biggest Issue I saw was the tracking of the final deeds. We have about 670 deeds for this project. We have all but about 70 in our records, however, the remaining 70 are proving difficult to track down.

One reason for not being able to locate these deeds is that we had a Title Company help us the first few months of the project and they have not been able to get us copies of these deeds. H.W. Lochner (one of the Design/Build partners who was responsible for acquiring the Right of Way) is trying to track down the missing deeds and we will eventually find them all but we need a better tracking method.

On the next Design/Build Contract, SR-201, I think we have a better process in place to handle these deeds.

LaMar Mabey-UDOT Central R/W-Project Oversight
Make sure the design builder has the right person/firm doing the right of way
Daily communication with DB's right of way oversight manager
Daily or every other day communication with Project Manager
Attend weekly UDOT core team meetings
Attend weekly DB's core team meeting
Attend all public meetings or hearings concerning the project.
Get to know the people or businesses along the project so when decisions are to be made you are familiar with whom you are dealing with.
Set realistic goals prior to the DB project
Be able to weigh all the information and make a decision within a short period of time.
Be will to agree to ROO's or ROE's so as to get on the property
Must be able to say "NO" and stand firm
Must be flexible enough and be willing to give a little to gain a lot
Must be a people person
Must be a person who will take charge in difficult situations and bring it to closure
Must be familiar with valuation or appraising and appraisal review
Must be familiar with negotiations
Must be familiar with condemnations
Must be familiar with closings
Must be a problem solver
Must be familiar with construction issues that may arise
Must have a good working relationship with those working on the project

Must have a good Right of Way team working on the project that are knowledgeable and are professional in their area of expertise
Set up a tracking system with the DB's Right of Way Oversight Manager to track the status of all the parcels of the project.
If you see a problem, don't be afraid to change or fix the problem
Get involved in project
Ask questions about the project and the design of the project.
Get to know as much about the project as possible. People will come to you for advise and answers because you are the one who knows it all
Don't be afraid to take a stand even if you have to stand-alone. Just make sure you have all the facts and they are correct
Must be able to think outside the box. Look at the larger picture.
Must be able to withstand a great deal of pressure from all sides (internal and external)
Must be a person people will trust and respect your opinion or recommendations on how to solve a problem or in a difficult situation that needs immediately attention.
Be willing to devote what ever time or energy that is required to bring closure to the project.
Be willing to step up and help out in situations because the end result reflects back upon UDOT and the Right of Way Department.

Karen Stein - UDOT Central R/W – Acquisition/Relocation
Problem Description -Turnkey right of way is problematic when the consultant right of way agent is not qualified to oversee all aspects of Right of Way. Information disseminated by the D/B right of way team was often incorrect and or misleading which caused problems for the property owners and displacees.
Communication and coordination may be problematic if the consultant is not on site for the duration of the ROW acquisition phase.
Also, the RFP for this project was not specific enough in certain areas. This caused confusion for the consultant manager and the rest of the R/W team. Responsibilities were unclear and resulted in unclear expectations, and poor communication between the consultant and subconsultants for R/W. Central UDOT right of way was required to play a very active role in processing claims, managing the right of way processes and keeping the project on schedule. The consultant ROW manager was replaced twice. (The project had 3 total mangers.)

Solution –
The Right of Way section of the RFP needed to be revised for future DB projects. See the SR-201 (pin 2977) revised RFP which incorporates changes that were needed.
For future projects, the DB must be fully qualified to oversee all aspects of right of way. UDOT should not train the DB or the subs. It is the responsibility of the DB to be fully qualified to perform and supervise the performance of all right of way activities from preliminary title reports, document prep, appraisal, appraisal review, acquisition, relocation, closing and title searches. Direct management of the right of way activities must be included in the responsibilities of the DB. UDOT right of way staff should only be required to provide oversight activities and not be directly involved in either the design, acquisition, relocation or title processes. UDOT must retain oversight responsibility and payment authorization and must be kept informed as to the status of the project. The D/B should not dissuade UDOT from communicating with right of way subcontractors if the need arises. Finally, the D/B must be retained under the terms of the RFP until the acquisition and relocation files have been reviewed and properly closed.
Acquisition forms, relocation claims and other right of way documents need to be submitted timely and close out procedures need to be completed by the D/B.

