FINITE ELEMENT ANALYSIS OF EXISTING PRESTRESSED CONCRETE BRIDGE

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1. INTRODUCTION

The ultimate load capacity is the important indicator to evaluate structural performance of the existing bridge superstructures. To acquire realistic and precise information, the field load testing is one of the prospective procedures to achieve the goal. However, this method is neither cost effective nor convenient. Regarding today available commercial finite element analysis software, the structural performance assessment can be handled numerically.

In this case study, the ultimate load capacity of existing prestressed post-tensioned concrete bridge superstructure was analytically calculated using the 3D finite element analysis (3D FEA). To this end, the analytical results compared to the field assessment results indicated that the 3D FEA is fairly good to predict the ultimate load capacity of existing prestressed post-tensioned concrete bridge superstructure.

2. TARGET BRIDGE

The target bridge is prestressed post-tensioned concrete T-girder bridge located in Haboro province, Hokkaido prefecture. It consists of 5 simple support spans, with 4 girders for each 36 m span. The prestressing force of 0.28 MN was applied for both longitudinal and transverse prestressing tendons. Figure 1 shows the superstructure cross-section and detail of the prestressing tendons. Also, the basic material properties were determined from bridge structural drawing and specification. For concrete, the ultimate compressive strength and elastic modulus are 40 and 35,860 MPa, respectively. For longitudinal and transverse prestressing tendons, the yield strength are 1,300 and 1,450 MPa, respectively, and the ordinary reinforcement has yield strength equal to 276 MPa.

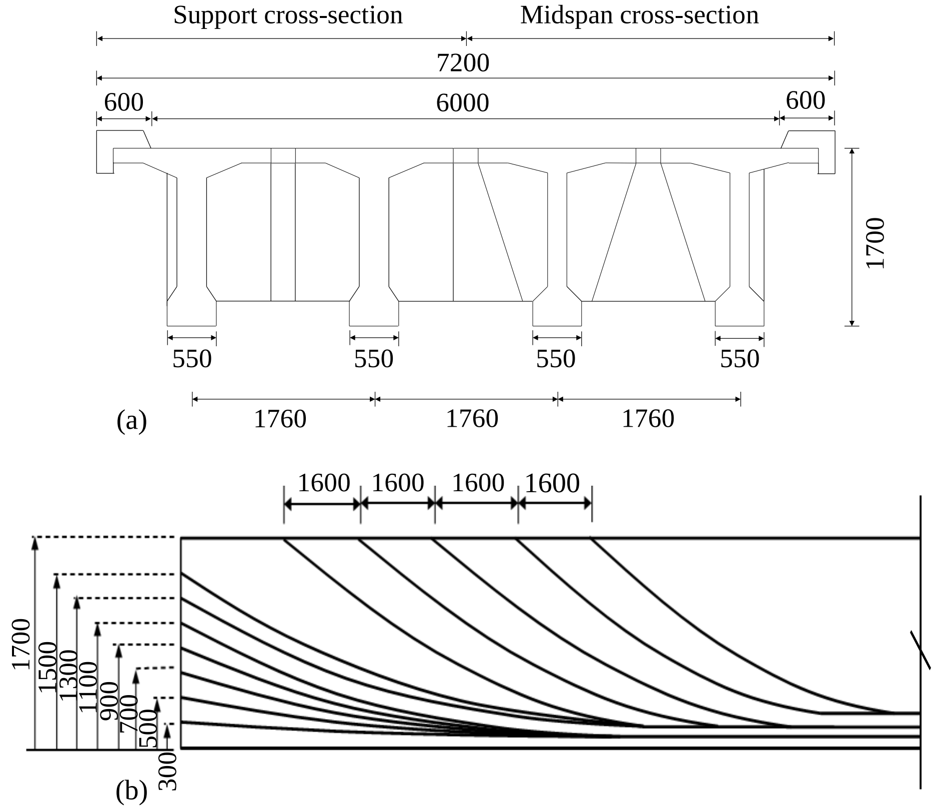

Fig.1 (a) Superstructure cross-section (b) Detail of prestressing tendons (Unit: mm)

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3. FINITE ELEMENT ANALYSIS

A commercial software 3D ATENA was implemented to conduct the nonlinear finite element analysis. The 3D tetrahedral solid element embedded with constitutive laws (Cervenka et al. 2016) was applied for concrete. The smeared crack combined with fixed crack principle (Cervenka et al. 2016) was used for considering concrete cracking and crushing. To account for the influence of the ordinary reinforcement such as stirrups, the concept of smeared reinforcement (Cervenka et al. 2016) was introduced.

