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BASAL STUDY ON SIMPLE THICKNESS EVALUATION FOR ROAD-LIGHTING POLES WITH LOCAL CORROSION NEAR THE BASEPLATE

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In this study, a simple thickness evaluation method was proposed for corroded road-lighting poles based on thickness measurement results of a dismantled road-lighting pole which had been used for about 40 years. The remaining thickness in cross-section of this specimen was measured by using both of Ultrasonic Thickness Gauge (UTG) and 3D portable laser scanner in order to investigate the accuracy of average thickness which could be obtained from only 4 measuring points at intervals of 90 degrees in circular cross-section. In this UTG measurement, the smoothing process, which will be carried out ordinarily by using electric grinder around measuring points, was abbreviated from the considering of labor-saving and additional thickness loss. From the measurement results, UTG measurement under the condition of no smoothing process will overestimate the actual remaining average thickness depending on surface roughness due to corrosion. Finally, an example of simple thickness evaluation, which uses average thickness and standard deviation based on only four measuring points, was shown for more reasonable UTG inspection of corroded road-lighting poles.

Keywords: Corrosion, Lighting pole, Average thickness, Ultrasonic thickness gauge.

1 INTRODUCTION

In recent years, the collapse of road accessory poles, such as road-lighting or traffic signs, are gradually increasing in Japan. One of the reasons for this problem is severe corrosion damage near the baseplate due to aging deterioration. In common inspection for corrosion damage of road-lighting poles, Ultrasonic Thickness Gauge (UTG) was applied to calculate the remaining average thickness of the cross-section in h < 60 mm (h: height from upper surface of baseplate) after visual observation. This UTG inspection was carried out when obvious corrosion damages were found in visual observation, and four measuring points at intervals of 90 degrees in circular cross-section are measured for calculating average thickness. Here, it must be considered that the number of road-lighting poles is very large in periodic inspection method. On the basis of mentioned above, UTG inspection will have some latent problems for improving to more reasonable method, as follows:

1) The steel surface with more large roughness due to corrosion may deteriorate the accuracy of UTG measurement results.

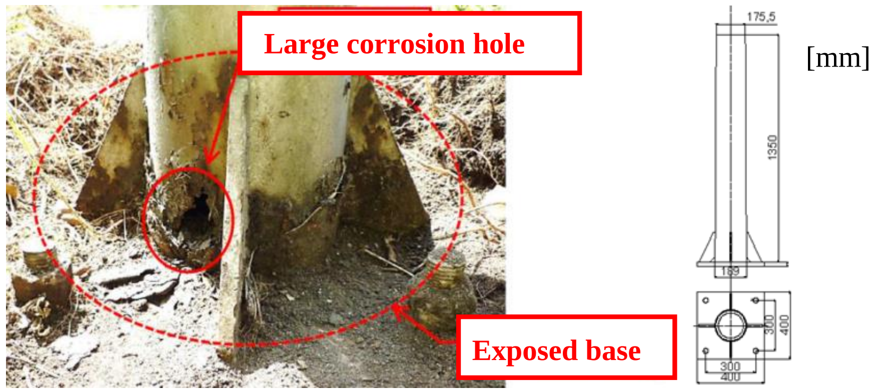


Photo 1. In-situ condition and dimensions of road-lighting pole specimen.

2) The smoothing process, which will be carried out by using electric grinder around measuring points, will generate additional loss of working time and thickness.

In this study, a simple thickness evaluation formula was proposed for corroded road-lighting poles based on UTG measurement results (25mm measuring intervals) of an actual dismantled steel pole. The remaining thickness in cross-section was measured by using both of UTG and 3D portable laser scanner (3D scanner) in order to clarify the accuracy of UTG measurement under the condition of no smoothing process.

2 CORRODED POLE SPECIMEN FOR THICKNESS MEASUREMENT

The corroded pole specimen in this study is a dismantled road-lighting pole, which had been used for about 40 years at coastwise road in Yamaguchi prefecture, with severe local corrosion near the baseplate. Photo 1 shows in-use condition and dimensions of this specimen. This pole has 4 stiffening ribs (t = 12 mm) on a baseplate, but this baseplate was covered with many clod and weed. The distance from coast of Seto Inland Sea was only 100 m. In Photo 1, a large corrosion hole between 2 ribs could be confirmed near the baseplate. The initial thickness (t_0) of this pole would be 4.5 mm.

