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Transportation Research Division

Technical Report 02-3

The Use of Micro-Surfacing for Pavement Preservation

Interim Report - Second, Third, Fourth Year, December, 2005

Transportation Research Division

The Use of Micro-Surfacing for Pavement Preservation

Introduction

The Maine Department of Transportation (MDOT) is responsible for maintaining approximately 14,000 kilometers 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 trying 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).

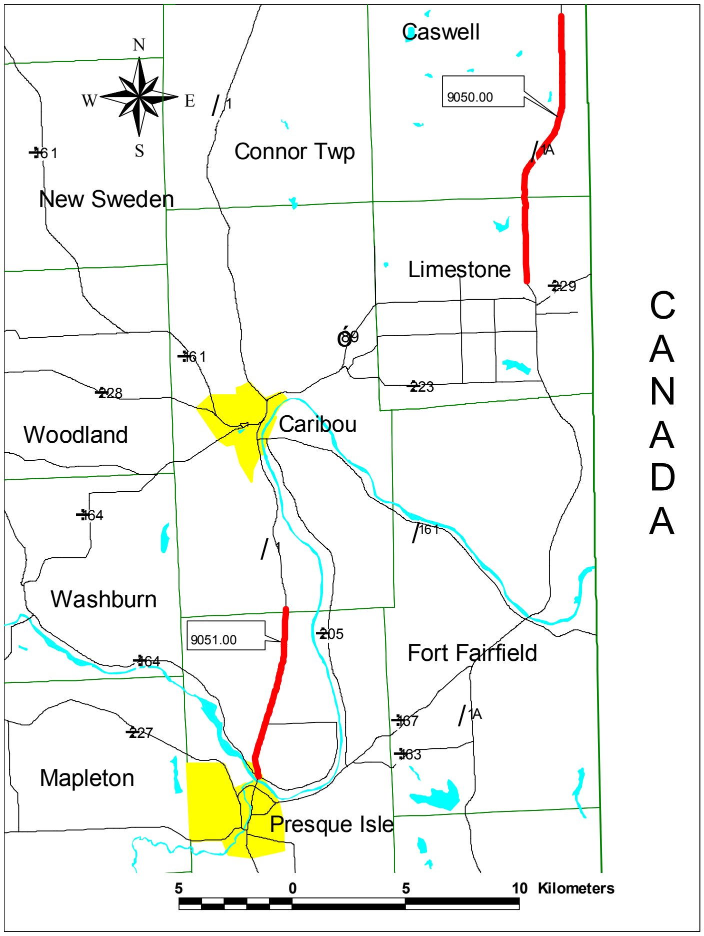

Figure 1: Project Location Map

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 four 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 will be summarized for each test section in the Crack Survey portion of the report.

Smoothness

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, and 2005. The ARAN was not available to collect data in 2004.

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.

Table 1: IRI Range and Descriptions

PIN 9051.00 Presque Isle - Caribou

Smoothness test results obtained from Sections 1, 2, 3, and 4 are displayed in Figure 2.

IRI values in Micro-Surface Section 1 decreased 0.07 m/km (4.4 in/mi) in 2003 to an IRI of 0.72 m/km (45.6 in/mi) then increased 0.05 m/km (3.2 in/mi) in 2005 to an IRI of 0.77 m/km (48.8 in/mi). Micro-Surface Section 4 experienced a slight increase of 0.11 m/km (7.0 in/mi) in 2003 to an IRI of 1.11 m/km (70.3 in/mi) then remained about the same in 2005 with an IRI of 1.10 m/km (69.7 in/mi).

IRI values in HMA Section 2 decreased 0.09 m/km (5.7 in/mi) in 2003 to an IRI of 0.68 m/km (43.1 in/mi) then increased 0.09 m/km (5.7 in/mi) in 2005 to 0.77 m/km (48.8 in/mi). Section 3 values decreased 0.07 m/km (4.4 in/mi) to an IRI of 0.66 m/km (41.8 in/mi) in 2003 then increased 0.14 m/km (8.9 in/mi) in 2005 to 0.80 m/km (50.7 in/mi).

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

Micro-Surfaced portions of the project have a slightly rougher ride than HMA. IRI values for Micro-Surface treatments decreased 0.03 m/km (1.9 in/mi) in 2003 to an IRI of 1.01 m/km (64.0 in/mi) then increased 0.04 m/km (2.5 in/mi) to an IRI of 1.05 m/km (66.5 in/mi) in 2005.

HMA treatments decreased 0.02 m/km (1.3 in/mi) in 2003 with an IRI of 0.82 m/km (52.0 in/mi) then increased 0.13 m/km (8.2 in/mi) in 2005 to an IRI of 0.95 m/km (60.2 in/mi).

