SEIKOWAVE

Examples of 3D analysis

May 7, 2022

Seikowave

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Abstract

Limitation of the traditional way

- Objects to measure
  - Tunnels and bridges need close-looking for evaluation, but too many to execute using traditional tools.
    - Bridges in Japan 720,000+
    - Tunnels 10,000+
  - Corrosion on production plants needs precise measurement for better life estimation, but hard to get detail figures.
    - Using UT, but
      - Unable to use from the corroded side
      - Unable to use around welding lines
- Other issues
  - Visual inspection including photographing
    - Tends to subjective evaluation
      - Thus, the evaluation may vary by inspector by inspector
    - Hard to quantify. Hard to predict life expectancy
  - In local area, lack of human resources
  - There are many area hard to measure by the traditional way

Solution using non-contact, optical way

- Proposed solution
  - Digitization and visualization of inspection area by pattern light projection
    - Measurement from a damaged surface is possible
    - By 3D coordinate conversion of the target location
      - Color contour diagram (visualization)
      - CSV file (quantified) with grid basis figures
        - » Easy to understand the progress of deterioration
  - From subjective judgment to objective judgment by numerical value
    - By standardizing equipment and analysis means, anyone can obtain almost constant results.
      - Can be a trump card to solve the shortage of local human resources

3D measurement tool

Equipment appearance

Features:

- No on-site calibration required
- No need to attach a marker
- No need for accurate positioning
- Handheld measurement possible
- Dustproof and splashproof

Main specifications

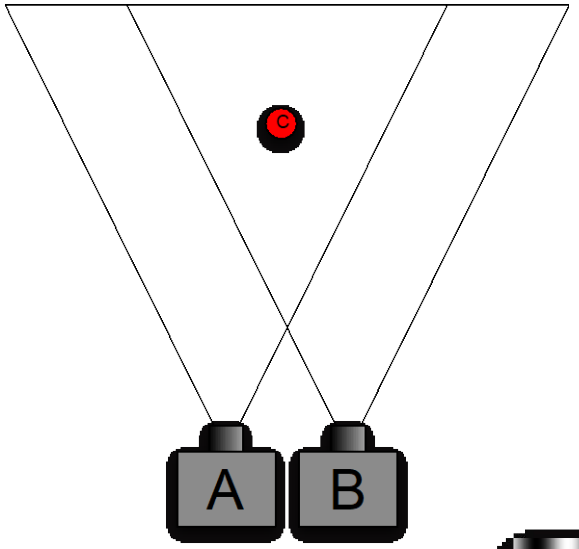
Individual specifications

- 3DSL-Rhino 400mm
  - Area to measure @ 450mm standoff
    - 150mm x 270mm
  - Working distance range
    - 350mm ~ 470mm
  - Resolution
    - XY: 400um, Z: 50um or less
  - Corrosion depth precision
    - Z: +/-50um (1 sigma)
- 3DSL-Rhino 200mm
  - Area to measure @ 200mm standoff
    - 80mm x 140mm
  - Working distance range
    - 160mm ~ 250mm
  - Resolution
    - XY: 200um, Z: 30um or less
  - Corrosion depth precision
    - Z: +/-30um (1 sigma)

Common specifications

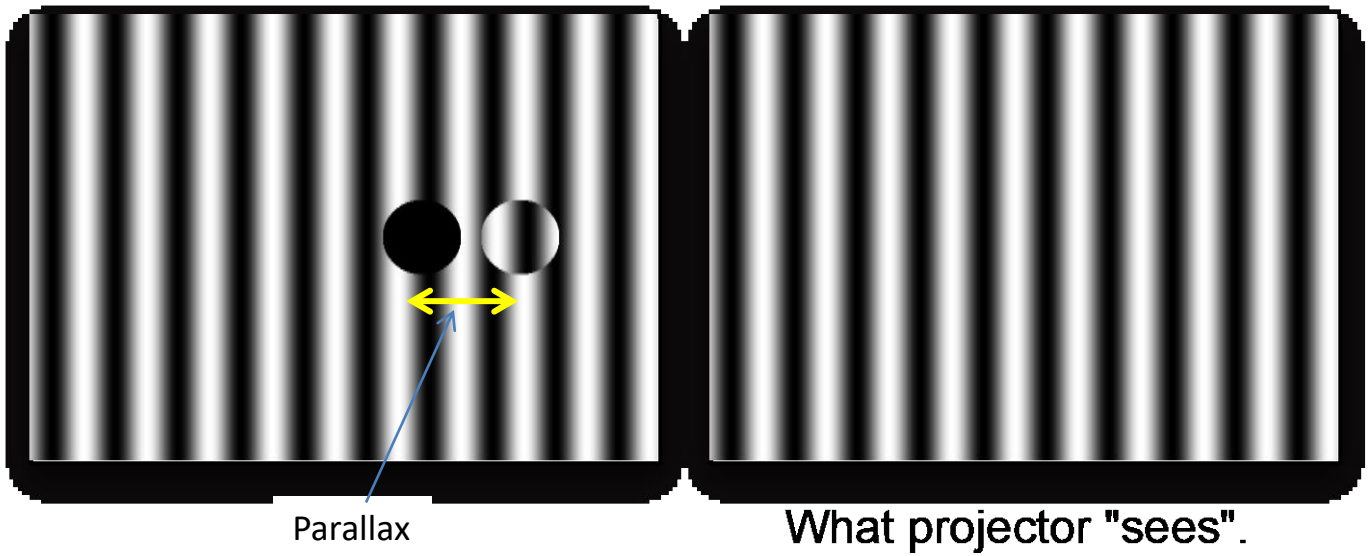
- Number of 3D coordinates per single scan
  - 300,000
- Time to capture images
  - 80ms @ 300fps
  - 34ms @ 700fps
- Data file format
  - Seikowave original (.skw)
  - Can be save with .ply format
- PC interface
  - GigE (1000 Base T)
- Operation hour
  - 6 hours + by 100Wh battery pack
- Operation temperature
  - -10C ~ +40C

Structured Light Projection



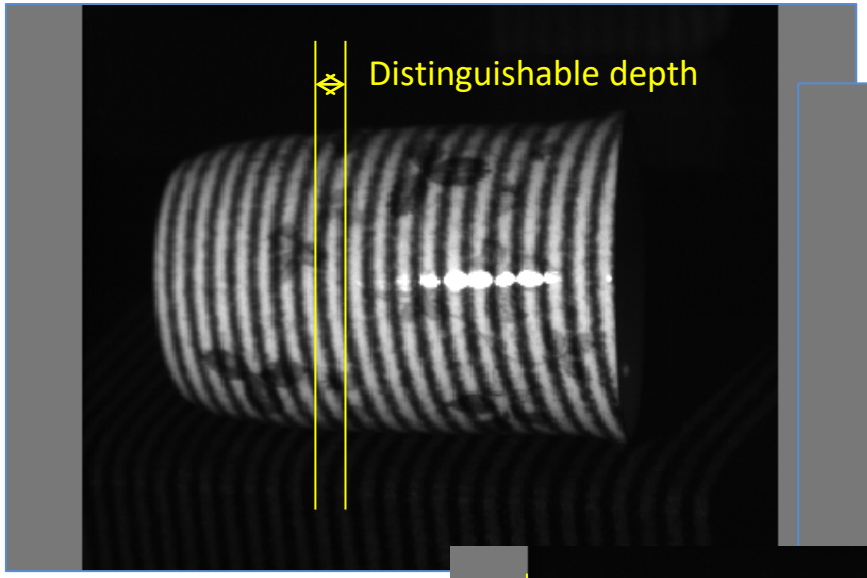
It enables very fast measurement of whole area

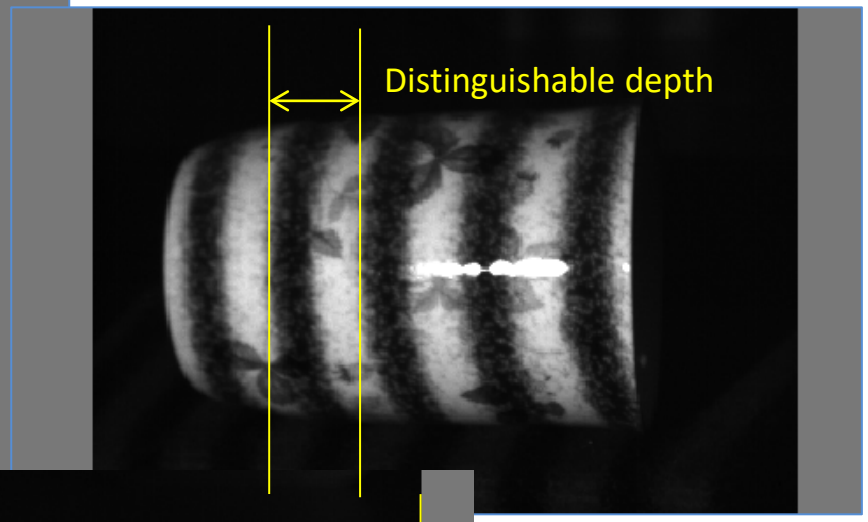
Vision of Camera A



Three patterns, total 24 frames

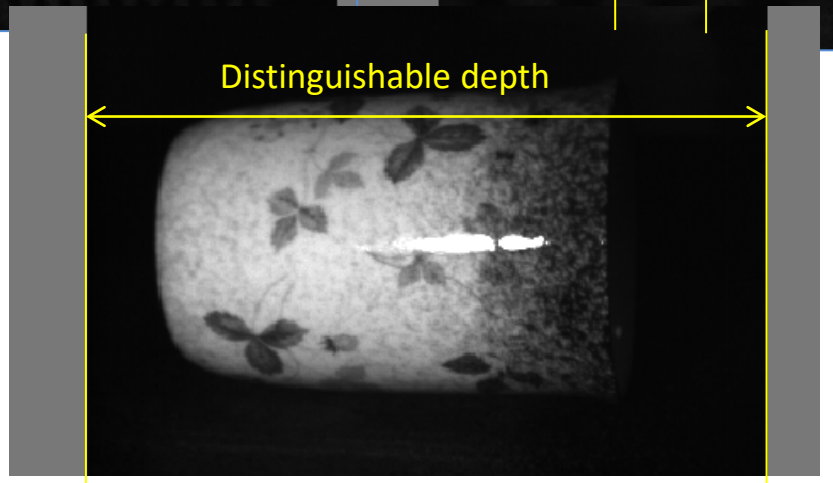
32f pattern





8f pattern

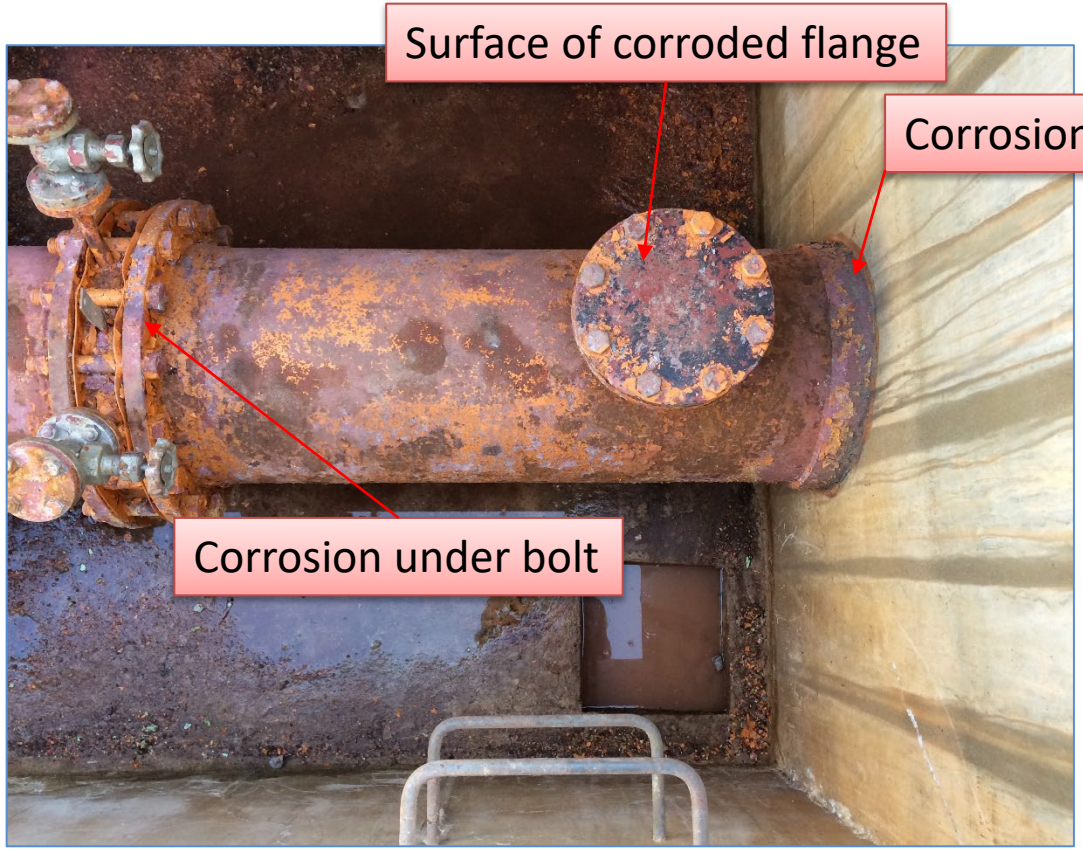
1f pattern

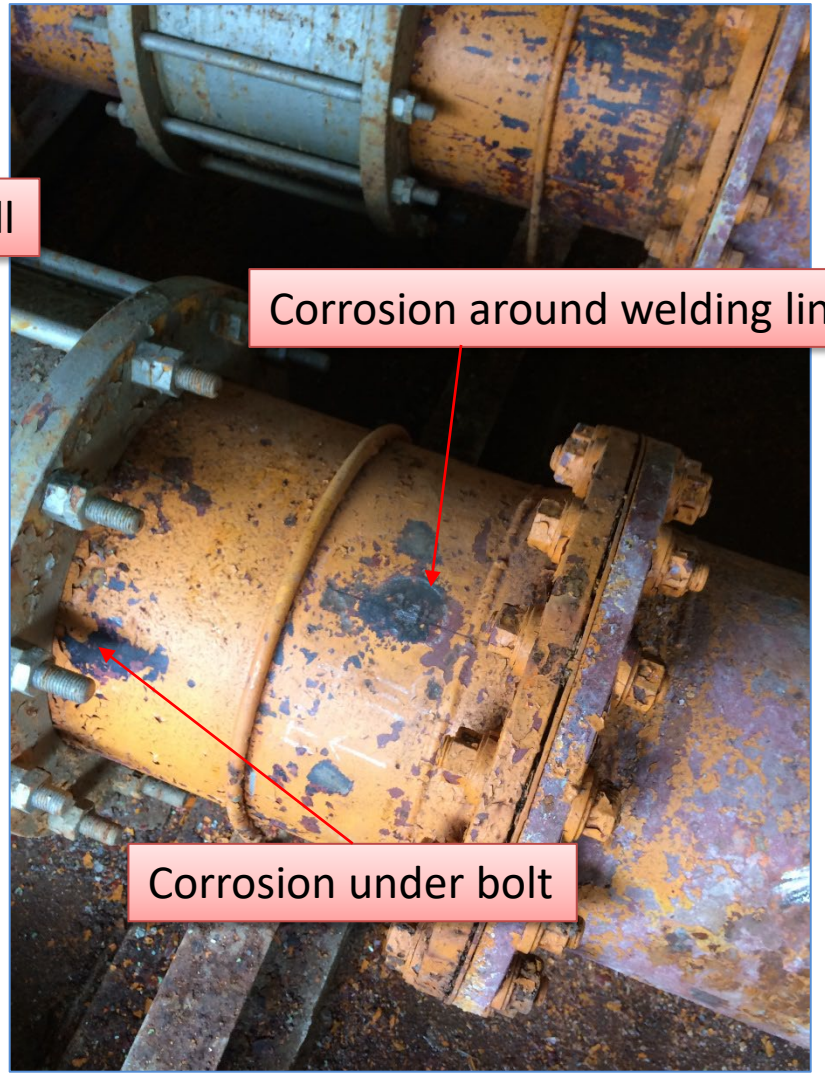


1f								8f								32f							
0	+2π/8	+2π/8	+2π/8	+2π/8	+2π/8	+2π/8	+2π/8	0	+2π/8	+2π/8	+2π/8	+2π/8	+2π/8	+2π/8	+2π/8	0	+2π/8	+2π/8	+2π/8	+2π/8	+2π/8	+2π/8	+2π/8

EXAMPLES OF STEEL STRUCTURE MEASUREMENT & ANALYSIS

Area, hard to access by traditional tools

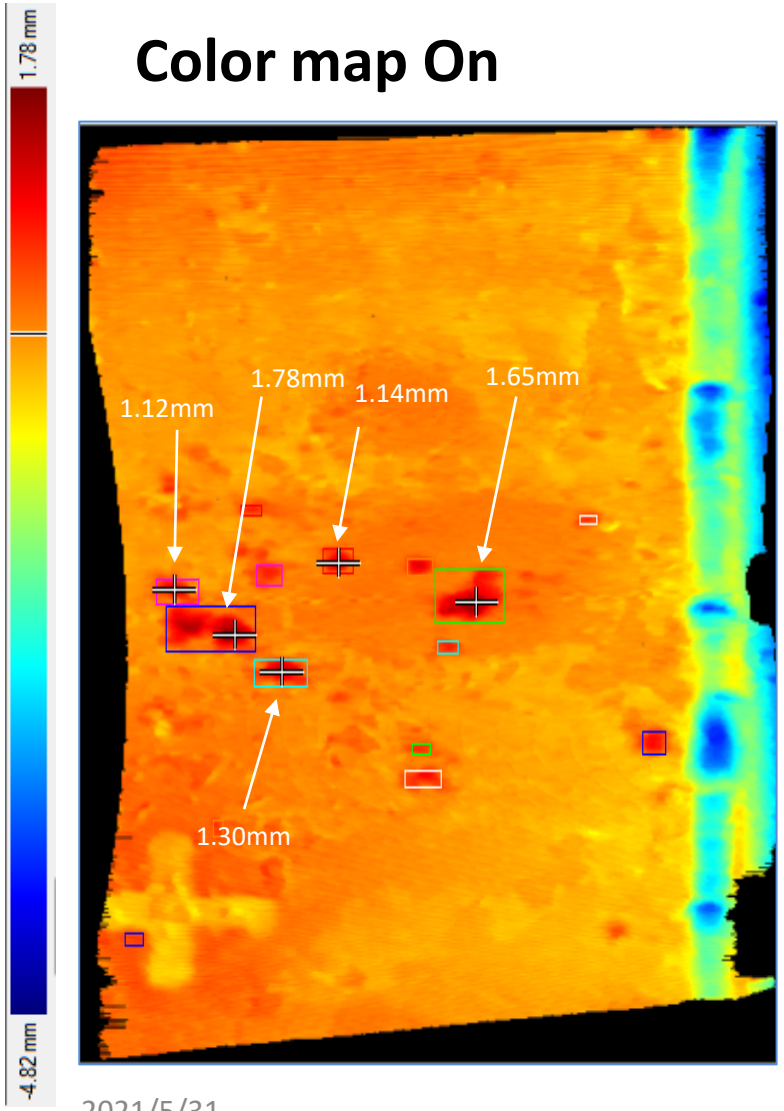




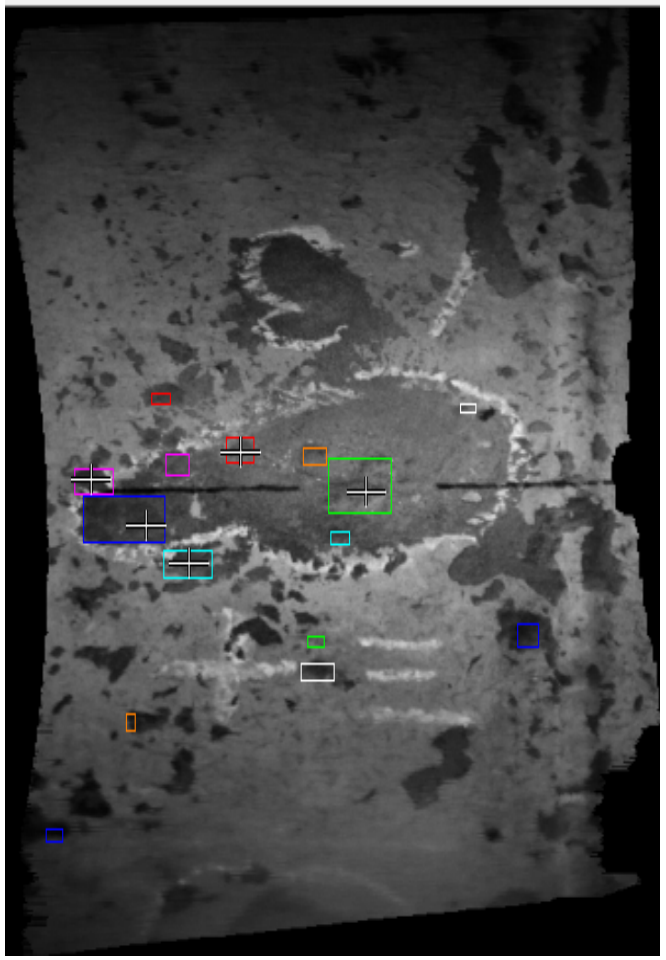
UT or Depth Gage are not usable

Detection of corrosion and wall thinning in difficult-to-access areas

Color map On



Color map off



List of corrosions

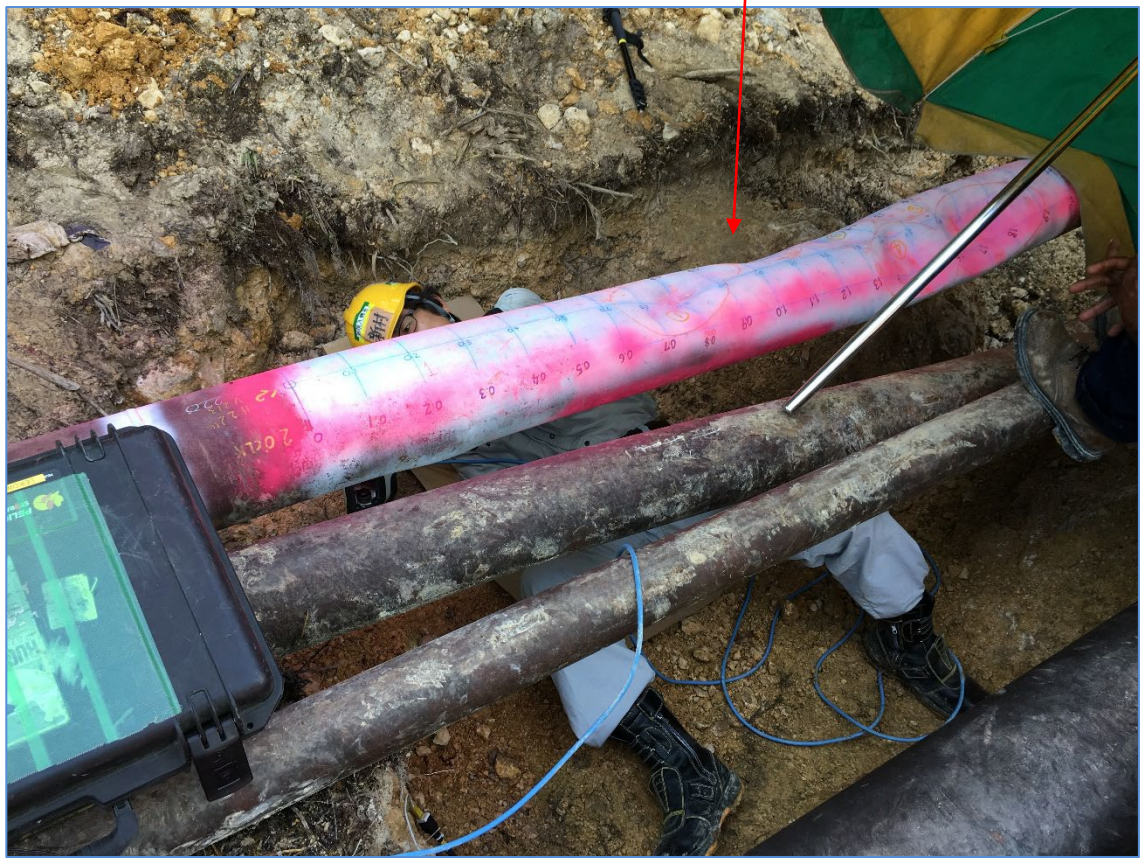
Fitted radius 204.09

Feature	Max Depth	Area	Width	Length
01	1.78	325.50	15.50	21.00
02	1.65	288.00	18.00	16.00
03	1.30	112.50	9.00	12.50
04	1.14	56.00	8.00	7.00
05	1.12	85.00	8.50	10.00
06	1.12	36.00	6.00	6.00
07	0.97	51.00	6.00	8.50
08	0.93	41.25	7.50	5.50
09	0.79	15.75	3.50	4.50
10	0.78	20.00	4.00	5.00
11	0.78	17.50	3.50	5.00
12	0.77	42.00	7.00	6.00
13	0.69	13.75	5.50	2.50
14	0.67	10.00	2.50	4.00
15	0.67	18.00	4.00	4.50