3 REMAINING THICKNESS MEASUREMENT FOR SPECIMEN

3.1 Thickness Measurement using 3D Scanner and UTG

Before the thickness measurement, remaining paints and rusts on steel surface were removed by sandblast. The range of thickness measurement is 0 mm < h < 250 mm. At first, the portable 3D scanning system was applied to thickness measurement of specimen. This system can obtain 3D coordinate values of steel surface at the intervals of less than 1 mm by irradiating 2 wide laser beams (measurement accuracy: 50 μm). Then the remaining thicknesses of specimen were calculated from two-sided 3D coordinate values at 2mm mesh. In this study, the thickness measurement results obtaining by using 3D scanner ware treated as the most probable value. In this study, the thickness measurement results by using 3D scanner are treated as the most probable values. The thickness contour map of specimen is shown in Figure 1 as development diagram. From this figure, it will be found that severe corrosion damages progressed

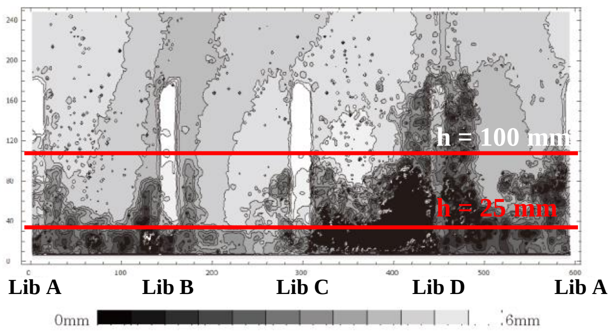


Figure 1. Thickness contour map (3D scanner).

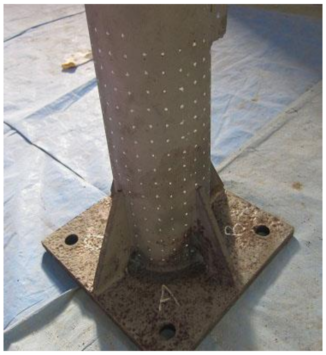
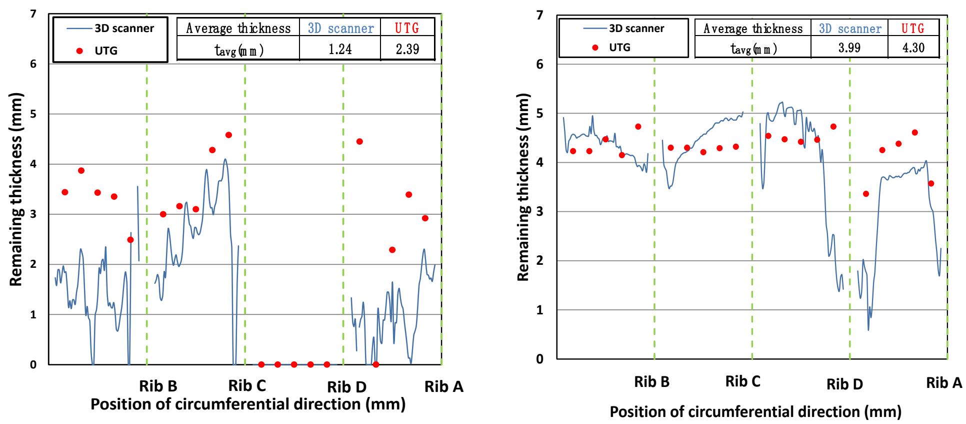


Photo 2. Measuring points for UTG.



(a) h = 25 mm.

(b) h = 100 mm.