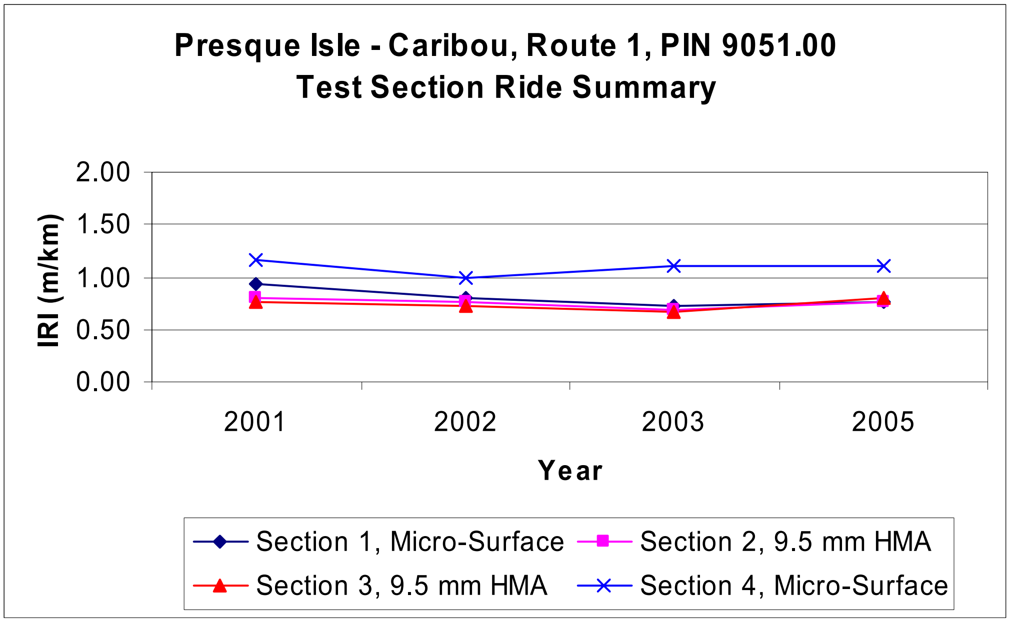

Figure 2: Presque Isle Test Section Level IRI Summary

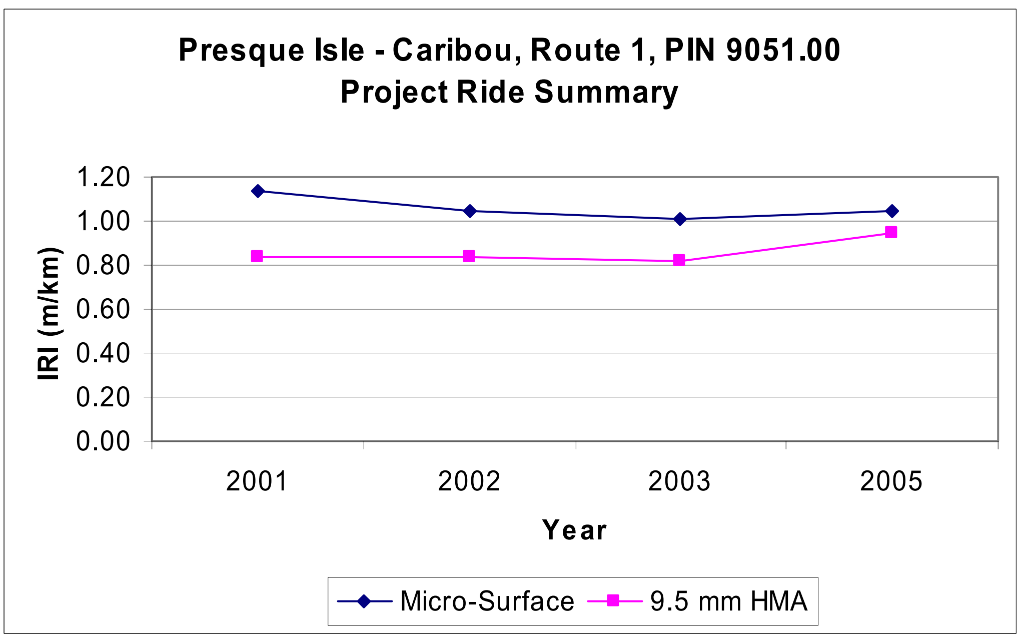

Figure 3: Presque Isle Project Level IRI Summary

PIN 9050.00 Limestone - Caswell

Figure 4 contains smoothness test results for Section 5 and 6. Micro-Surfacing has higher IRI values than the HMA section.

IRI values for Micro-Surface Section 5 has decreased 0.19 m/km (12.0 in/mi) in 2003 to an IRI of 1.26 m/km (79.8 in/mi) then increased 0.19 m/km (12.0 in/mi) in 2005 to an IRI of 1.45 m/km (91.8 in/mi).

Section 6 with HMA steadily increased by 0.05 m/km (3.2 in/mi) in 2003, an IRI of 0.96 m/km (60.8 in/mi), and 0.14 m/km (8.9 in/mi) in 2005 an IRI of 1.10 m/km (69.7 in/mi).

The ARAN also collected data on the entire length of this project. Results are displayed in Figure 5.

Micro-Surface IRI values from 2003 to 2005 are smoother than HMA values. Tests on the Micro-Surfaced areas have decreased 0.03 m/km (1.9 in/mi) to a value of 1.04 m/km (65.9 in/mi) in 2003, 0.09 m/km (5.7 in/mi) smoother than HMA treated areas. In 2005 the IRI increased 0.08 m/km (5.1 in/mi) to its highest value of 1.12 m/km (71.0 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 0.05 m/km (3.2 in/mi) in 2003 to an IRI of 1.13 m/km (71.6 in/mi) then increased an additional 0.17 m/km (10.8 in/mi) to an IRI of 1.30 m/km (82.4 in/mi) in 2005.

All IRI values remain in the smooth range of 1.02 – 1.57 m/km (65-99 in/mi).

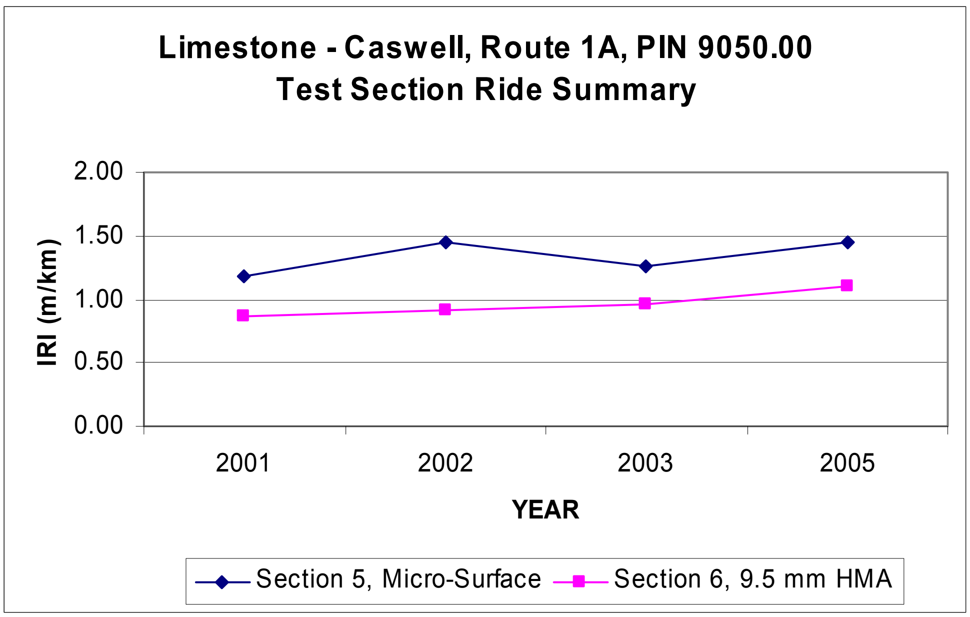

Figure 4: Limestone Test Section Level IRI Summary

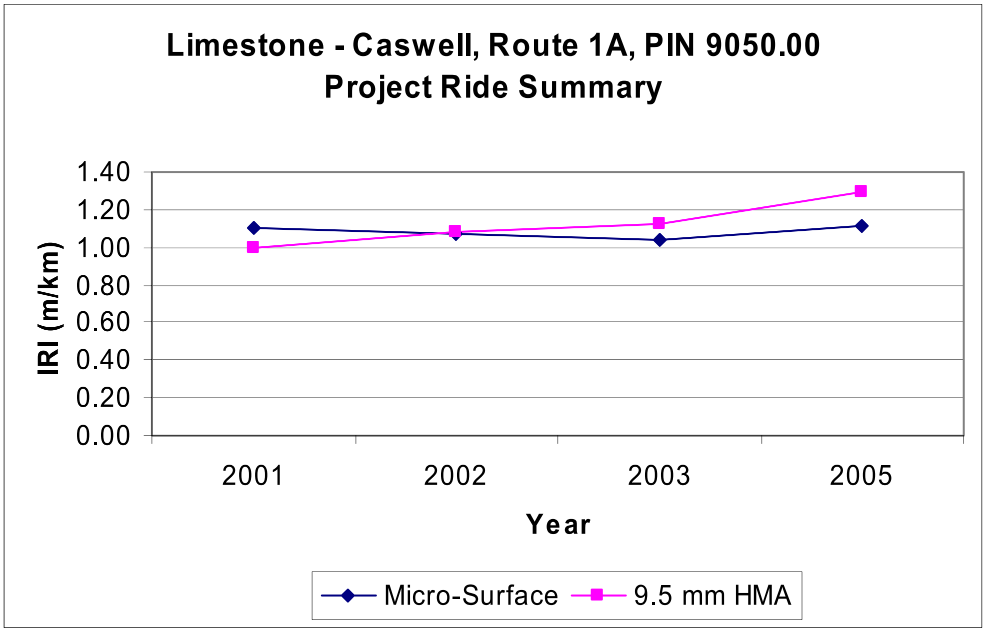

Figure 5: Limestone Project Level IRI Summary

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).

