New Attempt to Maintenance of Steel Bridge Coating in Expressway

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Abstract

In the steel bridge of the expressway in NEXCO, most of the rust prevention and protection method is painting. To reduce cost of the painting maintenance, the realization of an effective painting repair technique is necessary.

To solve this problem, we attempted a basic study on non destructive inspection technique with terahertz wave to grasp the corrosion degree under the coating, and confirmation about the effect of the simple coating removal technology using the special tool experimentally on the site. In this paper, summary and test result of these technique is described.

Introduction

Now, the expressway length that NEXCO manages is 8,732km[1)2)3)]. As for the road structure ratio of the road structure, earthwork is about 75%, tunnel is about 10%, and bridge is about 15%. The bridge length is about 1,150km, and the number is 6700 bridges. As for the bridge type ratio, concrete bridge is about 70% and steel bridge is about 30%, the steel bridge length is about 2100km[4)].

In the maintenance cost of the bridges, repair paint of the steel bridges accounts for most. Because it is predicted that these cost will be increased in future, a new effective paint repair technique is required.

From the background, we attempted two experimental study about a new paint repair technique. This report discuss the outline of these method.

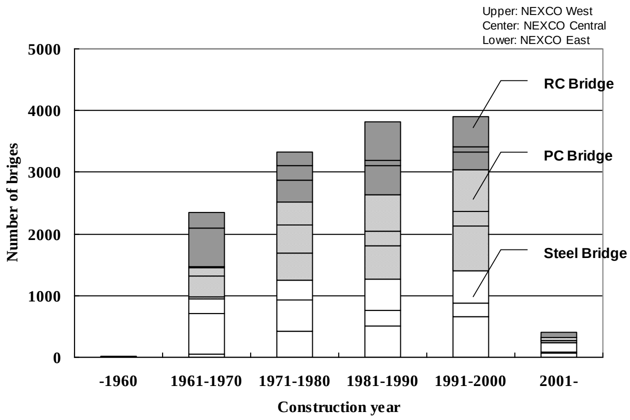

Fig.1 Bridge type ratio of expressway managed by NEXCO

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The maintenance Problem of the painting in the steel bridge

In the steel bridge of NEXCO more than 90%, the painting is used for rust prevention. The change of repainting coating specifications for general environment in NEXCO is shown in Fig.2.[5)] As you can see, we changed its specification from general coating to heavy duty coating, considering life cycle cost and minimum maintenance.