Steve Poulsen – UDOT Project Manager
The design/builder was tasked to clear all ROW, entailing over 300 property owners involving over 900 parcels running through the main business districts of the two impacted communities of Draper and Riverton City. Once GRW received "Notice To Proceed", it quickly became

apparent to UDOT ROW that GRW's ROW lead was not up to the task and UDOT made GRW aware of these concerns. This issue was brought forth in August of 2002. Additionally, the title company selected by GRW was not clearing title and issuing checks to property owners in a timely manner. Once these problems started to hit home with GRW management and their schedule, GRW approached UDOT for help and agreed to pay for Richard Jones work to complete ROW payments to property owners.
As a result, in an attempt to beat the "air conformity" date deadline of July 10, 2002, the UDOT project team had about 8 months to develop an RFQ, review and make necessary changes and award the project.
This resulted in less than ideal review times by internal UDOT personnel for all sections of the RFP contract, including ROW. Additionally, the 12300 South Project did not have a dedicated UDOT team, devoted solely to the project, as did the previously awarded I-15 Re-construction Project and the Legacy highway Project.

These factors contributed to an inadequate time frame for critical analysis of UDOT's expectations in many of the contract requirements, including ROW acquisition.
Overall I view the 12300 South Project and specifically the ROW effort by the design/builder, GRW as a success. This was due, in large part, to the level of commitment and partnering by both GRW & UDOT. The 12300 South design build project was unique in several areas which impacted ROW.

Originally the 12300 South project was to be performed through the typical design/bid/build approach over several years and constructed in segments between 700 East to Bangerter Highway. The Environmental Assessment was signed on September 15th, 2001 and reflected the design/bid/build approach and identified the segments upon which the overall corridor would be built over time. Due to the events of September 11th, 2001, the project was identified as an "economic stimulus" type of project which would inject the Utah economy including the communities of Draper and Riverton.

Additionally, UDOT was under an EPA "air conformity" date of July 10, 2002 which loomed over all UDOT projects that would add capacity, which 12300 South would do. Therefore, UDOT decided to change the project to a design/build and include the entire corridor between 700 East and Bangerter Hywy. This decision was made in late 2001.

Therefore to beat the "air conformity" date, the UDOT project team had about 8 months to develop an RFP, review and make necessary changes and to award the project before July 10, 2002. This resulted in less than ideal review times by internal UDOT personnel for all sections of the RFP contract, including ROW. Additionally, this design/build project did not have a dedicated UDOT team, devoted solely to the project like previous UDOT design/build projects such as the I-15 re-construction and the Legacy highway project.

These factors resulted in many aspects of the contract documents, such as ROW requirements of the design/builder, not having the proper review time to critically analyze what UDOT was asking and expecting the design/builder to accomplish via ROW and the time period UDOT expected this to be done.

The design/builder was tasked to clear all ROW and this entailed over 300 property owners involving over 900 parcels running through the main business districts of the two impacted communities of Draper & Riverton City. Once GRW received "Notice To Proceed", it quickly became apparent to UDOT ROW that GRW's ROW lead was not up to the task and UDOT made GRW aware of these concerns. This issue was brought forth in August of 2002. Additionally, the title company selected by GRW was not clearing title and issuing checks to property owners in a timely manner. Once these problems started to hit home with GRW

management and their schedule, GRW approached UDOT for help and agreed to pay for Richard Jones work to complete ROW payments to property owners.

UDOT could have stood by and criticized GRW and possibly watched GRW's ROW efforts end in a train wreck and been able to say "I told you so", but the result of this type of posturing would have been a black eye to both GRW and the UDOT from both a public involvement standpoint as well as from a contractual standpoint of drawing a line in the sand and telling GRW it's their problem to solve, which I believe is against UDOT's current policy to partner with contractor's to solve problems. This partnering approach, when applied to ROW, led to immediate positive results for both GRW as well as UDOT and was a basis for creating trust and a positive working relationship from the start that resulted in a project (to date) that has had minimum ROW go through condemnation.