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

Rut depths in Micro-Surface Sections 1 and 4 have increased 1.3 mm (0.05 in) and 0.5 mm (0.02 in) in 2003 to a depth of 8.8 mm (0.35 in) and 7.8 mm (0.31 in) respectively. In 2005 rut depths increased 1.5 mm (0.06 in) and 0.6 mm (0.02 in) to a depth of 9.3 mm (0.37 in) and 8.4 mm (0.33 in) respectively.

HMA rut depths for Sections 2 and 3 decreased by 1.6 mm (0.06 in) and 1.8 mm (0.07 in) in 2003 to depths of 4.9 mm (0.19 in) and 3.4 mm (0.13 in) respectively. Rutting increased again in 2005 by 0.2 mm (0.01 in) and 2.1 mm (0.08 in) to depths of 5.5 mm (0.20 in) and 5.5 mm (0.22 in) respectively.

Figure 7 contains a summary of rut depth measurements collected on the length of the project. Micro-Surface portions increased 0.7 mm (0.03 in) in 2003 to a depth of 7.4 mm (0.29 in) then decreased 0.2 mm (0.01 in) to a depth of 7.1 mm (0.28 in) in 2005.

HMA portions decreased 1.7 mm (0.07 in) to a depth of 4.0 mm (0.16 in) in 2003 then increased 1.0 mm (0.04 in) to a depth of 5.0 mm (0.20 in) in 2005.

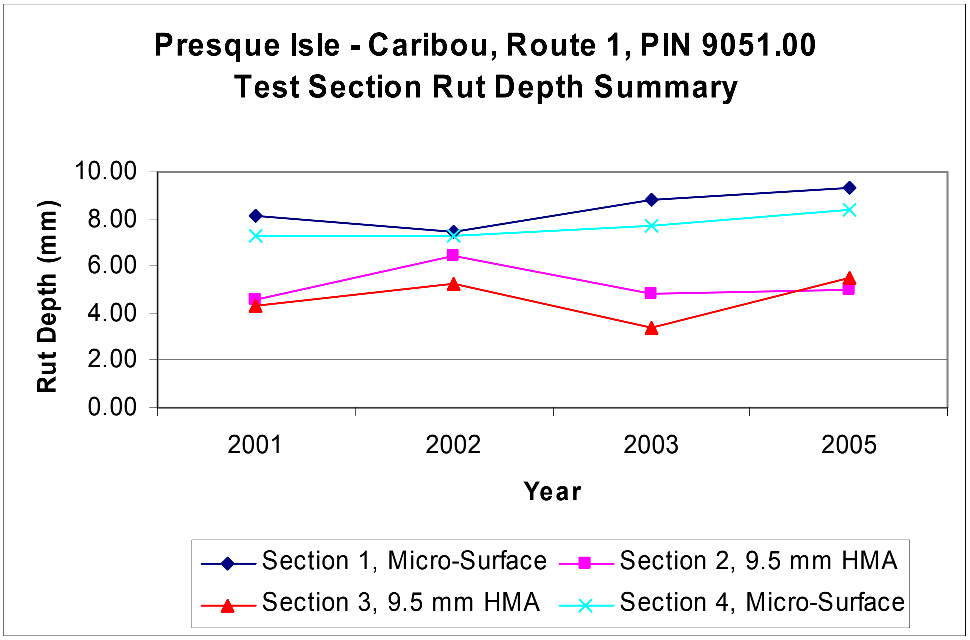

Figure 6: Presque Isle Test Section Level Rut Depth Summary

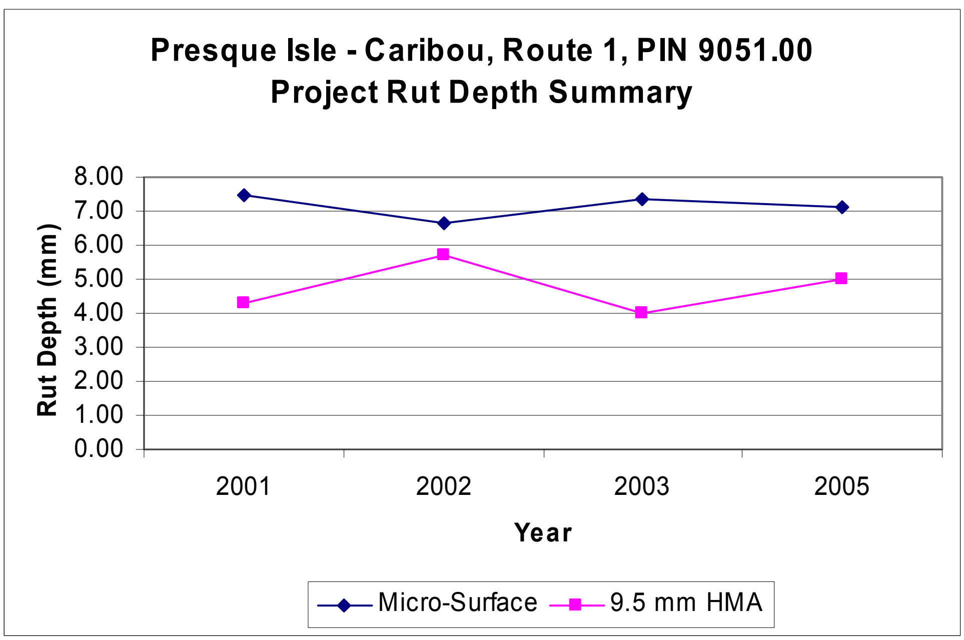

Figure 7: Presque Isle Project Level Rut Depth Summary

PIN 9050.00 Limestone - Caswell

Rutting decreased on both sections in 2003 and 2005. Figure 8 contains a Rut Depth Summary of the test sections. Micro-Surface Section 5 decreased 12.2 % from 7.2 mm (0.28 in) to 6.3 mm (0.25 in) in 2003. Rutting decreased an additional 32.3 % in 2005 to a depth of 4.3 mm (0.17 in).

HMA Section 6 decreased 31.8 % from 4.3 mm (0.17 in) in 2002 to 2.9 mm (0.11 in) in 2003. Rut depths decreased another 22.4 % in 2005 to a depth of 2.3 mm (0.09 in) in 2005.

Average rut depths for the project also decreased in 2003 and 2005. Figure 9 displays a summary of the results. Micro-Surface treated portions of the project decreased 24.4 % from 7.7 mm (0.30 in) in 2002 to 5.8 mm (0.23 in) in 2003. Rutting decreased an additional 27.1 % to a depth of 4.2 mm (0.17 in) in 2005.

HMA portions of the project decreased 31.4 % from 4.8 mm (0.19 in) in 2002 to 3.4 mm (0.13 in) in 2003 then an additional decrease of 30.2 % to a depth of 2.3 mm (0.09 in) in 2005.

