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Maine Department of Transportation

Transportation Research Division

Technical Report 02-3

The Use of Micro-Surfacing for Pavement Preservation

Final Report - April, 2009

Transportation Research Division

The Use of Micro-Surfacing for Pavement Preservation

Introduction

The Maine Department of Transportation (MaineDOT) is responsible for maintaining approximately 8300 miles of public highways. Maintenance of these highways consists of rehabilitation or reconstruction when the road has deteriorated to an unacceptable level. With economic fluctuations and ever increasing traffic levels, this policy does not effectively address the needs of the highway system when maintenance is necessary and creates a backlog of deficient highways.

To reduce this trend, many states have adopted the policy of Pavement Preservation. This policy consists of applying preventative maintenance to the roadway before it has deteriorated to an undesirable level, which maintains structural integrity and extends service life of the pavement. Length of time between costly rehabilitation is increased, reducing the cost of maintaining the highway system. Several states have reported that they were able to improve the overall condition of their highway system after implementing this approach and that every dollar spent using preventative maintenance could save up to six dollars in future spending.

Maine has two types of roads: “A” roads, which are built to state standards and “B” roads, which are not. Pavement Preventive Maintenance (PPM) can be used effectively on “A” roads to extend service life.

Examples of PPM treatments include Crack Sealing, Hot Maintenance Mulch, Thin Overlays, and Micro-Surfacing. Crack Sealing prevents water and debris from entering cracks in the pavement by sealing them with a rubberized material. Hot Maintenance Mulch is a hot mix asphalt pavement with little or no crushed aggregate and is typically used on “B” roads. Thin Overlays are dense - open graded Superpave mixes, with or without recycled asphalt pavement incorporated into the mix, that are typically used on “A” roads. Micro-Surfacing is a thin layer of a mixture of polymer-modified asphalt emulsion, mineral aggregate, mineral filler, and water.

This report will examine the application of Micro-Surfacing to extend the service life of two projects in Aroostook County.

Scope

Project Identification Number (PIN) 9051.00 is located on Route 1 between the cities of Presque Isle and Caribou and PIN 9050.00 is located on Route 1A between Limestone and Caswell. Figure 1 contains a project location map. Each project was resurfaced with Hot Mix Asphalt Overlay and Micro-Surfacing. Both projects have Test and Control Sections to evaluate and monitor frictional resistance, reflective cracking, rutting, and roughness.

PIN 9051.00 begins at station 10+000 and ends at 18+514. This project has two sections of Micro-Surfacing, one between stations 11+225 and 13+500 and another between 16+780 and 18+514. A Level 2 Overlay, comprised of a minimum depth of 13 mm of 9.5 mm Hot Mix Asphalt (HMA) Shim topped with

30 mm of 9.5 mm HMA Surface, was placed on the remaining sections. To evaluate each treatment, two 100-meter test and two 100-meter control sections were established. Micro-Surfaced test sections begin at station 13+300 (Section 1) and 16+880 (Section 4). Control sections begin at station 13+600 (Section 2) and 16+580 (Section 3).

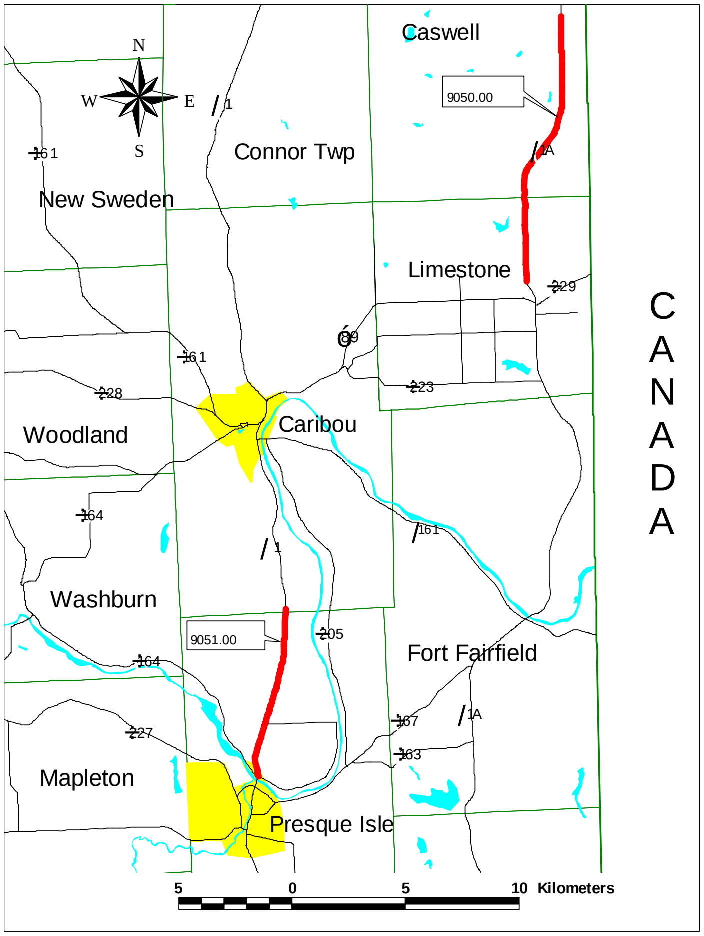

Figure 1: Project Location Map

Project limits for PIN 9050.00 are from station 9+990 to 23+600. Micro-Surfacing was placed between stations 9+990 and 16+000. A Level 2 Overlay with a minimum depth of 15 mm of 9.5 mm HMA shim and 30 mm of 9.5 mm HMA surface mix were placed between stations 16+000 and 23+600. One 100-meter test and one 100-meter control section were established. The Micro-Surfaced test section begins at station 15+800 (Section 5) and the control section begins at station 16+100 (Section 6).

Construction

Mix Design materials, properties, and trial batch information as well as construction equipment and Micro-Surface placement procedures are not included in this report but can be reviewed in the construction report titled Maine Department of Transportation Technical Report Number 02-3, The Use of Micro-Surfacing for Pavement Preservation, (March, 2002).

Project Evaluation

The overall appearance of Micro-Surfacing resembles an open-graded mix with exposed stone as the wearing surface. After five year’s exposure to winter conditions, the Micro-Surfaced portions of each project continue to show signs of snow plow abrasion at centerline, mid-point between wheel paths, and shoulder joint areas. Wheel path areas continue to show signs of wear. Much of the stone matrix has been abraded. The amount and severity of plow wear and abrasion will be summarized for each test section in the Visual Inspection and Crack Survey portion of the report.

International Roughness Index

Smoothness measurements were collected utilizing the Departments Automatic Road Analyzer (ARAN). This is an ASTM Class I profile-measuring device that is capable of accurately measuring roadway smoothness. The ARAN utilizes lasers and accelerometers to measure the lateral profile of each wheel path every 12.5 mm (0.5 in) then averages those measurements every 20 meters (66 ft). Smoothness is displayed in International Roughness Index (IRI) units. Table 1 contains a range of IRI values and descriptions for each range. Data was collected in 2001, 2002, 2003, 2005, and 2006. The ARAN was not available to collect data in 2004.

Table 1: IRI Range and Descriptions

IRI (Meters/Kilometer)	IRI (Inches/Mile)	Verbal Description
1.02 - 1.57	65 – 99	Comfortable ride at 105/65 kph/mph. No noticeable potholes, distortions, or rutting. High quality pavement.
1.58 - 3.15	100 – 199	Comfortable ride at 88/55 kph/mph. Moderately perceptible movements induced by occasional patches, distortions, or rutting.
3.16 - 4.73	200 – 299	Comfortable ride at 72/45 kph/mph. Noticeable movements and swaying induced by frequent patches and occasional potholes. Some distortion and rutting.
Greater than 4.73	Greater than 299	Frequent abrupt movements induced by many patches, distortions, potholes, and rutting. Ride quality greatly diminished.

PIN 9051.00 Presque Isle - Caribou

IRI values over the five year period have changed very little as display in Figure 2.

Roughness in Micro-Surface Section 1 and Section 4 increased 6 percent from last year to a value of 0.81 and 1.17 m/km (51.3 and 74.1 in/mi) respectively. Both values continue to be in the high quality pavement range.

IRI values in HMA Section 2 and Section 3 increased 3 and 4 percent respectively to a value of 0.77 and 0.73 m/km (48.8 and 46.3 in/mi). Both sections have had consistently smooth IRI readings and remain in the high quality pavement range.