Additionally, the Environmental Asssessment was performed by Horrocks Engineers under contract with UDOT. During this period, Horrocks was also tasked with clearing ROW in and around the UPRR crossing (which was one of the segmented phases to be done when the project was to be a design/bid/build). So, when the department changed to design/build and when GRW was awarded the contract, we had the overlapping problem of Horrocks having done some significant ROW work in the area of the UPRR railroad including the extensive shoo-fly area running north and south of 12300 South.

Because Horrocks assisted UDOT in clearing ROW in this area without the benefit of a 100% design, it was necessary to keep Horrocks under contract for much of the project in order to answer questions as well as do additional ROW work, such as deeds and instruments in the railroad area where they has institutional knowledge. This, I believe, was viewed by all (GRW, UDOT ROW) as the right thing to do and Horrocks was very responsive in addressing questions by GRW Design etc. I mention this only to re-enforce the complexity of the ROW effort especially when layered over the change from design/bid/build to design/build.

My conclusions of how ROW was handled on 12300 South design/build project are:

when changing from a design/bid/build type of project to a design/build project a "new" estimate of costs should be undertaken to correctly assess the differences between these two approaches. That said, the estimate provided by UDOT ROW done under the design/bid/build atmosphere proved to be very accurate when viewed in the 20/20 hindsight mirror, three years later.
When UDOT decided to make such fundamental changes to such a large project and do so within a 8 month period in order to beat deadlines such as air conformity and infusing the Utah economy with a project identified as an "economic stimulus" type of project in the aftermath of 9/11, critical review times become secondary;
UDOT Management decision not to dedicate a UDOT oversight team (like the I-15 and Legacy design/build) and all the associated backup personnel, for the 12300 South project. This resulted in UDOT accepting a greater level of risk of oversight, contract administration, review of contract documents and overall management of the project;
Should another similar design build project be done one specific item that needs more clarification is the contractor's responsibility regarding tie-in to private property such as sidewalks. Without the benefit of a completed design, the interface between UDOT ROW line and private property needs to be examined in more detail to determine responsibility.
Should another design/build project similar in scope to the 12300 South project be done by UDOT, the department shouldn't expect any contractor to be able to do include "turn-key" ROW tasks without extensive UDOT ROW involvement…unless the department is willing to allow the contractor to fail.

All said, I am convinced that the ground breaking “turn-key” ROW effort required of GRW was a success for the contractor, the department, the communities of Draper and Riverton and the 300+ individual private property owners.

Later from Steve Poulsen:
Craig & Ken, I'm a bit concerned about the implication of this Lesson Learned. I agree completely that for design/build projects where we can identify surplus properties we want to save, (in advance, without a design is problematic due to design/build) there should a provision in the contract that requires the design/build contractor to re-establish the necessary tie-ins such as sidewalk and landscaping. However, in the case of 12300 South project we identified, in the RFP, the properties Craig is referring to be demolished by the contractor. Once we got into the project and got some design done (and through a partnering effort with GRW and UDOT) we were able to save the properties & structures and thus GIVE UDOT Property Management these properties to rent and sell, which once sold the proceeds will probably go to the General Fund and not back to the 12300 South project. This is something which I think is very unfair to project budgets: project funds pay for properties, along with necessary improvements and then turned over to Property Management to sell and the proceeds go to the General Fund and the project budget is the loser.
I believe if a project is paying for property & improvements on surplus property, the project should get some if not all the proceeds for any such sale. This last point, I think, is a Lesson Learned I would like added to your report. Additionally, in the case of the properties Craig mentions, we will be discussing some of the property deficiencies with GRW to determine what GRW is responsible to fix. Additionally, UDOT Property Management has been able to rent some of these properties, during the last couple of years and I would think rent monies could be used for necessary repairs especially when any sale proceeds will go the GF.