External mechanical damage on pipes

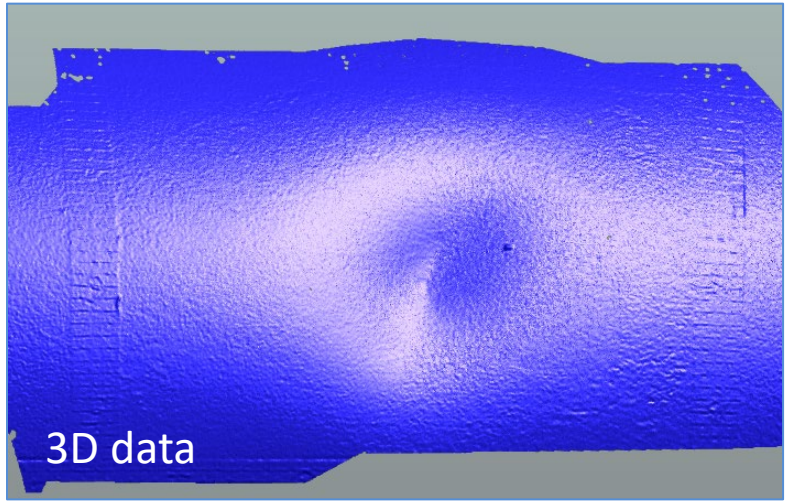
Measurement of external damage

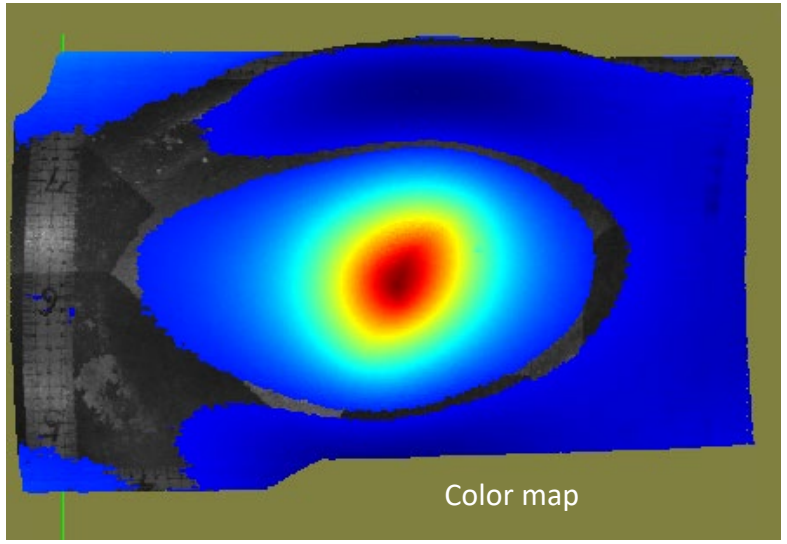
Complicated deformation

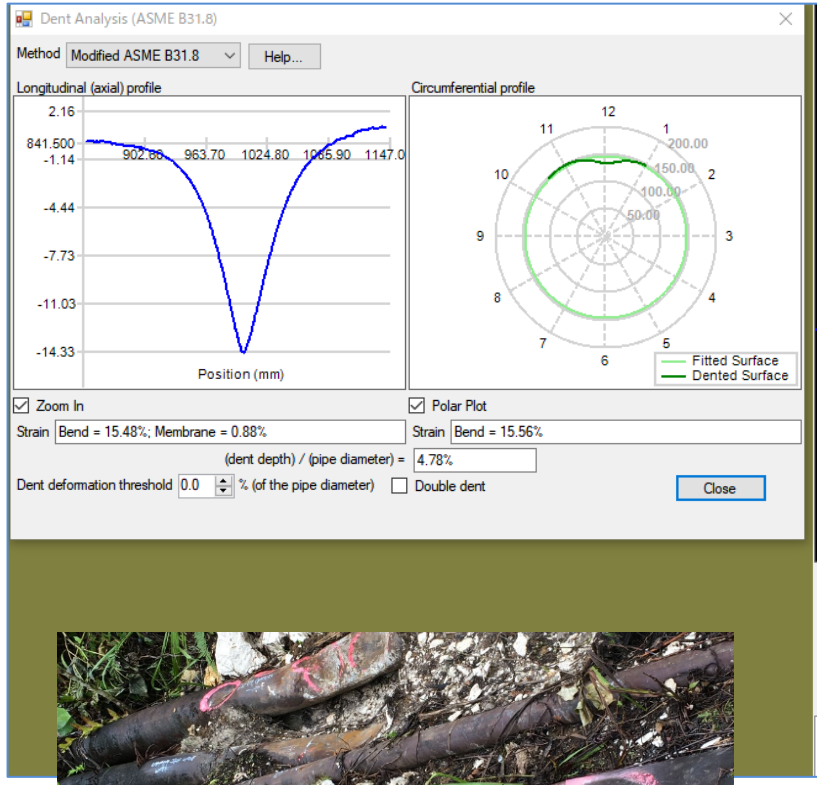


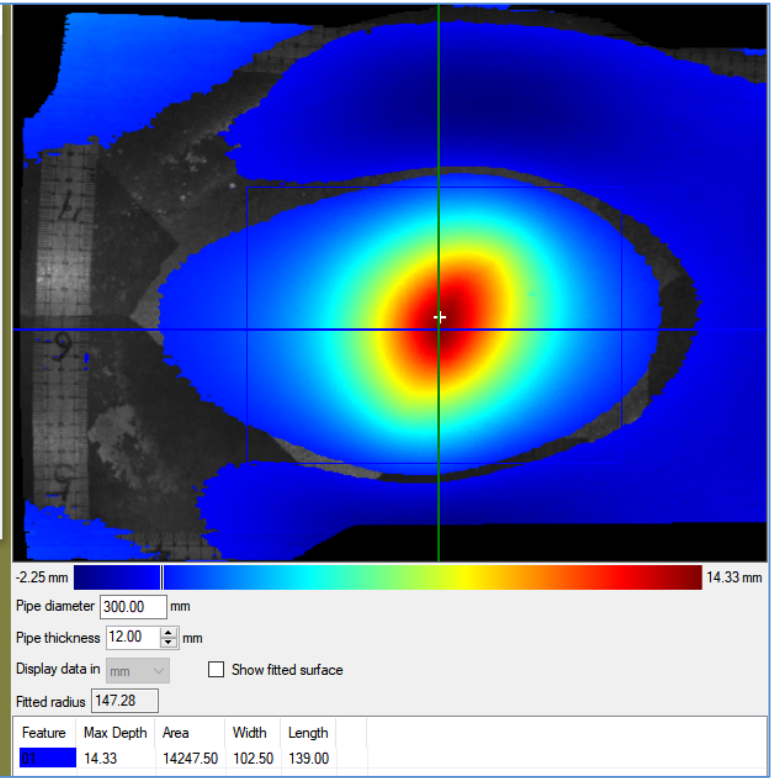
Precise data acquisition for FEM analysis

Analysis of external damage







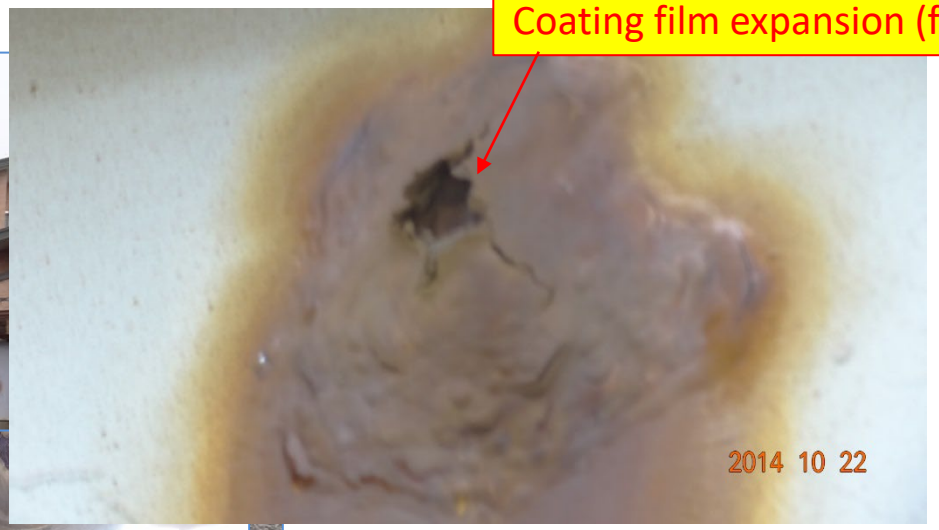


The collapse of the pipeline due to falling rocks was measured three-dimensionally. By performing finite element analysis of the three-dimensional deformation data, it was immediately analyzed whether it could be used as it is or whether it needed to be repaired, which contributed to the early decision on the start of oil production.

Bridge secular variation (painting, bolts and nuts)

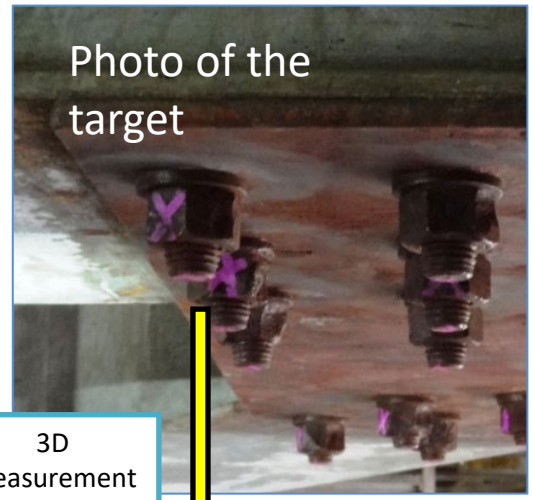
Anti-corrosion treatment
and deformation of nuts

Coating film expansion (fragile)

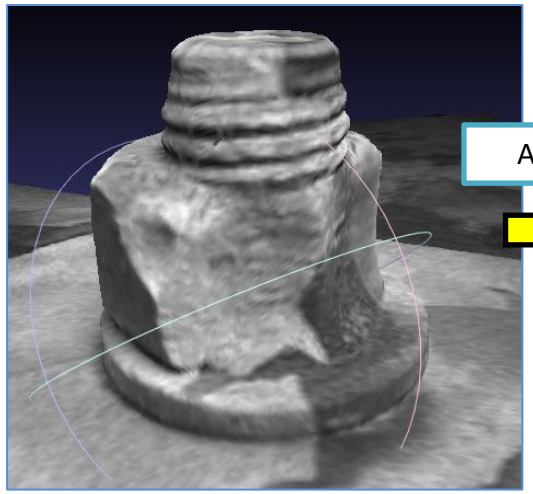


Bridge secular variation (painting, bolts and nuts)

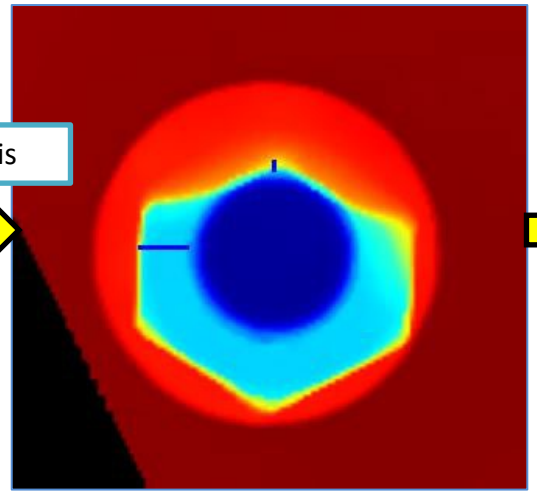
Fitness for service of thinned nut



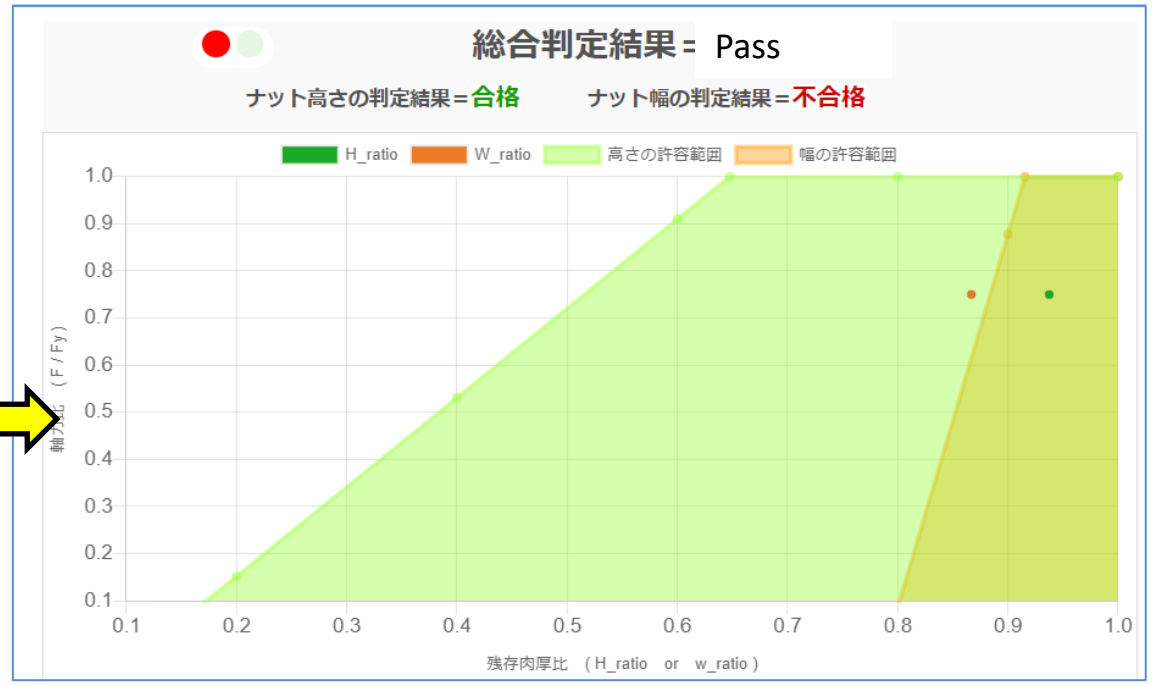
3D measurement



Analysis



FFS assessment

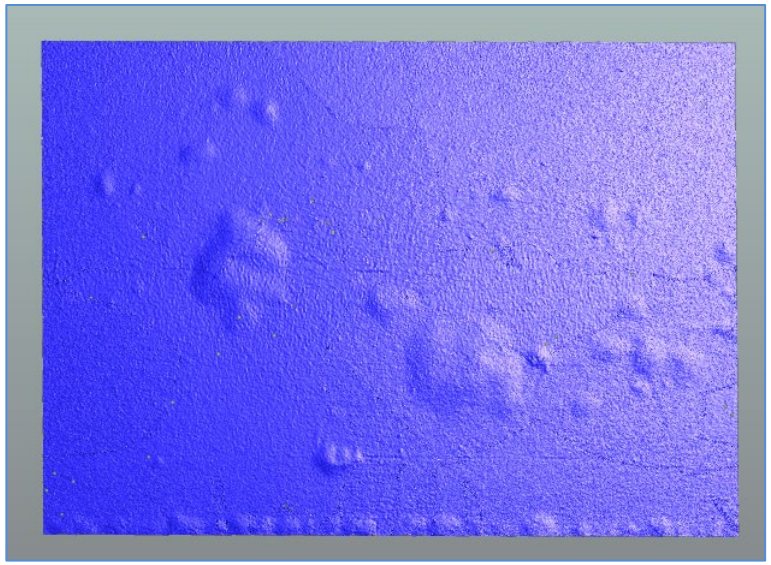


Quantification of changes over time in paint film swelling

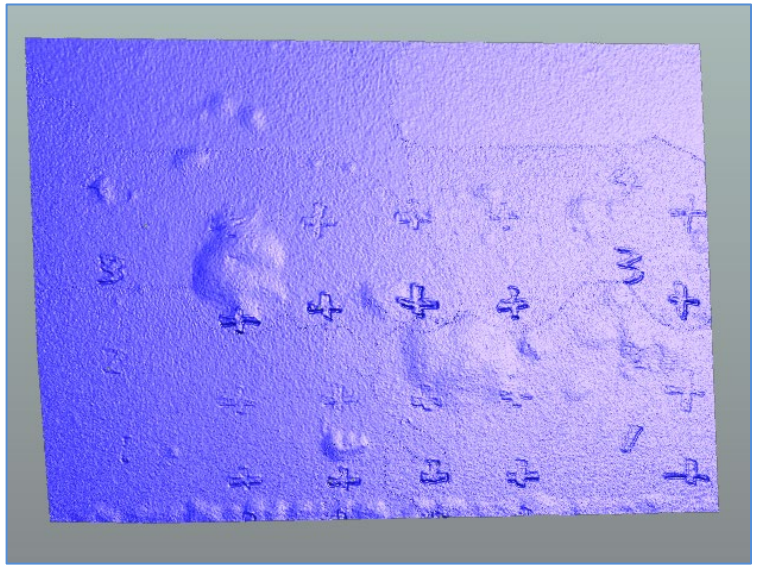
As of January 2018

Coating film swelling, transition of 3D data

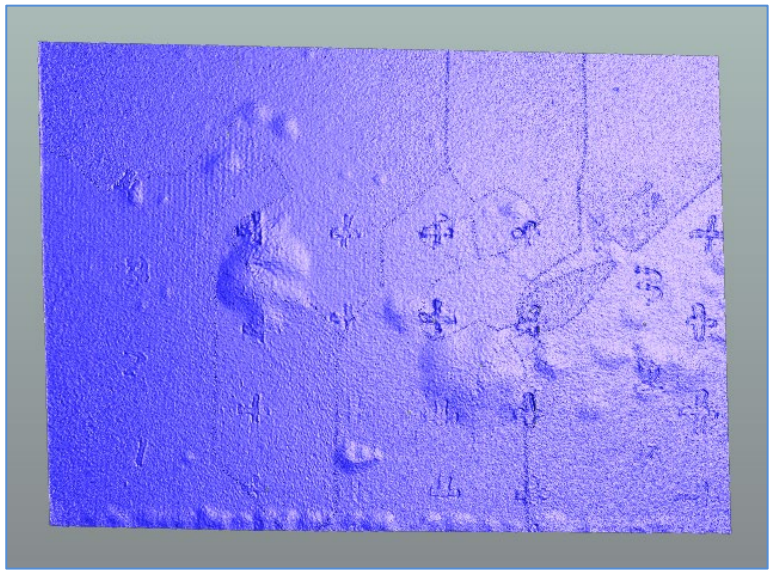
As of Jan. 2019



As of Feb. 2020

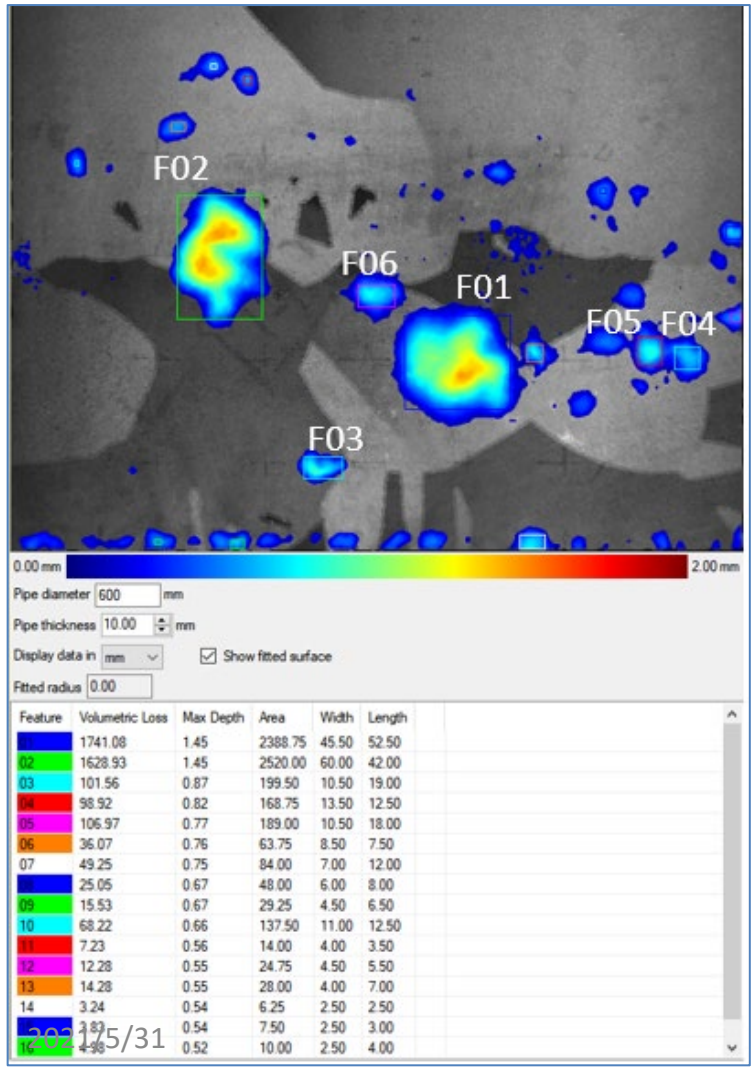


As of Apr. 2021



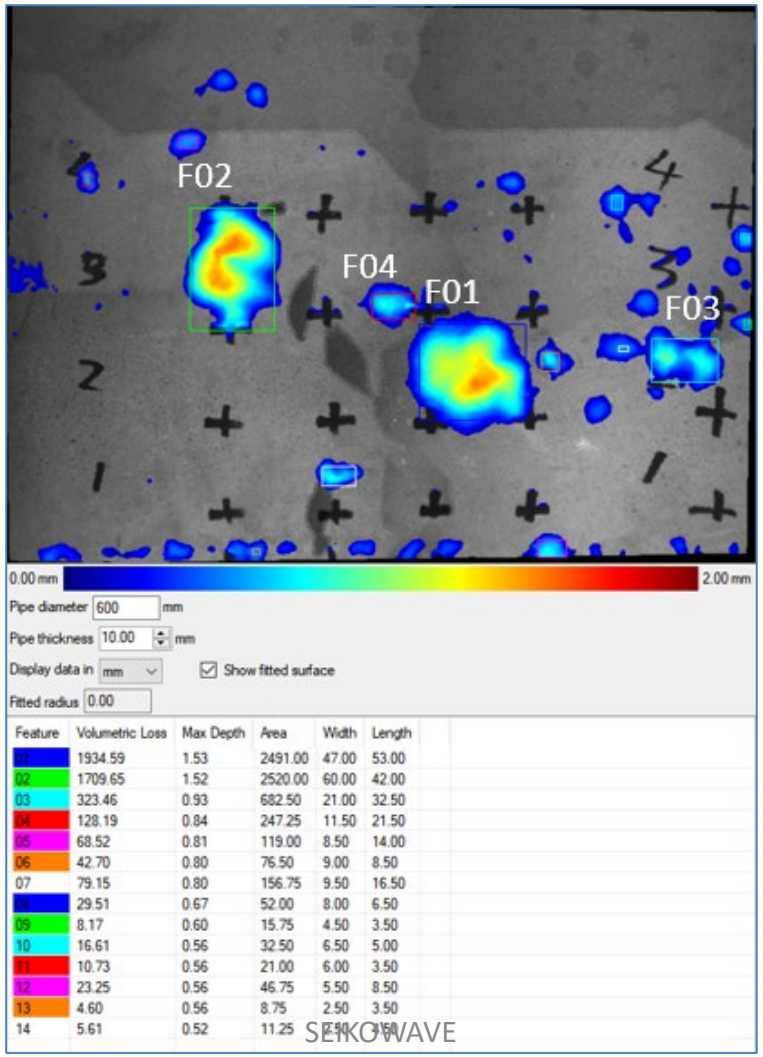
Quantifying the degree of swelling of the coating film

As of Jan. 2019



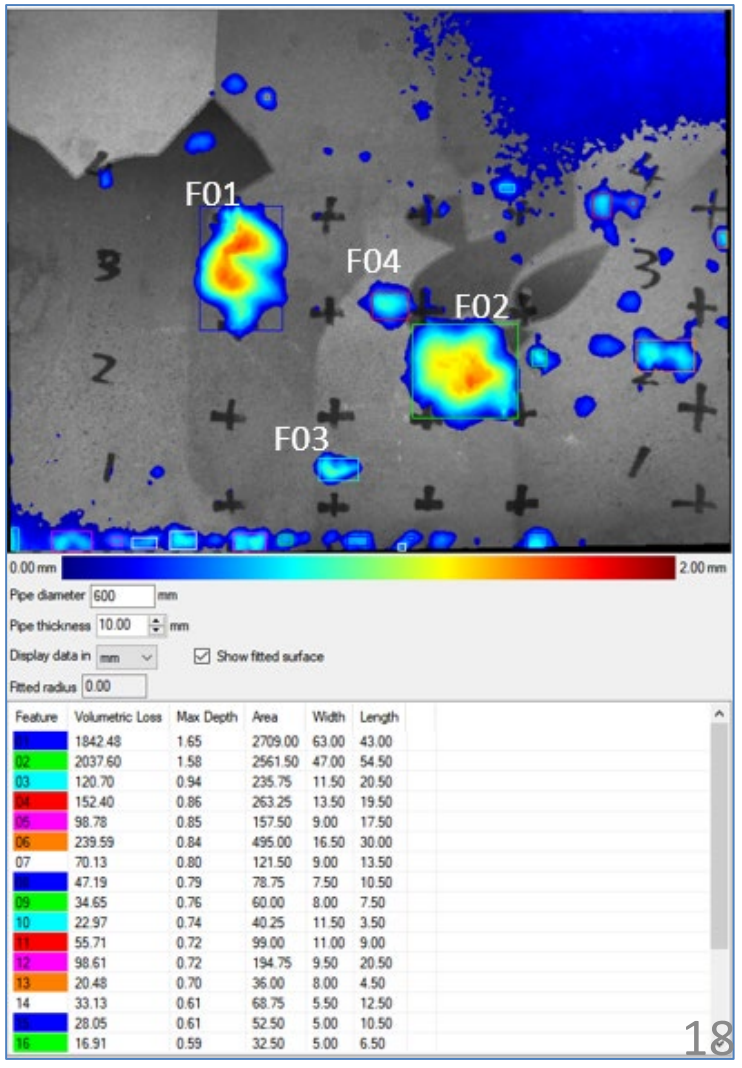
Feature	Volumetric Loss	Max Depth	Area	Width	Length
01	1741.08	1.45	2388.75	45.50	52.50
02	1628.93	1.45	2520.00	60.00	42.00
03	101.56	0.87	199.50	10.50	19.00
04	98.92	0.82	168.75	13.50	12.50
05	106.97	0.77	189.00	10.50	18.00
06	36.07	0.76	63.75	8.50	7.50
07	49.25	0.75	84.00	7.00	12.00
08	25.05	0.67	48.00	6.00	8.00
09	15.53	0.67	29.25	4.50	6.50
10	68.22	0.66	137.50	11.00	12.50
11	7.23	0.56	14.00	4.00	3.50
12	12.28	0.55	24.75	4.50	5.50
13	14.28	0.55	28.00	4.00	7.00
14	3.24	0.54	6.25	2.50	2.50
15	3.83	0.54	7.50	2.50	3.00
16	4.98	0.52	10.00	2.50	4.00

