Evaluation of the Bridge Health Integrity: Case Study on 3-span Continuous Corroded Steel Girder Bridge

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1. Purpose

In Japan, more than half of steel railway bridges are aged over 60 years. Corrosion of steel members is a main factor in deterioration of steel bridges. Further, the maintenance budget is limited. Careful evaluation of existing structures for the feasibility of carrying current loads and estimation of the priority maintenance sequence, management system of the governed bridges to make the best cost efficiency are essential. Therefore, understanding the influence of structure mechanism caused by corrosion on the load carrying capacities to find a suitable weight value for assessment of bridge health integrity is one of great concern to bridge maintenance engineers. In this study, we statistically analyzed the three level of corrosion found on main girders of steel bridges based on actual bridge inspection data, and examined if corrosion concentrated on an edge of the end main girder and the center of main girder, the supporting, how influences the load-carrying capacity of a steel bridge through numerical analysis.

2. Weight Optimization Method of Corroded Plate Girder

1) Bridge health inspection: In Gifu prefecture, bridge inspection manual is divided the visual regular inspection works into four types as follows; simple check, preliminary check, detail check and history of steel-bridge check.
2) Weight optimization method for bridge health integrity: To plan maintenance and management, a soundness index to quantitatively express the degree of bridge deterioration is necessary. In this study, we evaluated the health level with a 5-level index. The 5-level health index is based on the degree of deterioration and the priority of deterioration (Hosoe, 2006).

3. FEA Model

In this study, the finite element analyses (FEA) were carried with the DIANA version 9.2. The nonlinear elastic-plastic material, the Newton-Raphson rule and the von Mises yield criterion were assumed for the material properties. The geometry of upper-flange size is 550×44 mm^2, the web size is 2423×18 mm^2, the lower-flange size is 700×33 mm^2, the concrete size is 10020×320 mm^2. The analytical models with three different corrosion levels were modeled where the average plate thickness reduction ratio is 15%, 30% and 50%, respectively.

4. Numerical Results of 3-span Continuous Girder Model

The yield strength and ultimate strength in the analytical prediction were estimated. when the span ratio is 0.5:1, 0.6:1, 0.8:1, among the numerical results that the damage occur in the element 3 (E3) at the center of mid-span of the beam model and in next element 2 (E2, intermediate support) becomes yielding. Figs. 1 shows the relationship between buckling value and the average of plate thickness reduction, where the span ratio is 0.5:1, 0.6:1, 0.8:1, respectively. It seems that the buckling value of type 2 corrosion pattern is almost larger than the others. Because the particular corrosion location, such as intermediate support dominates the failure mechanism order in this structure. When the span ratio is 1:1, 1.2:1, among the numerical results, the damage occurs in the element 1 (E1) at the center of side-span of the beam model. Figs. 2 show the relationship between buckling value and the average of plate thickness reduction, where the span ratio is 1:1, 1.2:1, respectively. It seems that the buckling values of three type damage pattern of corrosion are almost same. The intermediate support does not dominate the structure failure mechanism order in this structure. These results suggest that the span ratio, the damage pattern of corrosion and structure’s failure mechanism priority order give some influence to each other.

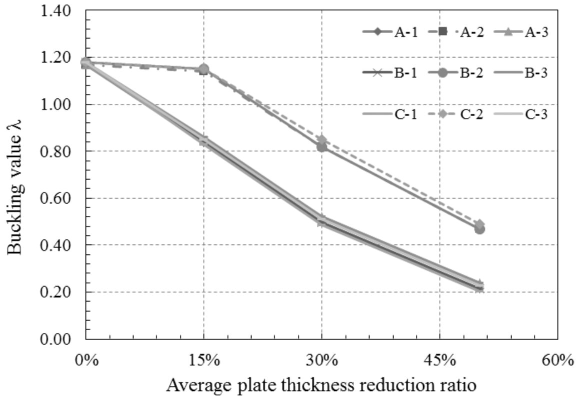

Fig.1 Relationship between the average of plate thickness reduction and buckling value for span ratio 0.5:1, 0.6:1, 0.8:1

5. Discussion

When span ratio is 0.5:1, 0.6:1, and 0.8:1, among the numerical results, the damage occur in the element 3 (E3) at the center of mid-span of the beam model and in next element 2 (E2, intermediate support) becomes yielding. When span ratio is 1:1and 1.2:1, among the numerical results, the damage occurs in the element 1 (E1) at the center of side-span of the beam model. Therefore, the span ratio gives influence to the load-carrying capacity and affects the structure failure mechanism order.

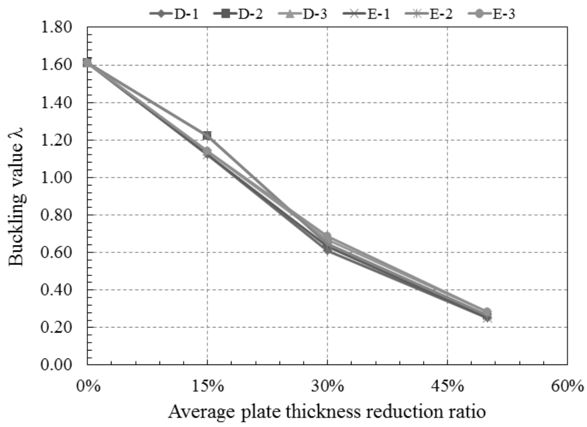

Fig.2 Relationship between the average of plate thickness reduction and buckling value for span ratio 1:1, 1.2:1

When span ratio is 0.5:1, 0.6:1, and 0.8:1, it seems that the buckling value of type 2 corrosion pattern is almost larger than the others. Thus, it can assume the weight factor of intermediate support is larger than the others. Therefore, the weight optimization method can used to predict the bridge health integrity in these cases. When span ratio is 1:1 and 1.2:1, it seems that the buckling values for three damage pattern corrosion are almost same. The intermediate support does not dominate the structure failure mechanism order in this structure. Thus, it can assume the weight factors are same in these cases.

Therefore, the concept of the proposed weighted optimization method for bridge health integrity can be descripted. Current assessment methods of corrosion-damaged steelwork involve regular inspection, which tends to be used very conservatively. The proposed system can assist engineering to decide the bridge health integrity, which is generally decided by personal experience or custom.

6. Conclusions

1) For corrosion-damaged structures, the weight factors are attributing to the corrosion type, structure span ratio and structure’s failure mechanism priority order.

2) From the result, we can assumed the weight factor and predict the health integrity of bridge structure.

7. References

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