For comparison the ARAN collected data on the entire length of the project. Figure 3 contains a summary of the test results.

Both treatments are in the high quality pavement range but Micro-Surface treatments continue to have higher IRI values than HMA treatments.

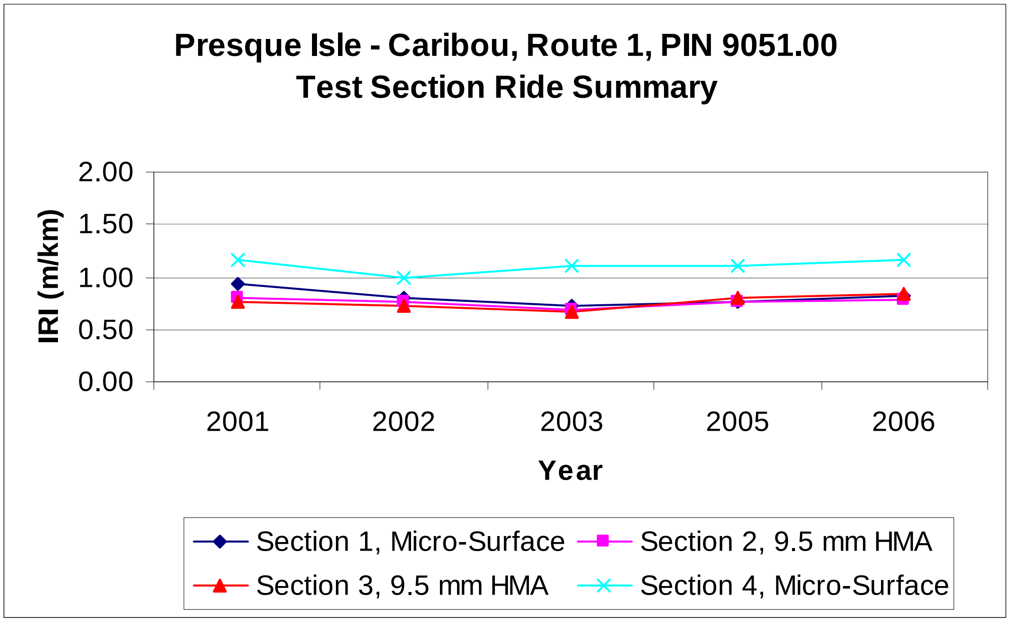

Figure 2: Presque Isle Test Section Level IRI Summary

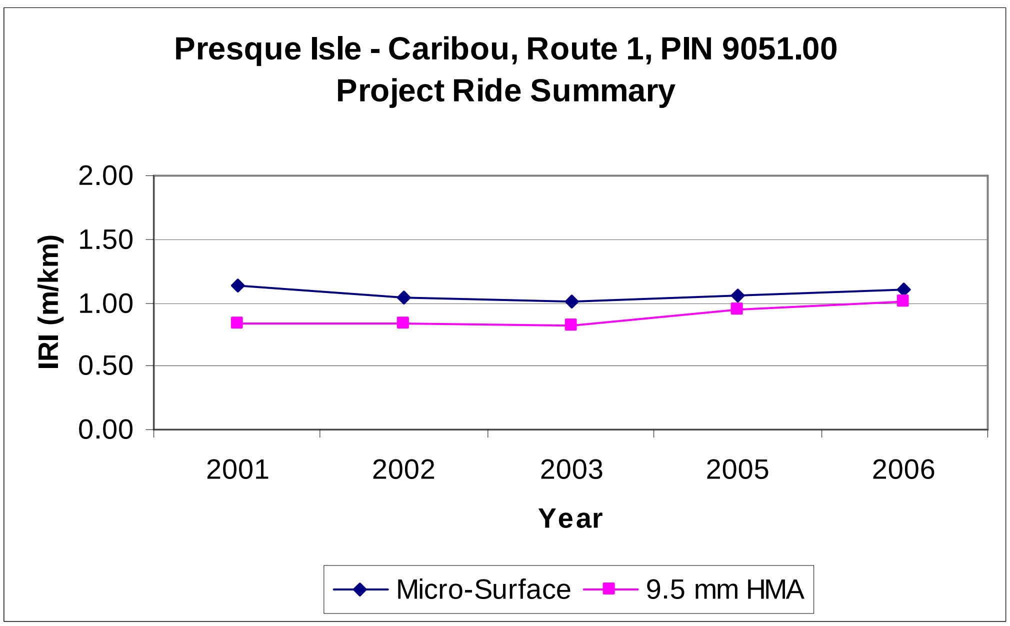

Figure 3: Presque Isle Project Level IRI Summary

PIN 9050.00 Limestone - Caswell

Figure 4 contains smoothness test results for Section 5 and 6. Micro-Surfacing continues to have higher IRI values than the HMA section. Test results remain in the high quality pavement range.

IRI values for Micro-Surface Section 5 increased from 1.45 m/km (91.9 in/mi) to 1.48 m/km (93.8 in/mi).

Section 6 with HMA has increased from a reading of 1.10 m/km (69.7 in/mi) to 1.13 m/km (71.6 in/mi).

The ARAN also collected data on the entire length of this project. Results are displayed in Figure 5. All IRI values remain in the smooth range of 1.02 – 1.57 m/km (65-99 in/mi).

IRI values have increased each year on the HMA portion of the project to a level that is rougher than the Micro-Surfaced portion. The ride increased from 1.30 m/km (82.4 in/mi) in 2005 to 1.41 m/km (89.3 in/mi) in 2006.

Micro-Surfaced areas have a smoother ride. Values increased from 1.12 m/km (71.0 in/mi) to 1.16 m/km (73.5 in/mi).