As of Feb. 2020



Feature	Volumetric Loss	Max Depth	Area	Width	Length
01	1934.59	1.53	2491.00	47.00	53.00
02	1709.65	1.52	2520.00	60.00	42.00
03	323.46	0.93	682.50	21.00	32.50
04	128.19	0.84	247.25	11.50	21.50
05	68.52	0.81	119.00	8.50	14.00
06	42.70	0.80	76.50	9.00	8.50
07	79.15	0.80	156.75	9.50	16.50
08	29.51	0.67	52.00	8.00	6.50
09	8.17	0.60	15.75	4.50	3.50
10	16.61	0.56	32.50	6.50	5.00
11	10.73	0.56	21.00	6.00	3.50
12	23.25	0.56	46.75	5.50	8.50
13	4.60	0.56	8.75	2.50	3.50
14	5.61	0.52	11.25	2.50	3.50

As of Apr. 2021



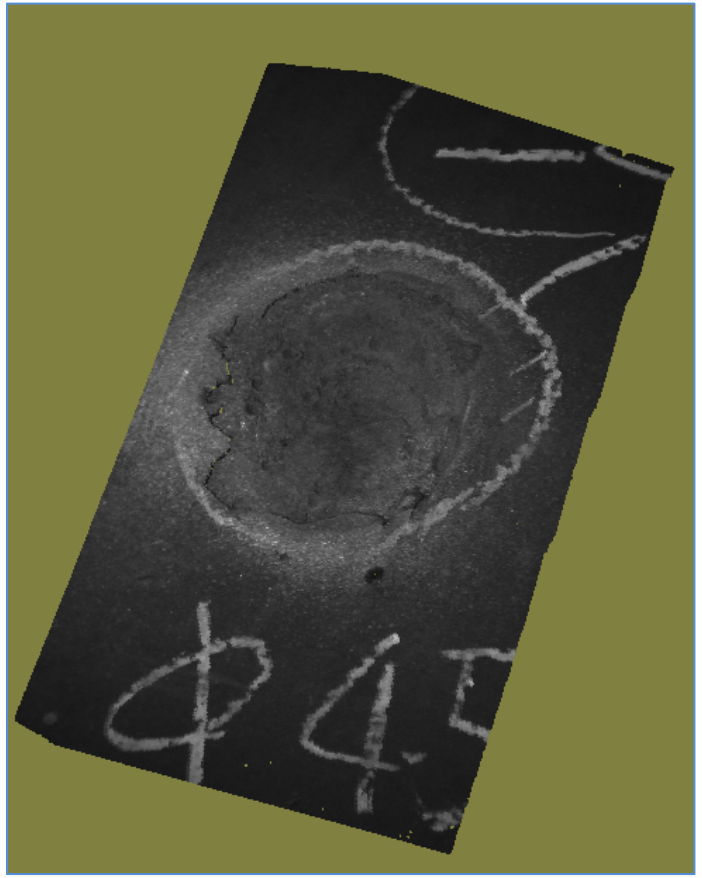
Feature	Volumetric Loss	Max Depth	Area	Width	Length
01	1842.48	1.65	2709.00	63.00	43.00
02	2037.60	1.58	2561.50	47.00	54.50
03	120.70	0.94	235.75	11.50	20.50
04	152.40	0.86	263.25	13.50	19.50
05	98.78	0.85	157.50	9.00	17.50
06	239.59	0.84	495.00	16.50	30.00
07	70.13	0.80	121.50	9.00	13.50
08	47.19	0.79	78.75	7.50	10.50
09	34.65	0.76	60.00	8.00	7.50
10	22.97	0.74	40.25	11.50	3.50
11	55.71	0.72	99.00	11.00	9.00
12	98.61	0.72	194.75	9.50	20.50
13	20.48	0.70	36.00	8.00	4.50
14	33.13	0.61	68.75	5.50	12.50
15	28.05	0.61	52.50	5.00	10.50
16	16.91	0.59	32.50	5.00	6.50

Painted bridge repair work site

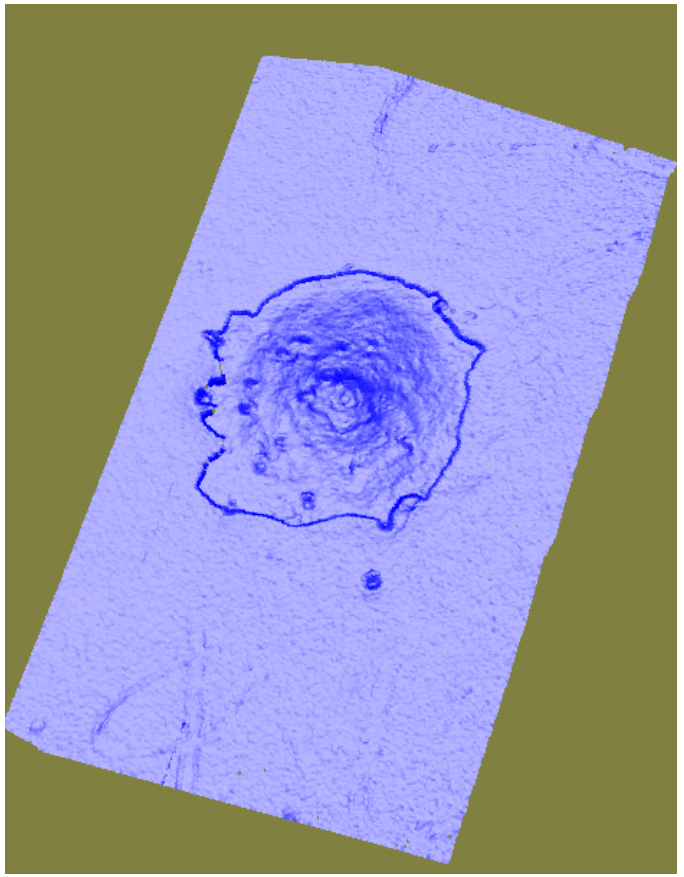
Thinning due to raindrops

Photo

3D data screen shots

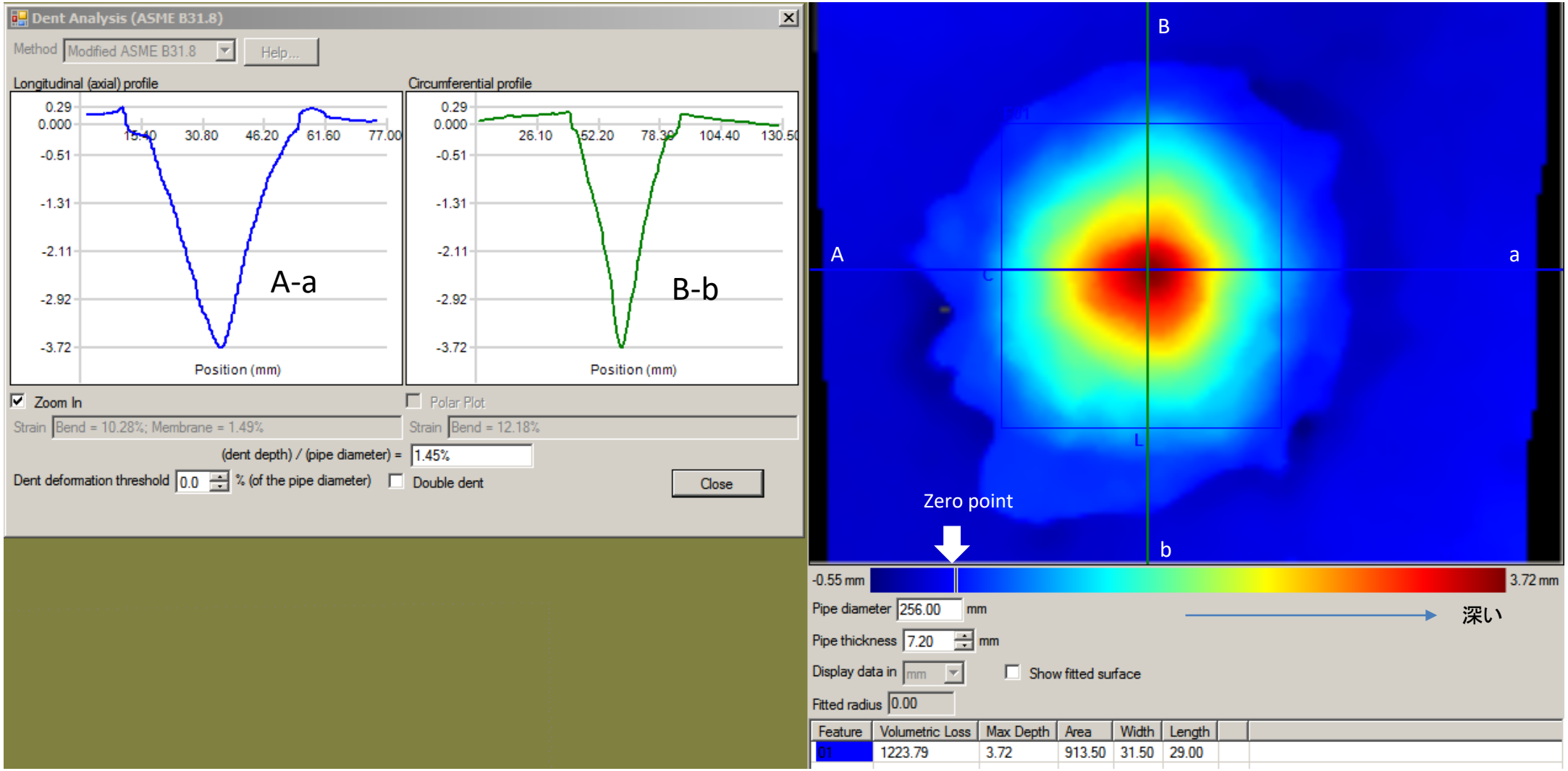


C15-S3.PLY

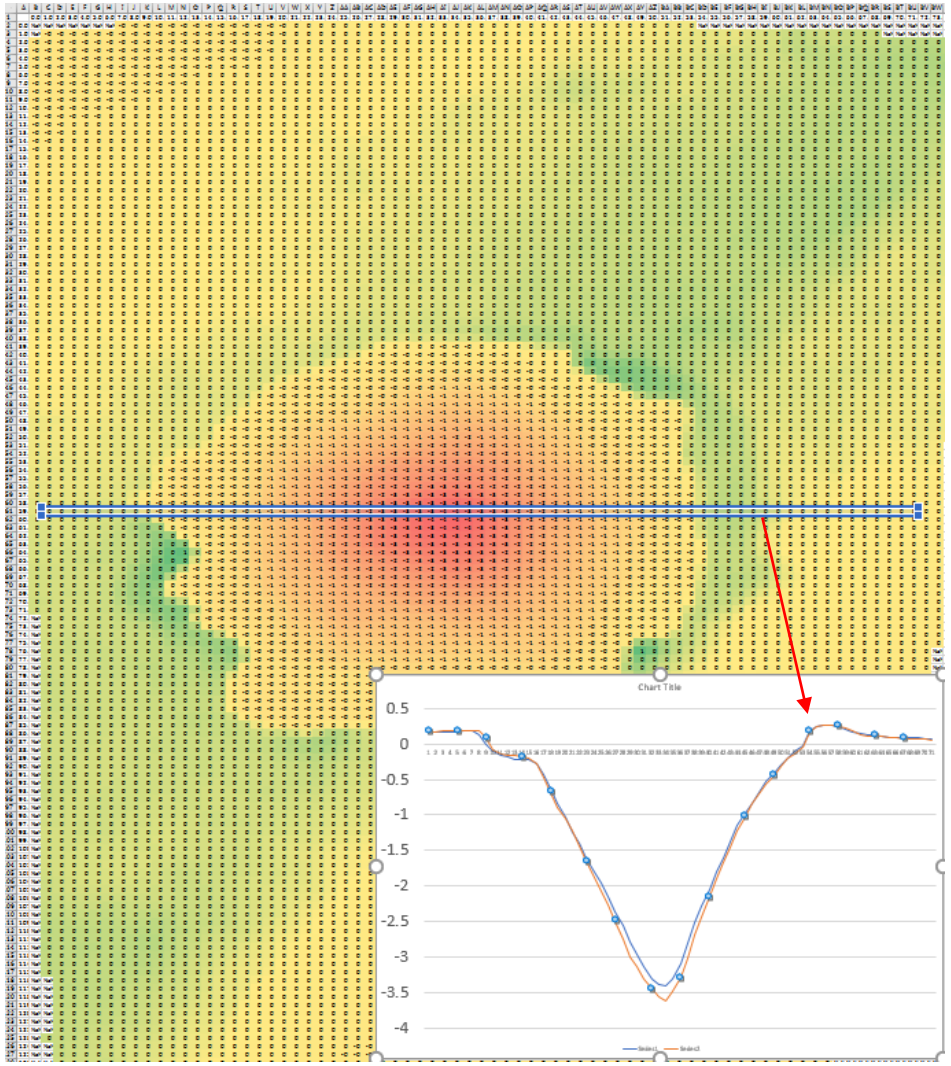


Depth analysis

Cross section profile



CSV file output, color and graph by Excel

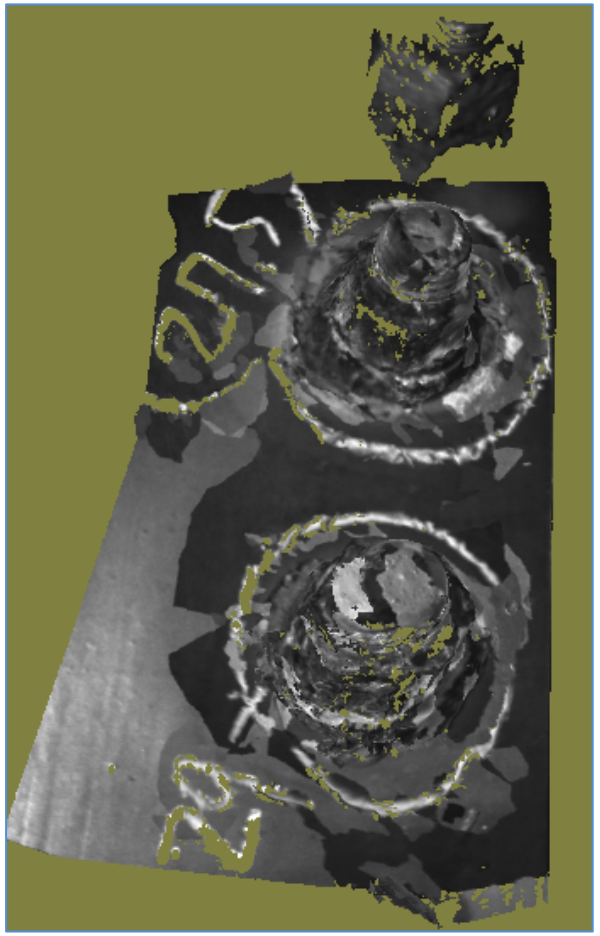


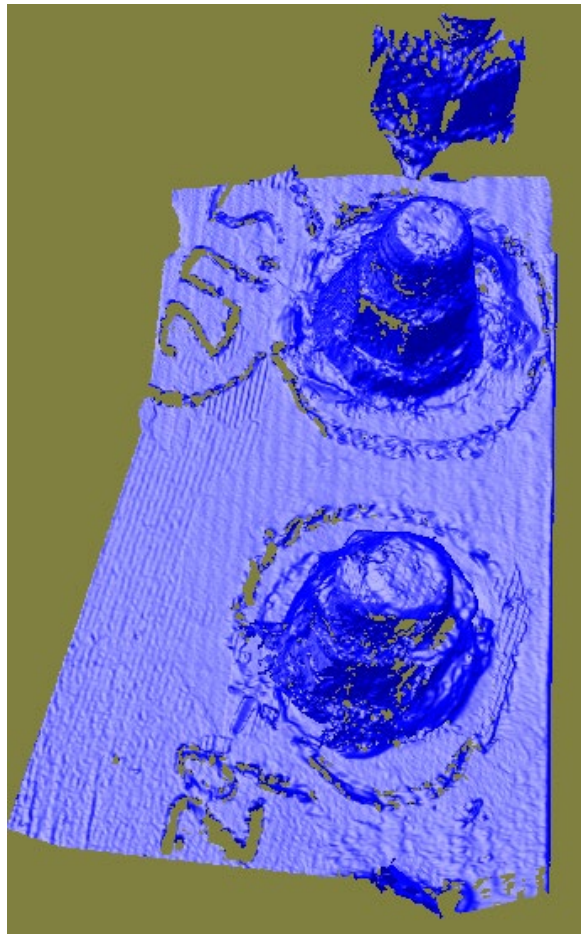
C15-S3 1mm x 1mm avg.xlsx

Deterioration of bolt rust prevention treatment

Photo

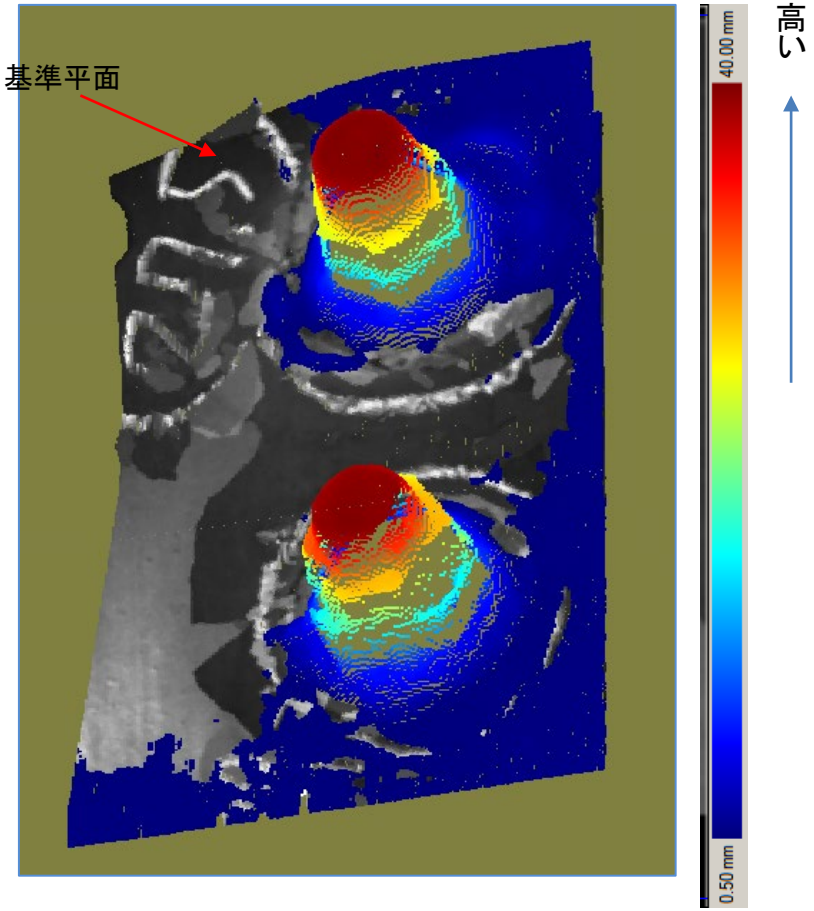
3D data screen shot



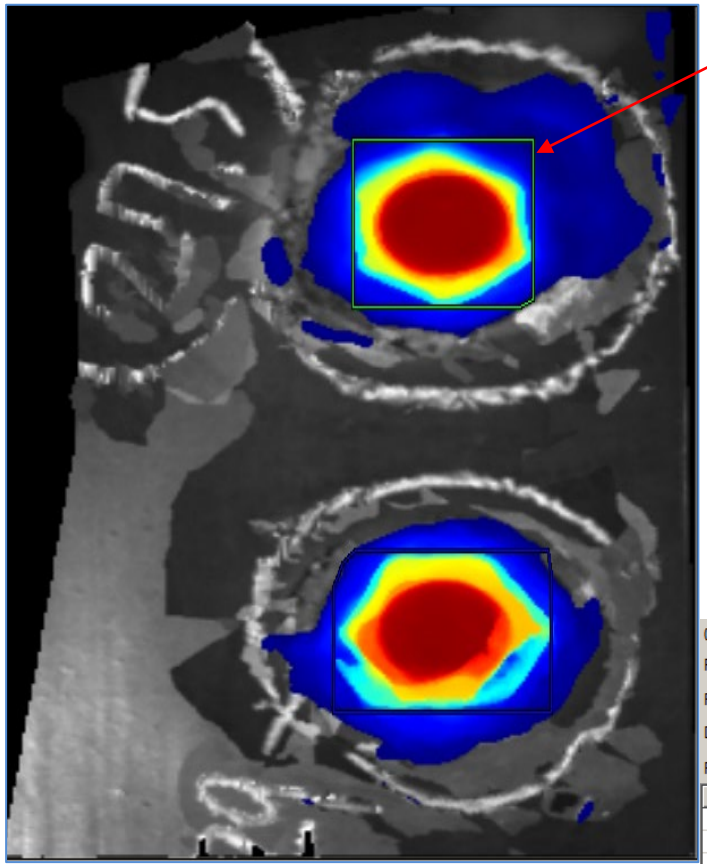


Remaining volume after cleaning

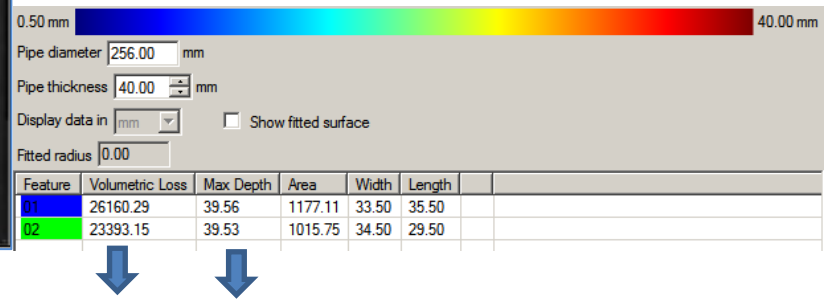
Height color map



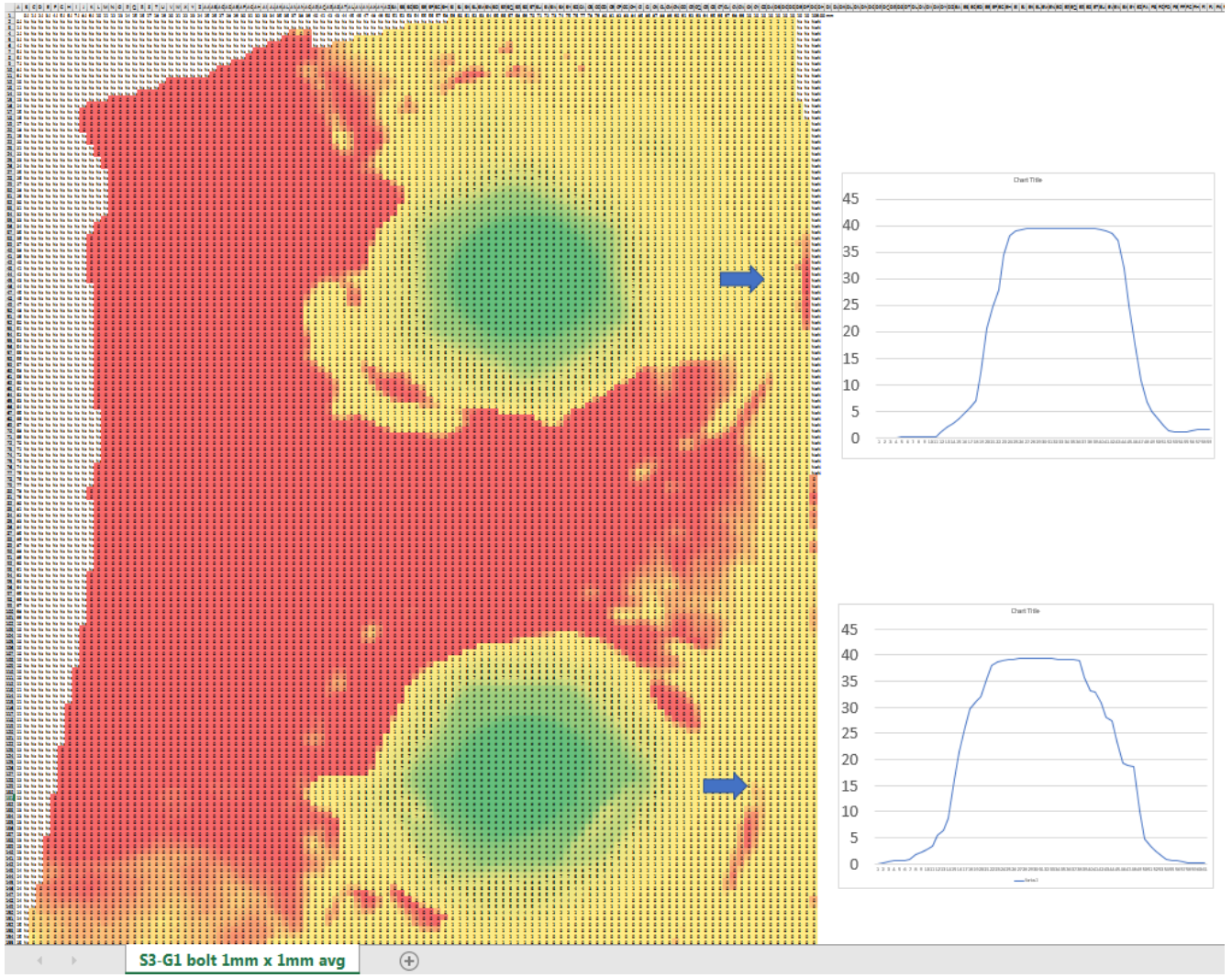
Remaining volume of nut



Remaining volume in green square is listed in the table below.