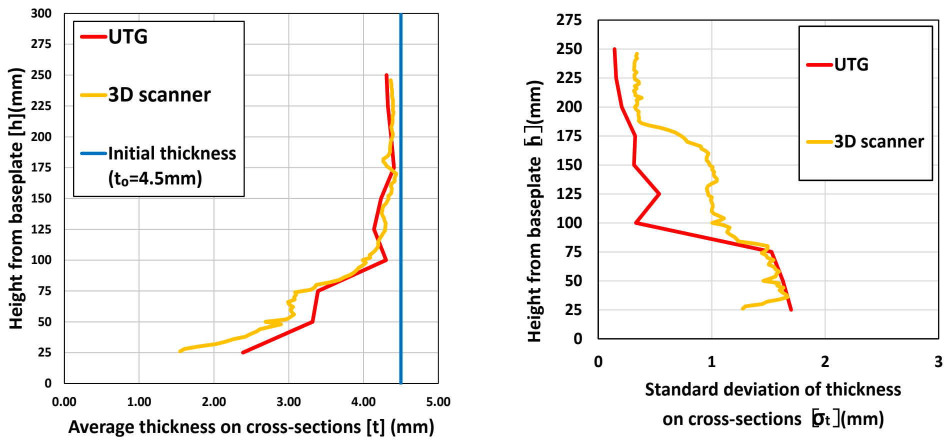
Figure 2. Remaining thickness distributions in a cross-section.

near the baseplate under h < 75 mm. Especially, a large corrosion hole between Rib C and D is marked, since both ribs were in a direction towards seaside while in use.

On the other hand, UTG measurement was carried out without smoothing process around measuring points at 25 mm mesh as shown in Photo 2. The circular contact probe (ϕ9 mm, ultrasonic velocity: 5,920 m/sec, frequency: 5 MHz, measurement accuracy: 10 μm) and pipe measurement jig were applied for this measurement.

3.2 Comparison of Measurement Results

Figure 2 shows the examples of remaining thickness distribution obtained from 3D scanner and UTG measurement results in a cross-section of h = 25 mm and 100 mm. The number of measuring points per one cross-section are 254 (3D scanner) and 20 (UTG), respectively. In Figure 2(a), it could be noticed that the UTG results (red dots) are greater than that of 3D scanner. And, the average thickness calculated from UTG



(a) Average thickness.

(b) Standard deviation of thickness.

Figure 3. Relationship between h and statistical thickness parameters.

results was overestimated about 1.15 mm than actual thickness. However, in the h = 100 mm section, which has minor corrosion as compared to the section of h = 25 mm, the measuring results obtained from 2 different devices significantly approximated each other, as shown in Figure 2(b). From these facts, it is thought that overestimation of remaining thickness in UTG measurement was caused by surface roughness due to severe local corrosion. In addition, the average thickness and thickness distributions of 3D scanner and UTG are almost the same at the section in the range of h > 100mm.

Figure 3 shows the relationship between h and statistical thickness parameters. From Figure (a), the average thickness (t_{avg}) in a cross-section was decreased remarkably in the range of h < 75 mm. In this portion, it is thought that the clod and salty weed on baseplate would accelerate corrosion progress. And, it can be confirmed that the UTG measurement is more likely to overestimate remaining thickness when the height from baseplate is smaller. Figure (b) shows the relationship between h and standard deviation of thickness (σ_t). In the range of h > 75 mm, because many pitting corrosion which has the diameter smaller than that of UTG probe are distributed widely on steel surfaces, UTG probe cannot measure the corrosion wastage by their pitting corrosion. Therefore, σ_t of UTG results will become smaller than that of 3D scanner. On the other hand, in the range of 25 mm < h < 75 mm, because the large corrosion pits, which may affect to the average thickness, are generated all over the surface, it can be thought that the variation of measured thickness is a little more than 3D scanner.

4 A SIMPLE THICKNESS EVALUATION METHOD BY USING UTG

4.1 Concept for Simple Evaluation Method for Average Thickness

According to the inspection manual for road-lighting structures and traffic signs published Ministry of Land, Infrastructure, Transport and Tourism in Japan, UTG inspection is carried out when obvious corrosion damages were found in visual observation, and 4 measuring points at intervals of 90 degrees in circular cross-section are measured for calculating average thickness.

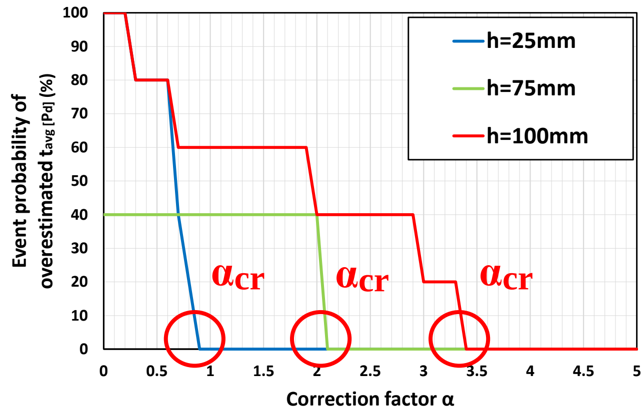


Figure 4. Event probability of overestimated P_d.

