Development of Design Techniques for Road Bridges to Minimize Effect of Ground Deformation

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1. Introduction

In the 2016 Kumamoto Earthquake, there was a case of delay in early recovery of the function because of damage to the main beam and other important parts of the bridge in securing the serviceability of bridge (Fig. 1) as a result of slope collapse, ground displacement, etc. in addition to the shaking of the earthquake. From the lessons learned from this incident, Kumamoto Earthquake Recovery Division has been developing design techniques required to control breaking pattern in order to minimize the effect on functional recovery of the bride even if the substructure of the bridge moves greatly due to slope collapse or ground displacement.

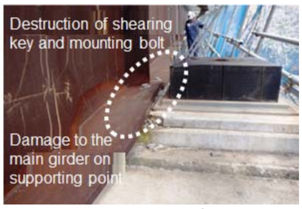


Fig. 1: Example of damage to the bridge bearing by the Kumamoto Earthquake

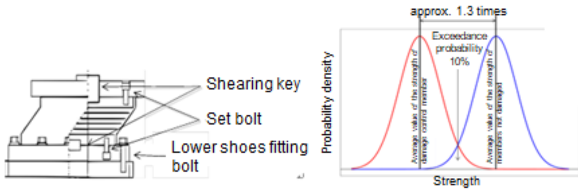
As a method of controlling breaking patterns in a bridge, this paper reports the status of study on design technique considering damage control focused on bearing and their fitting part.

2. Design concept of damage control type bearing

This study examines design techniques by determining in advance which part of bearing will be first destructed in a condition where the bearing ultimately breaks and designing the part so that the breaking pattern is generated with a certain level of reliability. In this study, control of breaking pattern is conducted by providing a significant difference of strength (stratified strength) between members that cause bearing and other members.

3. Shear test of damage control type bearing

In order to check whether the damage control type bearing causes the breaking pattern as expected by design, a shear test of laminated rubber bearing, to which surface pressure was applied to a certain extent, was conducted. For the rubber bearing used in this test, lower-shoes fitting bolts were selected as a member causing breaking in consideration of the viewpoints of functional recovery performance, including smaller level difference at girder end caused by breaking, certainty of damage control, and ease of replacement. Stratified strength was also designed so



(a) Damage control member **(b) Stratified strength**

Fig. 2: Design concept of damage control type bearing

Fig. 3: Bearing shear test

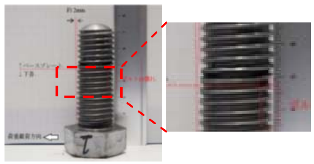


Fig. 4: Deformation of lower shoes fitting bolts

that when the shearing strain (horizontal displacement / height of the main unit of rubber bearing) of rubber bearing is 300%, lower shoes fitting bolts reach the final shearing stress but strength of over 1.3 times the stress is secured for members other than lower shoes fitting bolts (Fig. 2).

In the shear test, after conducting reversed cyclic loading at 4 stages until the shearing strain of rubber bearing reaches 300%, one-way loading was conducted until 350% considering as well safety of the test equipment used (Fig. 3). Since the test result showed that no breaking occurred at any part under the loading level of 350%, no breaking pattern could be confirmed. It was, however, confirmed that only the lower shoes fitting bolts, one of damage control members, deformed and the main unit of rubber bearing and other bolts had no damage (Fig. 4).

4. Conclusion

We intend to further study to improve damage control type bearing as required based on the test results.