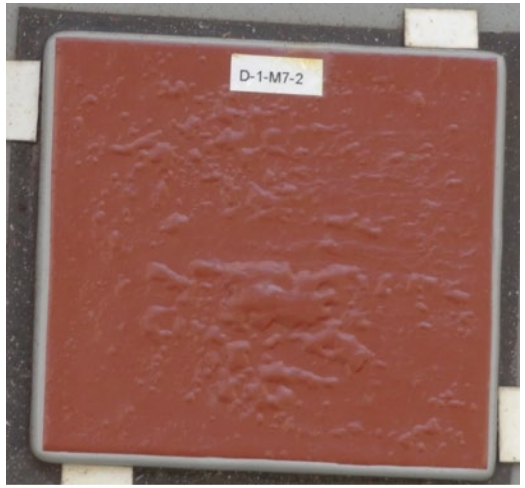
CSV file output, color and graph by Excel



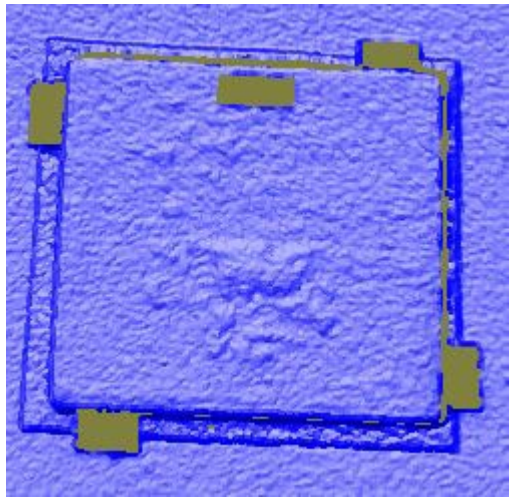
S3-G1 bolt 1mm x 1mm avg.xlsx

On-site measurement of exposure test pieces

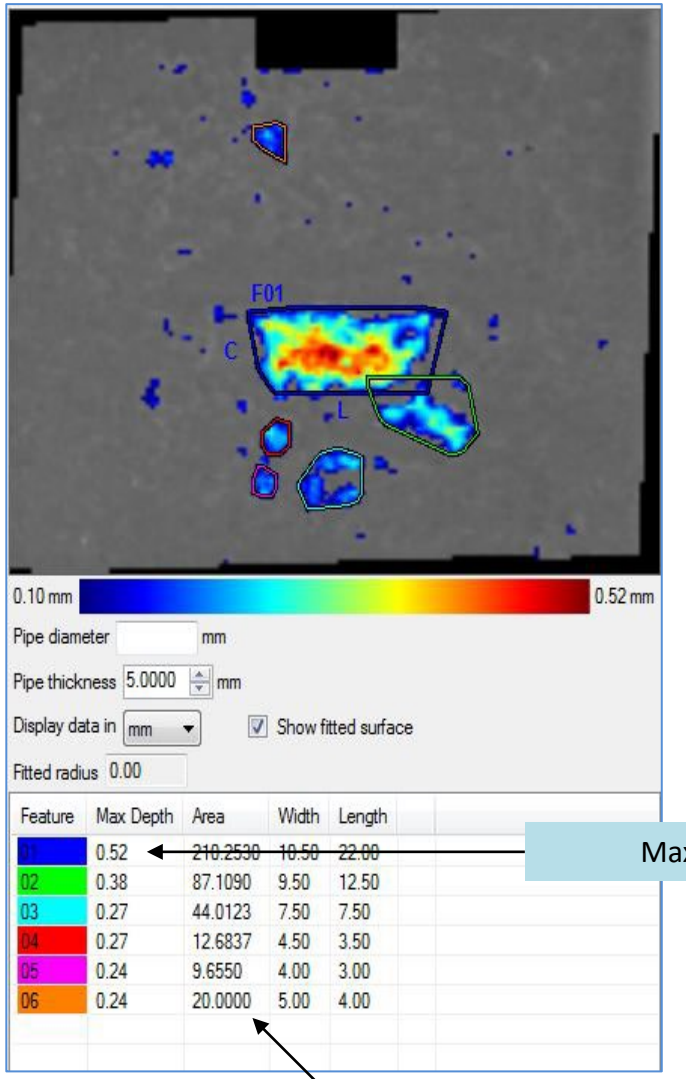
Photo of an exposure test piece



3D measurement image of exposure test piece (No shading information)



Quantification of the amount of excitement



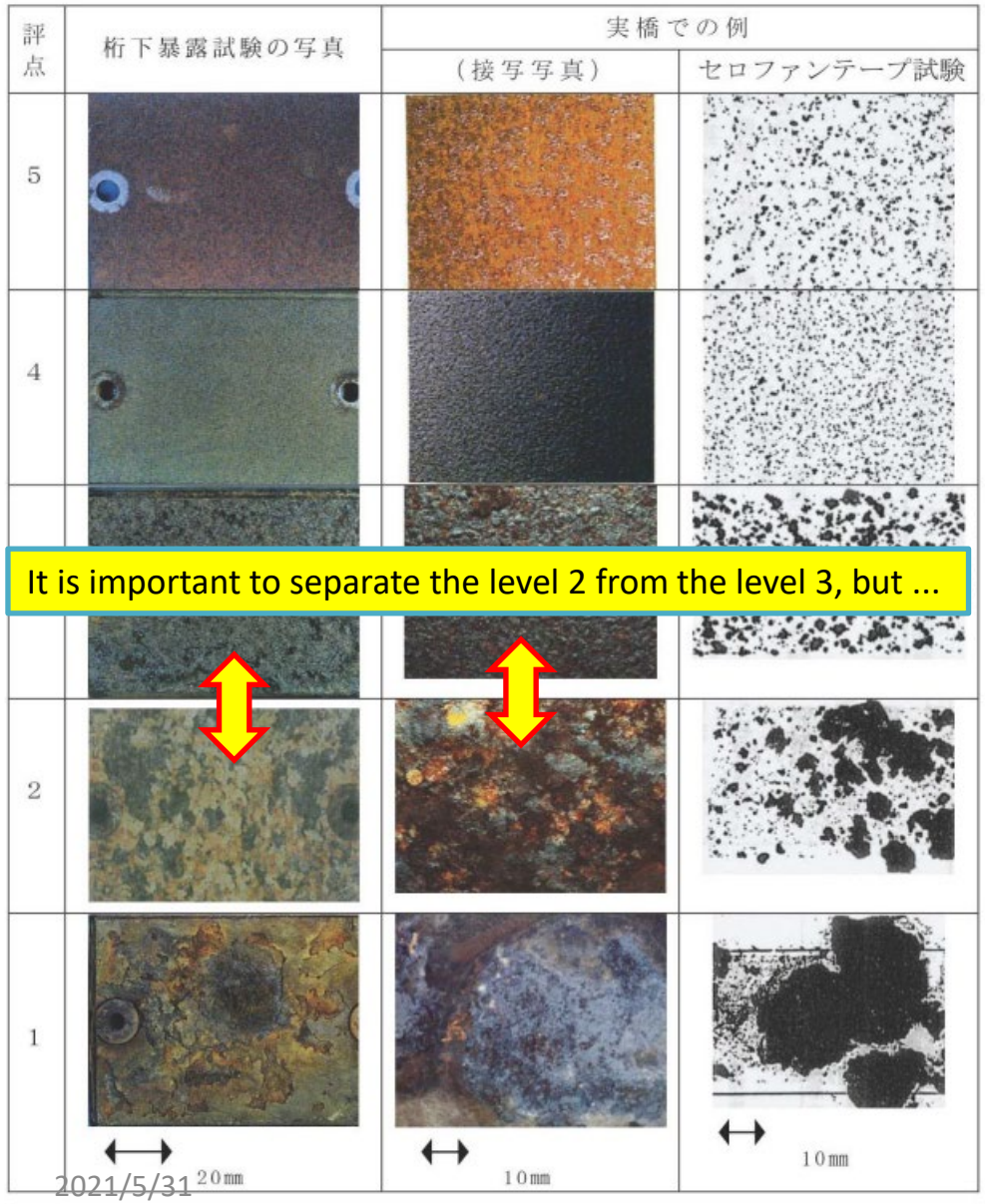
Max height

Area of excite area

Effect: Conventionally, the exposure test piece was removed and the shape was precisely measured in the laboratory. Therefore, the number of test pieces is reduced by removing the test piece. Since it can be measured in the field, continuous observation is possible, and the number of test pieces can be reduced = the exposed field area can be reduced.

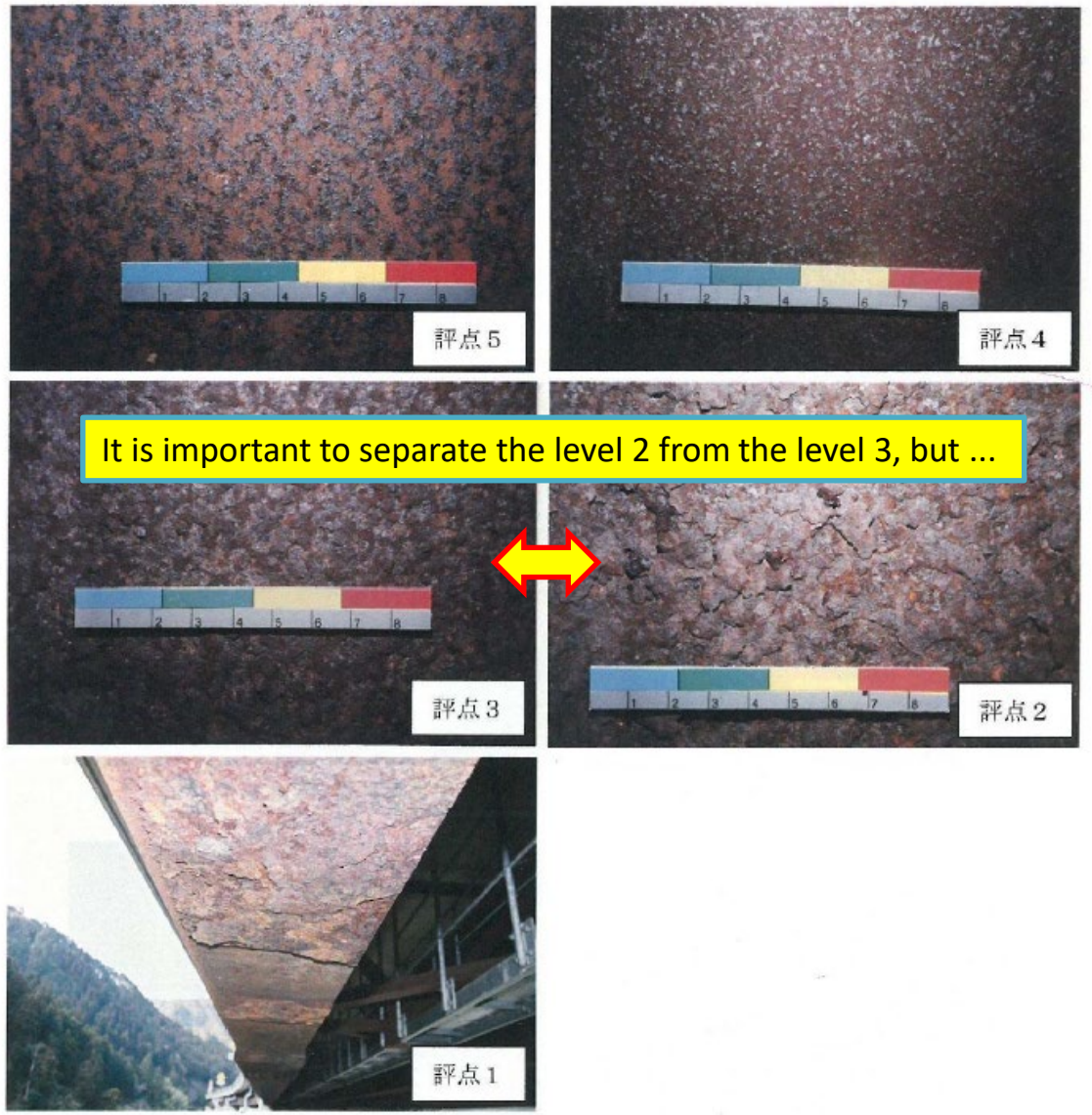
Weathering steel bridge (progress of corrosion)

Weathering Steel Bridge Corrosion Evaluation



It is important to separate the level 2 from the level 3, but ...

図-1.1 さび外観評点と写真見本 1.3)

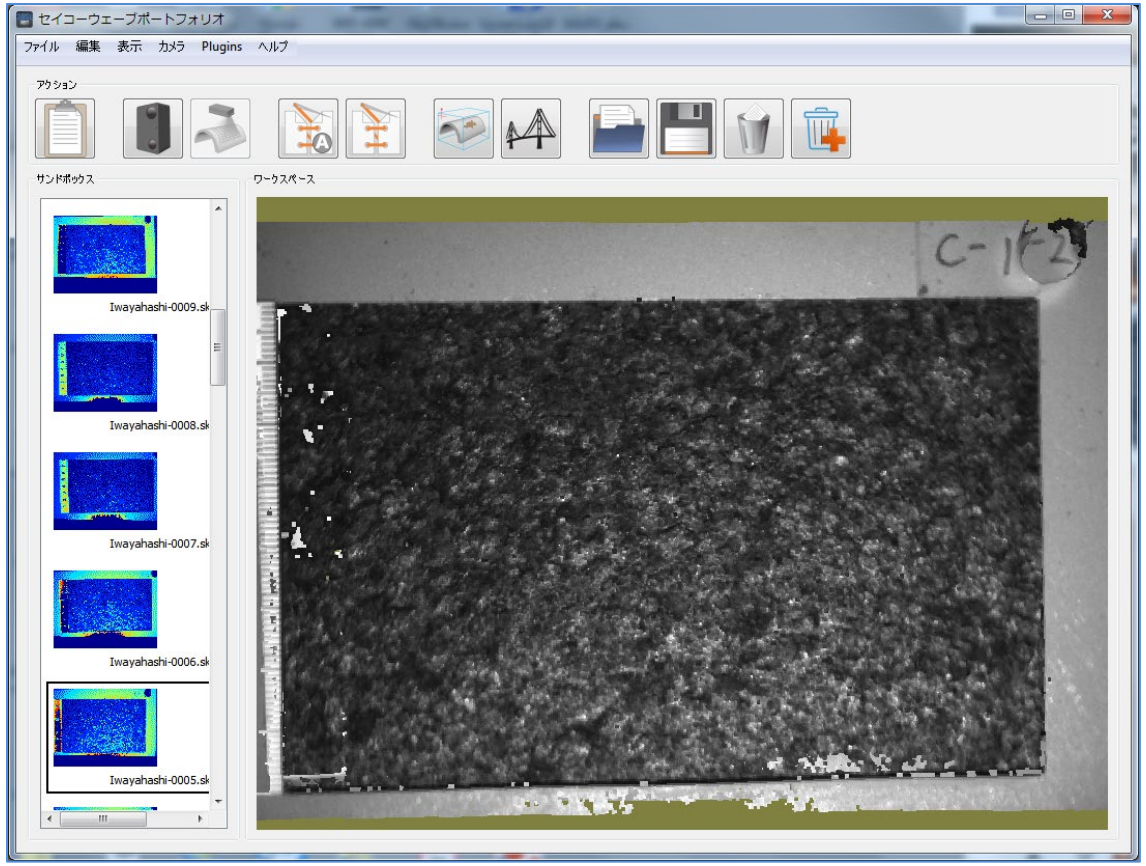


It is important to separate the level 2 from the level 3, but ...

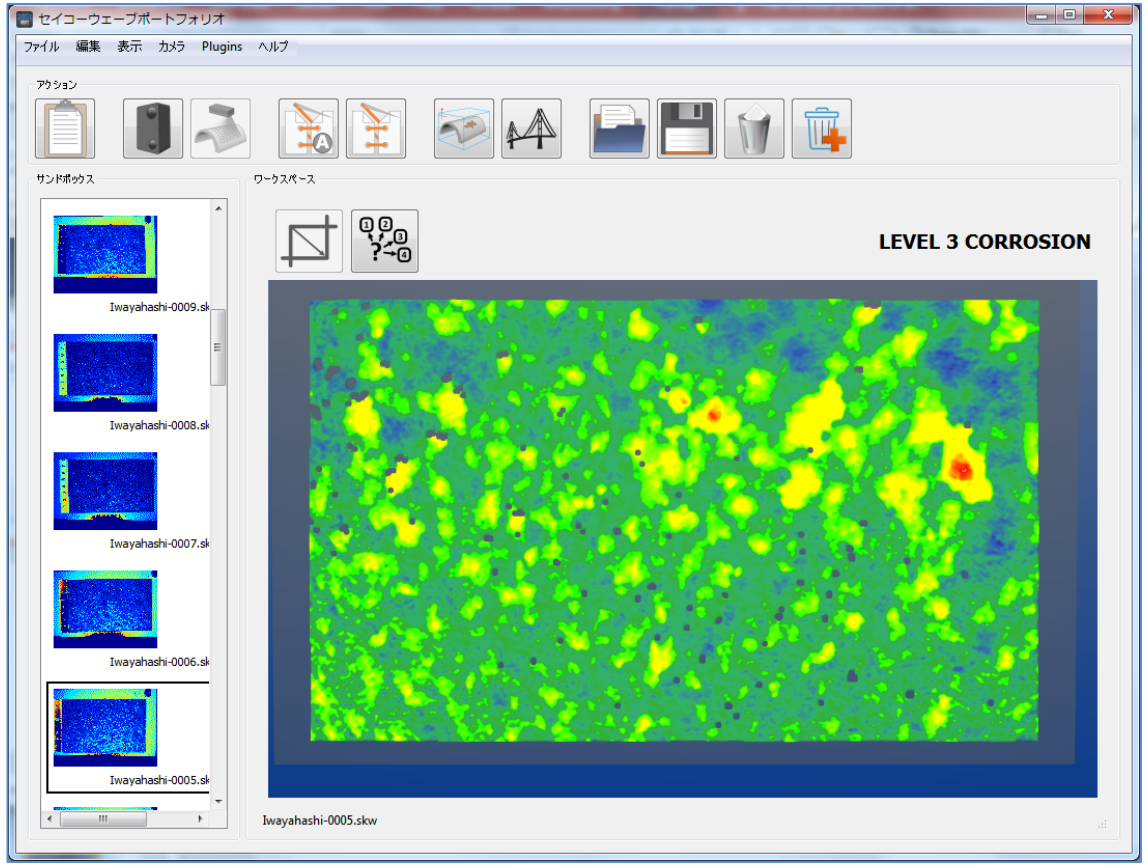
図-1.3 各外観評点における代表的なさび外観（架設後 10 年以上経過した橋梁での事例）1.6)

Corrosion level (scoring) evaluation software

3D measurement



Corrosion evaluation



Effect: By digitally determining the boundary between the level 2 and the level 3, it becomes possible to objectively determine the necessity of repair without relying on personal factors.

Oil tank; visual inspection of side wall plates

Tank side wall:
Problems and solutions for visual inspection

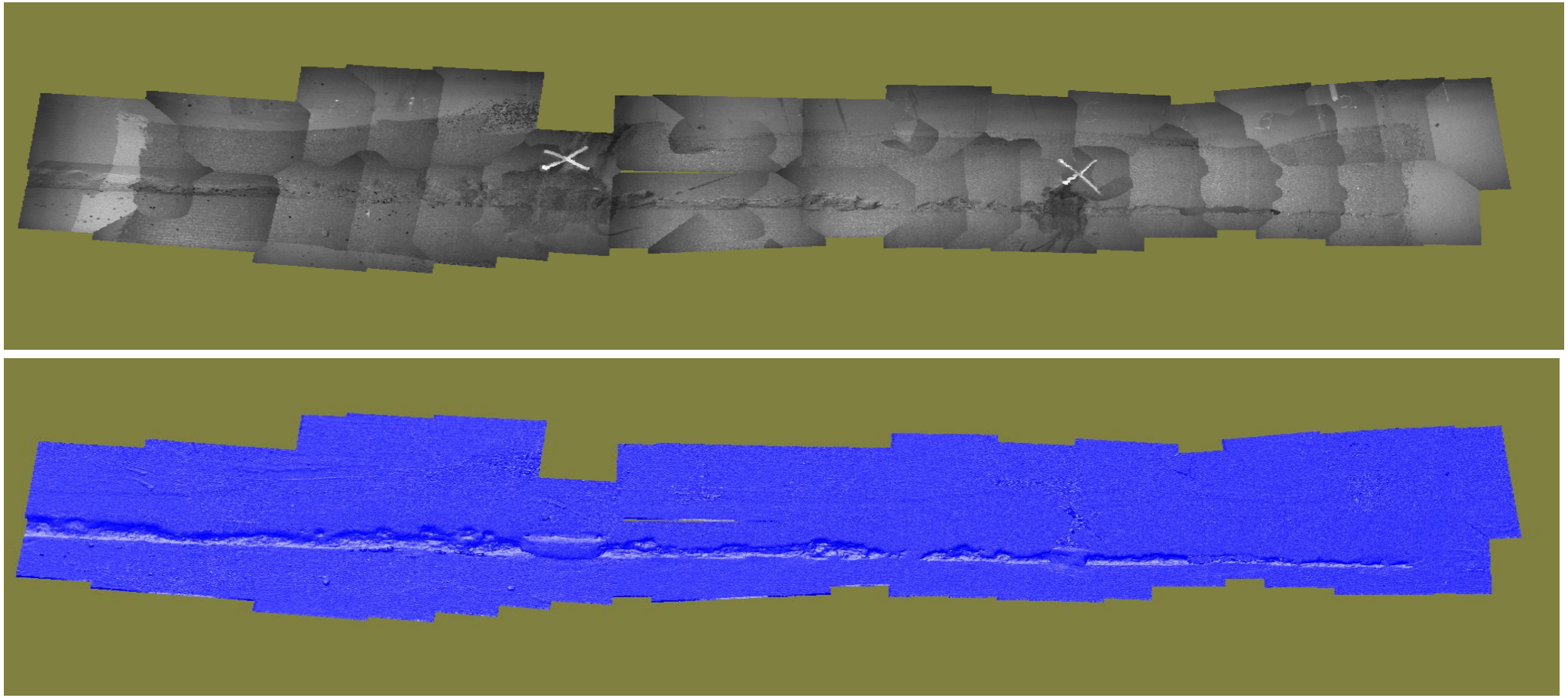
- Challenges of conventional visual inspection: Excerpt from "Safety & Tomorrow“

- All bottom plates are to be measured for thickness, but side plates are to be checked for thickness only when corrosion is observed. If corrosion is found by visual inspection of the side plate, measure the corrosion depth using a depth gauge, etc., and in the case of the old method tank, confirm that the residual wall thickness is 3.2 mm or more. If it is less than 3.2 mm, the current Fire Service Act stipulates that repairs should be carried out. However, it is a self-evident fact that the location selection of the maximum corroded point and the accuracy of the measured values are affected by the skill level and physical condition of the inspector, and it is confirmed whether the corrosion measurement point position is the same at the next inspection or not. Often it is unclear. In this way, it can be said that the method using the depth gauge has some difficulty in grasping the measurement accuracy and the history of corrosion progress.