However, it was confirmed that UTG will tend to overestimate the remaining thickness than in reality, from the measurement results. Therefore, it is thought that the thickness evaluation method, which can obtain the average thickness by using only 4 measurement results with considering of safe side, will be required for more reasonable UTG inspection. And, not only the average thickness but also the condition of surface roughness due to corrosion should be included to the thickness evaluation formula. So, a simple thickness evaluation formula was proposed in this study as follows:

$$t_m = t_{avg} - \alpha \times \sigma_t \quad \text{.....................................(1)}$$

Here, t_m: modified average thickness toward safe side, t_{avg}: average thickness of 4 measuring points, σ_t: standard deviation of 4 measuring points. The parameter α is a correction factor for deducting overestimated thickness depending on σ_t.

4.2 Discussions of Correction Factor

Figure 4 shows the relationship between the event probabilities of overestimated average thickness P_d and the thickness correction factor α. Event probabilities P_d can be calculated by counting the number of overestimated cases in all combinations of measuring unit, as shown in Figure 5.

These overestimated cases mean the modified average thickness t_m, which was obtained from Equation (1), was greater than the actual average thickness (obtained from 3D scanner). Correction factor α was changed numerically at the intervals of 0.1, after counting the number of overestimated cases. From Figure 4, it will be found that the event probabilities P_d will decrease with an increase in correction factor α. From this calculation, the critical correction factors α_{cr} when P_d reached 0% were decided in the case of h = 25 mm,75 mm, 100 mm. Figure 6 shows the relationship between α_{cr} and σ_t. In this figure, σ_t was obtained from 20 measuring points cross-section at h = 25 mm, 75 mm, 100 mm, respectively. If the correction factor α was decided from relationship such as Figure 6 by using the measurement result of only four measuring points, the average thickness will be modified easily from Equation (1) toward the safe side with consideration of the roughness condition (σ_t) of corroded surface. However, it should be noted that the α_{cr}-σ_t relationship will requires the investigation for more cases of other corroded road-lighting poles in order to enhance reliability and generality.

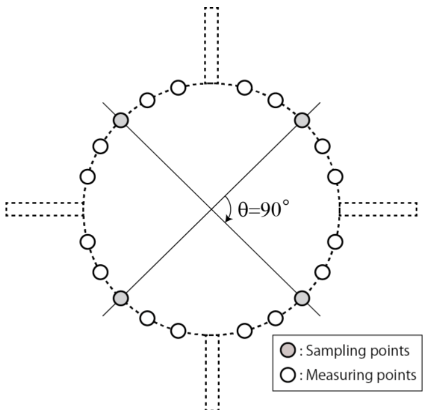


Figure 5. A measuring unit with 4 sampling points.

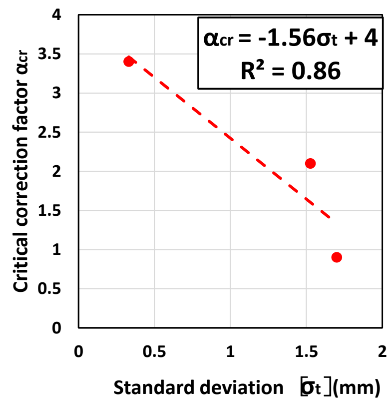


Figure 6. α_{cr}- σ_t relationship.

5 CONCLUSIONS

The remaining thickness measurements of a dismantled road-lighting pole were carried out focusing on the local corrosion near the baseplate. In this thickness measurement, two devices were applied in order to investigate the accuracy of UTG measurement.

From the measurement results, UTG measurement under the condition of no smoothing process will overestimate the actual remaining average thickness depending on surface roughness due to corrosion. Finally, an example of simple thickness evaluation, which uses average thickness and standard deviation based on only 4 measuring points, was proposed by using Equation (1) for more reasonable UTG inspection of corroded road-lighting poles. In this equation, the correction factor α should be decided from focusing attention on standard deviation of thickness.

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