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US 40 Field Visit
August 30, 2004
Slab Jacking Concerns

Attendees:
Jason Davis, Region Three Operations Engineer
Tim Biel, UDOT Materials Engineer
Bill Lawrence, UDOT Concrete Engineer
Val Davis, Region Three Heber Maintenance Station Supervisor
Richard "Barry" Sharp, UDOT Research Specialist
Michelle Page, UDOT Development Engineer

Introduction:

On Monday, August 30th a field visit was made to US 40 following a call received from Jason Davis regarding slab jacking panel failure in the travel lanes. It was proposed that UDOT Materials and Research meet with Region Three Maintenance personnel to determine the extent of the "failures" and identify rehabilitation measures. In the process long and short-term recommendations were developed and noted as follows.

Discussion:

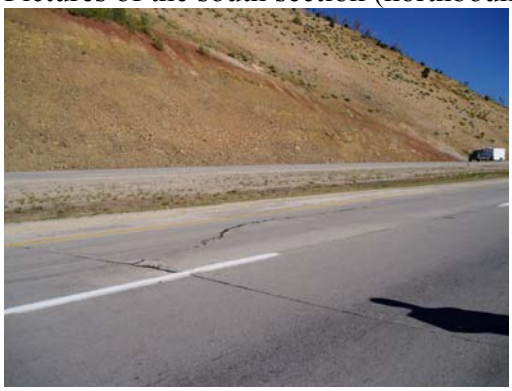
The north (east end) section, northbound US 40, had existing cracking prior to the slab jacking. A possible reason for the existence of these cracks was that of hot concrete setting and the saw cutting of the control joints happening too late. In regards to slab jacking, as long as the cracks were one per panel and acting as a working joint Tim saw no reason why this was a problem. He did say that slabs with corner cracks might be harder to control while jacking. It did appear that there was a void issue in each of these locations; however, to know for sure the panels would have to be removed and the base checked for voids. The main question needing answered at this location was whether the slabs were still moving/settling or not.

Pictures of the north section:

The next location visited was to the south (west), both southbound and northbound. Southbound appeared to be in relatively good condition. Barry found a discarded nozzle from the URETEK machine that made the group wonder if the crew had installation problems while slab jacking these panels. There was also evidence of foam pouring outside of the drill holes at this location. On the northbound section it appeared the panels had been over injected due to the "crown" that was induced. It was noted that the profile survey appeared to be taken from an existing low and was not extended through the pavement section to the north. If so, this is probably what created the new "bump" as drivers drove past the slab-jacked sections.

Pictures of the south section (southbound):

Pictures of the south section (northbound):



Recommendations:

Short-term – At the north end section, an asphalt overlay should be applied until such time as the slabs can be removed/repaired paying careful attention to the removal of any loose portions of concrete that will continue to move and vibrate. These will "break" through the asphalt if not removed. It is likely that this overlay will have to be touched up at the end of each winter season due to removal that is likely to occur while snowplowing this section of roadway. In the next location to the south, the southbound section can be left alone while the northbound section needs fixing. Fixing should include patching of the pothole, sealing of the cracks and grinding the panel joints smooth. Again, paying careful attention to the removal of any loose portions of concrete prior to potholing or crack sealing.

Long-term – Replace those panels with multiple cracks in both northbound sections, including those shoulder panels that appear unsupported. (Further identification of the full extent of removal may be necessary due to changes that may occur between now and then; for assistance contact Tim Biel at (801) 965-4859.) It would be a good idea to get survey shots of the north section prior to the short-term overlay to compare with the elevation of the panels prior to removal. This would indicate whether the panels are still moving. If they are, the base needs to be excavated and stabilized prior to installing new panels. If not, the base can be left as is and the panels placed directly on it.

Action Item for Research:
Barry Sharp to contact URETEK and find out what notes they have regarding installation at these locations.

Follow-up:
URETEK did not have additional field data available in their files regarding observations made during installation. They did have the original survey points and elevations if the region were to decide to re-survey and identify the current elevation differences. A field visit was held with Kent Nichols a few days after the initial field visit with UDOT personnel. Similar comments to those noted above were discussed/commented on. At the conclusion of the second field visit no new information was presented. Therefore, the preceding recommendations remain valid when approaching this particular location.