For prestressing tendons, the truss element was adopted, and the perfect bond between concrete and prestressing tendons was assumed. One important note is that, to precisely simulate the actual situation in which the target span finally hit with the adjacent span due to the longitudinal displacement, the surface spring elements were utilized at the roller end of target span.

4. RESULT AND DISCUSSION

Figure 2 shows the load-deflection curve of four girders where the applied load is on the girder 1 (G1). Regarding the comparison between the analytical results and the experimental results, the 3D FEA can precisely reproduce the actual behavior observed during the field assessment. The maximum load capacity obtained from 3D FEA is 3.01 MN which is 2.41 times higher than the flexural design ultimate load capacity of 1.25 MN analytically calculated regarding the ACI code (ACI 2008).

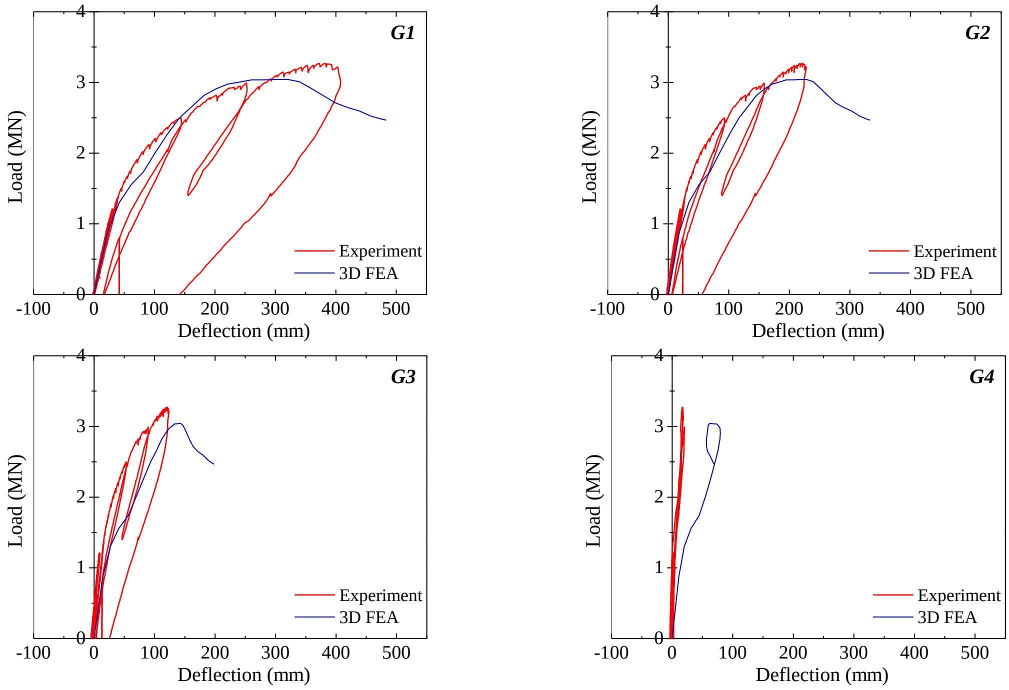

Fig.2 (a) Load-deflection curve of four girders: G1, G2, G3, and G4

5. CONCLUSIONS

To evaluate the structural performance of existing prestressed post-tensioned concrete bridge superstructures, the ultimate load capacity was analytically computed using 3D FEA. Finally, the results can be summarized that:

- The 3D FE model with proposed surface spring elements at the roller end can represent the actual behavior of the existing bridge superstructure.
- Since the 3D FEA exhibits higher ultimate load carrying capacity than the design ultimate load capacity, therefore, the old prestressed post-tensioned concrete T-girder bridge assessed in this study has significant reserve capacity.

REFERENCE

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