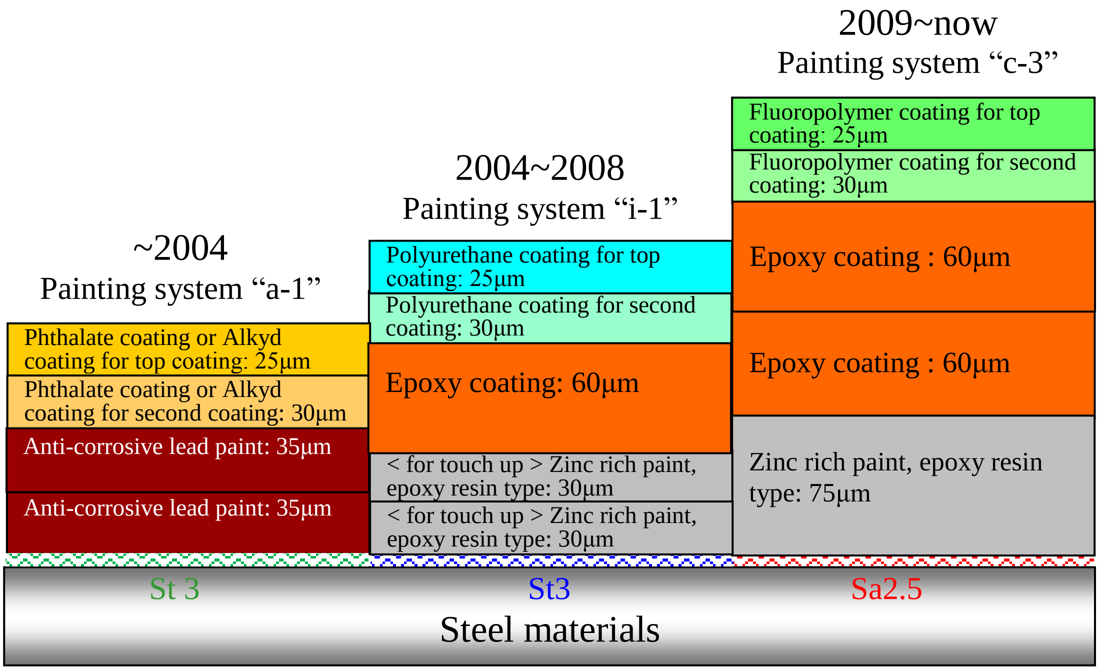


Fig.2 The change of painting specifications in NEXCO

For maintenance of the painting in NEXCO, Paint View System have been used. Paint View System detects the deteriorated coating with photograph, and it can judge necessity of painting repair from deterioration forms and the deterioration area ratio of the coating (Fig.3).

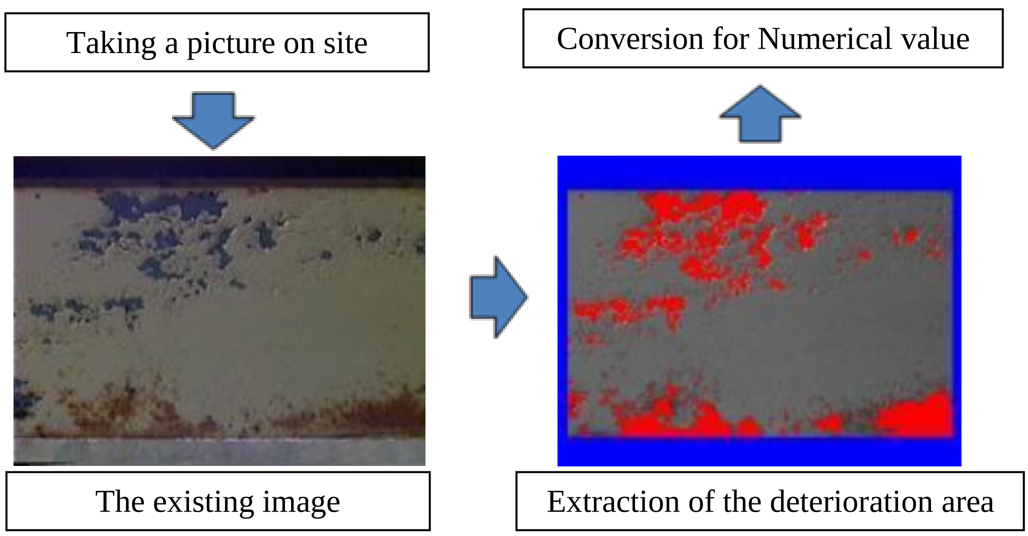


Fig.3 Detecting the deterioration area of painting using NEXCO Paint View System

Deterioration data of the coating are accumulated by the Paint View System. According to its data, deterioration of the general painting (painting system “A” or “a” painting system) progresses as shown in Fig.4. If painting life is when a deterioration area reached 5.0% , the average life of pro-general painting is about 17 years.