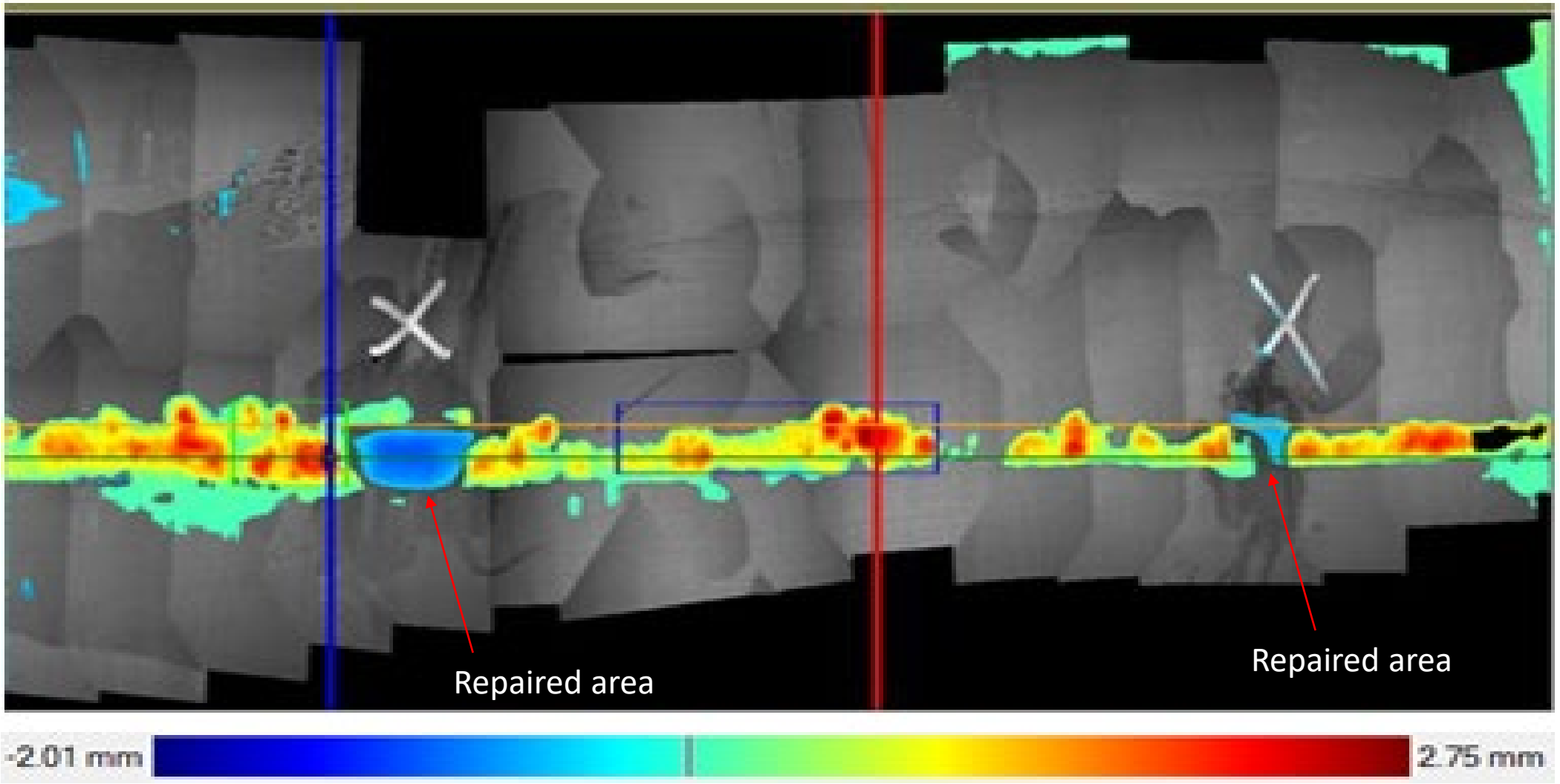
- Solution by optical 3D measurement method

    - The maximum corroded location can be identified by batch measurement on a surface-by-surface basis.
    - Data converges within a certain error range no matter who measures it.
    - The marking points are converted into data together, and the measurement points are clear.

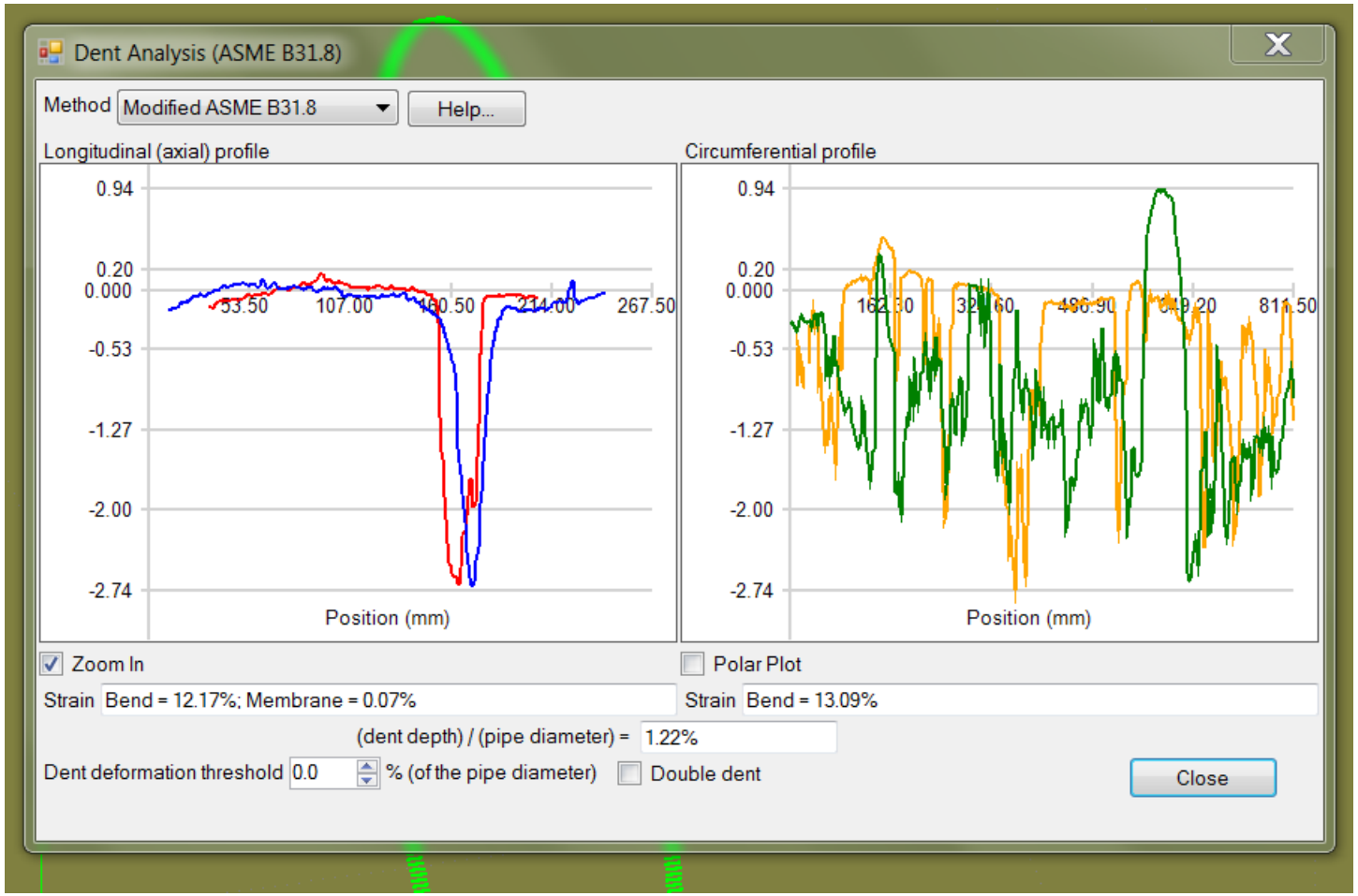
Shape measurement results around the weld line



Analysis of depth of corrosion

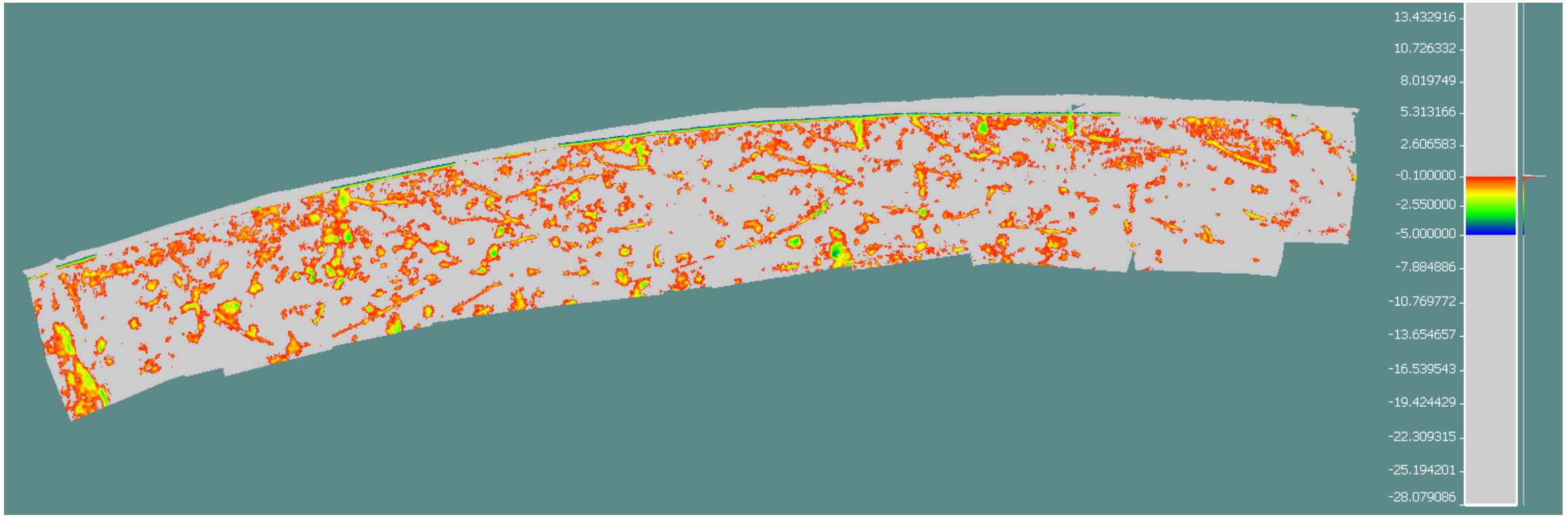


Depth profile



The maximum wall thinning point is automatically detected, and the wall thinning depth in the longitudinal direction and the circumferential direction is plotted.

Corrosion of tank bottom plate (side plate peripheral area)

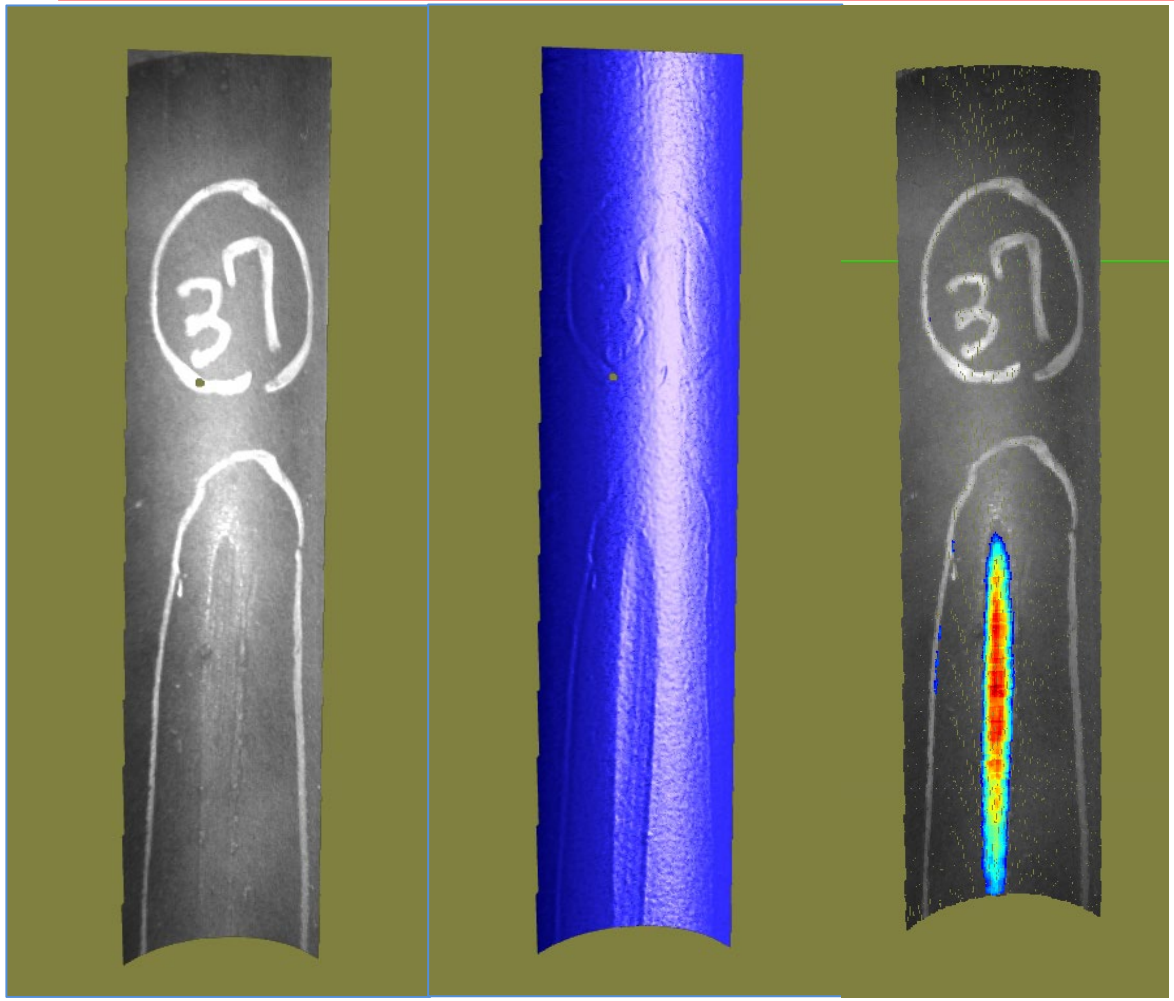


Corrosion of the bottom plate under the lining progresses with the service life.
The bottom plate is originally not flat due to welding thermal strain during construction, and if pitting corrosion progresses, it becomes difficult to measure with an ultrasonic wall thickness gauge or depth gauge. Conventionally, grasp of accurate corrosion amount (residual wall thickness) was difficult.

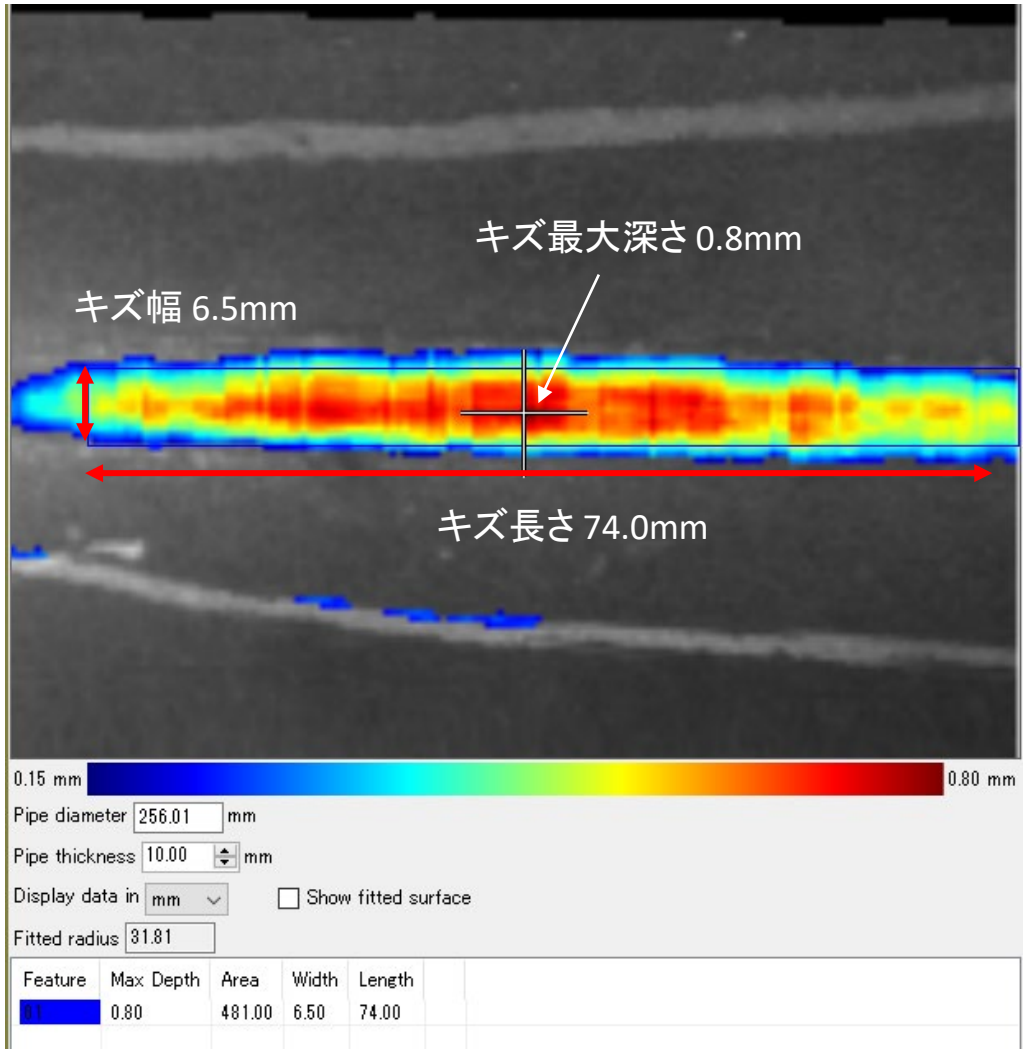
Seikowave has developed an analysis method that eliminates the influence of wavy strain on the plate by performing measurements using an optical three-dimensional measurement that can be measured on a plane basis.

Boiler internal water cooling pipe damage measurement

水管壁には上下方向に多少の歪みが発生しているが、この解析ソフトウェアでは、その歪みに影響されずに、キズ深さを検出可能。



外形64mm

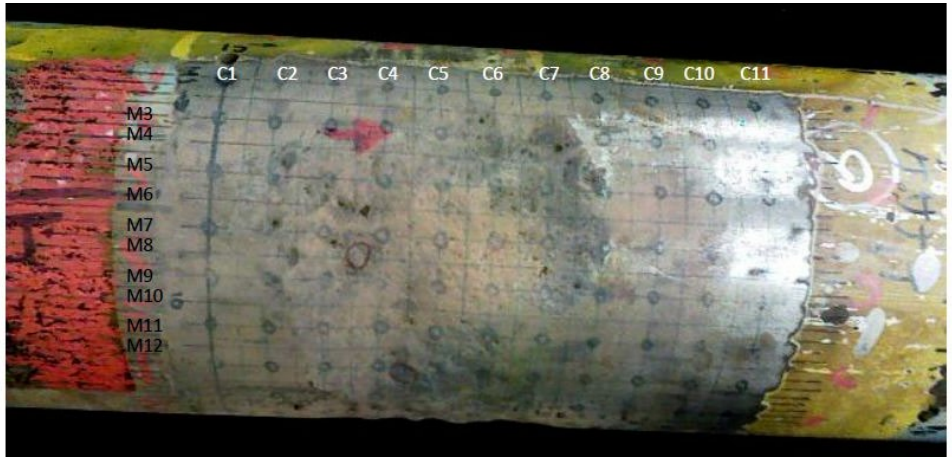


Uni-Fitness

FITNESS FOR SERVICE EXAMPLES COMPLIANT TO WES2820 (JAPAN), API-579

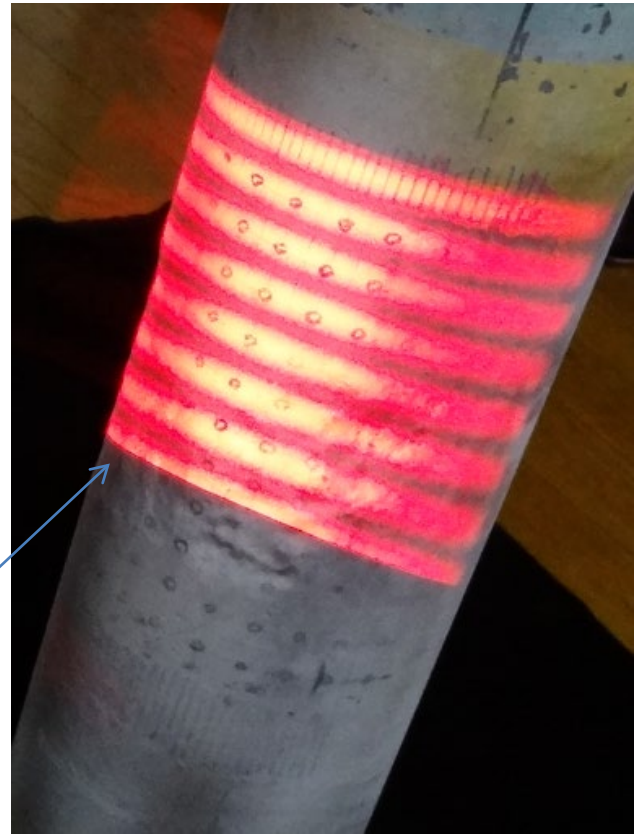
Thinned metal pipe

Target pipe



Nominal pipe thickness = 7.2mm
Outside diameter = 165mm
Inside diameter = 150.6mm

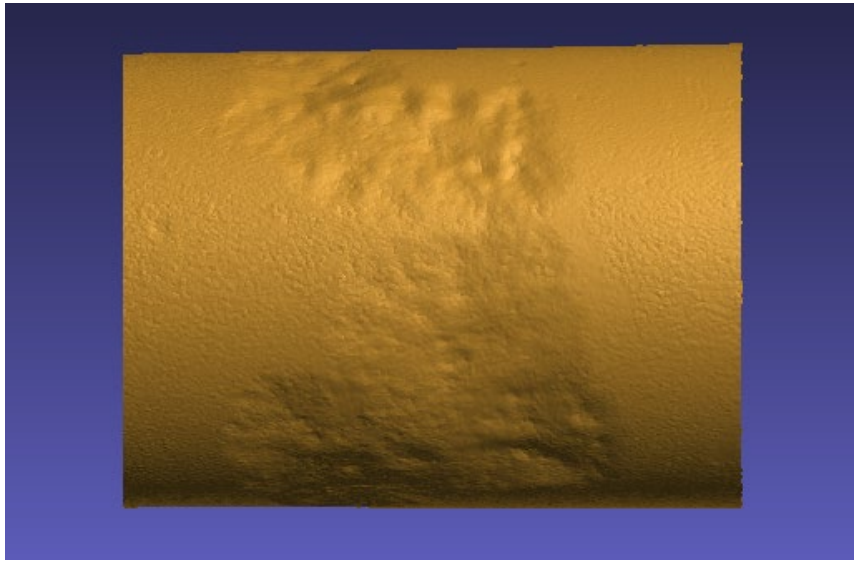
3D measurement



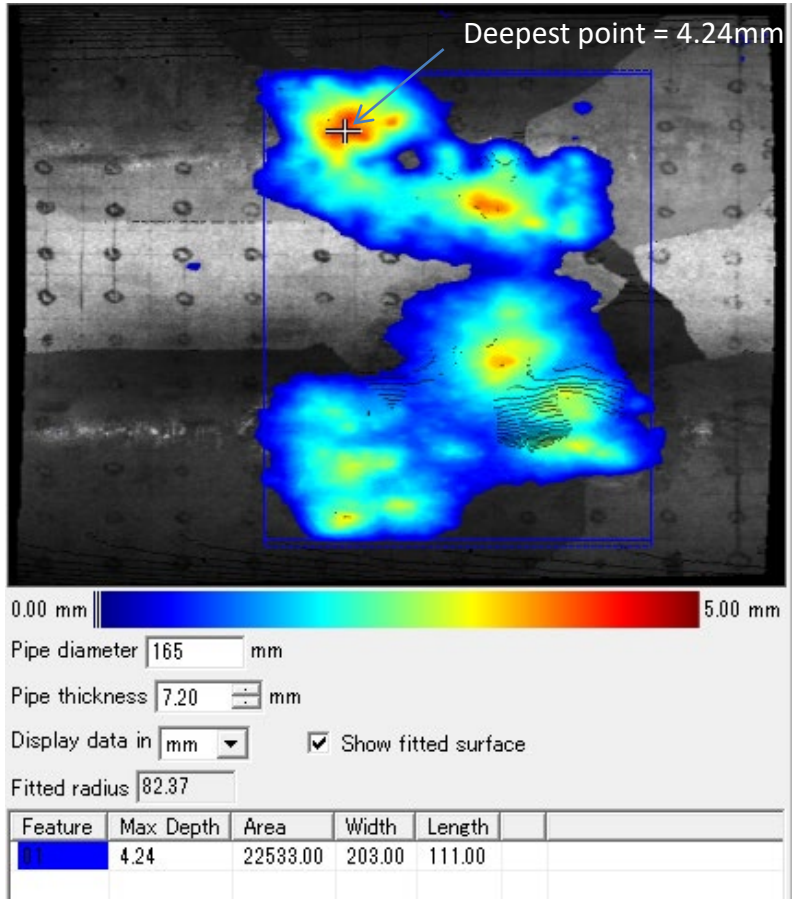
Phase-shifted pattern is projected to the target surface.