The decrease in rut depths could be attributed to the amount of plow wear on Micro-Surfaced sections, detailed in the Visual Inspection portion of the report, and heavy loads riding on centerline depressing centerline and between wheel path areas of Level 2 sections smoothing out the roadway profile.

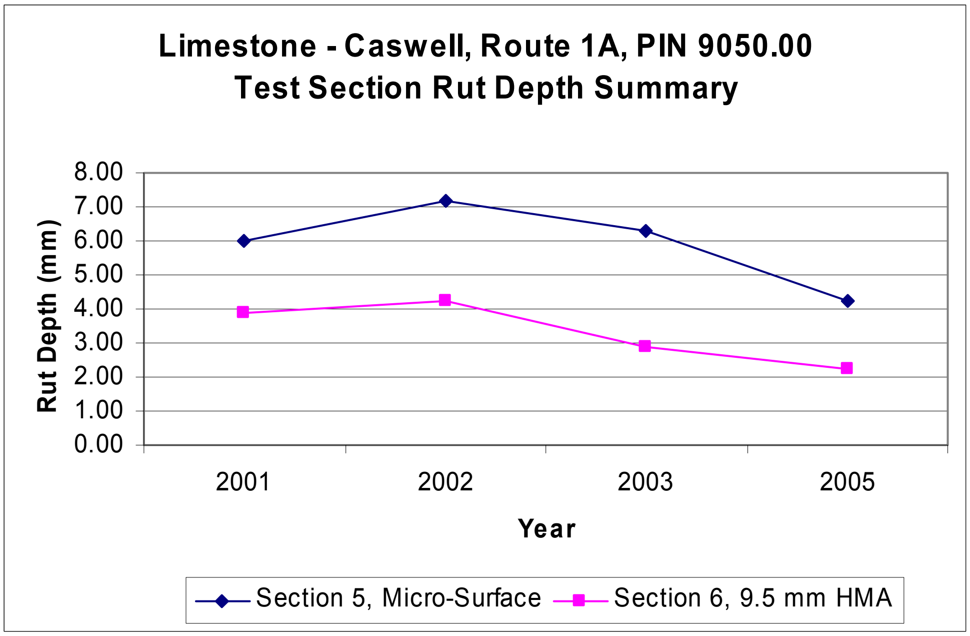

Figure 8: Limestone Test Section Level Rut Depth Summary

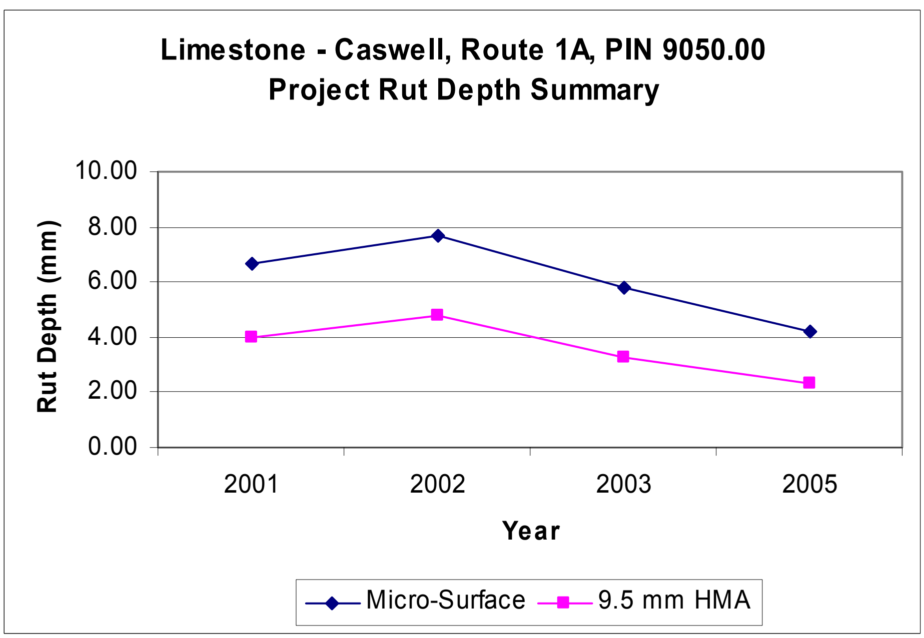

Figure 9: Limestone Project Level Rut Depth Summary

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. Frictional resistance increased from a FN of 49.9 in 2002 to 51.7 and 55.5 in 2003 and 2004. Frictional resistance decreased 4.86 % in 2005 to a FN of 52.8.

Frictional resistance on 9.5 mm HMA decreased 3.8% in 2003 to a FN of 45.5 followed by an increase of 8.5 % to a FN of 49.7 in 2004 and a decrease in 2005 to a FN of 47.0.

PIN 9050.00 Limestone - Caswell

Figure 11 displays a summary of Frictional Numbers for the Limestone project. Micro-Surfaced portion increased in 2003 and 2004 to a FN of 59.9 and 60.3 respectively. Frictional resistance decreased 1.3 % to a FN of 59.4.

HMA Frictional Numbers decreased slightly from 54.8 to 54.3 in 2003 then increased 4.4 % to a FN of 56.8 in 2004. In 2005 there was another small decrease of 3.0 % to a FN of 55.1.