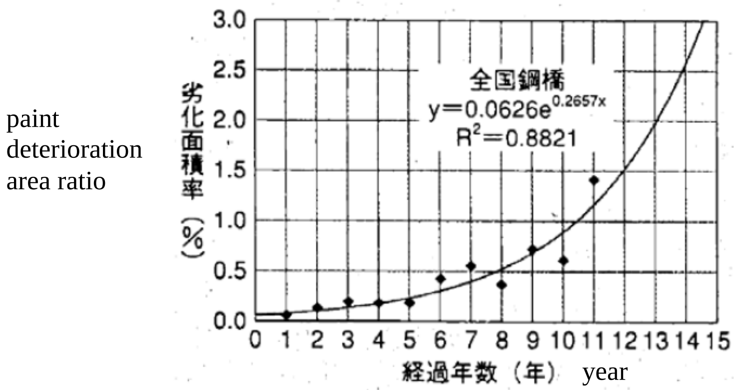


Fig.4 Deterioration curve of the painting (general painting system) [6)]

If dividing the number of bridges in NEXCO by life of the general painting by simple calculation, the repair painting is necessary higher than 120 bridges every year.

Therefore, high durable painting specifications have been adopted since 1997 in NEXCO. However, many old bridges using general painting system have repaired many times and gradually shorten for the repair cycle.

This reason is that deteriorated coating have been grinded by disk sander (According to ISO 8501-1 St 3) and general painting system have been painted repeatedly (Fig.5).

Some results of accelerate corrosion test to confirm painting durability in NEXCO Research Institute is shown in Fig.6. The method of remove rust by tool have been inferior in the durability. As for this reason, because the steel materials surface cannot be completely removed the rusts on irregularity surface made of the corrosion, such a point corrodes from the inside of the coating let accelerate the coating deterioration. Therefore, as for the deterioration after the repair painting, same parts often deteriorates early.

Fig.5 Grinding by power tool such as disk sander (According to ISO 8501-1 St 3)

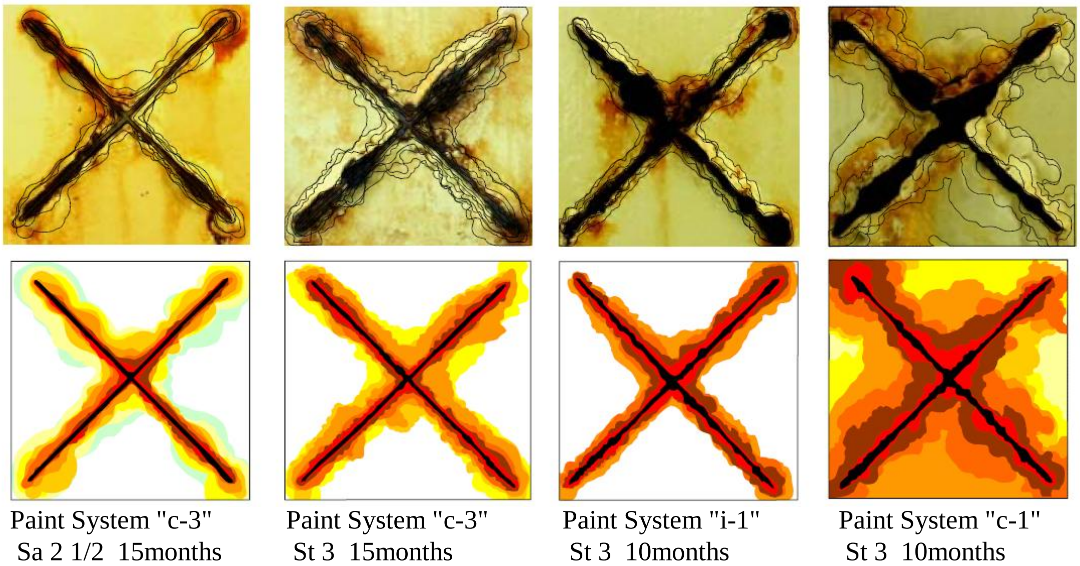


Fig.6 Accelerate corrosion test for painting

Because of its results, surface cleanliness method by blasting (According to ISO 8501-1 Sa2.5) has been focused recently. (Fig.7)

However, blasting on site is limited because of environmental problems such as scattering dust and loud noise from the construction site. In addition, the complicated structures such as gusset plate, stiffener often decrease the work space, so processing time of blasting becomes longer. Moreover, because the interval time from blasting to painting is limited, the construction efficiency is often very bad and its repair cost may be more expensive.[7)]

Fig.7 Cleanliness processing by blasting(According to ISO 8500-1 Sa2.5)

From these background, we attempted experimental study of two themes. One of these is a basic study on innovative non-destructive inspection to detect the corrosion area in coating. The other is a performance confirmation examination of the blasting method using the special tool on site. This method can remove the partial rust and corrosion economically and clear environmental problems.