On July 20, 2005 while visiting with Jason Davis regarding this section of US 40 it was noted that the "bump" discussed on Page 2 of this document delaminated completely this spring.

FY06 Research Projects

POOLED FUND LEAD STATE COSTS
Pavement Marking Life Cycle
WASHTO X
Dynamic Passive Pressure on Abutments and Pile Caps

POOLED FUND NON LEAD STATE COSTS
TCCC Training Management & Development
Western Alliance for Quality Transportation Construction
Evaluation of the Safety Edge
Traffic Management Center
Aurora Program
Western Transportation Institute -- Evaluation of Road Weather Information System Program at UDOT (Subset of Aurora program with UDOT as the lead state)
Demonstration and Evaluation of ITS Technology for the Rural Highway Environment a.k.a. "FRONTIER"
Evaluation of Low Cost Safety Improvements

CURRENT SPR STUDIES
DOWN-DRAG OF PILES
BRIDGE SCOUR COUNTERMEASURES Phase II
BRIDGE DECK STRATEGY
DEVELOP UTAH WETLAND ASSESSMENT METHOD
LONG TERM MONITORING OF I-15 EMBANKMENT
PREVENTIVE DECK JOINT & SURFACE TREATMENT STRATEGY
EVAL. TRAFFIC & SAFETY INITIATIVES (CONTRACT EXTENSION)
PRIORITIZATION OF IMPORTANT ROUTES (CRITICAL LIFELINES)
IMPLEMENTATION OF AASHTO DESIGN GUIDE
WEB-DELIVERED PAVEMENT & TRAFFIC DATA
N/D EVAL METHOD FOR STRESS IN GIRDERS
HEALTH MONITORING OF I-15 STRUCTURES
MATERIALS CHARACTERIZATION FOR THE AASHTO 2002 PAVE DESIGN GUIDE
UTAH LTPP MONITORING
IMPACTS OF RAISED MEDIANS
MONITORING SPLICED GIRDERS, DECK PANEL JOINTS & FRP RETROFIT
MONITOR MSE WALLS, PHASE 2
LOAD RATE ON AXIAL AND LATERAL PILE CAP
ROCKFALL HAZARD RATING SYSTEM

STATE STUDIES
EVALUATE WORK ZONE TRAVELER INFO. SYS.
DYNAMIC CHARACTERISTICS OF NEW BRIDGES
STRONG MOTION INSTRUMENTATION OF BRIDGE SITE
ADAPTIVE SIGNAL CONTROL IMP & EVAL*
EFFECTIVENESS OF HOV LANES, PH 3*
UTAH INTERSECTION SAFETY*
SMART PDA

2005 UTRAC PROJECTS
Mitigate Queue Lengths in Work Zone Traffic Control
Cost-effectiveness & Indicators-Pavement Rejuvenation
Full-Depth Recycling and Stabilization of Pavement Base Layers
Design Methods for Unique Culvert Installations
Extract Vehicle Classification from TOC Video
Advanced Warning Signal Site Selection Evaluation Matrix
Dynamic Passive Pressure on Abutments & Pile Caps
Improvement of Deck Concrete Mix Design and Curing Pratices
Worker Visibility
Skid Index Trigger Values
Asphalt Binder Uniformity
Bridge Scour Countermeasure Phase II
Access Management Performance Index
Evaluation of Effects of Stay in Place Forms on Bridges
Targeted and Adaptive Simulator Training for Winter Maintenance
Determination of Crash Costs for Use in Benefit/Cost Analysis (Value of Life)
Evaluation of Rapid Mapper Technology
Older Driver Study: Evaluation of Safety Effects of Pavement Markings and Signage
Pavement Marking Study (Test Sections)
Good Roads Cost Less
SMA Paving Mechanistic Properties
Geophysical methods to prioritize mitigation options for SR-9 in the Coal Hill landslide area