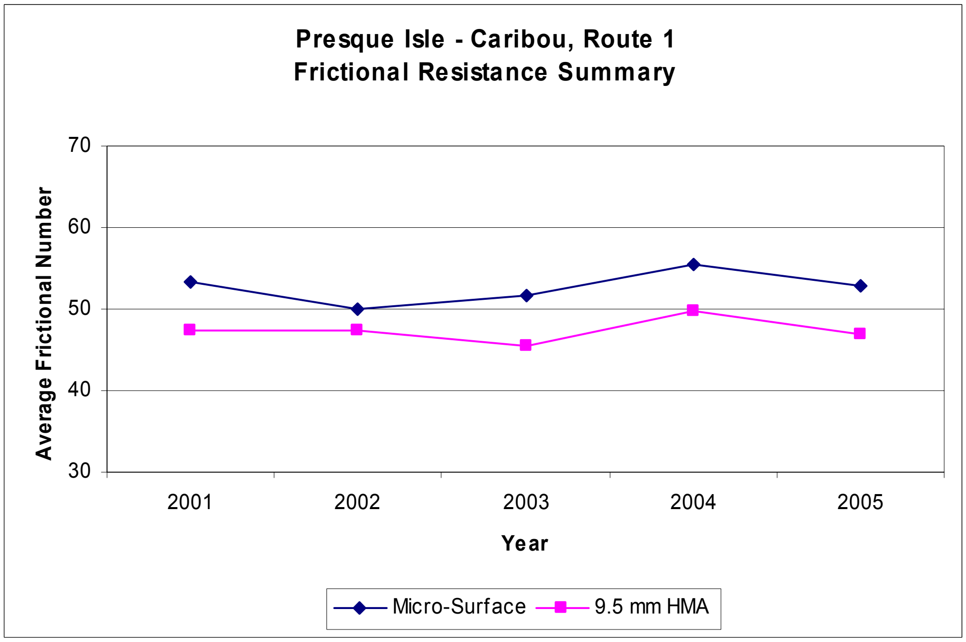

Figure 10: Presque Isle Frictional Resistance Summary

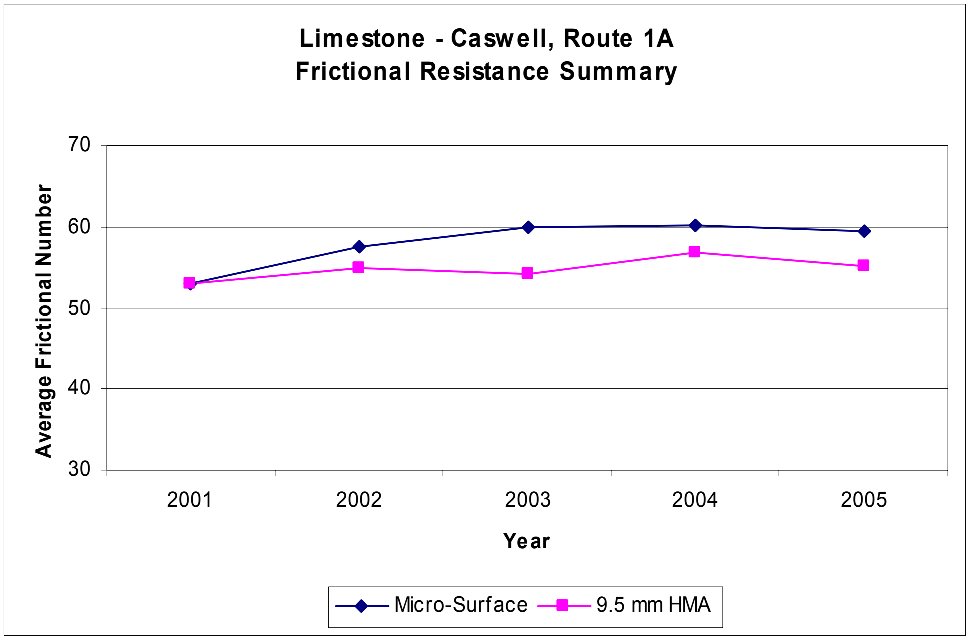

Figure 11: Limestone Frictional Resistance Summary

Visual Survey

Appendix A contains photos of each test section.

Photos 1, 2, and 3 are of Micro-Surface Section 1 taken in 2003, 2004, and 2005 respectively. It is apparent that the amount of centerline and quarter point plow abrasion has increased each year. Photo 2 displays areas in Section 1 where Micro-Surfacing has worn down to the original HMA surface. Another interesting observation is the herring bone plow wear pattern at centerline, a result of the plow skipping on the roadway during snow removal. By 2005 the quarter point has worn down to the original surface as displayed in Photo 3. Section 4, displayed as Photo 4, has similar wear patterns.

Photos 5 and 6 are of Control Sections 2 and 3 respectively. The surface looks very good and both sections have very little plow wear.

Plow abrasion on Section 5 of the Limestone – Caswell project is displayed in Photo 7 and 8. Abrasion at centerline has increased each year from 2003 to 2005. Photo 7 displays the amount of wear in 2003. In 2005 Micro-Surfacing has completely worn away exposing HMA surface the entire length of the section as displayed in Photo 8. Quarter point and shoulder joint abrasion is not as severe as compared to Sections 1 and 4.

Control Section 6 has very little plow abrasion 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.

Figure 12 contains a crack survey of Micro-Surface Section 1. This section had the lowest amount of preconstruction 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.

Figure 13 contains a crack survey of Control Section 2. 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.

Figure 14 displays the amount of cracking on Control Section 3. No additional transverse cracking has been observed. Much of the shoulder joint has 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.

Figure 15 contains a diagram of Micro-Surfaced Section 4. Most of the original cracks have reflected through in 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.

Micro-Surfaced Section 5 is displayed in Figure 16. A majority of the original cracks have reflected through in 2003 with a number of small areas of longitudinal wheel path cracking. By 2004 nearly all of the original cracks were visible and the longitudinal wheel path cracks were increasing. A few small areas of longitudinal and transverse cracks were observed in 2005.

A crack survey for Control Section 6 is exhibited in Figure 17. 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.

Summary

After four year's exposure to traffic and weather, Micro-Surfaced sections are showing considerably more wear and tear 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 than the Level 2 HMA sections.

Micro-Surfacing does not reduce rutting as well as the Level 2 HMA treatment.

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 Level 2 sections.

Frictional Resistance is slightly higher than the Level 2 HMA portions of each project.

Other than the plow abrasion, the Micro-Surface treatment has been performing well at a lower cost. The final report will include a life cycle cost analysis to determine if Micro-Surfacing is a cost effective alternative to Level 2 HMA resurfacing.

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Additional Literature:
The Use of Micro-Surfacing for Pavement Preservation, Construction Report, March 2002

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APPENDIXES

APPENDIX A

Photo 1: Section 1 Micro-Surface Centerline Plow Abrasion; September, 2003.

Photo 2: Section 1 Micro-Surface Centerline Plow Abrasion; August, 2004.

Photo 3: Section 1 Micro-Surface Centerline and Quarter Point Plow Abrasion; September, 2005.

Photo 4: Section 4 Micro-Surface Centerline and Quarter Point Plow Abrasion; September, 2005.

Photo 5: Section 2 Control Pavement Condition; September, 2005.

Photo 6: Section 3 Control Pavement Condition; September, 2005.

Photo 7: Section 5 Micro-Surface Pavement Condition; September, 2003.

Photo 8: Section 5 Micro-Surface Pavement Condition; September, 2005.


Photo 9: Section 6 Control Pavement Condition; September, 2005.