Fundamental researches about the Non Destructive Inspection method of the coating deterioration using the Terahertz wave

1. Investigation contents and outline of Terahertz Imaging system

A steel material has no transmittance for electro-magnetic wave, however, it is reported in a past study that by using reflection imaging terahertz wave, the surface figure which is hidden under the coating is detectable.[8)] Therefore we examined three following contents in this study.

(1) Trial terahertz imaging using the deterioration coating specimen
(2) Terahertz imaging using the specimen which made a rust shape to confirm detection performance intentionally
(3) Examination to identify transmission properties of various paint using for a bridge

The examination was carried out in collaborative investigation with Iwate Prefectural College. The testing equipment used an apparatus as shown in Fig.8, and carried out the examination on a condition as shown in table 1.

Fig.8 Terahertz Imaging system
(Iwate Prefectural College owned)

Table 1 Terahertz Imaging measurement specifications

Item	Contents
Measuring system	Reflection imaging (probe scan)
Oscillation element	TUNNET 170GHz
Detector	0bias SBD at RT
Measurement area	Depends on each examination （about 60mm×60mm）
Scan size	0.5／1.0㎜step
Stabilization condition	8e-5,　avg1 or 2

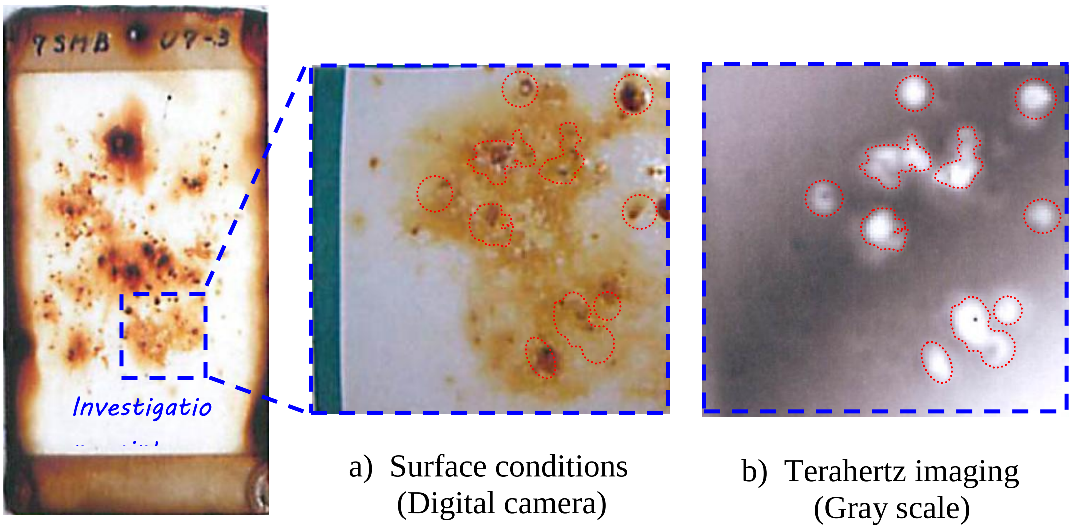
2. Investigation by the deterioration coating specimen

Prior to a detailed investigation, to grasp appropriate frequency condition of the terahertz wave and an image of the deterioration coating, we tested the examination measurement by the deterioration coating specimen.

