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“Technical Research and Development for Road Policy Quality Improvement”
Study Summary

No.	Title	Principal Researcher
No.29-7	Development of advanced diagnostic and repair technique for weathering steel bridges	Yamaguchi Univ. Prof. Toshihiko Aso

In order to realize efficient and rational maintenance of weathering steel bridges, this research and development aims at systematic upgrading of corrosion diagnosis and repair techniques for weathering steel. Therefore, the following are carried out: Development of corrosion prediction simulation technology of weathering steel bridge, upgrading of corrosion rating method, evaluation of repair method of corroded weathering steel, corrosion evaluation of weathering steel bridge, and proposal of repair flow.

1. Backgrounds and Objects

Weathering steel is a steel material which forms dense protective rust on the steel surface and sufficiently reduces the corrosion rate. Since weathering steel bridges do not require painting and are advantageous from the viewpoint of life cycle cost, many bridges were constructed. To properly maintain and extend the life of weathering steel bridges, it is necessary to establish an evaluation method of the environment in which the bridges are constructed, an evaluation method of rust generated on steel surfaces, and an effective repair technique. In this study, in order to establish a method to extend the life of weathering steel bridges, a corrosion environment simulation method and a rust evaluation system were constructed, and repair methods were compared.

2. Activities in Research Period

(1) Development of simulation technology to predict corrosion for weathering steel bridges

Corrosion of weathering steel bridges is known to be affected by various factors in complexity. For this reason, it is not easy to predict the actual corrosion. Therefore, by combining three-dimensional modeling technology and environmental evaluation simulation, the authors aim to construct a system that can simulate the corrosion level at each part of bridge.

(2) Advancement of corrosion detection methods using ICT technology

The rust generated in the weathering steel was evaluated by the cellophane tape test, but there were individual differences in the evaluation depending on the skill of the evaluator. Therefore, an image analysis method is applied to the rust image collected by the cellophane tape test to construct a system in which an inspector or a manager simply evaluates the state of rust without depending on the degree of skill.

(3) Elucidation of repair effect of corrosion-resistant steel

By comparing the repair techniques of weathering steel, the relationship between corrosive environment and rust state and repair method will be clarified. Therefore, an exposure experiment was conducted at three locations (Okinawa, Yamaguchi, Shimane) using test pieces in which a substrate adjustment method, a coating method, a salinity removal method, and the like were combined, and the effect of the repair was verified.

(4)Proposal of corrosion evaluation and repair flow of weathering steel

Based on the results of the above (1) to (3), a systematic evaluation and repair flow from a corrosion environment evaluation, a corrosion condition evaluation, a repair method determination, and a future prediction are proposed.

3. Study Results

(1) Development of simulation technology to predict corrosion for weathering steel bridges

As a corrosion prediction simulation method for weathering steel bridges, we tried to link three-dimensional terrain data with bridge models based on thermal fluid simulation software. Using this system, it was confirmed that it was possible to evaluate with considerable accuracy the tendency of the flying salinity observed in the target bridge. By considering the topography, it was confirmed that the flow situation in the girder around the

pier was grasped, and that the influence range and the range of abnormal corrosion matched well.

(2) Advancement of corrosion detection methods using ICT technology

The individual rust particles were replaced with a circle of the same area from the rust image, the particle size addition curve was obtained by the circle equivalent diameter which is the diameter of the circle, and the threshold value related to the rust score was shown by the circle equivalent diameter of cumulative 100 minute rate 40% and 100% of this particle size addition curve. The concordance rate with the technician evaluation by this method was 74.0% for the cellophane tape test sample used for setting evaluation criteria, and the concordance rate between the technician evaluation and the image analysis evaluation in the test sample was 92.1%, showing good accuracy.

(3) Elucidation of repair effect of corrosion-resistant steel

In this study, exposure tests using various repair coatings were carried out in Okinawa, Shimane and Yamaguchi where corrosive environments are different. In areas affected by atmospheric salinity, Rc-II and Rc-I coating systems and organozinc-rich paints and modified epoxy resin paints are applicable as emergency life-prolonging measures. In the region which is not affected by the salinity in the air, the repair by the Rc-II coating system, the Rc-I coating system (Include a no-wash process), the simple coating system, the non-coating system is considered to be effective, when the corrosion factor is perfectly removed.

(4) Proposal of corrosion evaluation and repair flow of weathering steel

In order to spread the results of this study to diagnostic repair of weathering steel bridges, this paper proposes (1) a corrosion prediction simulation technique, (2) a corrosion determination method, and (3) a flow of repair procedures.

4. Papers for Presentation

T. Aso, Y. Tokieda, K. Tajima, Y. Nakamura, K. Sakamoto, Rust Rating System using Image Analysis for Weathering Steel Bridges , Proceeding of Bridge Engineering Institute Conference, pp.88 – 92, 2019.

5. Study Development and Future Issues

The corrosion evaluation using numerical analysis for the life extension of steel structures is very important problem, and the research will be advanced in future. In the rust judgment by the image analysis, the system which enabled the evaluation which was almost equivalent to the engineer was constructed. In the future, it will be necessary to examine the validity of the present evaluation level division. The qualitative relationship between the repair method and the corrosive environment was clarified by the exposure test. Based on these results, test repairs will be conducted on the actual bridge, and the reliability of the repair method will be further improved through comparison with the exposure test.

6. Contribution to Road Policy Quality Improvement

Since weathering steel bridges are advantageous from the viewpoint of LCC because they can be used without painting, many bridges have been constructed recently. The results of this study can be applied to the maintenance of these bridges and contribute to the life extension of weathering steel bridges. That is to say, when unexpected corrosion occurs in a weathering steel bridge, this research grasps simulation to estimate the cause of corrosion, evaluation of corrosion condition, and repair to extend life as a series of flows.

And, the result of this study can be carried out by bridge managers, inspection traders, and construction traders in the wide range, and it is regarded as a result which greatly contributes to the improvement in the quality of road policy.

7. References, Websites, etc.

None