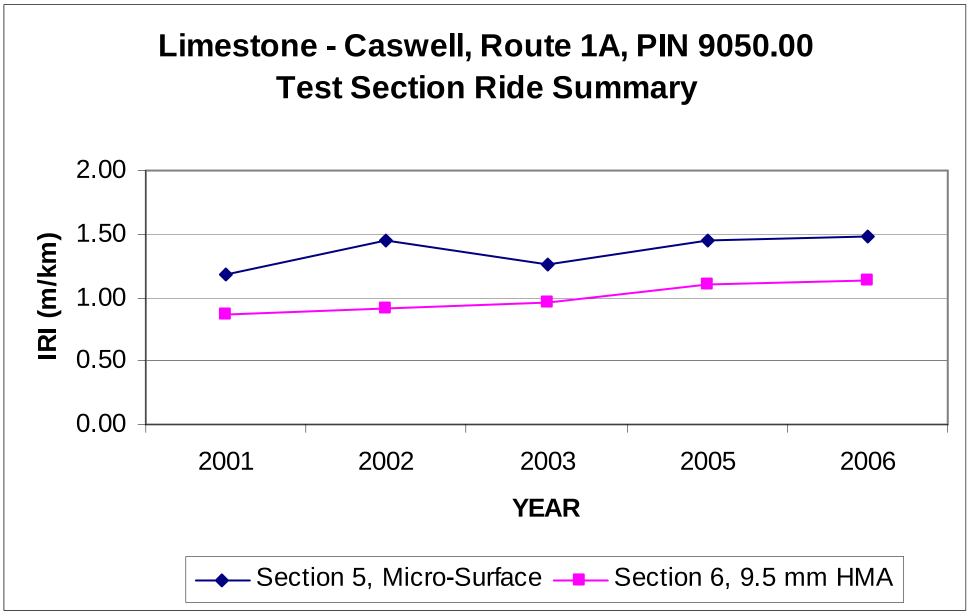

Figure 4: Limestone Test Section Level IRI Summary

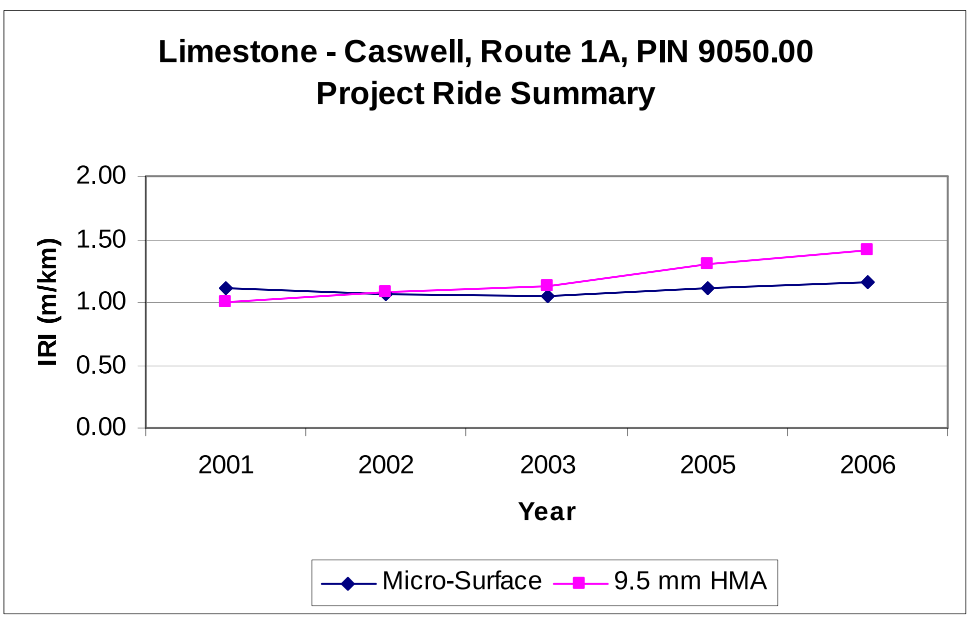

Figure 5: Limestone Project Level IRI Summary

Rut Depth

The ARAN was utilized to collect rut depth measurements. Data is collected using two synchronized, laser based devices to measure transverse profile of a lane up to 4 m (13 ft) wide. Transverse profile measurements of the roadway are sampled every 100 mm (4 in) across the lane at a sampling rate of 1.1 m (3.7 ft) at a speed of 80 km/h (50 mph). Rut depths can be measured to an accuracy of 1 mm (0.04 in).

PIN 9051.00 Presque Isle - Caribou

HMA rutting continues to be less severe than Micro-Surfaced areas. Figure 6 contains a summary of rut depth measurements for each test section.

Rutting in Micro-Surface Section 1 has increased 65.6 percent from a reading of 9.3 mm (0.37 in) in 2005 to 15.4 mm (0.61 in) in 2006. Micro-Surface in both wheel paths of the south lane has worn down to the original HMA. Resultant rut depths are deeper than pre-construction rut depths by 2.4 mm (0.09 in) as display in Appendix A, Photo 5.

Rutting in Micro-Surface Section 4 has not increased as much as Section 1. Depths increased from an average of 7.8 mm (0.31 in) in 2005 to 8.4 mm (0.33 in) in 2006 an increase of 7.7 percent.

Rutting in HMA Section 2 and 3 continue to be less severe than the Micro-Surface Sections. Rut depths have increased from a reading of 5.0 mm (0.20 in) in 2005 to 8.6 mm (0.34 in) in 2006 in Section 2 and 5.5 mm (0.22 in) in 2005 to 7.6 mm (0.30 in) in 2006 in Section 3.

Figure 7 contains a summary of rut depth measurements collected on the length of the project. The HMA treatment continues to have less rutting than the Micro-Surface treatment.

Micro-Surface portions increased from a reading of 7.1 mm (0.28 in) in 2005 to 10.2 mm (0.40 in) in 2006 an increase of 44 percent.

HMA portions increased from an average of 5.0 mm (0.20 in) in 2005 to 7.1 mm (0.28 in) in 2006, an increase of 42 percent.

PIN 9050.00 Limestone - Caswell

Rutting increased on both sections in 2006. Figure 8 contains a Rut Depth Summary of each test section.

Micro-Surface Section 5 increased from an average of 4.25 mm (0.17 in) in 2005 to 4.53 mm (0.18 in) in 2006, an increase of 7 percent.

HMA Section 6 increased from an average of 2.25 mm in 2005 to 3.78 mm in 2006, an increase of 68 percent.

Average rut depths for the project also increased in 2006. Figure 9 displays a summary of the results. Micro-Surface treated portions of the project increased from an average of 4.24 mm (0.17 in) in 2005 to 4.65 mm (0.18 in) in 2006, an increase of 10 percent.

HMA portions of the project increased 44 percent from an average of 2.28 mm (0.09 in) in 2005 to 3.28 mm (0.13 in) in 2006.