The specimen exposed at Oyashirazu Coast exposure test area for about 13 years, and the back side was used. Painting specification of this specimen was the “I” painting system in the NEXCO painting standard. (first coating: Organic zinc Rich paint 75 μ m, middle coating: polyurethane resin paint for middle coating 30 μ m, final coating: Polyurethane resin paint for final coating 25 μ m)

Fig.9 is the result of a measurement. The back side of exposed specimen gets rusty on the coating surface because of existing dew including the rust juice for a long time, and as for the rust spreads through the coating appearance and a real rust area becomes indistinct.

Terahertz imaging can be detected only a rust and corrosion point removing dirt with the rust juice in the coating surface.



a) Surface conditions (Digital camera)

b) Terahertz imaging (Gray scale)

Fig.9 Investigation result by the deterioration coating specimen

3. Detection performance test of the corrosion in the coating

Painting specification of the specimen (Fig.10) were used two kinds of painting system. One is the “a-1” painting system (the phthalate series painting). The painting system was generally adopted in the past. The other is the “c-3” painting system. The coating is thickness and adopted for the repairing painting system at present.

The result of the terahertz imaging is shown in Fig.11. As a result, for both specimens of the “a-1” painting system and the “c-3” painting system, the rust area can be detected enough precisely.

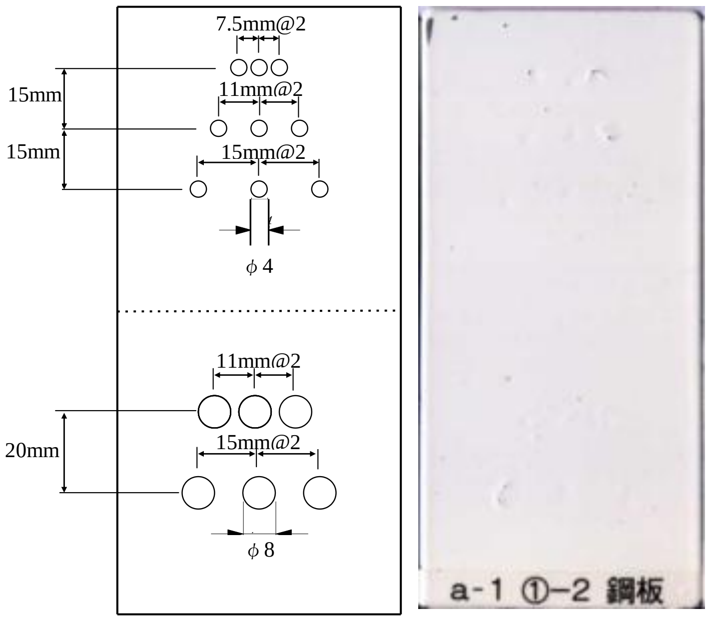


Fig.10 The position of the rust area and the painted specimen

Some absentminded point was seen partially. Because there is the place where strength of receiving wave is very week, so it seems the rotation of this area becomes hard to relatively distinguish it. However, the difference of the detection performance by the kind of painting specifications is small by this test result.

Seeing the results of other parts, an imaging of big rust area was clearer than the small rust area case. In addition, there was not combined every rust area. (The smallest distance between the rust is 5mm) Therefore, this method can be distinguished an individual rust area.