APPENDIX B

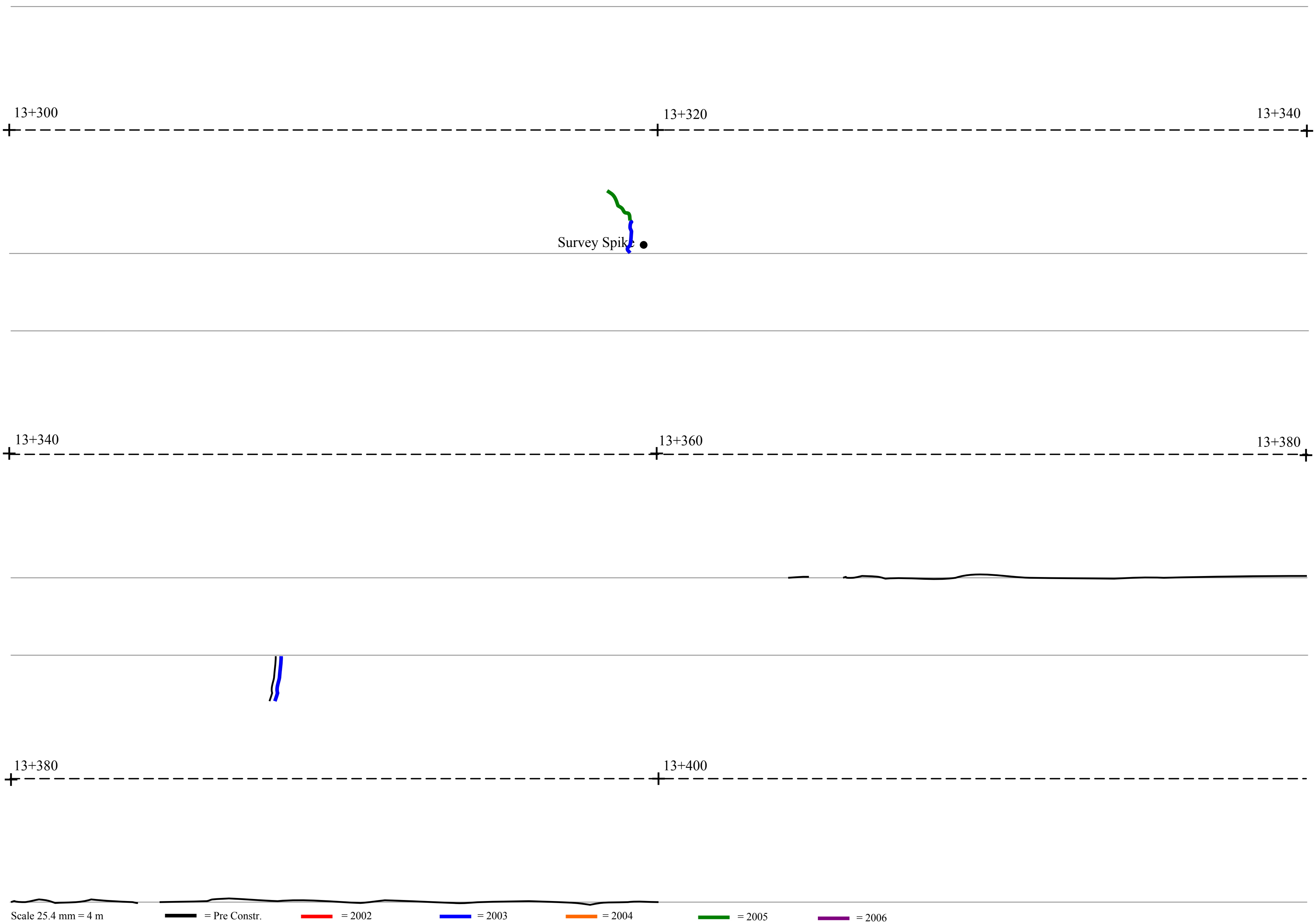

Figure 12. Section 1 Micro-Surface Crack Survey

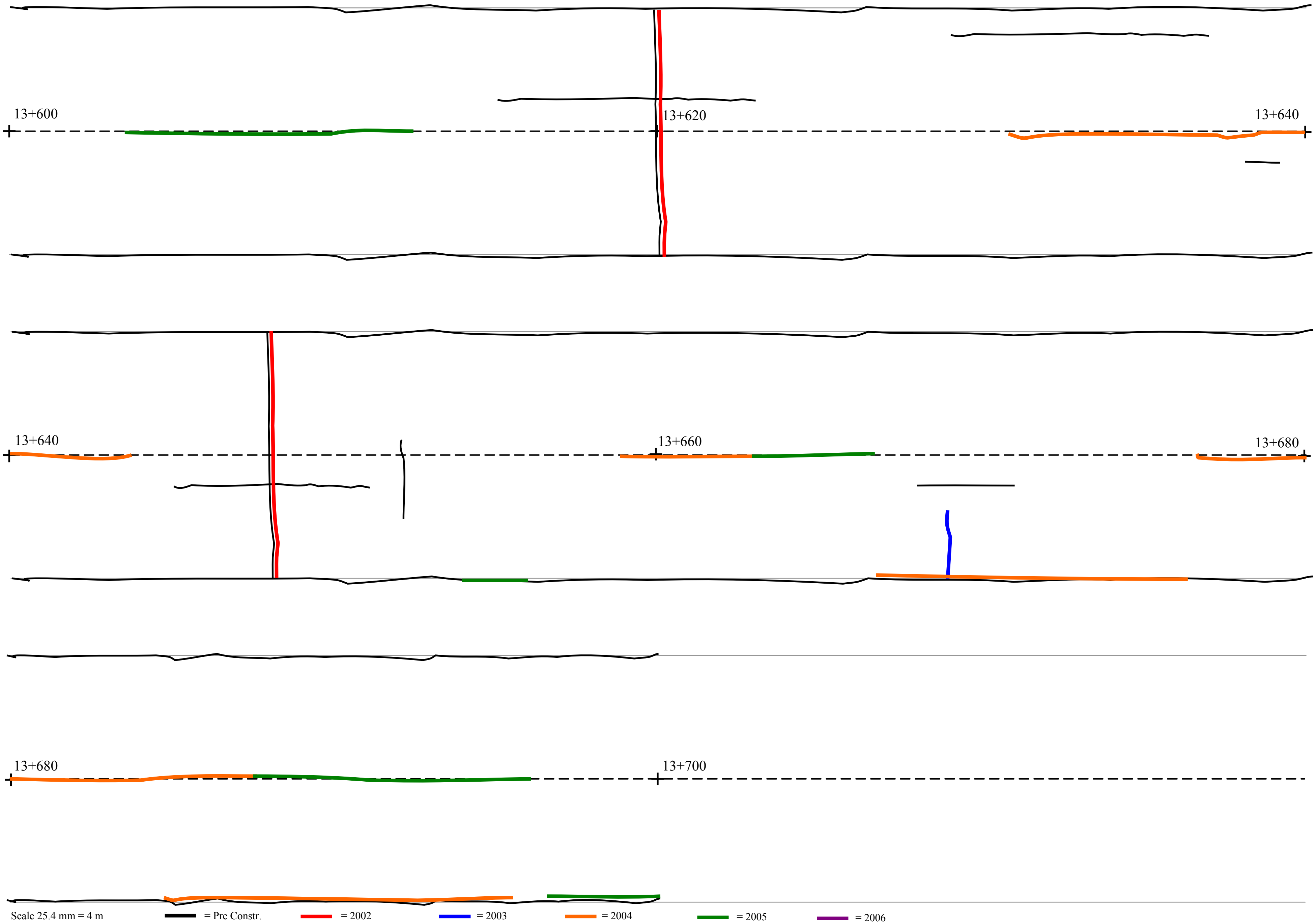

Figure 13. Section 2 Control Crack Survey