3D analysis

3D data (no texture)

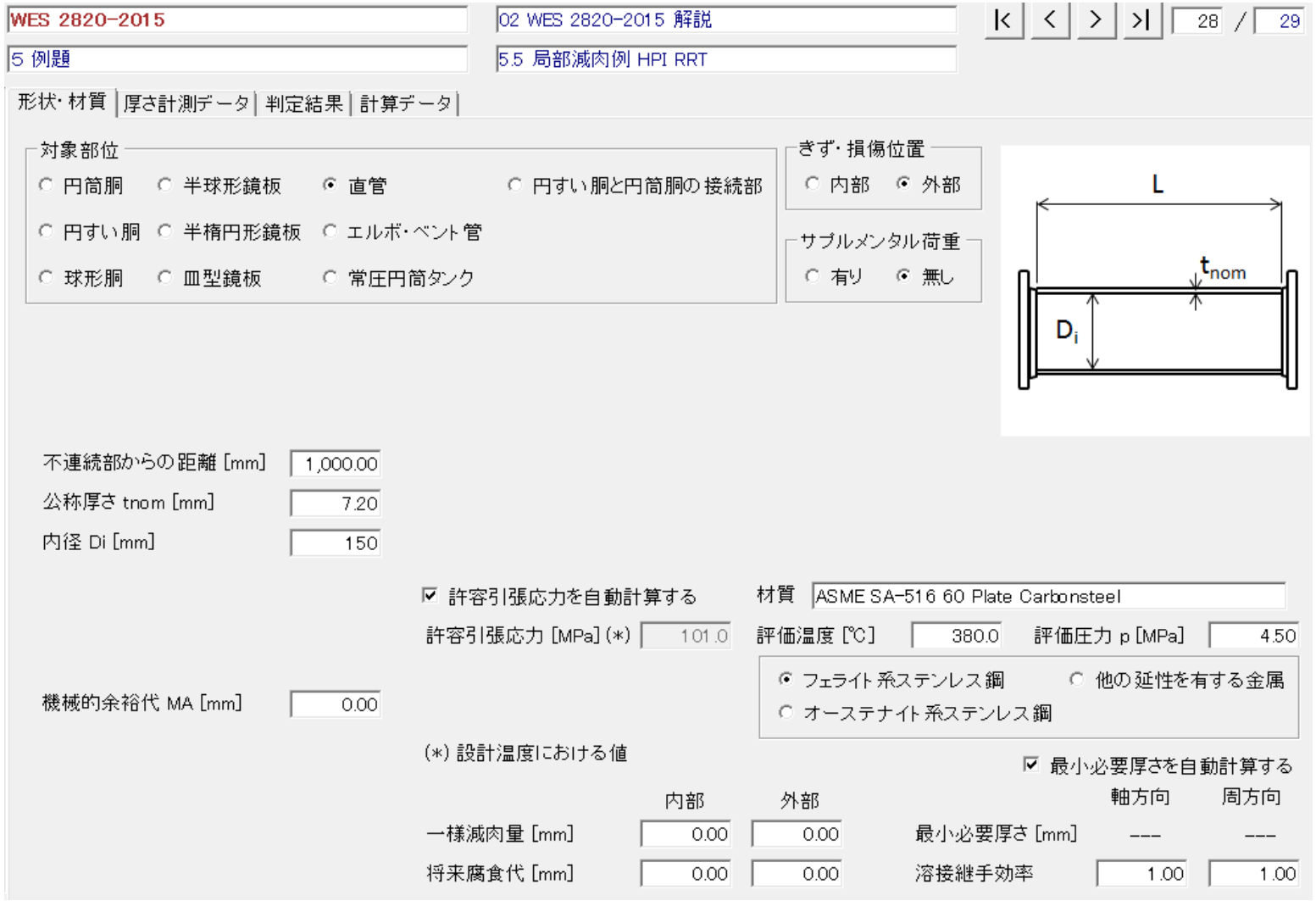


Corrosion color map



CSV data of the corroded area

Enter parameters of the pipe to analyze



Use “Uni-Fitness” by IMC

Standard to use for evaluation are

- ASME FFS-2 / API-579

English version is also available.

Load CSV data of thinned area

WES 2820-2015 | 02 WES 2820-2015 解説 | 28 / 29

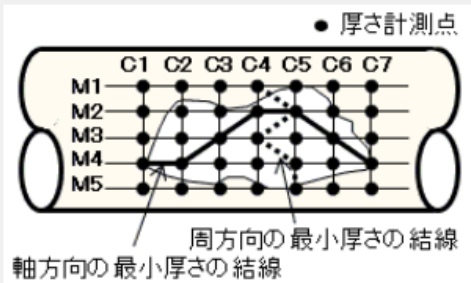
5 例題 | 5.5 局部減肉例 HPI RRT

形状・材質 | 厚さ計測データ | 判定結果 | 計算データ

厚さ測定法

○ 点厚さ測定法 ◉ 詳細厚さ測定法 ○ グループ

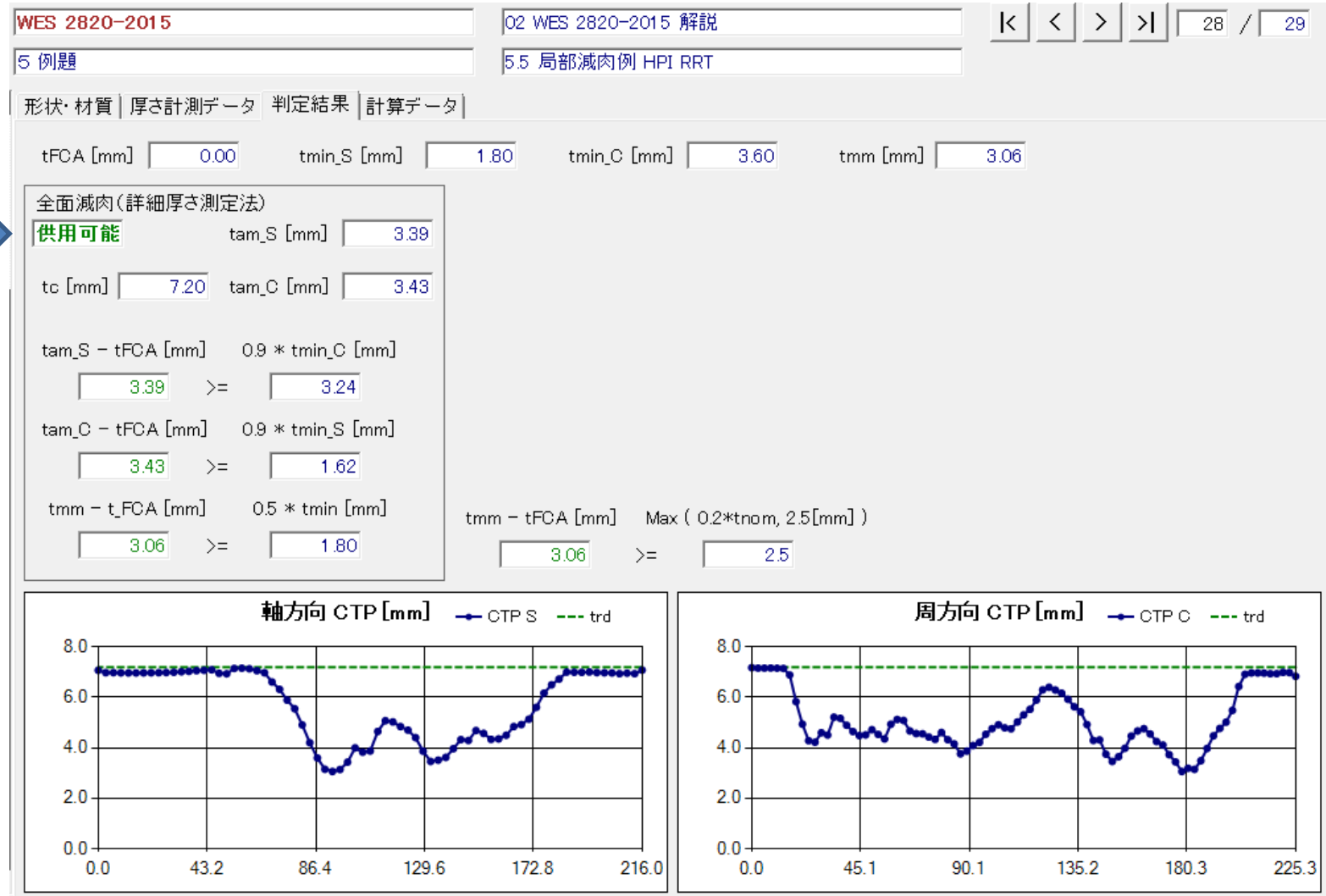
	軸方向	周方向	
測定点数	73	87	Excelデータの貼付け
グリッド間隔 [mm]	3.00	2.62	3DSLデータの取込み



	位置	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C
		0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	
M1	0.00	7.19	7.20	7.18	7.19	7.20	7.21	7.22	7.24	7.25	7.27	7.28	7.27	
M2	2.62	7.16	7.16	7.18	7.17	7.19	7.21	7.23	7.24	7.25	7.26	7.26	7.27	
M3	5.24	7.16	7.17	7.20	7.17	7.20	7.21	7.22	7.24	7.25	7.26	7.24	7.27	
M4	7.86	7.17	7.18	7.18	7.18	7.21	7.21	7.22	7.23	7.24	7.23	7.26	7.27	
M5	10.48	7.18	7.17	7.17	7.16	7.18	7.21	7.22	7.23	7.21	7.25	7.24	7.25	
M6	13.10	7.16	7.15	7.16	7.20	7.17	7.20	7.21	7.21	7.20	7.23	7.24	7.23	
M7	15.72	7.10	7.15	7.15	7.17	7.20	7.18	7.19	7.20	7.20	7.24	7.25	7.24	
M8	18.34	7.12	7.12	7.15	7.15	7.17	7.18	7.20	7.18	7.21	7.21	7.22	7.23	
M9	20.96	7.14	7.12	7.14	7.16	7.17	7.17	7.17	7.19	7.20	7.20	7.21	7.21	
M10	23.58	7.10	7.10	7.14	7.15	7.14	7.15	7.16	7.18	7.19	7.20	7.20	7.20	
M11	26.20	7.12	7.10	7.11	7.13	7.14	7.15	7.14	7.16	7.18	7.20	7.18	7.19	
M12	28.82	7.12	7.08	7.11	7.11	7.12	7.14	7.15	7.14	7.15	7.17	7.18	7.20	
M13	31.44	7.11	7.10	7.08	7.09	7.11	7.12	7.13	7.13	7.13	7.15	7.17	7.17	
M14	34.06	7.11	7.07	7.07	7.09	7.11	7.11	7.14	7.14	7.15	7.13	7.15	7.18	
M15	36.68	7.08	7.06	7.07	7.06	7.09	7.10	7.10	7.12	7.12	7.14	7.13	7.15	

Evaluation result

Pass

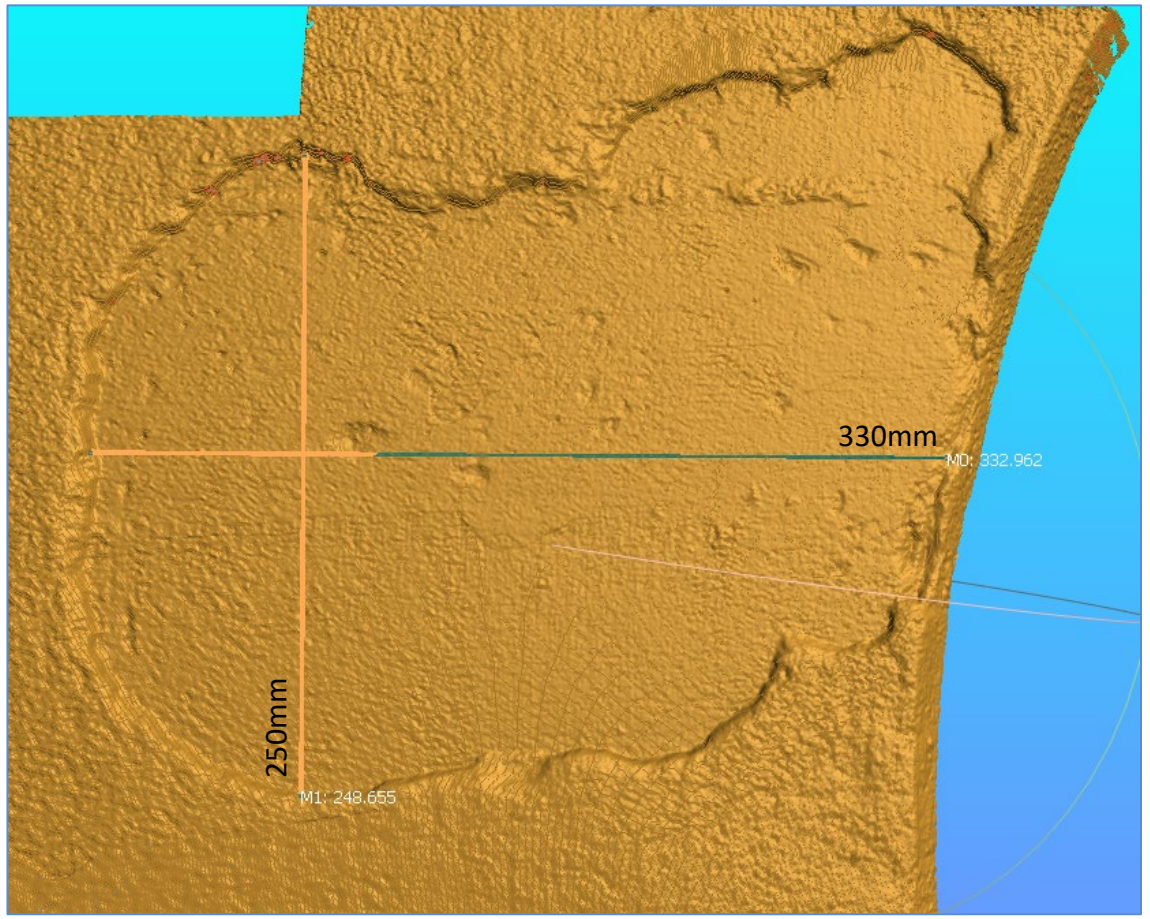


EXAMPLES OF CONCRETE STRUCTURE MEASUREMENT & ANALYSIS

Damage on concrete bridge

Measurement by 3DSL-Rhino

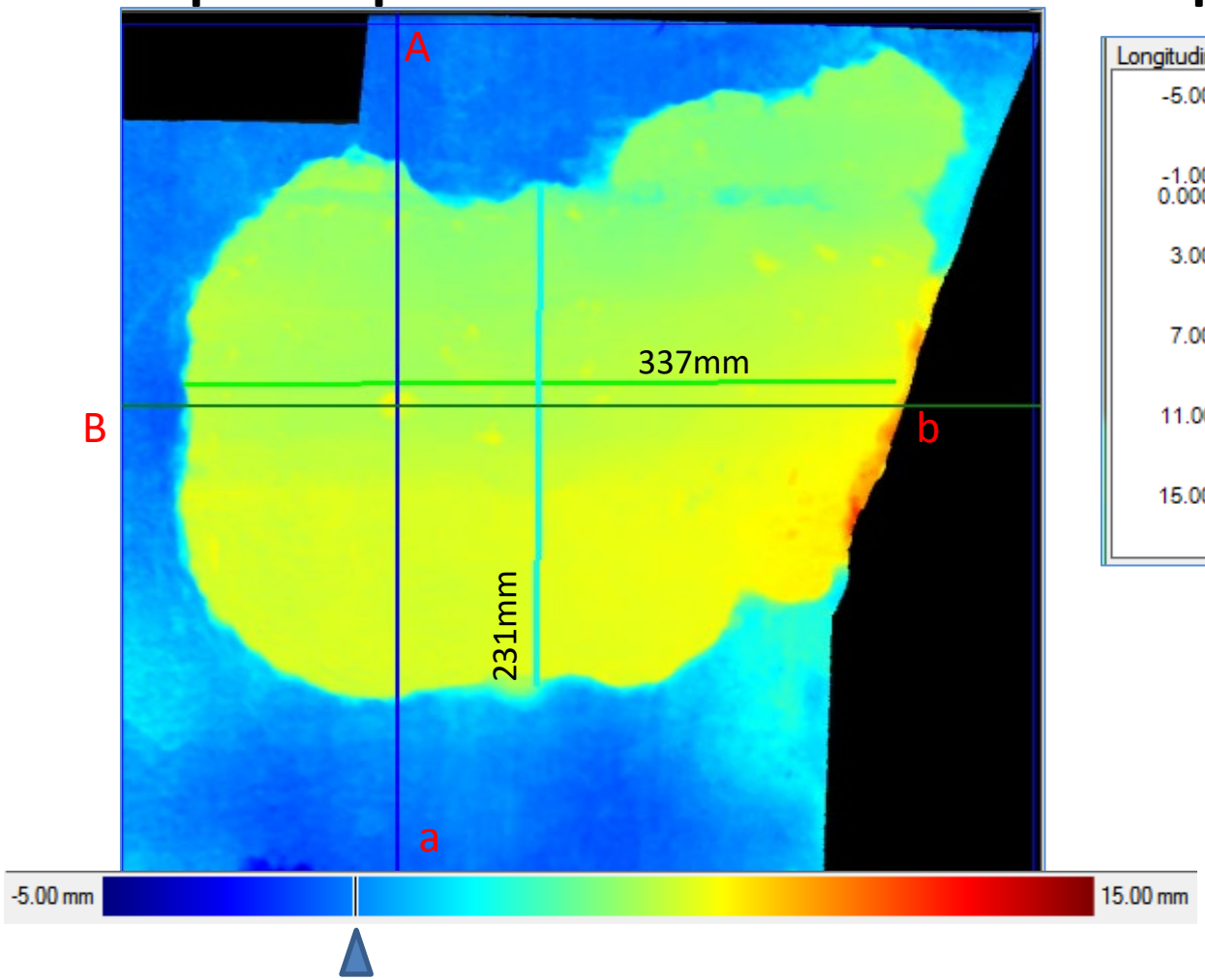
3D data



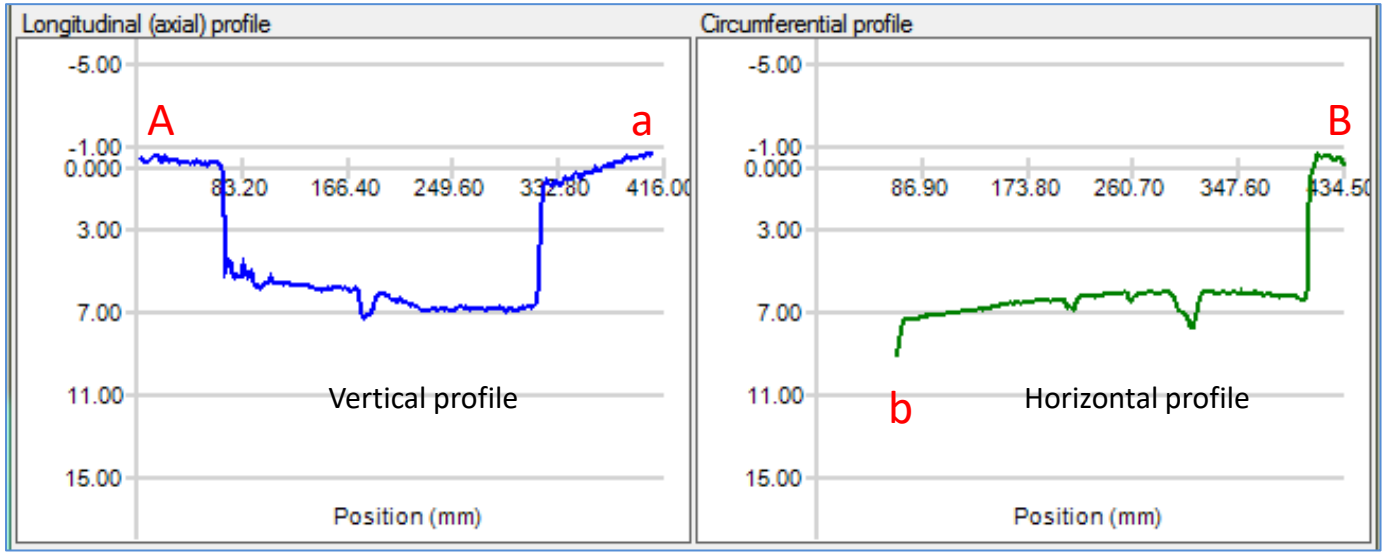
Total time for measurement and analysis is less than 1 minute.

Visualization with color map

Depth map



Depth Profile



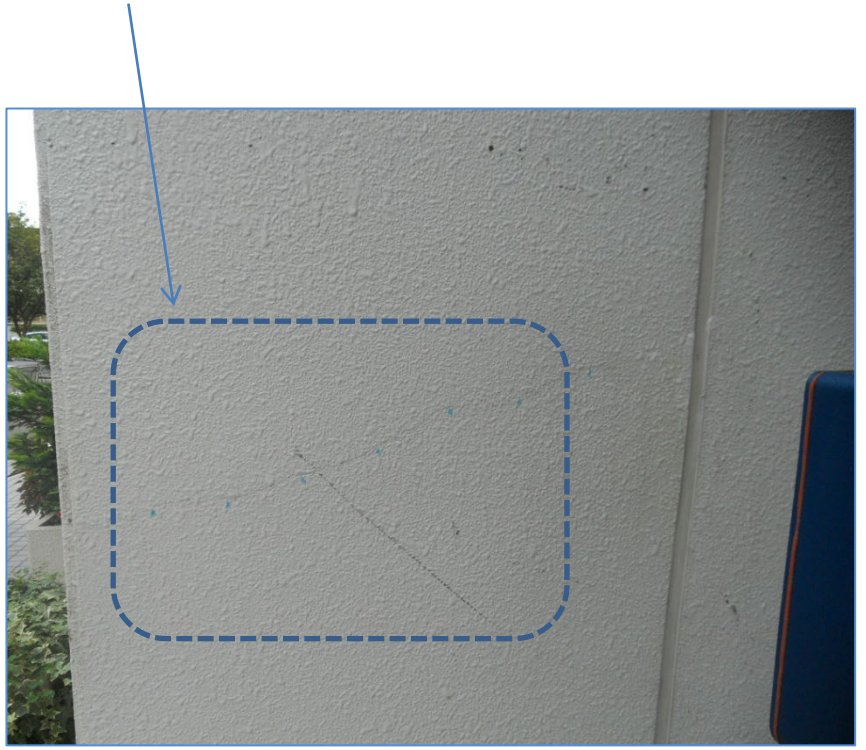
Feature	Volumetric Loss	Max Depth	Area	Width	Length
01	544603.10	11.65	176505.00	430.50	410.00
02	0.00				337.00
03	0.00				231.01