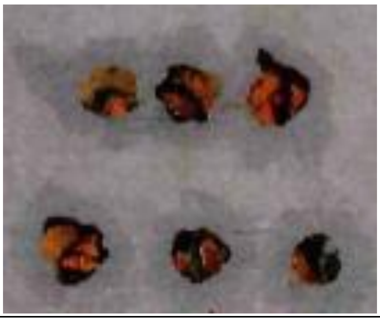
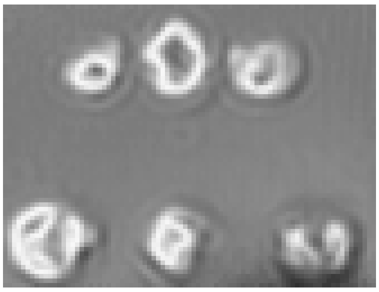
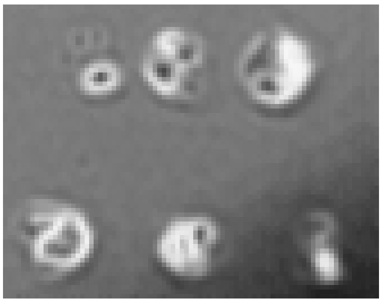
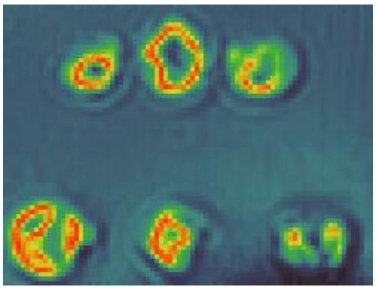
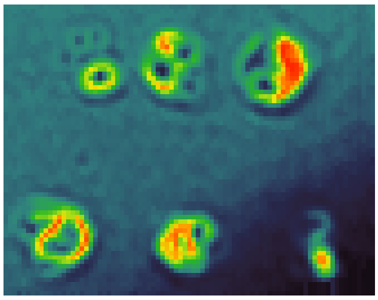
	Example of middle size diameter	
	Painting system“a-1”	Painting system“c-3”
Rust Type		
Imaging (Gray scale)		
Imaging (Color)		

Fig.11 Terahertz imaging of the specimen

4. Investigation into transmission properties by the difference in coating classification

We made single film test specimen of each painting classification and fixed it as shown in Fig.12. Then we measured incident power "P0" and transmission power "P1" of the terahertz wave and calculated the transmission ratio P1/P0.

The test result is shown in Fig.13, and Fig.14. As a result, it can be confirmed the following things.

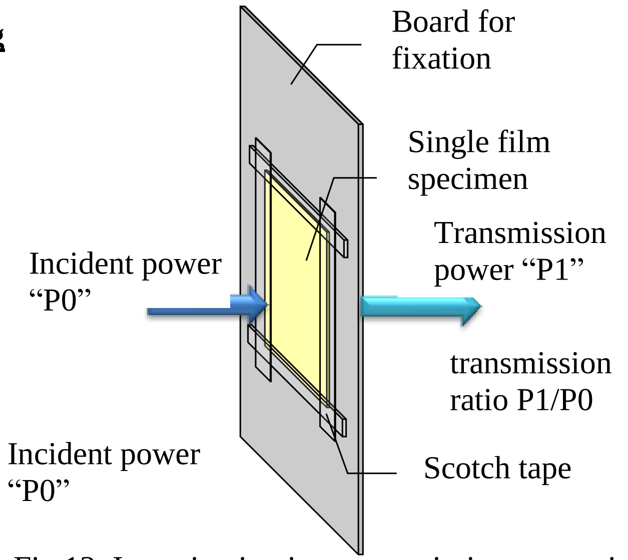
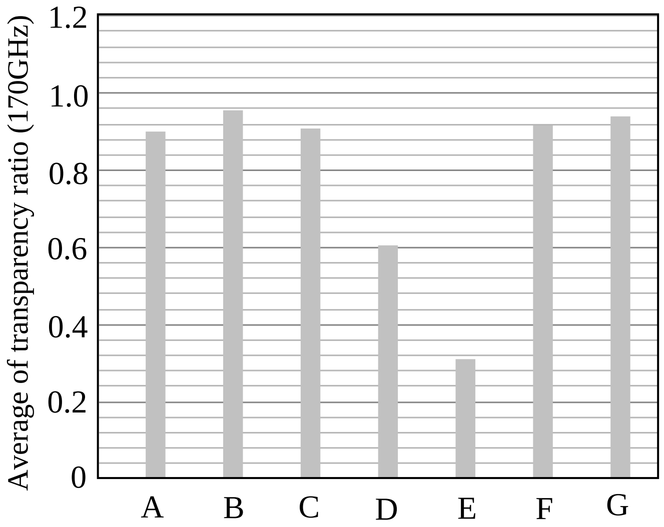


Fig.12 Investigation into transmission propertie

As for Anti-corrosive lead paint (40 μ m), Phthalate coating (26 μ m), and Phthalate coating (26 μ m), these transparency is very high. Therefore, the transparency of painting systems using those three (painting system"a-1") is high.