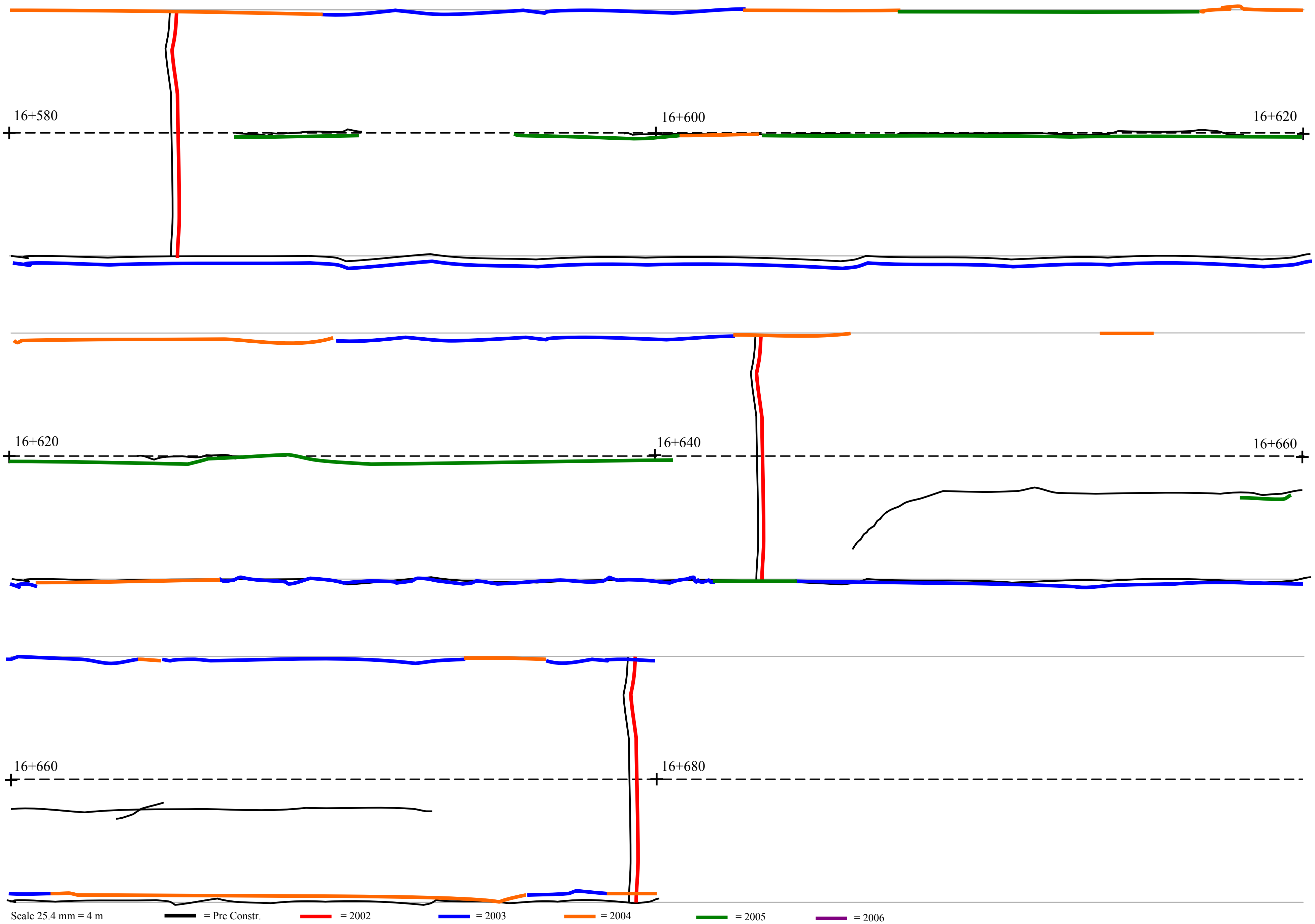

Figure 14. Section 3 Control Crack Survey

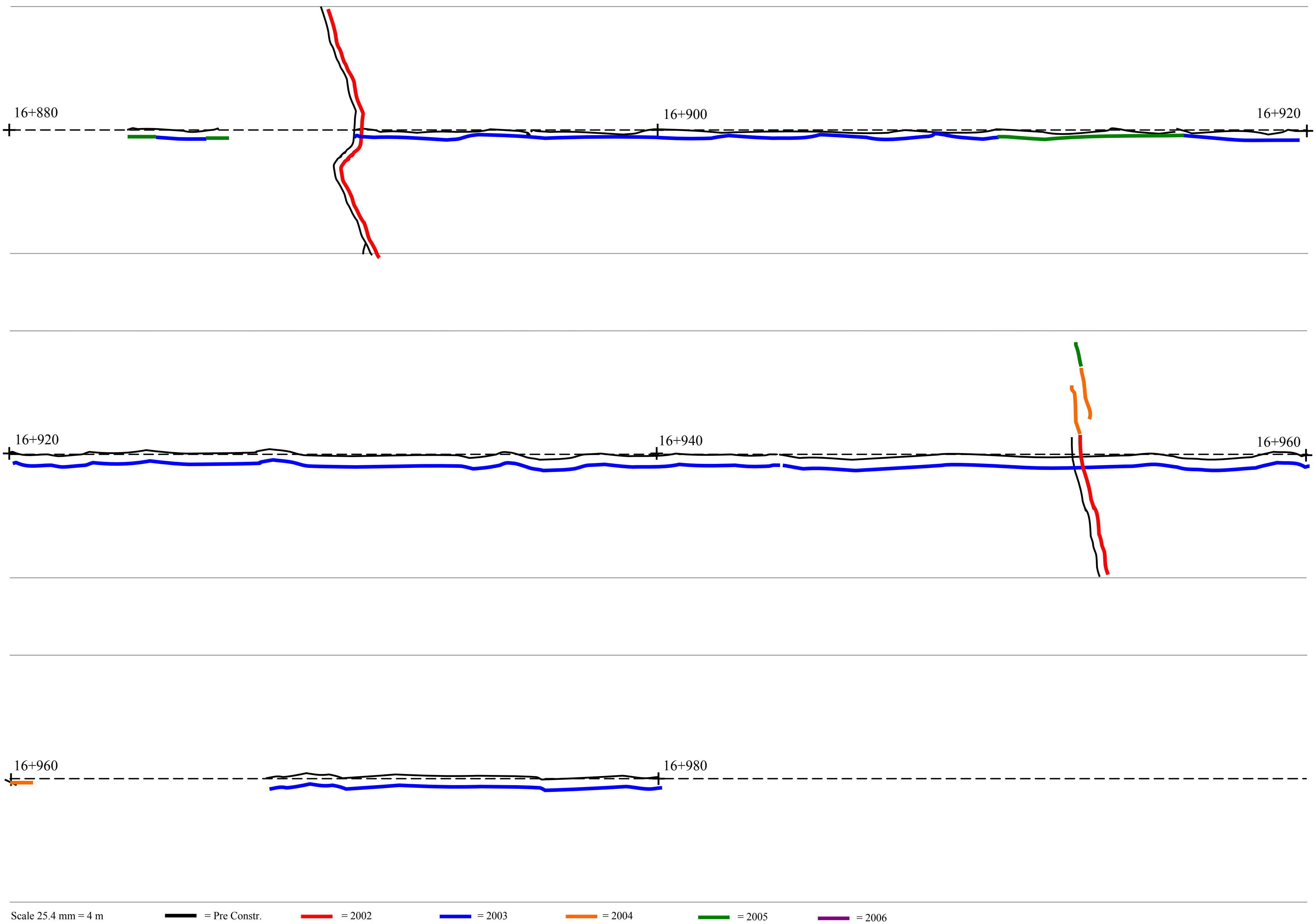

Figure 15. Section 4 Micro-Surface Crack Survey