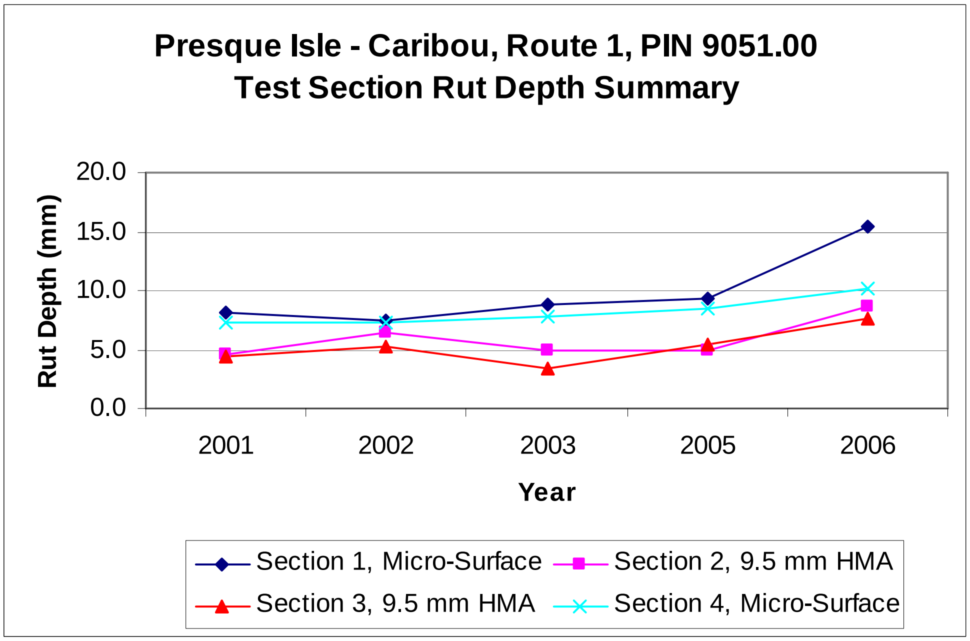

Figure 6: Presque Isle Test Section Level Rut Depth Summary

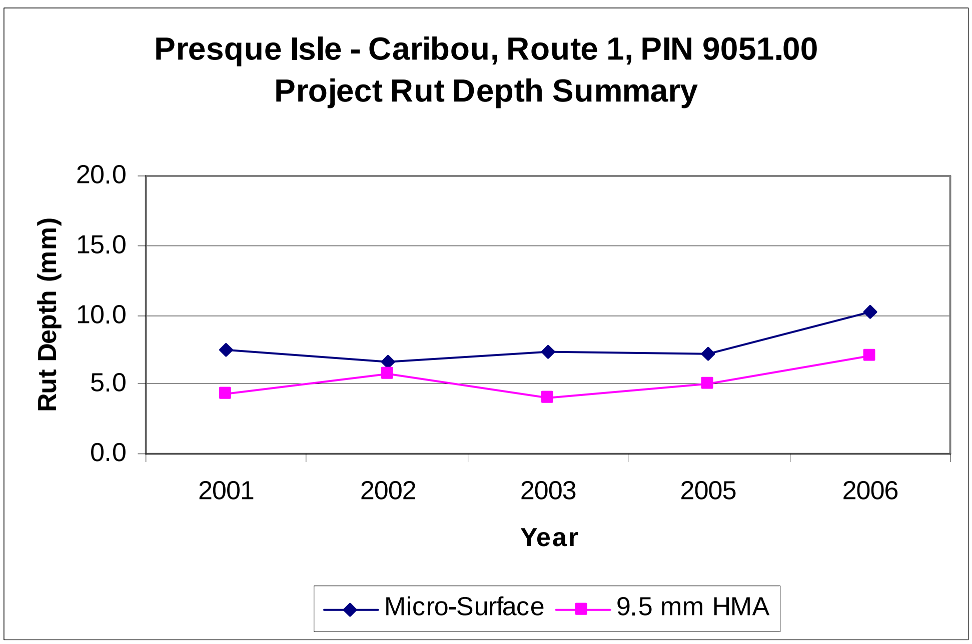

Figure 7: Presque Isle Project Level Rut Depth Summary

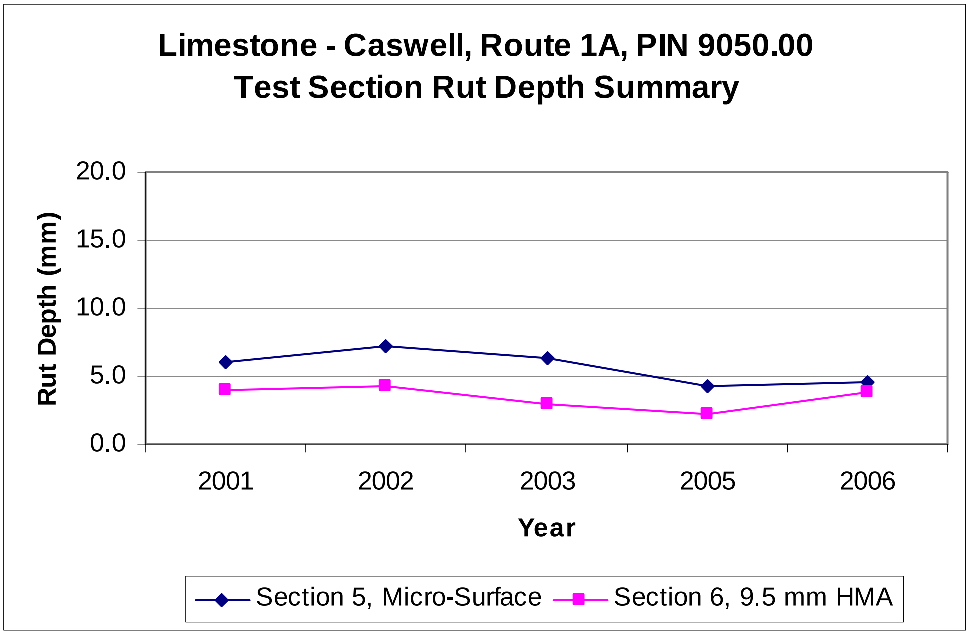

Figure 8: Limestone Test Section Level Rut Depth Summary

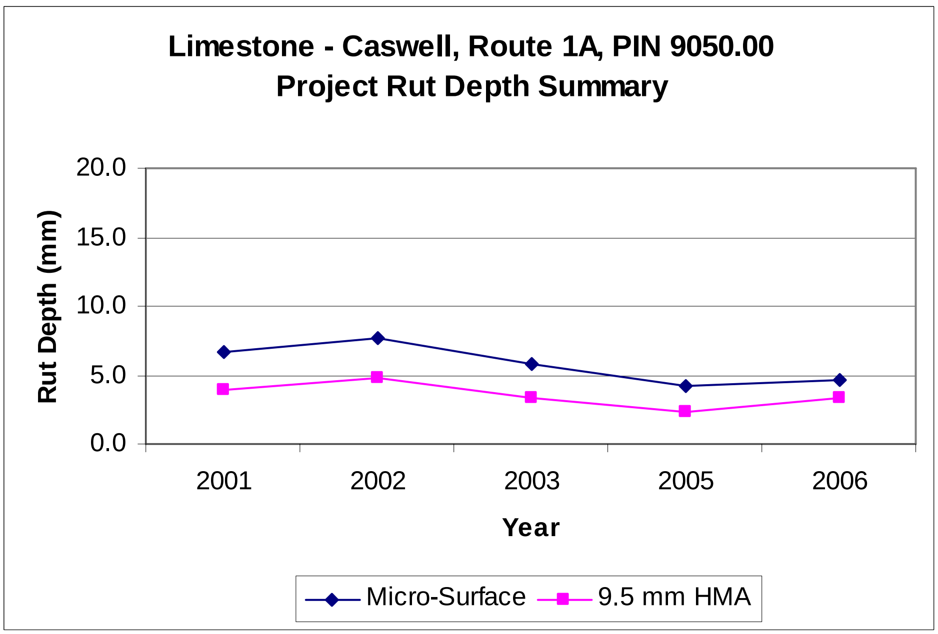

Figure 9: Limestone Project Level Rut Depth Summary

Frictional Resistance

The Department's Frictional Resistance Test Vehicle was utilized to collect Frictional data at random intervals in the left wheel path of each lane along the length of each project. Data was collected using ASTM E 274 Standard Skid Resistance Test Method with ASTM E 501 Skid Test Tires. Frictional Numbers of 35 or higher are considered acceptable by the Federal Highway Administration (FHWA).

Mean Frictional Numbers on Micro-Surfaced and 9.5 mm HMA treatments are well above FHWA's minimum specification. Micro-Surfaced areas have greater frictional resistance than the 9.5 mm HMA areas.

PIN 9051.00 Presque Isle - Caribou

Figure 10 contains a summary of Frictional Numbers (FN) for the Presque Isle project. Micro-Surface frictional resistance decreased from an average of 52.8 in 2005 to 51.0 in 2006, a 3.4 percent decrease.

Frictional resistance on 9.5 mm HMA decreased 1.5 percent from a reading of 47.0 in 2005 to a reading of 46.3 in 2006.

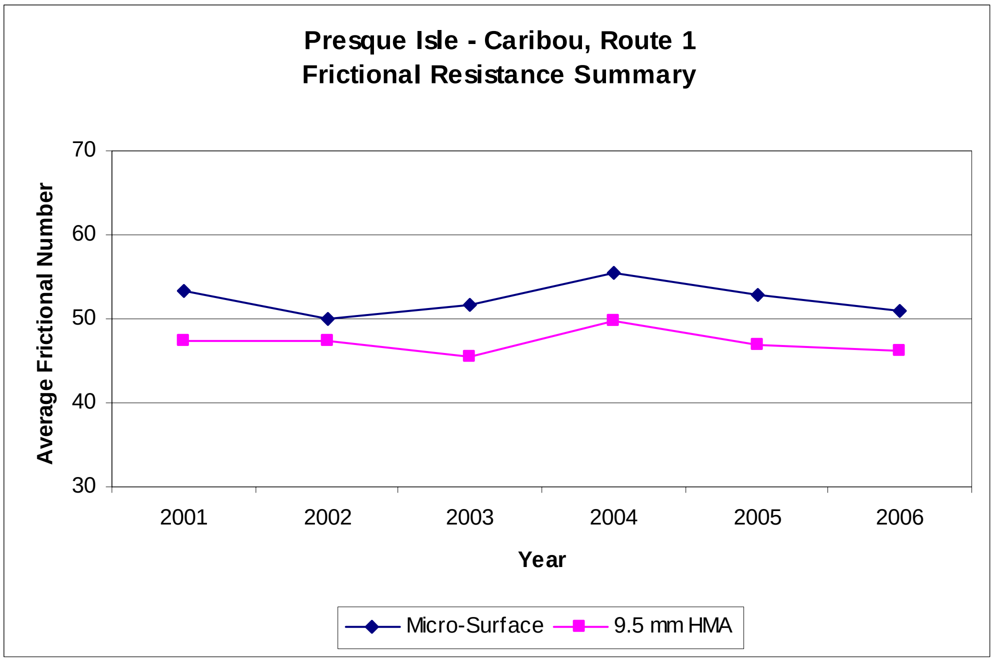

Figure 10: Presque Isle Frictional Resistance Summary

PIN 9050.00 Limestone - Caswell

Figure 11 displays a summary of Frictional Numbers for the Limestone project. Micro-Surface results increased 2.2 percent from an average of 59.4 in 2005 to 60.7 in 2006.

Frictional Numbers increased from an average of 55.1 in 2005 to 55.7 in 2006, an increase of 1.1 percent.

Frictional results have been fairly uniform ion the Limestone project with little change after two years exposure to traffic.

