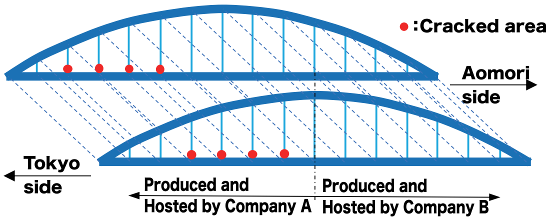
※Josei Measurement Technology;②-4

Repair Measures for Existing Bridges

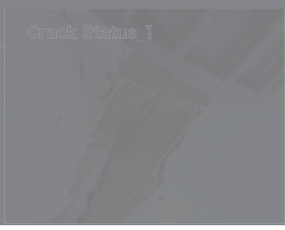
# Investigation of Causes and Countermeasure Design for Fatigue Cracks in Steel Bridges and Post-Countermeasure Effect Verification (Part 2)

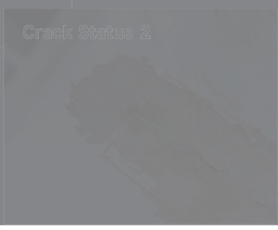
This case involves cracks that developed in the vertical members of Rose Bridge, as shown in the photograph. As indicated by the ● mark in the right diagram, the crack locations were concentrated at the base of the vertical members and were only confirmed on the Tokyo side. The completion records revealed that different manufacturers and construction companies were responsible for the Tokyo and Aomori sides. Below, we present Josei's investigation into the cause of the cracks and the proposed countermeasures.

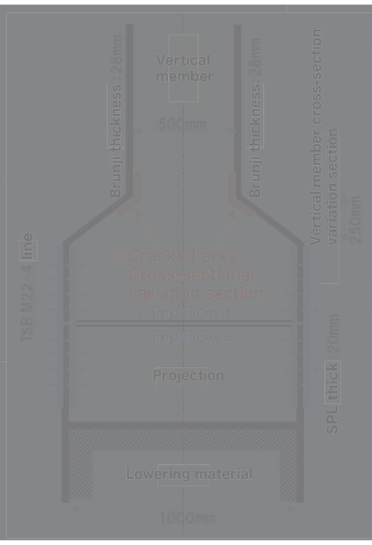



## Introduction to Crack Cases: Fatigue Cracks in Vertical Members (Impact of Construction Defects)

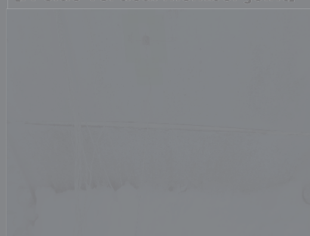
The vertical member where cracks were confirmed has a structure where Member ① and Member ② are joined with a fillet plate (t=20mm), as shown in the right diagram. The cracks were confirmed in the section with a change in cross-section on the Tokyo side (manufactured and erected by Company A). Visual inspection at the site revealed curved deformation at the boundary between Member ① and Member ② on the Company A side, as shown in the photo on the right (no deformation was observed on the Company B side). This curved deformation was determined to have occurred during fabrication due to web width errors, causing forced deformation when Members ① and ② were tightened with high-strength bolts.



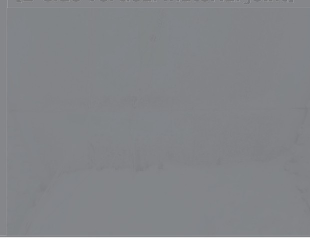




【A-side vertical member joint】



【B-side vertical material joint】

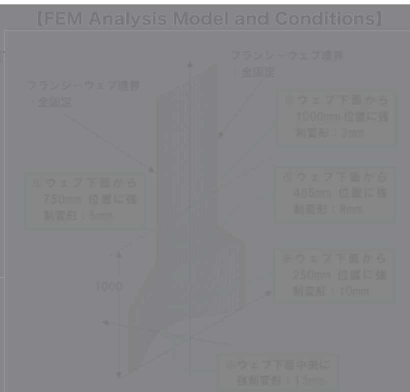


## Construction Defects and Reinforcement Countermeasure Effect Verification

As shown in the right figure, we applied a forced displacement measured on the vertical web member to evaluate the local stress level at the crack initiation point. Additionally, we measured the residual stress level at the ●-marked location using the drilling method to verify the validity of the analysis model. The agreement between the drilling method results ($\sigma$=31.8–32.1 N/mm²) and the FEM analysis results ($\sigma$=30.6 N/mm²) confirmed the validity of the analysis model. Consequently, it was determined that an extremely high local stress of $\sigma$=77.1 N/mm² had already developed at the crack initiation point. We concluded that the stress from repeated loading accumulated at this point, leading to the formation of a fatigue crack.

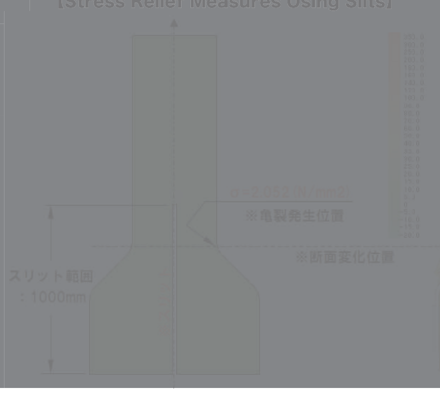
The key consideration in countermeasures is how to eliminate the stresses generated by this forced bending deformation. Two countermeasure proposals were evaluated: ① Stress relief through slits and ② Deformation suppression using protruding backing plate reinforcement. Option ② was adopted, prioritizing a reliable stress reduction strategy.

【FEM Analysis Model and Conditions】



【FEM analysis results】

【Stress Relief Measures Using Slits】



【Deformation Suppression Measures Using Projection-Type Brace Plates】

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