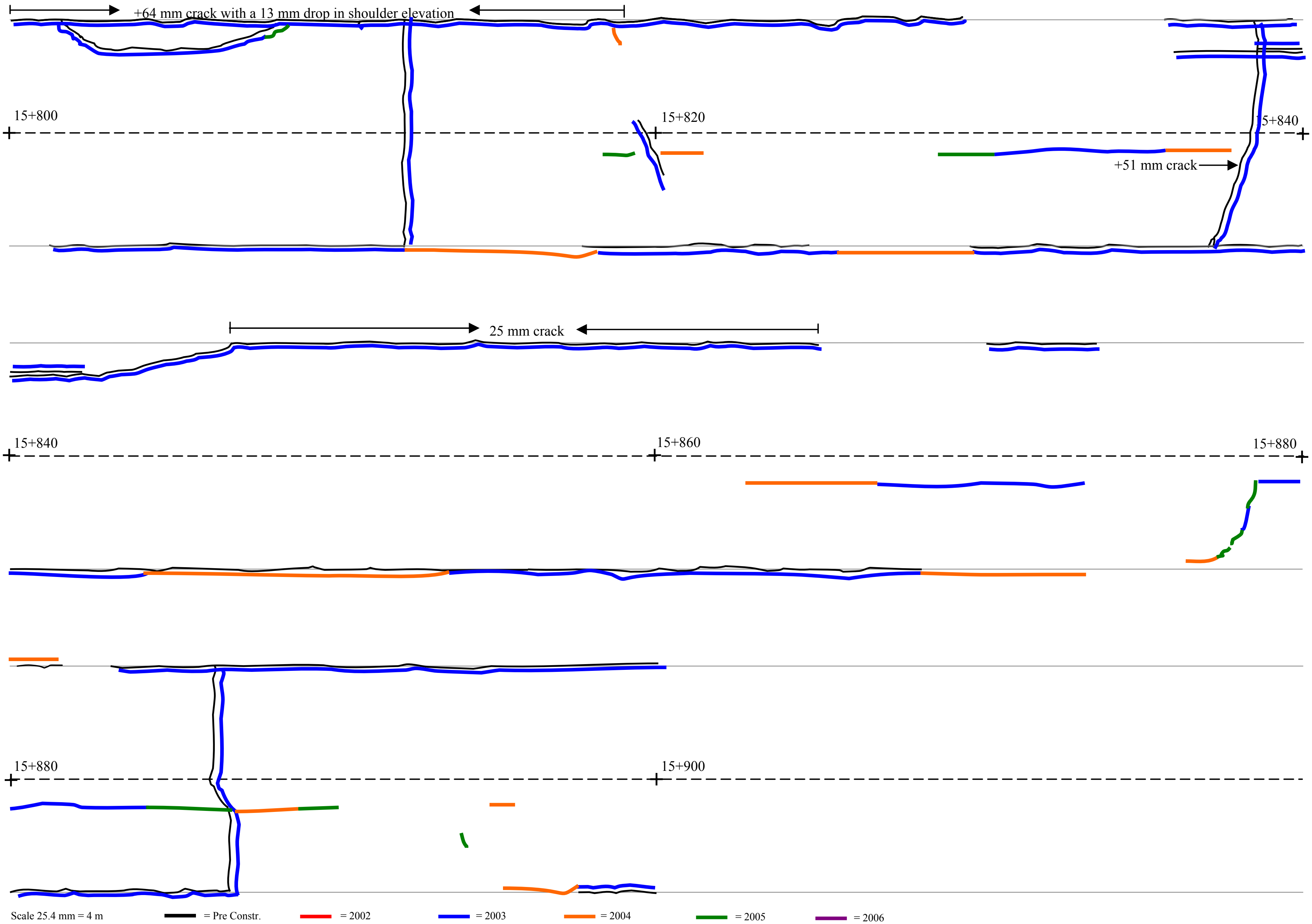

Figure 16. Section 5 Micro-Surface Crack Survey

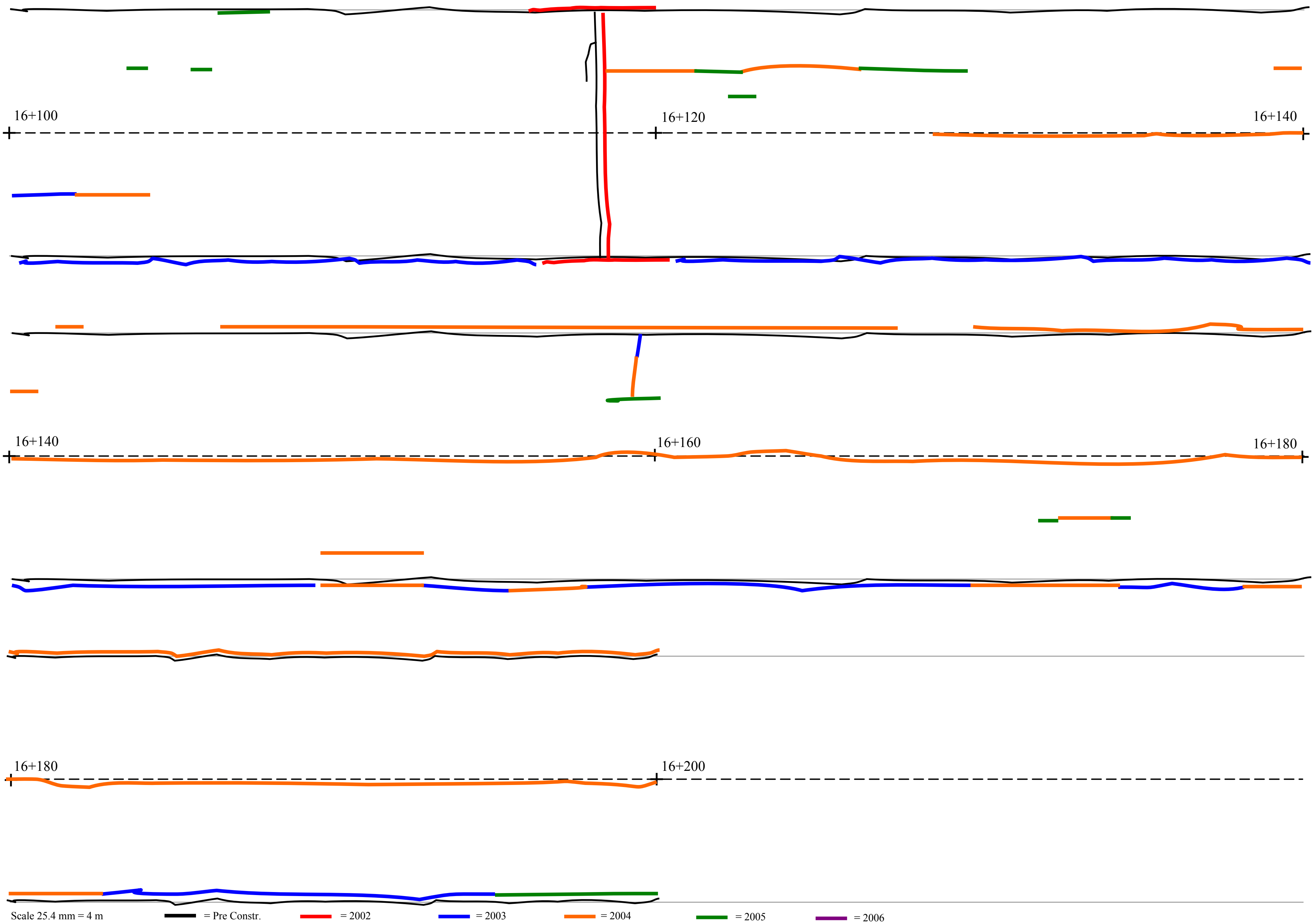

Figure 17. Section 6 Control Crack Survey