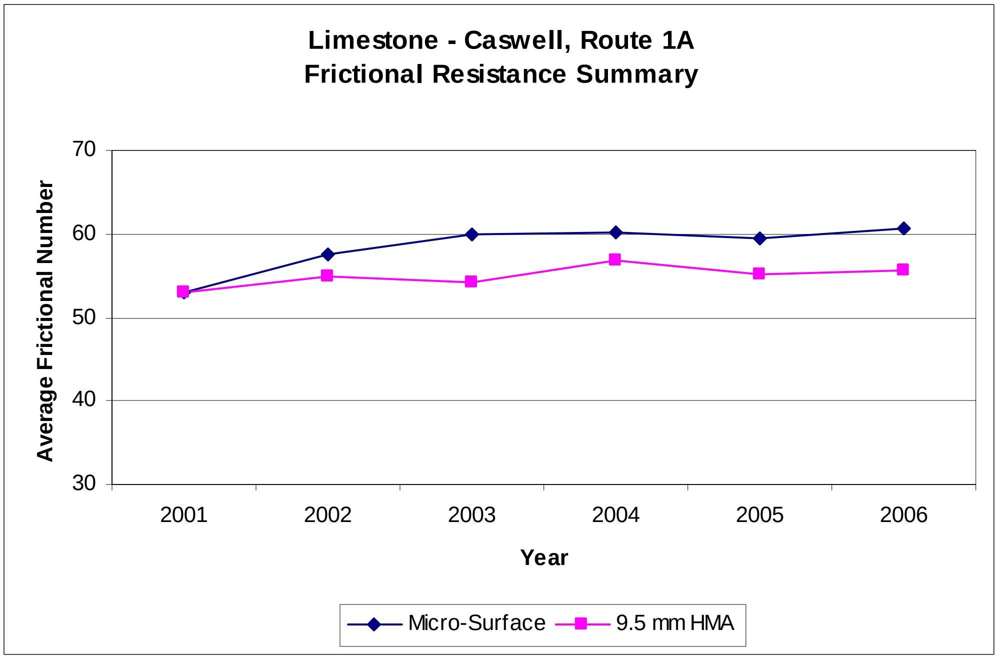

Figure 11: Limestone Frictional Resistance Summary

Visual Inspection

Micro-Surfaced portions have been wearing at a faster rate than HMA portions due to snow plow wear and traffic and most cracks have reflected through at a quicker rate than the HMA. Appendix A contains photos of each test section.

PIN 9051.00 Presque Isle - Caribou

HMA surfaced portions are performing as expected. Reflected cracking is delayed one or two years as compared to Micro-Surfaced portions and rutting is less severe. Section 2 and 3 are represented in Photos 1 and 2.

After five years of traffic with a Factored AADT of 8600 much of the Micro-Surface in Section 1 has worn down to the original HMA in each wheel path. Both wheel paths are worn in the south lane as displayed in Photo 3. The north lane has less wear on the outer wheel path as seen in Photo 4. Snow plows continue to abrade the centerline and shoulders throughout this Section. As mentioned earlier, rut depths are greater than pre-construction depths and appear to be deep enough to trap water which has the potential to cause vehicles to hydroplane, see Photo 5.

Micro-Surface Section 4 has less wheel path wear with the same amount of snow plow wear as seen in Photo 6. Average rutting is less severe in this section but there are isolated spots with deep ruts as shown in Photo 7. This section had less severe pre-construction wheel ruts which could account for the reduced wheel path wear.

PIN 9050.00 Limestone - Caswell

Plow abrasion at centerline on Section 5 is displayed in Photo 8. Snow plowing has abraded the centerline down to the original HMA throughout the entire section. Wheel path abrasion is less severe than the Presque Isle project, most likely due to the amount of traffic. This project has a Factored AADT of 1100.

Control Section 6 has very little plow abrasion or rutting and looks very good as depicted in Photo 9.

Crack Survey

Figure 12 – 17 in Appendix B contain crack surveys of each test section. Cracks are displayed using separate colors for each year: preconstruction – black, 2002 – red, 2003 – blue, 2004 – orange, 2005 – green, and 2006 – violet. Each year that cracks develop, the preconstruction cracks will be mirrored using the appropriate color for the year it was observed. Figures 12 – 15 represent the Presque Isle project, Figures 16 and 17 the Limestone project. There was very little cracking on the Presque Isle project more so on the Limestone project in 2006.

Figure 12 contains a crack survey of Micro-Surface Section 1. This section had the lowest amount of pre-construction longitudinal cracking and only one partial transverse crack. The partial transverse crack reflected through and a new transverse crack appeared in 2003. No additional cracking was observed in 2004. In 2005 the new transverse crack at station 13+320 extended into the roadway to about midway across the lane. In 2006 a transverse crack was observed running from centerline to the inner wheel path of the left lane at station 13+350 and a centerline joint crack is running from station 13+352 to 13+358.

Figure 13 contains a crack survey of Control Section 2. After the first year two full width transverse cracks had reflected through. A new transverse crack at station 13+670 was observed in 2003. In 2004 a portion of the shoulder joint had reflected through and new longitudinal cracking was noticed in much of the centerline. Additional centerline and shoulder cracking was noticed in 2005. The only crack observed in 2006 was a small portion of shoulder joint that reflected through at station 13+696.

Figure 14 displays the amount of cracking on Control Section 3. In 2002 all three transverse cracks had reflected through the pavement. Much of the shoulder joint had reflected through and a considerable amount of new shoulder joint cracking was observed in 2003. New and reflected shoulder joint cracking continued in 2004. By 2005 nearly all of the shoulder joint has cracked and all of the original centerline cracking has reflected through. New centerline cracking was observed on a third of the section. A small amount of longitudinal cracking in the wheel path is beginning to reflect through in 2005. A small amount of cracking was observed in 2006, new centerline crack between stations 16+590 and 16+595 and a new transverse crack is beginning to form from the shoulder to the quarter point at station 16+620 left.

Figure 15 contains a diagram of Micro-Surfaced Section 4. Two transverse cracks had reflected through in 2002. Most of the original cracks have reflected through by 2003. In 2004 only a small portion of new transverse cracking was observed at station 16+953. By 2005 all of the original cracks have reflected through and the transverse crack at station 16+593 has extended close to the left shoulder. No additional cracking was observed in 2006.

Micro-Surfaced Section 5 is displayed in Figure 16. There were no cracks observed in 2002. A majority of the original cracks reflected through in 2003 with a number of small areas of initial load cracking. By 2004 nearly all of the original cracks were visible and the initial load cracks were extending. A few small areas of initial load cracking and transverse cracks were observed in 2005. Initial load cracking continues to migrate in the wheel path in 2006 and a small amount of new longitudinal cracking was observed at station 15+860. The inner wheel path load crack at station 15+840 right has increased in width to 50 mm (2 in).

A crack survey for Control Section 6 is exhibited in Figure 17. In 2002 the only crack observed was the longitudinal and shoulder cracks at station 16+118. In 2003 roughly a third of the shoulder joint has cracked and a transverse crack has begun to cross the roadway at station 16+159. By 2004 nearly three quarters of the shoulder and centerline joint has cracked and a few small areas of longitudinal cracking were observed between wheel paths and in the outer wheel path. The transverse crack at station 16+159 has extended to the quarter point. In 2005 there was a small increase of cracking at the shoulder joint and additional cracking between wheel paths and in the wheel path. In 2006 a small amount of shoulder crack and centerline cracking was observed between stations 16+100 and 16+125. A small amount of initial load cracking on the inner wheel path at station 16+172 and 16+178 is visible and the load crack at 16+150 right has extended to station 16+155.

It appears that cracks reflect through Micro-Surfaced sections within two years and it takes three to four years for cracks to reflect through HMA surfaced sections.

Summary

After five year's exposure to traffic and weather, Micro-Surfaced sections are showing considerably more wear than the 9.5 mm HMA sections.

Most high spots of the Micro-Surfaced roadway have been abraded by winter snow removal equipment. In some areas the Micro-Surfaced treatment has been worn away completely.

Micro-Surfacing has higher IRI values and Frictional Resistance is slightly higher than Level 2 HMA sections.

Micro-Surfacing appeared to slow the progression of reflective cracking up until year 2003. After 2003 cracks reflected through the Micro-Surface sections at a higher rate than the HMA sections.

Micro-Surface treatments claim to add between five and seven years life to existing pavements. This appears to be the case on the Limestone project where the material is performing as expected. The only apparent issue is snow plow abrasion. Wheel path abrasion is not an issue due to low AADT volume.

Wheel rutting on the Presque Isle project is worn down to the original HMA. This condition has actually increased depth of rutting to levels greater than pre-construction levels. Traffic worn wheel path areas are deep enough to trap water which could cause a vehicle to hydroplane. It appears that high AADT counts attributed to excessive wheel rutting.