Lost volumn

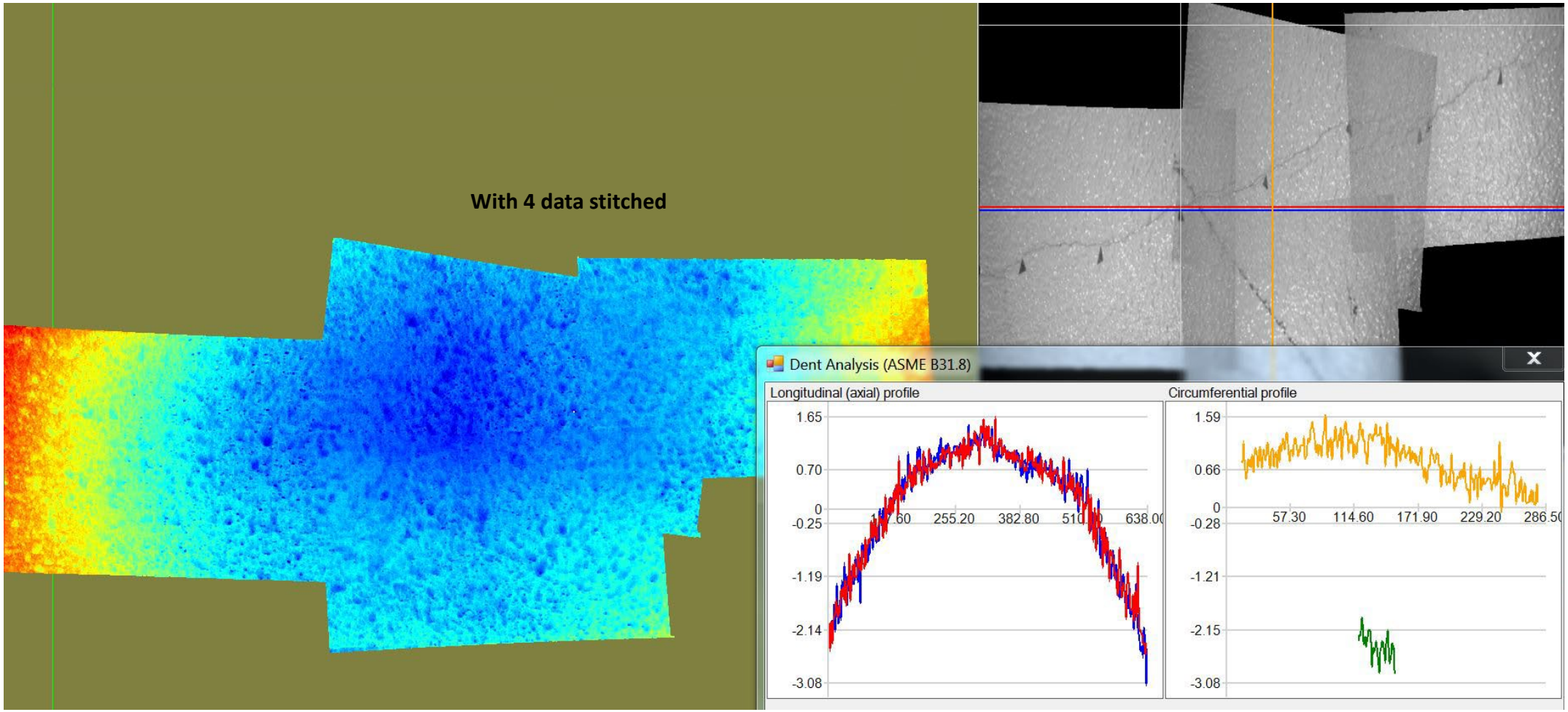
Swelling on concrete wall

Measurement

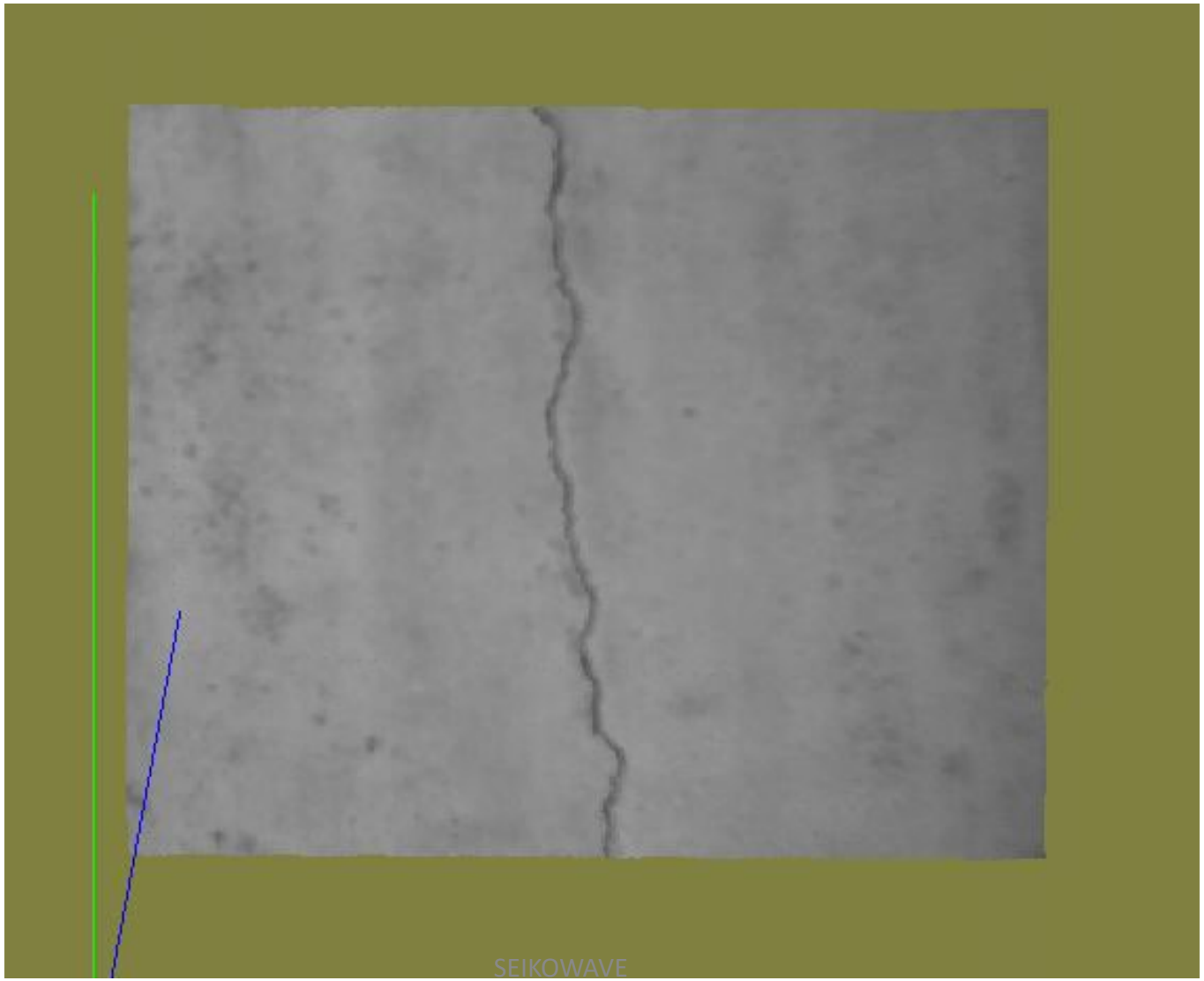
Area to analyze



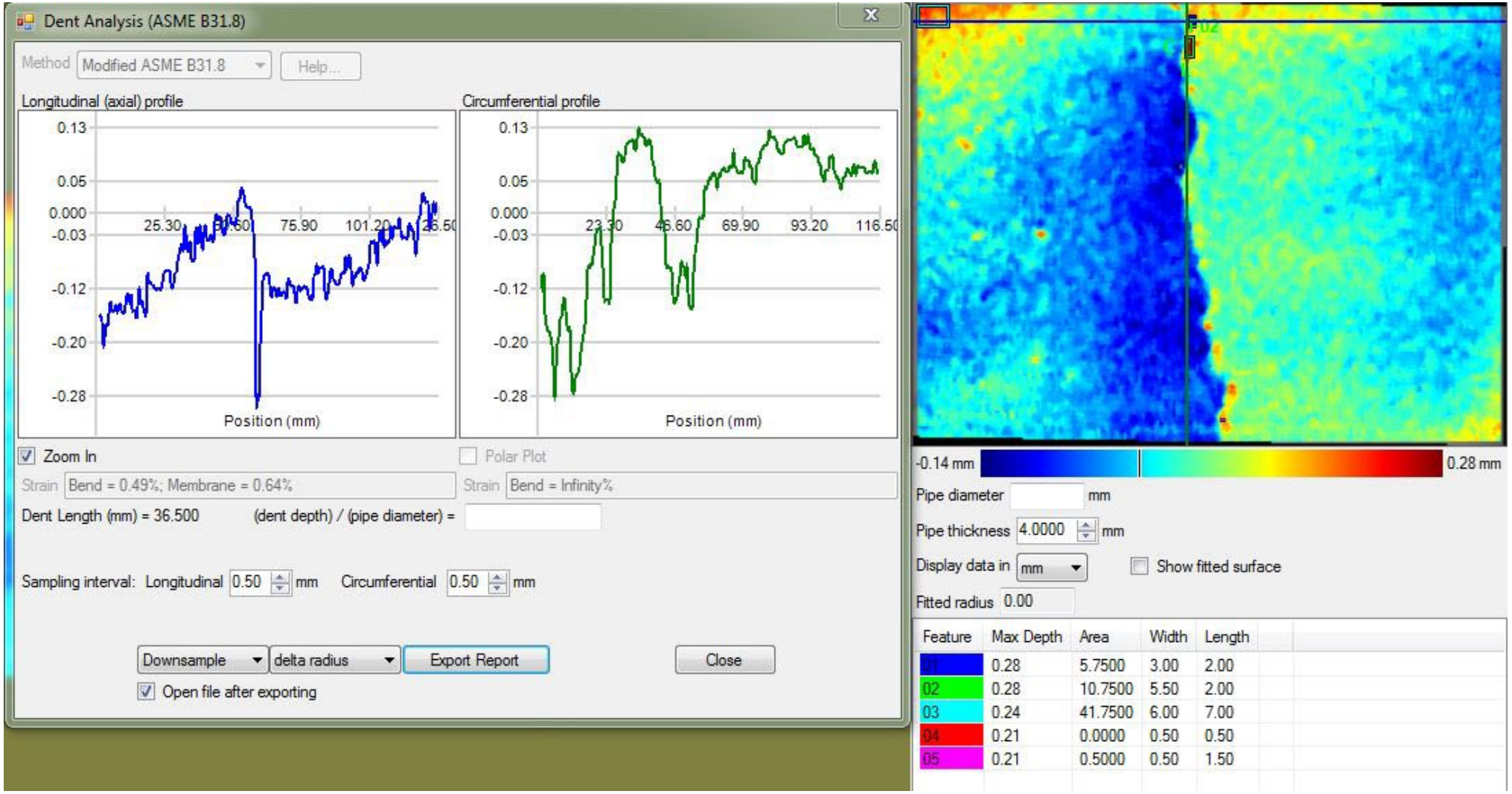
Visualization of swelling



Crack on concrete

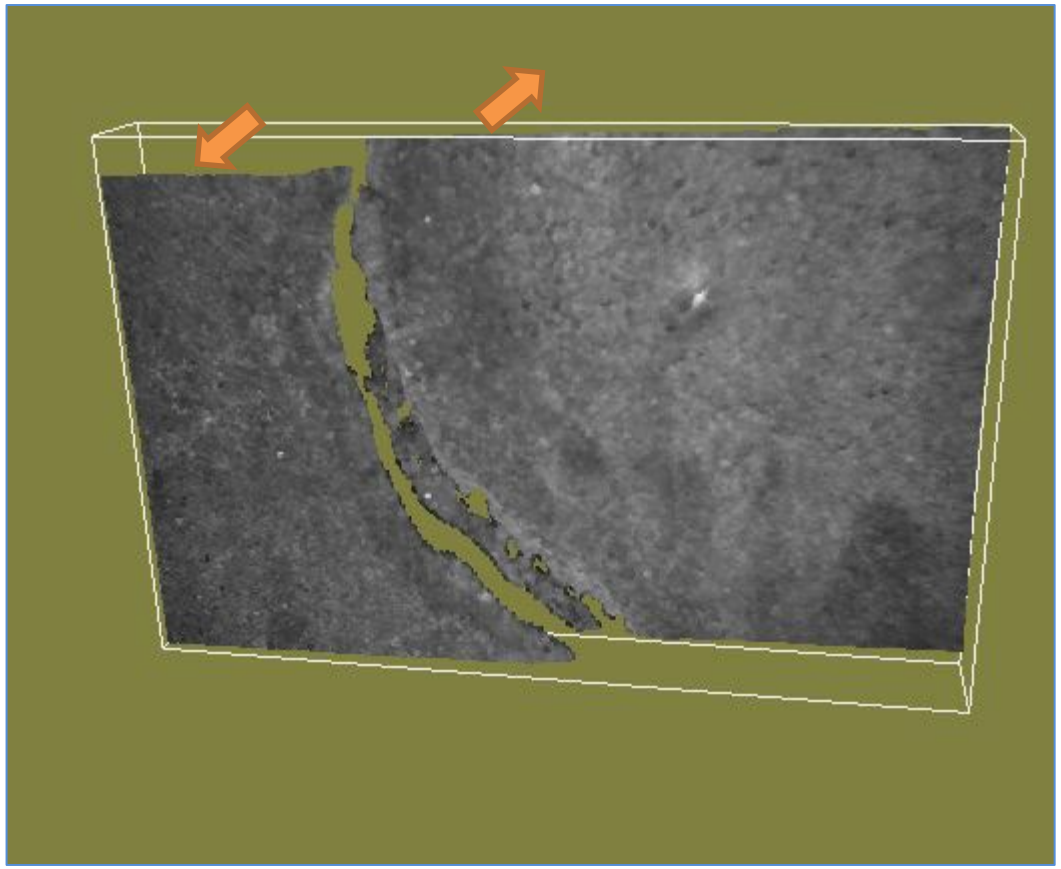


Visualization of crack

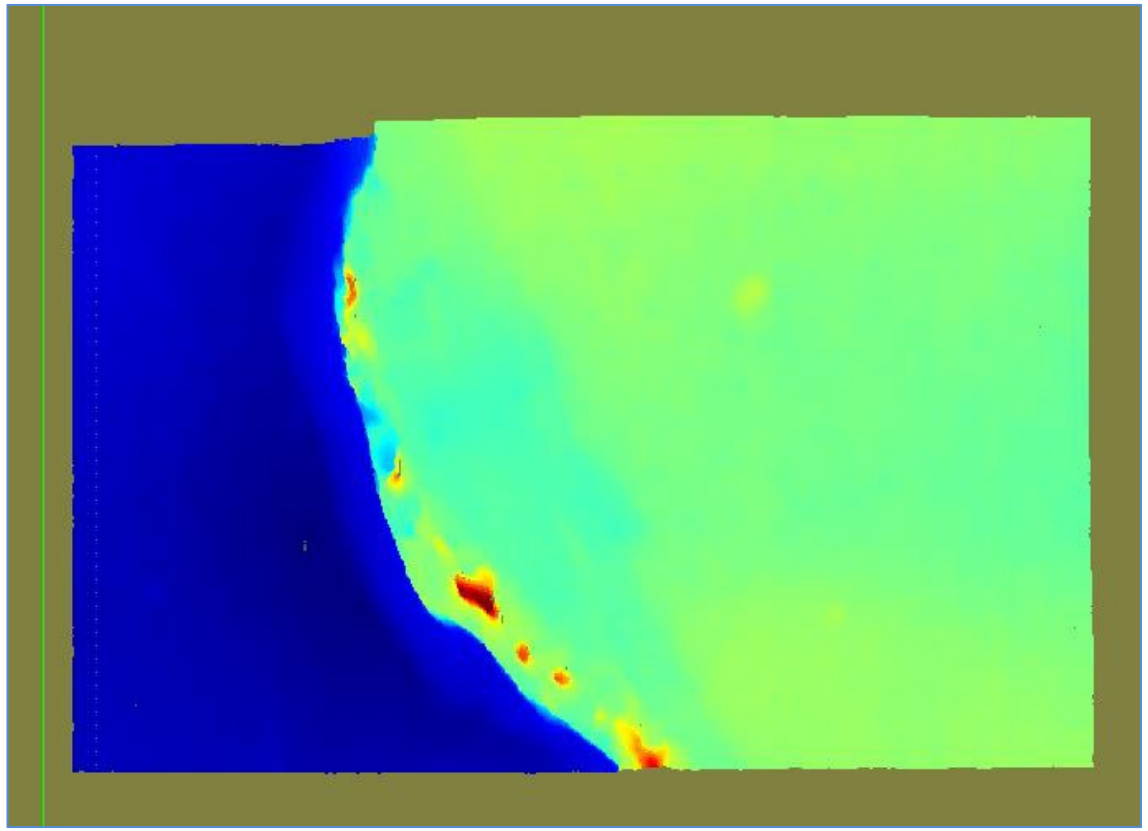


Damage on concrete after earthquake

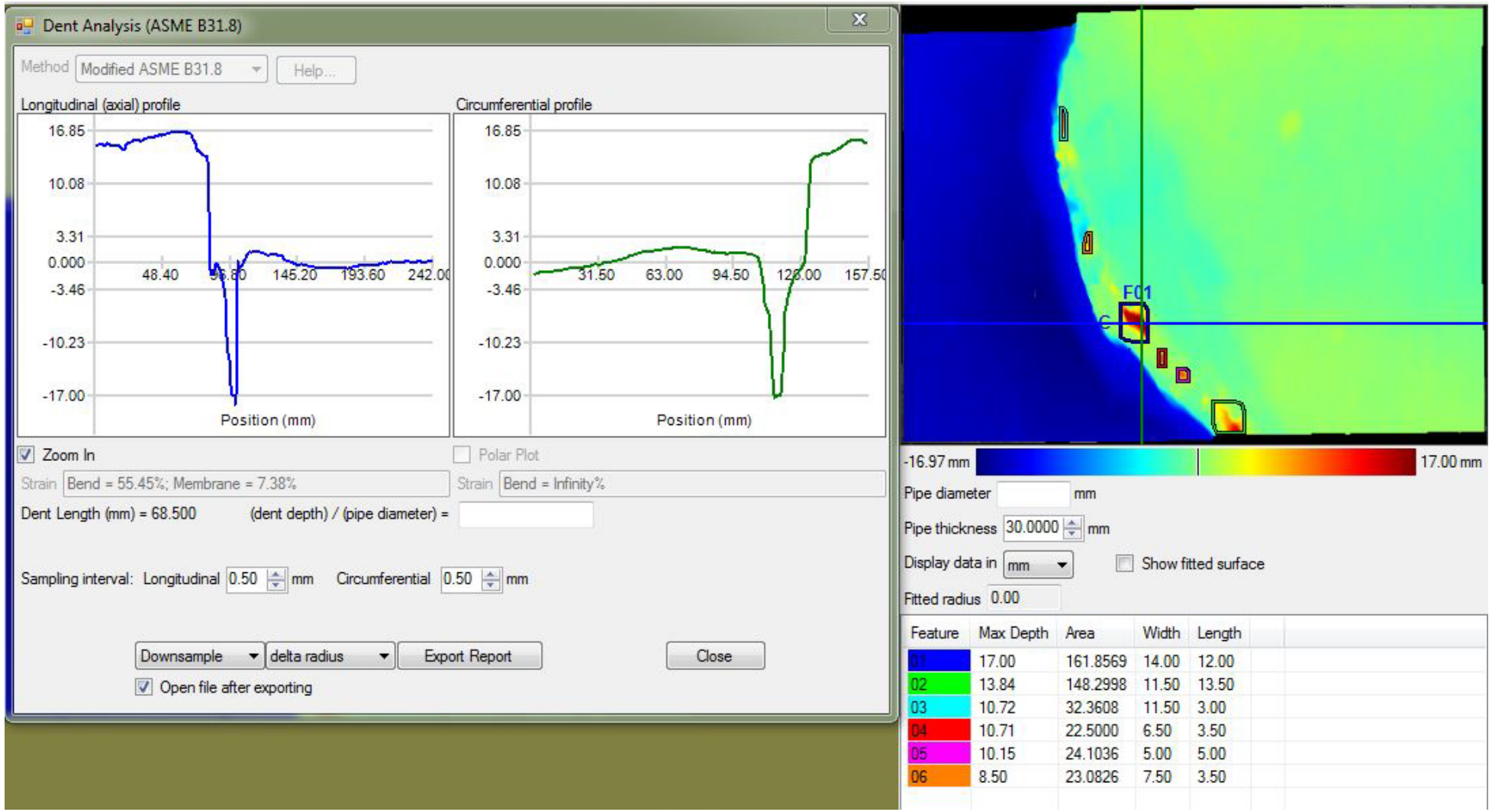
3D data



Color map

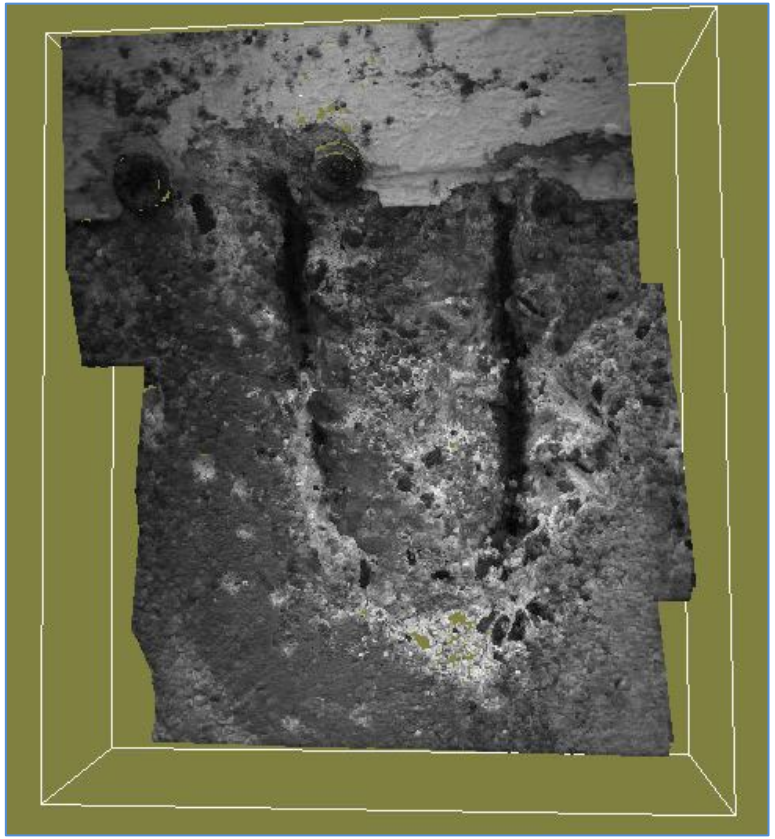


Profile of concrete surface



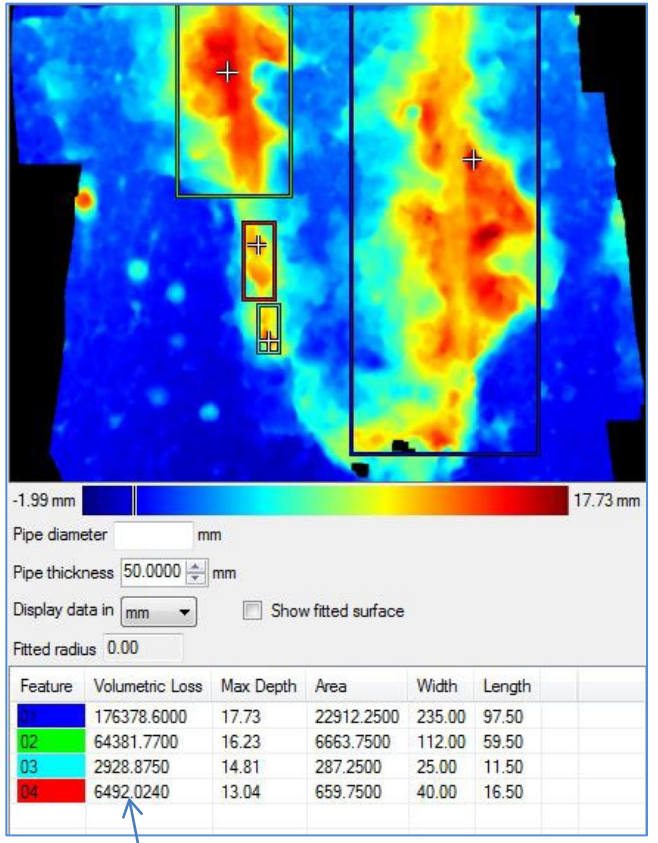
Damage of concrete surface due to Reinforcing bar swelling

3D data

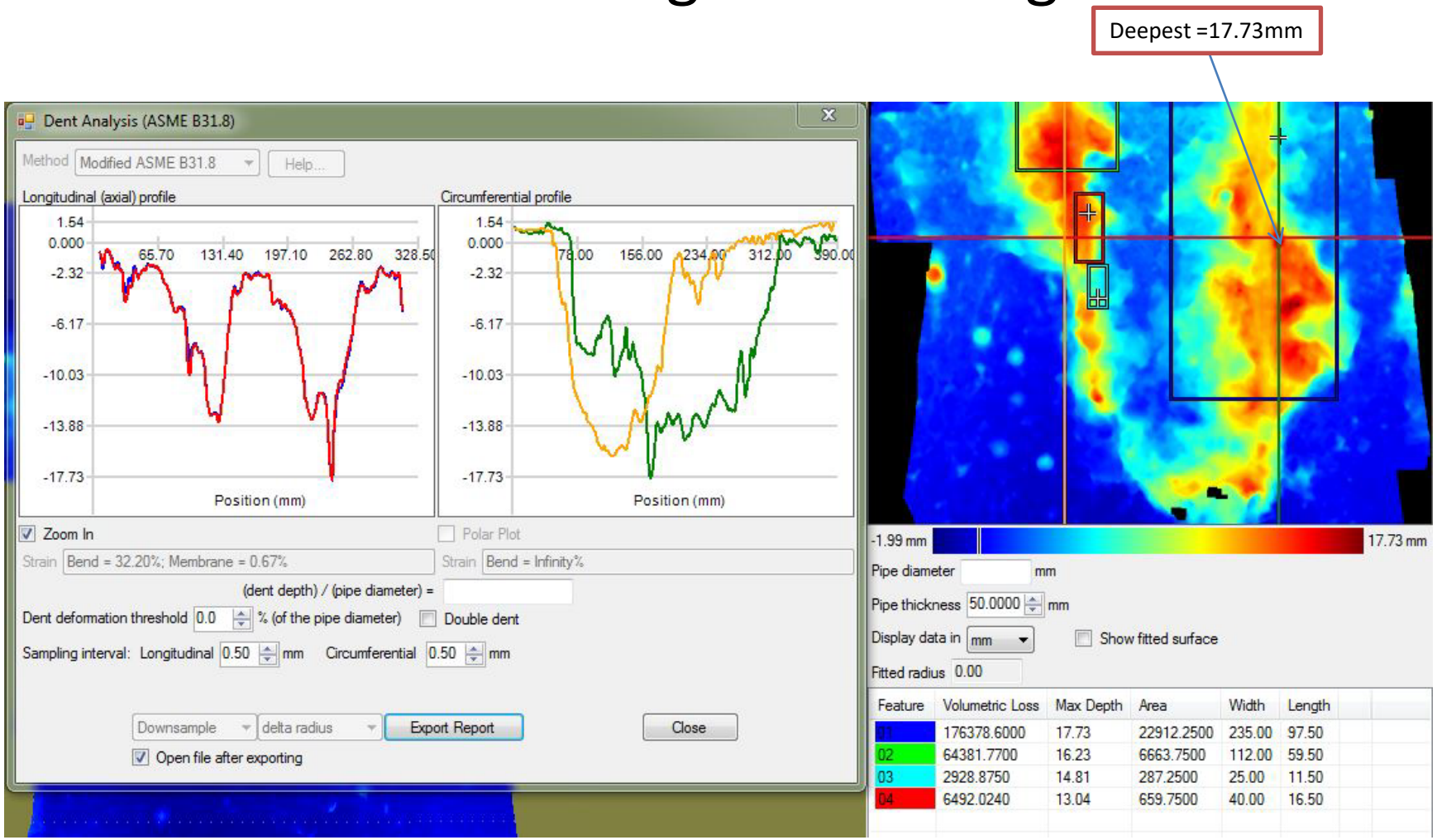


Courtesy by Prof. Kitano, Nagoya Univ.