As for Zinc Rich paint (102 μ m), and Epoxy resin paint (82 μ m), these transparency is comparatively low. As for Fluoropolymer coating (top coat is 49 μ m and second coat 38 μ m) , these transparency is very high. Therefore, the transparency of this painting system using those four (painting system"c-3") is slightly lower, but its system has practical performance.

In addition, from a coating thickness of epoxy resin paint and relations of the absorbance, it was confirmed that if coating was thick, the transmission ratio is lower (absorbency is higher).



A: Anti-corrosive lead paint
B: Phthalate coating
C: Epoxy resin paint
D: Modified epoxy resin paint
E: Zinc Rich paint
F: Fluoropolymer coating for coating:
G: Fluoropolymer coating for second coating:

Fig.13 Average of transparency of each coating

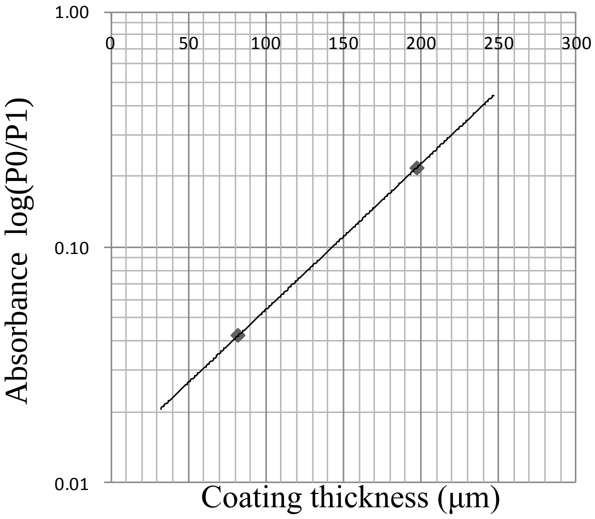


Fig.14 Relations of coating thickness and the absorbance of epoxy resin paint

5. Conclusion of Non Destructive Inspection using the terahertz

As a result of terahertz imaging investigation examination, the following matter can be confirmed.

(1) The detection of rust and corrosion in the coating is possible using terahertz imaging.

(2) Appropriate frequency of the electromagnetic wave to use in an investigation into rust and corrosion in the coating is around 170GHz.

(3) Measurement time is about 20 minutes per one place (60*60mm) using the prototype.

This study is one fundamental research about the application to non destructive inspection of the terahertz technique. To be using on site, it is necessary to enable scanning a wide area at high speed. So the development of the apparatus is necessary.

Test construction for confirmation of application to the new blast method using the special tool on steel bridge coating repair construction site

1. New blasting method with the special tool

To remove the rust of deterioration coating, we generally use grinding method with a machine tool such as a disk sander, or blasting method with abrasives. Blasting method has environmental problems due to noise and dust, therefore did not hardly ever be used. On the other hand, blasting becomes necessary because of changing in the painting specifications. There are many methods improved the abrasives and blasting machine to solve these problems, but mach of those method was too expensive. Therefore reasonable blasting method has been needed.

So we studied that the method which has been used in the field such as automotive, marine, plant recently, and can remove the rust as well as blasting method, can be applied to repair the steel bridge coating on site. The method need a special tool that named Bristle Blaster®(Fig.15), and developed in Germany. The principle of surface cleanliness is striking the subject with the many carbon spring steel or stainless steel spinning wires. The method with this tool can be the surface cleanliness as well as according to ISO 8501-1 Sa 2.5, as are also achieved for conventional blasting[9~11].