Excluding cost of traffic control and tack coat application, the cost of resurfacing with Micro-Surface was $2.18 / sq. meter and the product is expected to extend the life of the roadway from five to seven years. The cost and expected life span of Level 2 Overlay is $5.03 / sq. meter and eight to twelve years.

Micro-Surfacing could be used as a Pavement Preservation Program to cost-effectively extend pavement life on roadways with minimal traffic. It is not recommended on roadways with higher traffic counts.

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Additional Literature:

The Use of Micro-Surfacing for Pavement Preservation; Construction Report; March, 2002
The Use of Micro-Surfacing for Pavement Preservation; Interim Report, First Year; May, 2004

The Use of Micro-Surfacing for Pavement Preservation; Interim Report, Second - Third - Fourth Year; December 2005

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APPENDIXES

APPENDIX A


Photo 1: HMA Section 2; August, 2006.

Photo 2: HMA Section 3; August, 2006.

Photo 3: Section 1 Micro-Surface South Lane Wheel Path Abrasion; August, 2006.


Photo 4: Section 1 Micro-Surface North Lane Wheel Path Abrasion; August, 2006.

Photo 5: Section 1 South Lane Wheel Rut; August, 2006.

Photo 6: Section 4 Micro-Surface Centerline and Quarter Point Plow Abrasion; August, 2006.

Photo 7: Section 4 Outer Wheel Path of South Lane; August, 2006.

Photo 8: Section 5 Centerline Plow Wear; August, 2006.

Photo 9: HMA Section 6; August, 2006.

