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

No.	Title	Principal Researcher
No.26-4	Performance Recovery of Steel Girder End by Applying Cold Spray Technique	Ryukyu Univ. Assoc. Prof. Shimozato

The purpose of this research is to develop a highly durable anticorrosion technique for steel girder ends. Cold spray technique with mixed particles of zinc and alumina is applied as the anticorrosion technique in this research. The performance of corrosion protection and the field applicability are verified by a demonstration field test. Furthermore, the availability of cold spray coating as an anticorrosion base coat of both methods of patch plate repair and carbon fiber bonding is investigated from the viewpoint of recovering loading capacity.

1. Backgrounds and Objects

The purpose of this research is to develop a highly durable anticorrosion treatment for steel girder ends of severe corrosion and difficult treatment conditions. Cold spray technique with mixed particles of zinc and alumina (hereafter CS technique) is applied as the anticorrosion technique. Evaluation of the performance for corrosion is conducted, and the results are summarized as the working guideline. Finally, the field applicability of CS technique is verified by field test. Moreover, for the rupture of bridge members at girder ends due to severe corrosion, the recovery of shear capacity by patch plate repair method and carbon fiber sheet bonding method applying CS technique as anticorrosion base coating is verified.

2. Activities in Research Period

In order to develop the performance recovery technique of corrosion resistance and load carrying capacity for steel girder end, the followings were examined.

(1) Evaluation of anticorrosion performance by CS technique to corroded steel plate

The effective anticorrosion method toward remaining rust on corroded steel plate is required since it is too difficult to remove the rust due to the narrow working space. In this research, the coating formation mechanism by CS technique and the optimum mix ratio of zinc and alumina particles have been investigated. Furthermore, CS nozzles were improved to apply the narrow space, and the anticorrosion performance of them is evaluated. Based on these results, the working guideline was summarized.

(2) Demonstration field test for performance recovery of anticorrosion to corroded steel girder ends

Based on the guideline, CS technique applies to corroded steel girder ends, and the field applicability and the anticorrosion performance were evaluated by field test.

(3) Verification of recovering effect on loading capacity by each repair method with CS base coating

In order to recover the loading capacity for the rupture of bridge members at girder ends due to severe corrosion, the applicability of CS technique as anticorrosion base coating for patch plate repair method and carbon fiber sheet bonding method is investigated.

Photo 1　CS equipment

3. Study Results

(1) Evaluation of anticorrosion performance by CS technique to corroded steel plate

By applying CS technique with only zinc particles or only alumina ones or mixed them, the coating formation mechanism on the corroded steel plate was clarified. In addition, the optimum mixed ratio of zinc to alumina was defined 60 to 40. These results were summarized as the working guideline.

(2) Demonstration field test for performance recovery of anticorrosion to corroded steel girder ends

To apply the narrow space at the target bridge and to improve the treatment efficiency, CS nozzles were invented. Moreover, semi-automatic treatment equipment was developed. Using the

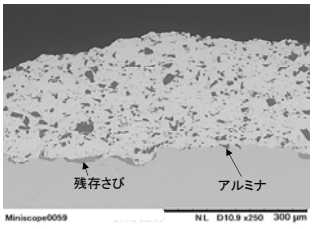

Fig. 1 CS coating on rust surface
（Zinc 60：Alumina 40）

guideline and the improved equipment, the field test was conducted at the girder ends of corroded steel bridge.

(3) Verification of recovering effect on loading capacity by each repair method with CS base coating

The effect of CS anticorrosion base coating on corroded concavo-convex surface on the performance recovery of loading capacity by patch plate and carbon fiber sheet bonding was examined by two types of experiments (1/3 scale and full scale models).

Photo 2 CS treatment under narrow space condition

Photo 3 Full scale specimen test

4. Papers for Presentation

1) Yusuke Kato, Tetsuhiro Shimozato: Demonstration test of the low temperature and low pressure thermal spray method (Cold Spray method) for corroded girder end, Workshop on Land, Infrastructure and Transport in Okinawa, 2017.7.

2) Go Takahashi, Tetsuhiro Shimozato: Investigation of shear capacity repair methods for corroded steel girder ends, Workshop on Land, Infrastructure and Transport in Okinawa, 2017.7.

5. Study Development and Future Issues

1) Application of CS technique on the remaining rust surface can be expected to prevent corrosion progression. In the future prospects, the corrosion protection effect on steel bridges under various corrosion environments, such as coastal area and antifreeze spray area, should be verified.
2) The anticorrosive performance at the narrow space, i.e. girder bridge ends and shoes by CS technique was demonstrated. Therefore, CS technique which can form a sufficient anticorrosion coating even in weak points against corrosion, such as plate edges and corners of high-strength bolt, should be developed.
3) In present standards, the rust removal and the smoothing of unevenness surface is required for the repair method, such as patch plate and carbon fiber sheet bonding. This study revealed that CS anticorrosion base coating on the repair surface does not affect the recovery effect of loading capacity experimentally. Furthermore, for the roughness on corroded surface used in this research, it can be expected that the sufficient recovery performance by patch plate repair method is obtained without smoothing of unevenness surface. In the future, the experimental data of patch plate repair method for various roughness level on corroded plates should ne amassed, and the range in application must be clarified.

6. Contribution to Road Policy Quality Improvement

・Contribute to life prolongation and low LCC maintenance for steel bridges

Steel girder ends are one of the weak points against corrosion, and the corrosion is major factor in the increasing maintenance cost of steel bridges. The effective duration by repair paint for corroded girder ends may not be long. In some cases, re-deterioration at repaired region occurs. One of the reasons is that rust on corroded plates cannot be removed completely because of narrow working space at girder ends. CS technique can form the anticorrosion coat on corroded plates since the rust removal and zinc coat formation can be conducted by the mixed particles of alumina and zinc. Therefore, high durability at corroded steel girder ends can be expected. In the next stage, CS technique may become high-integrity anticorrosion technique by the increasing CS application example for various structural types and environmental conditions.

・Incorporation into handbook for coatings and anticorrosion and manuals

It is necessary to include CS technique into handbooks and manuals together with commonly applied painting and metal spray. Hence, the range in application and quality control method must be discussed. CS anticorrosion technique will incorporate into “Painting manual for steel bridges in Okinawa”. Since corroded steel bridges become significantly increasing in Japan, this research results must contribute safety assurance of road assets and improvement of durability after repairing.

7. References, Websites, etc.

http://www.structur.tec.u-ryukyu.ac.jp/ （Ryukyu Univ. Faculty of Eng. Structural Eng. Lab.）