Fig.15 The Special Tool of New Blasting Method

2. Test construction with the new surface cleanliness method

The test construction carried out at the steel bridge of Ise Expressway in Mie Pref. The bridge had the local deteriorated coating at the end of girders, because of the influence of leakage water in deicing salt from the expansion joint (Fig.16). In the test, we investigated the surface roughness, dust, noise, cleanliness performance at the web, corner, gusset plate and the corrosion surface, and processing time on the bridge repair construction site.

(1) Surface Roughness

Fig.17 shows the result of a 10-point average roughness of the surface by measure method of JIS. Compared to painted steel, rust steel, mill scale and

Fig.16 Horisaka Bridge (Ise Expressway in Mie Pref. conventional general paint 23years)

galvanized steel, all surface can be removed the rust and coating, and can be secured over the roughness of 50 μ m. Also, in comparison with grinding, this method is expected to improve adhesion of the coating than its method with disk sander.

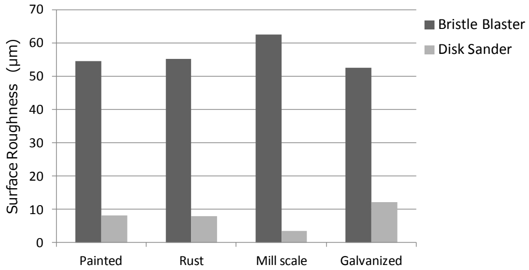


Fig.17 10-points ave. roughness of surface (by measure method JIS)

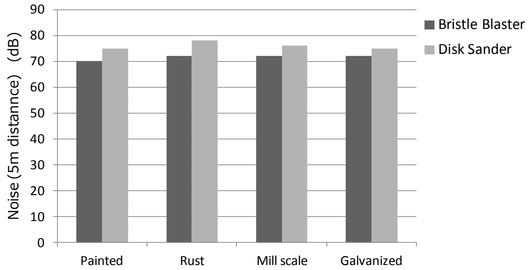


Fig.18 Noise Test

(2) Dust and Noise

Fig.18 shows the results of the noise measurement at 5m away from the work area. Regardless of the different surfaces, each sounds volume is same, and less than the sound volume of conventional grinding method with disk sander. Moreover, most of the dust did not occur.

(3) Surface Cleanliness

Fig.19(1) to (4) shows the treated surfaces after the work. This method is not worrying about cutting down the steel, the variations of surface cleanliness treatment is not much. Also, it can be good at the corner and around the bolts. Grinding with disk sander cannot be so. In addition, it can clean all the sever rusts (partial layered) on the corroded steel surfaces.

Fig.19 Treated Surfaces after the tests

(4) Workability and Processing time

We measured the processing time of cleaning at the web of the girder and around the bolts. Fig.20 shows the results. This result revealed that compared with the superior processing performance than grinding, in case of the conventional general painting.

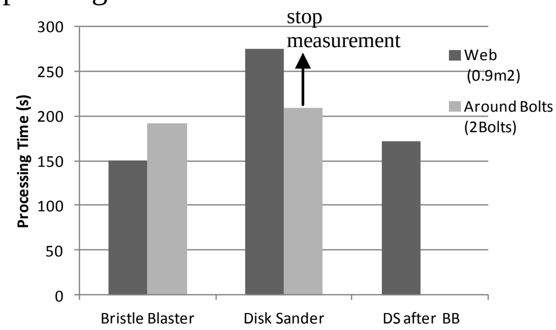


Fig.20 Processing time

Fig.21 Construction by new tool

As mention above, this method is reasonable, environmental and efficient than conventional grinding method with DS. And in case of repair at local deteriorated coating, the blasting with abrasives, this method is superior.

Conclusion

Durability of the coating to protect steel vary greatly on the condition of corrosive environment, coating specification, part of structure, construction and so on. If we can search the local weaknesses and remove and repair by proper method and specification, we can maintenance so good without significant cost increasing. Other than the above, we think that cleaning the girders is effective and has studying it.

We wish that this report is helpful to the maintenance of bridges in your future.

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