APPENDIX B

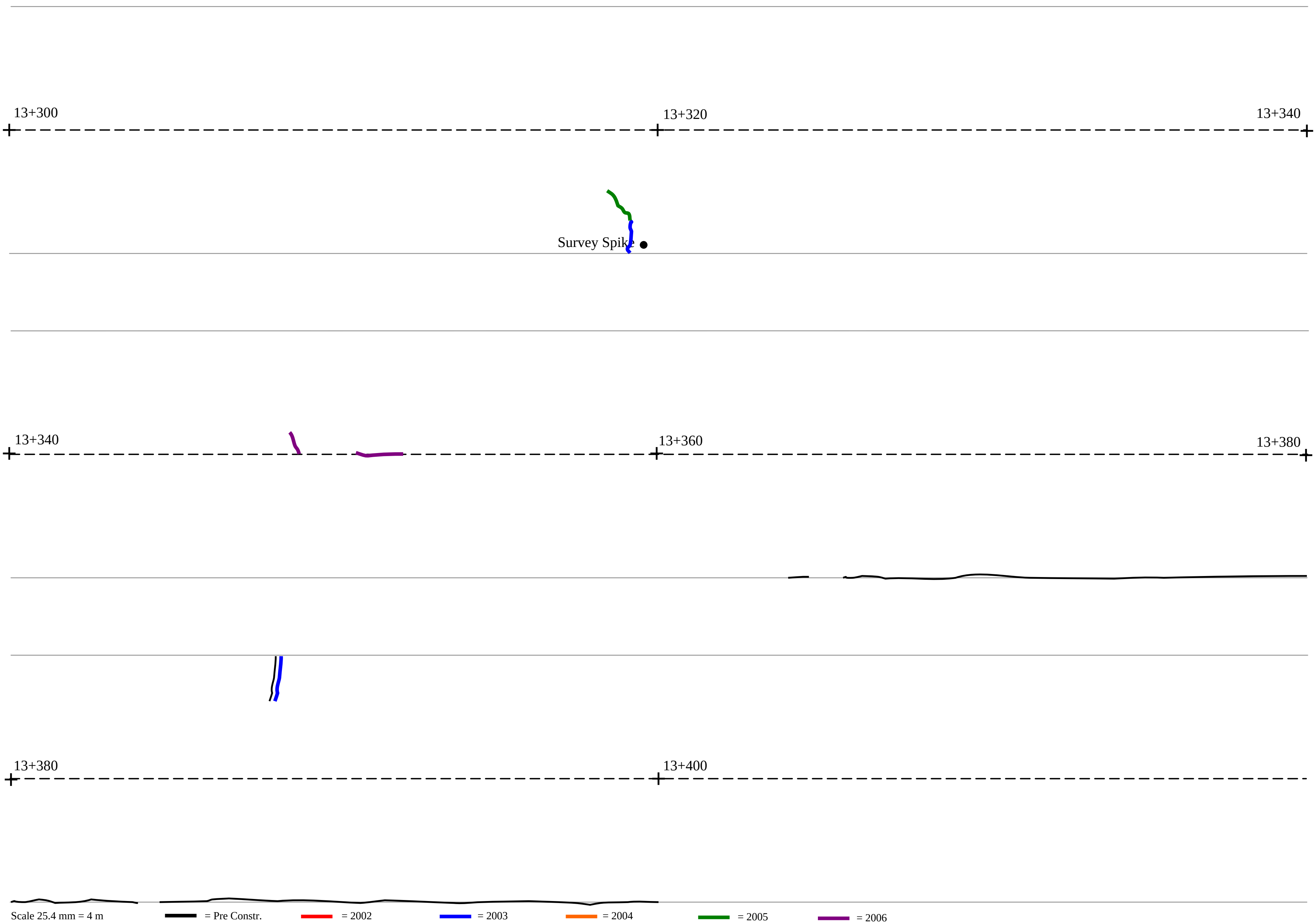

Figure 12. Section 1 Micro-Surface Crack Survey

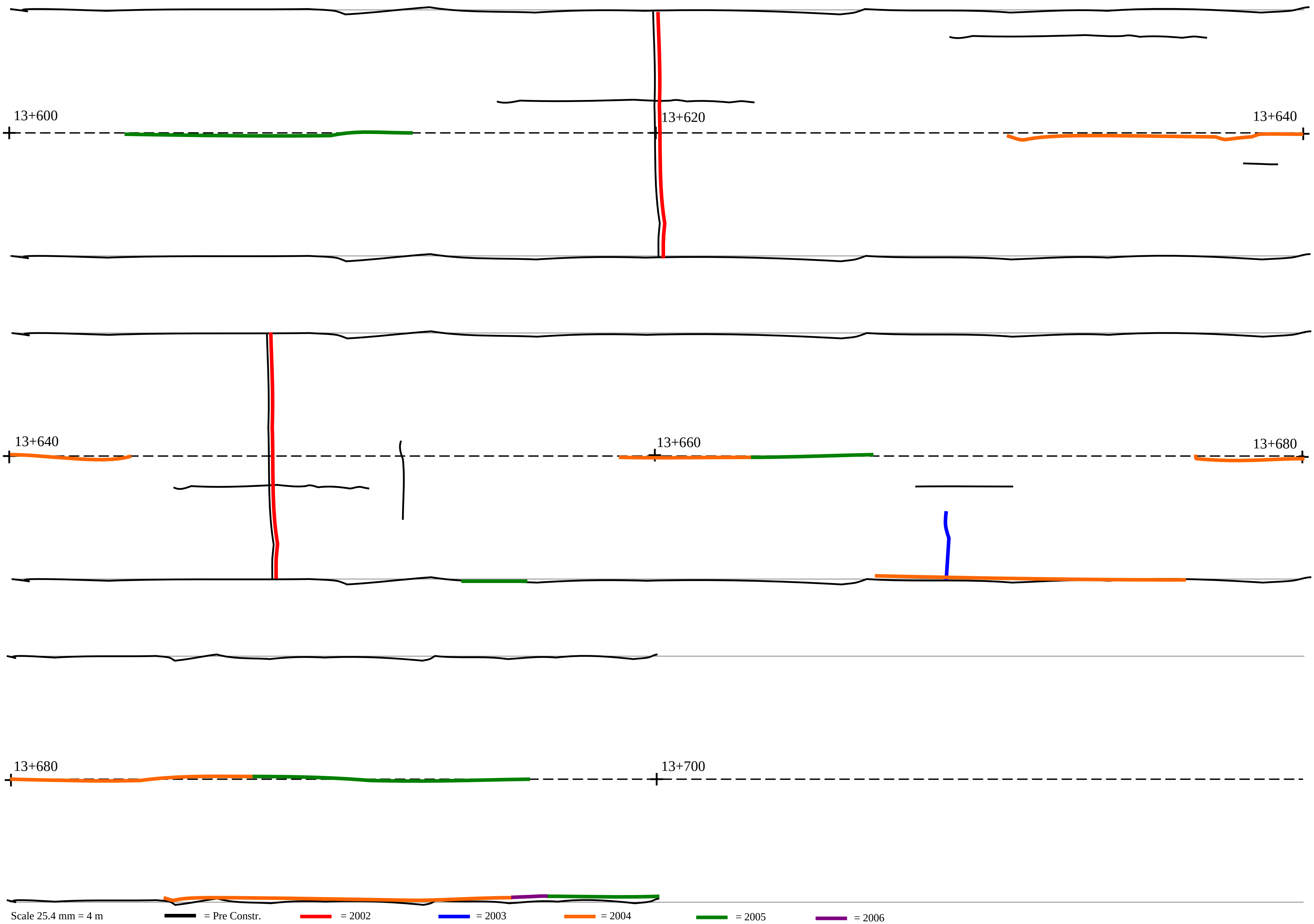

Figure 13. Section 2 Control Crack Survey

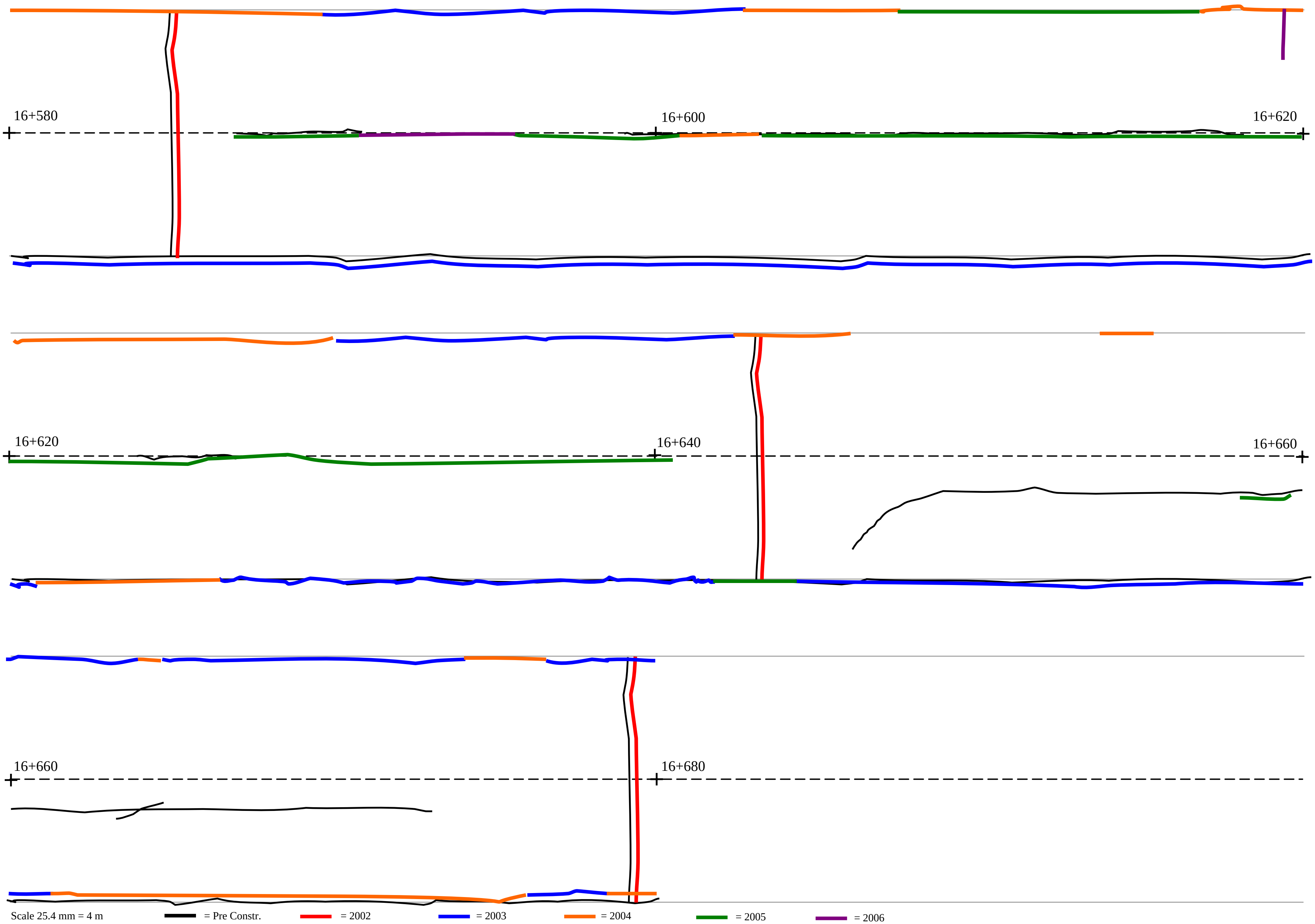

Figure 14. Section 3 Control Crack Survey