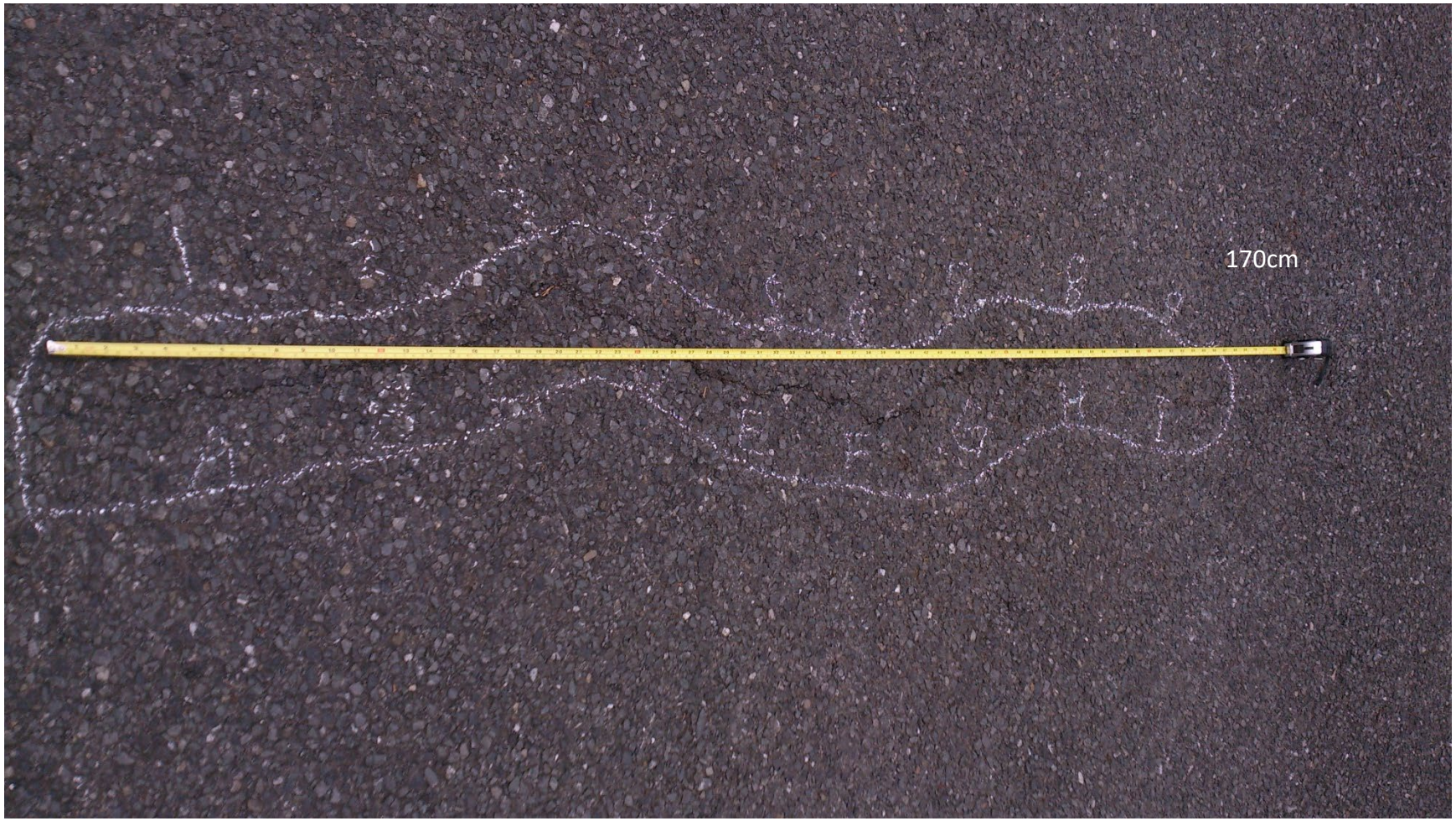
Color map



Damage of concrete surface due to Reinforcing bar swelling

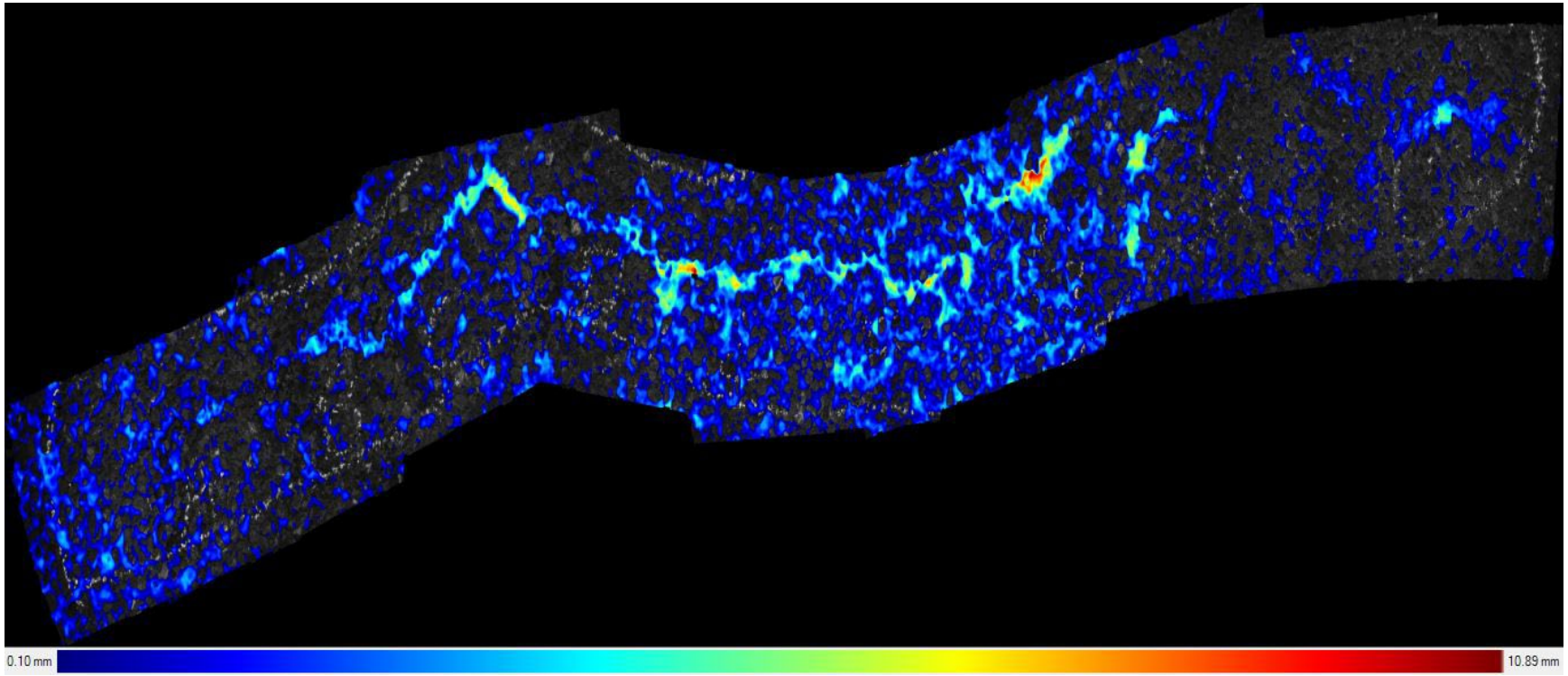


Cracks on the asphalt pavement



Cracks on the asphalt pavement

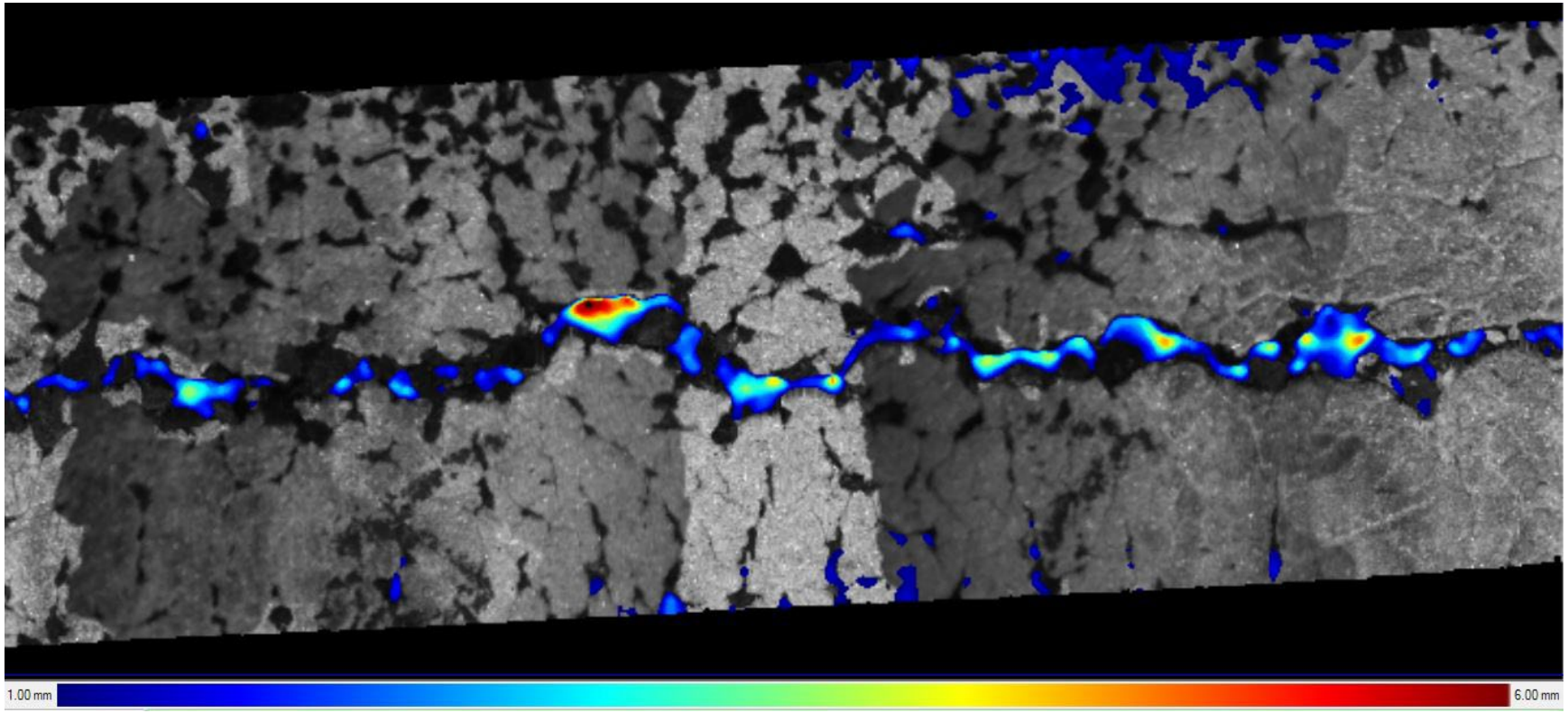
Local analysis



Cracks on the asphalt pavement

Cracks on the asphalt pavement

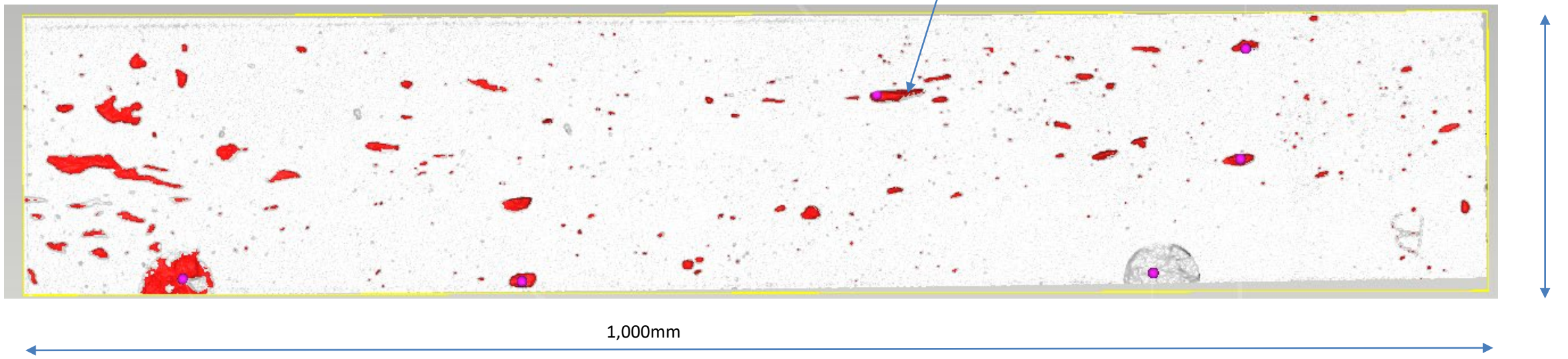
Colored only for 4mm or deeper



Analysis of Seismic isolation foundation concrete

Using a software, only voids with a depth of 0.5 mm or more and a length of 5 mm or more are colored, and the total area and area ratio are calculated (conventional manual work).

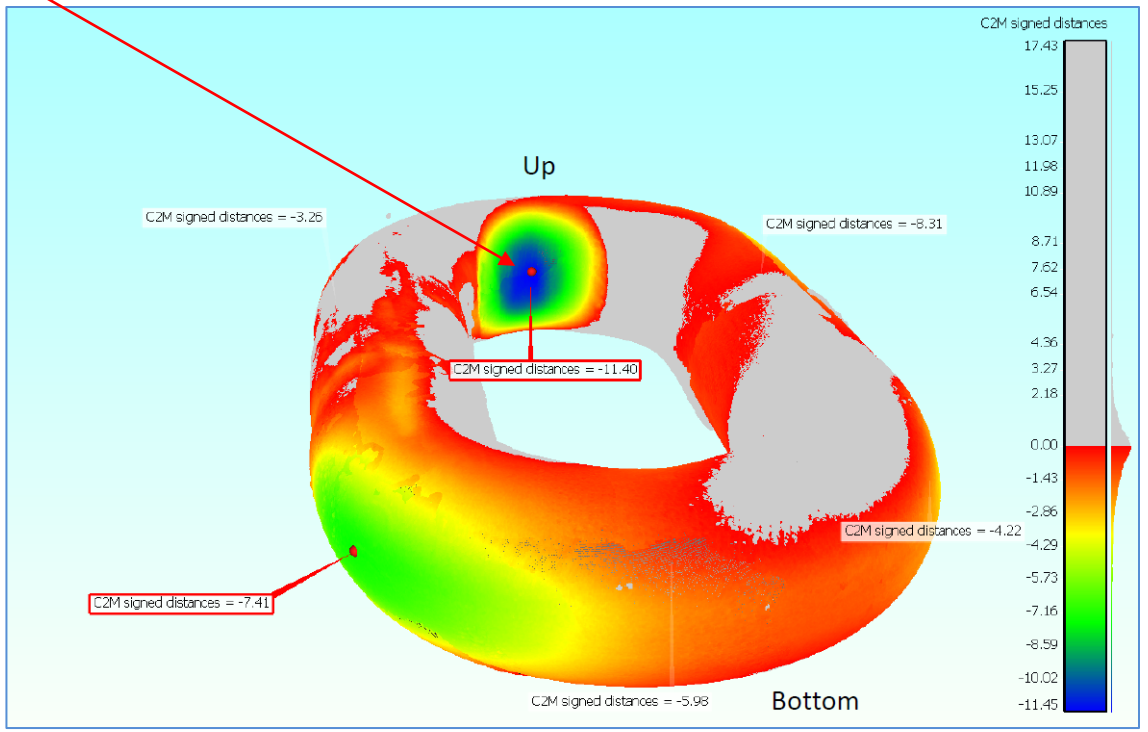
Total time for measurement and analysis is less than 30 minutes



All-around measurement and wear analysis of ship mooring chain

Wear location

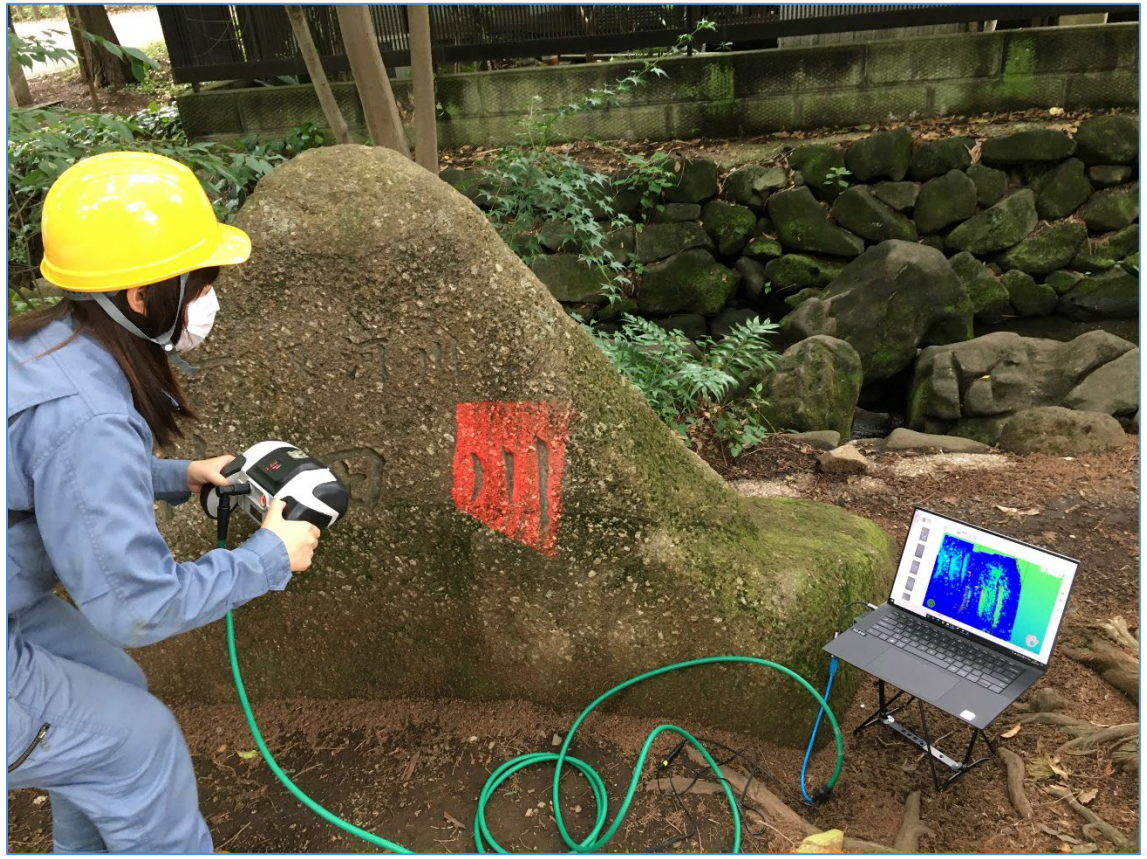
Corrosion location



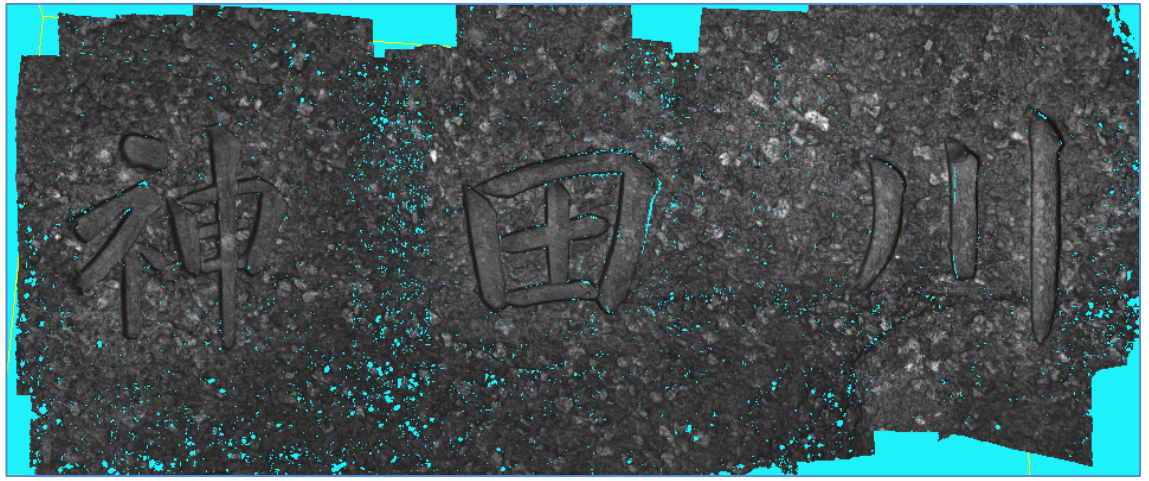
Total time for measurement and analysis is less than 30 minutes

Inscription on the stone monument

Measurement

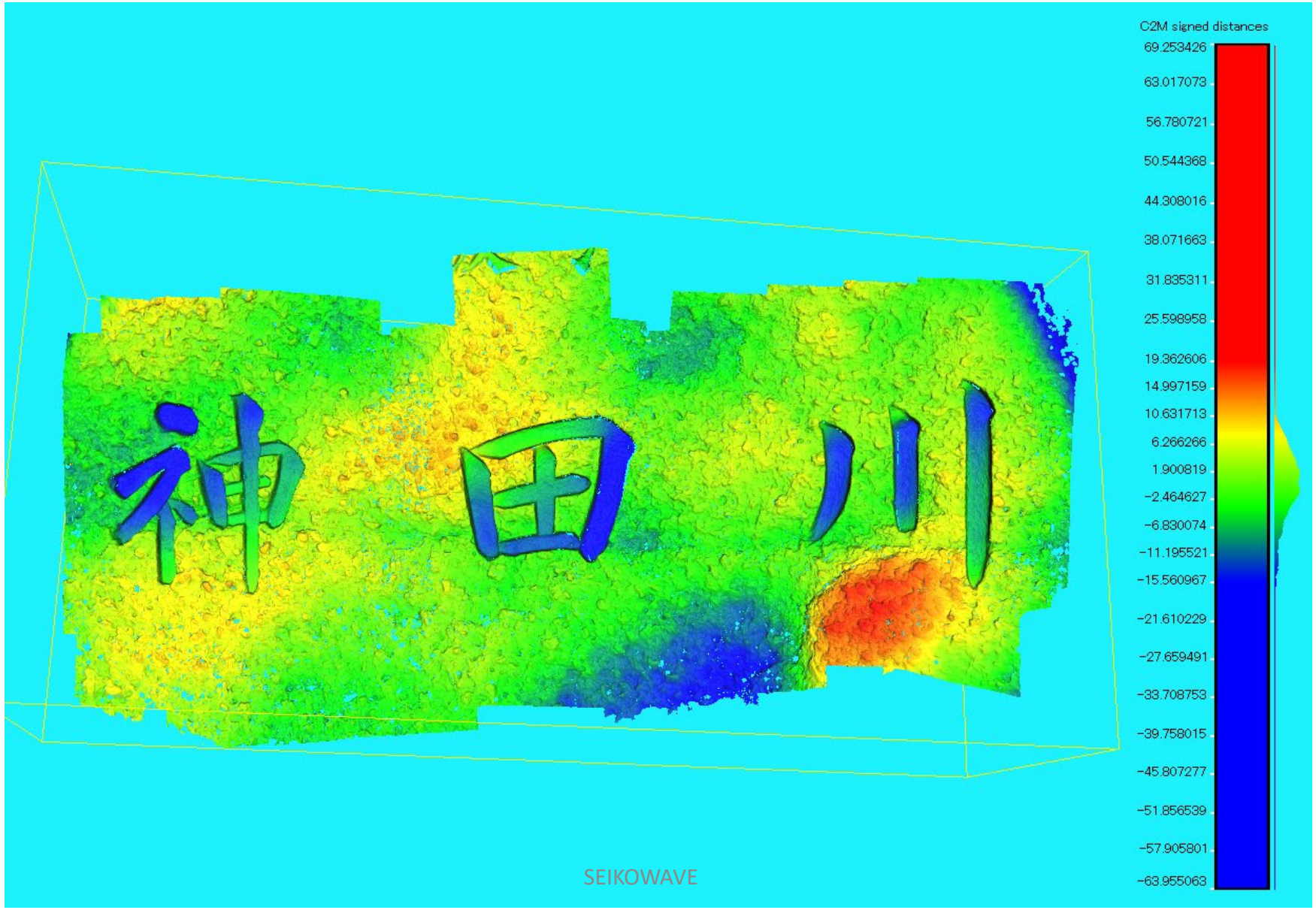


3D data



Total time for is less than 5 minutes

Clarification of the inscription on the stone monument



Conclusion

- Problem-solving proposal
  - Digitization and visualization of inspection points by pattern light projection
    - Measurement from a damaged surface is possible
    - By 3D coordinate conversion of the target location
      - Color contour diagram (visualization)
      - CSV file (quantified) for each grid
        - » Easy to understand the progress of deterioration
  - From subjective judgment to objective judgment by numerical value
    - By standardizing equipment and analysis means, anyone can obtain almost constant results.
      - Can be a trump card to solve the shortage of local human resources

Contact

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