

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

No.	Title	Principal Researcher
No.22-8	A study on simple repair methods for a crack in steel bridges	Nagoya Univ. Prof. Tateishi

This study develops three types of simple repair methods for a cracked steel bridge member, which are the ICR treatment, resin injection method and weld repair. Their effects and applicability are clarified through fatigue tests and finite element analysis, resulting in proposal of repair guidelines.

### 1. Backgrounds and Objects

Since a lot of fatigue damage have been observed in steel bridges and it will become more serious issues in the future, a simple repair method for a crack in steel bridge members has been strongly required.

This study focused on three repair techniques for a relatively small crack, such as the impact crack closure retrofit treatment (called ICR), resin injection method and weld repair. The ICR is performed with an air tool to peen plate near a crack and to produce plastic deformation of the steel surface in order to close crack opening. In the resin injection, resin is infiltrated into a crack, which can act as a wedge to control crack closure. The weld repair is a technique which removes a crack from a joint and restores it by welding.

Through fatigue tests and finite element analyses, the applicability of three techniques was investigated to establish them as practical level.

### 2. Activities in Research Period

**[ICR]** The effect of stress ratio, treating position, crack size and stress level on the life extension by the ICR was investigated with fatigue tests under tensile and bending loads. Besides, the applicability of the ICR to a fatigue crack from not only a weld toe but also a weld root was investigated. Finite element analysis was performed to reveal the effect of crack size, main plate thickness and loading types (tensile or bending loads), and then a remaining life prediction method after ICR was investigated. The ICR was applied to fatigue cracks in steel bridges to reveal its workability and applicability in the actual condition.

**[Resin injection method]** The applicability of the method for a crack under cyclic compressive loading was investigated by fatigue tests with out-of-plane gusset welded joints. Finite element analyses were performed to investigate the effect of elastic modulus and infiltration ratio of resin on the stress intensity factor at a crack tip.

**[Weld repair]** Welding tests were performed to reveal the influential factor to crack initiation in welding process under cyclic loading. Thermal elasto-plastic finite element analysis was performed to establish an estimation method of weld crack initiation condition.

### 3. Study Results

#### **[ICR]**

- Residual stress measurements by X ray diffraction method showed that the ICR can induce compressive residual stresses which are about 60-70% of the yield stress of steel plates.
- The fatigue life extension by ICR changed depending on stress range applied to the crack.
- Through finite element analyses, a prediction method for remaining life of the treated crack was proposed and its applicability was confirmed by fatigue tests with plate girder specimens.

#### **[Resin injection method]**

- Fatigue test results indicated that crack growth retardation is almost same regardless of injecting position (upward or downward) and types of resin.
- It is revealed by analyses that when a crack is completely filled with resin, crack growth retardation is expected even though the elastic modulus of the resin is relatively small, and that the infiltration depth of

the resin highly affects the crack growth rate.

### **[Weld repair]**

- Welding tests indicated that the weld crack tends to occur when the root gap opening displacement and load frequency becomes large.
- Based on the results of the welding tests and the analysis, this study developed a prediction method for the crack initiation during welding process under cyclic loading.

Based on the above research findings, repair guidelines were established based on the experimental and analysis results.

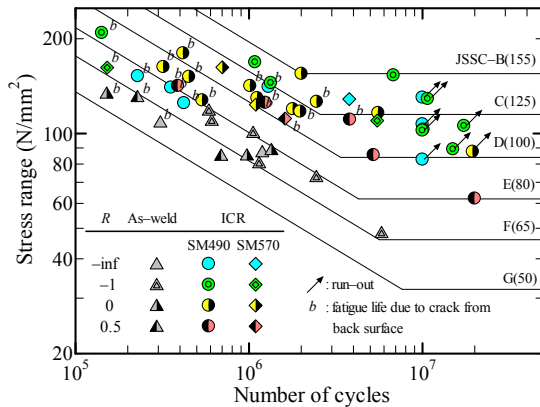


Fig.1 Fatigue life extension by ICR (effect of stress ratio)

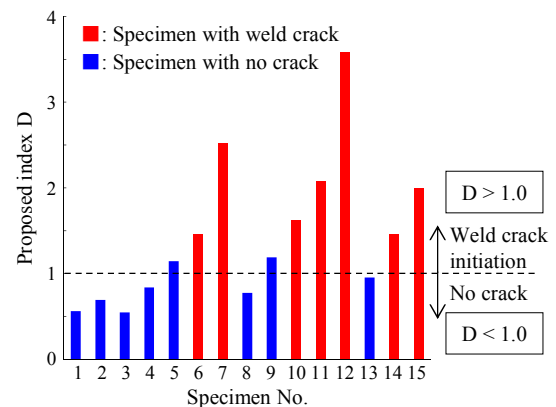


Fig.2 Prediction results of weld crack initiation

## 4. Papers for Presentation

- 1) Hasegawa Y., Hanji T., Tateishi K. and Choi S.M. (2013) A study on weld repair of steel members under cyclic loading, Proc. of the 12th Japan-Korea Joint Symposium on Steel Bridges, CD-ROM.
- 2) Tateishi K., Hanji T., Tsuruta Y. Sasada S. and Choi S.M. (2013) Fatigue life extension of cracked welded joints by ICR treatment under tensile loading, Proc. of the 10th PSSC, pp.493-498.
- 3) Tateishi K., Hanji T., Ishikawa T. and Shimizu M. (2015) Fatigue life extension by ICR treatment for cracked weld joints subjected to tensile or bending loads, J. of Struct. Eng., JSCE, Vol.61A, pp.627-637.
- 4) Hattori M., Hanji T. and Tateishi K. (2015) Simple repair method for fatigue cracks in welded joints by resin injection, Proc. of the IABSE Conference Nara, CD-ROM.
- 5) Hanji T., Hasegawa Y., Tateishi K. and Shimizu M. (2015) An Estimation Method for Weld Crack Initiation in Weld Repair under Cyclic Loading, Proc. of the 8th ISSS (in printing)

## 5. Study Development and Future Issues

### **[ICR]**

- It is necessary to accumulate and storage the application results of the ICR to actual bridges according to the guideline proposed in this study. And then, the results should feed back to the guideline.

### **[Resin injection method]**

- It is necessary to find appropriate resin and injection method, and also to establish an inspection technique to confirm the infiltration depth of resin into a crack.

### **[Weld repair]**

- It is necessary to verify the proposed prediction method for weld crack initiation through different types of welded joint, welding method, and also develop an inspection technique after welding.

## 6. Contribution to Road Policy Quality Improvement

The regulation of close inspection for highway bridges of more than 2m-long will increase the possibility to detect a relatively small crack in steel bridges, resulting in an increasing number of cracks. The repair techniques in this study target a small crack, therefore, the research findings such as repair guideline are extremely useful in future maintenance of steel bridges.

## 7. References, Websites, etc.

<http://skyarch.civil.nagoya-u.ac.jp/>