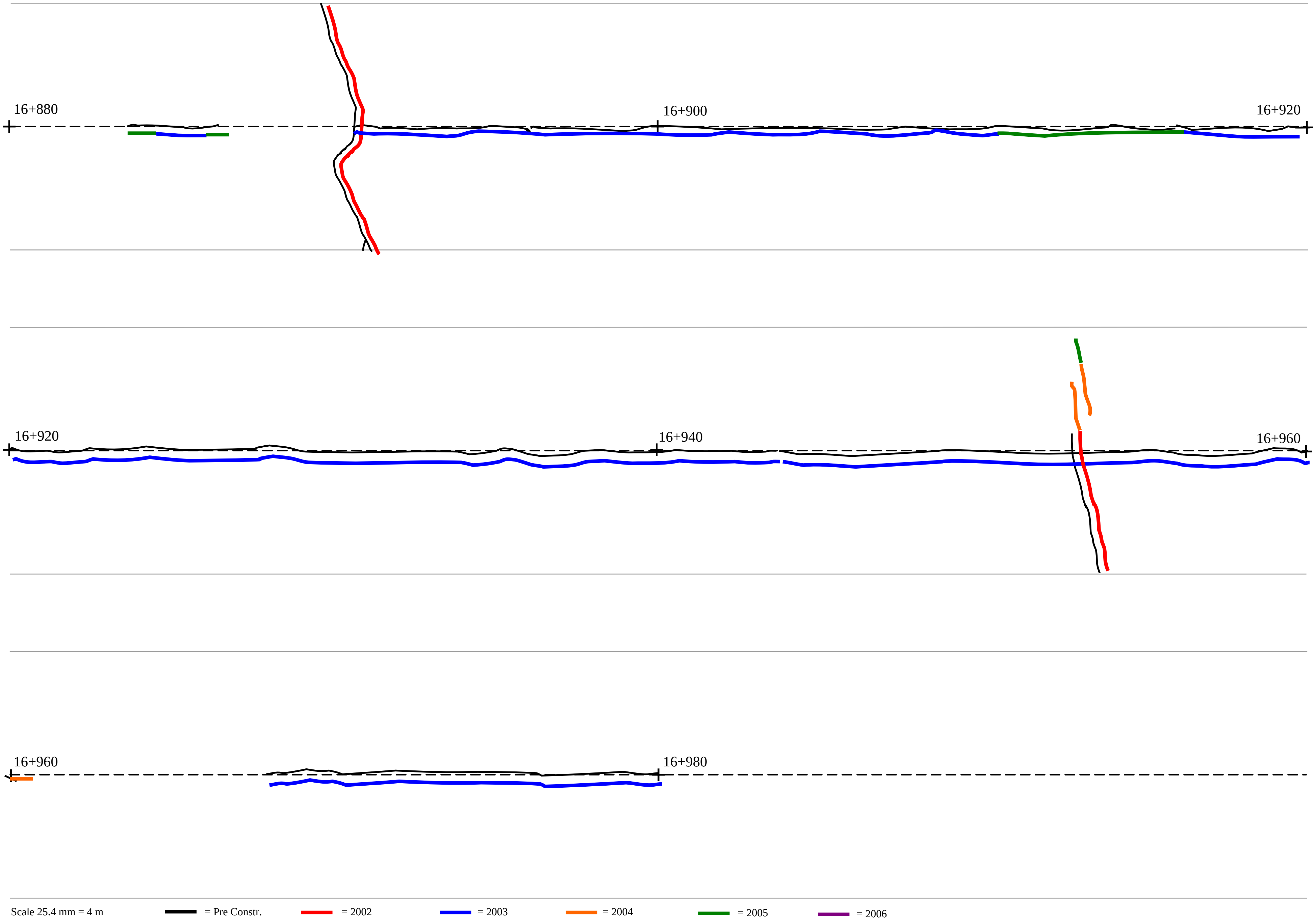

Figure 15. Section 4 Micro-Surface Crack Survey

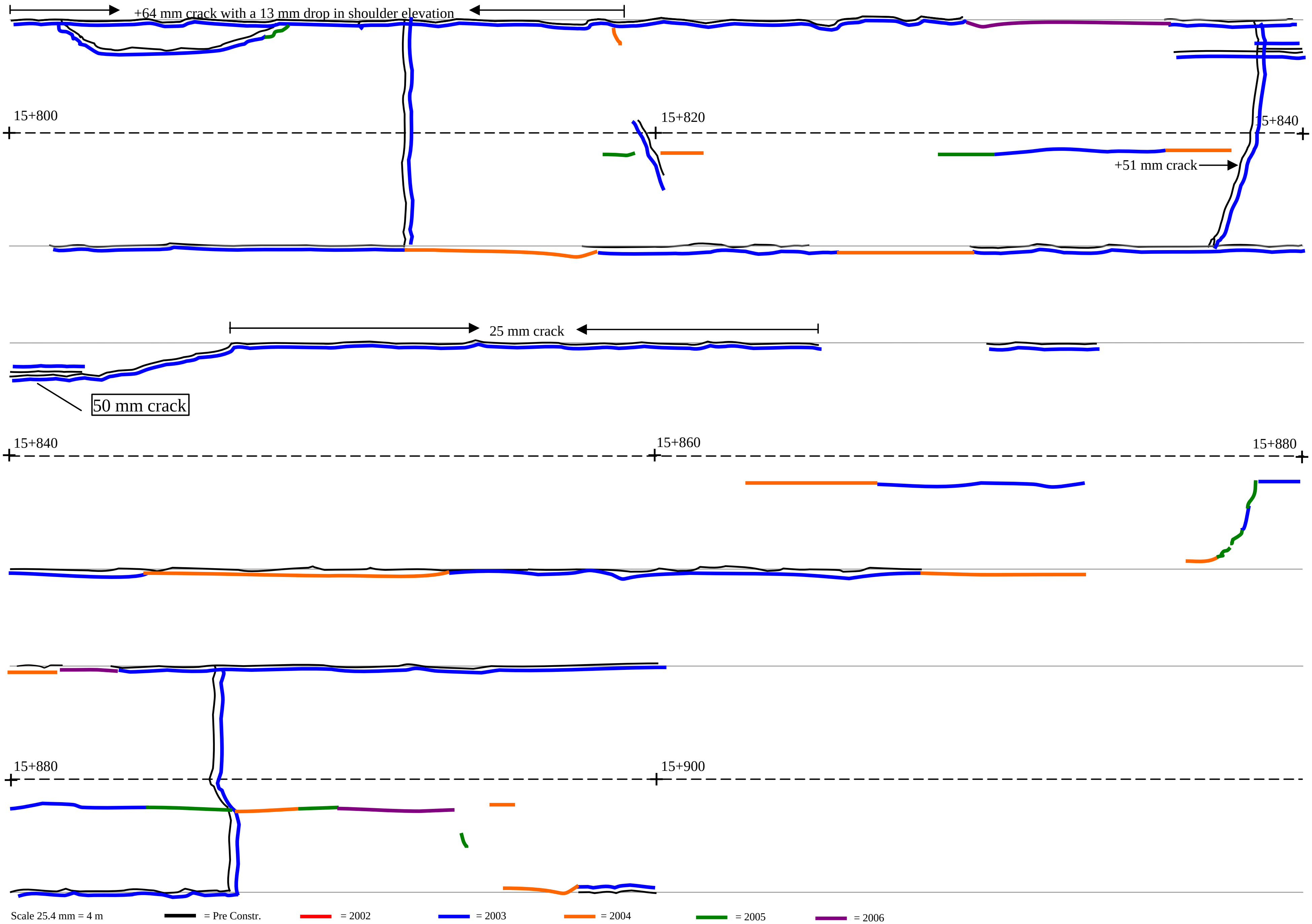

Figure 16. Section 5 Micro-Surface Crack Survey

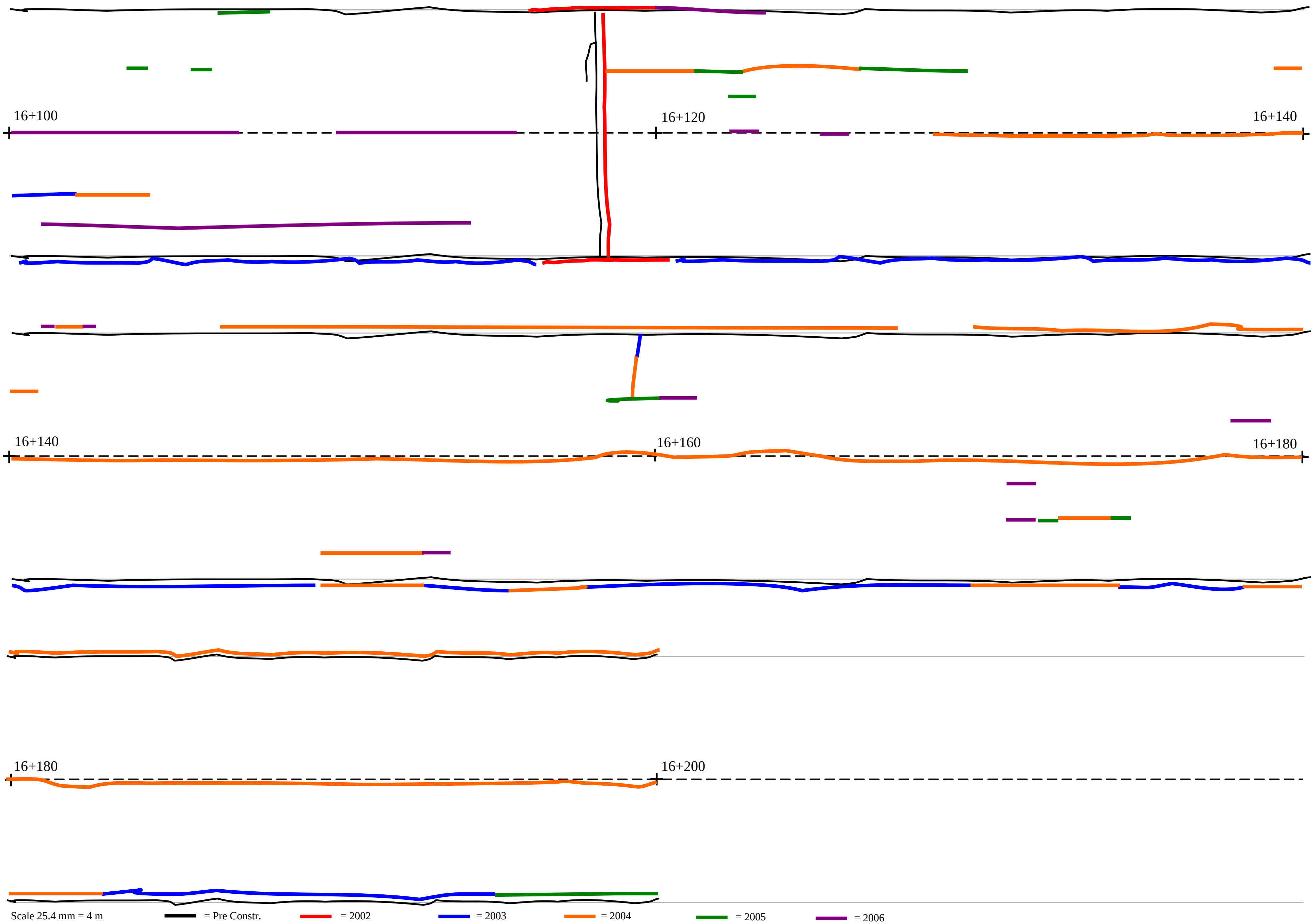

Figure 17. Section 6 Control Crack Survey