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Seismic Performance of the Reinforced Concrete Girders Obtained from an Existing Building Constructed in 1961

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1 Introduction

The seismic performance of existing buildings in Japan is typically evaluated based on their structural drawings in accordance with the standards established in the Japanese Building Disaster Prevention Association's (JBDPA) 2001 guidelines. However, the actual components of the existing buildings frequently differ from their structural drawings; this complicates the accurate evaluation of their seismic performance. The equations recommended in the seismic evaluation were empirically derived using small scaled test specimens manufactured in the laboratory. In this study, the mechanical properties of concrete and the seismic performance of actual RC girders were investigated through experimental evaluations.

2 Existing Building and Experimental Procedure

The building under investigation is a five-story RC building; it was constructed in 1961 and was used for residual purposes. Fig. 1(a) shows an image of the building. The building's poor seismic performance could be attributed to a low amount of shear reinforcement. To estimate the mechanical properties of concrete, concrete cylinders were obtained when the building was demolished in 2017 as shown in Fig. 1(b). Two girders were obtained from the roof floor without any damage using a wire saw as shown in Fig.1(c). The material tests were performed using concrete cores and steel bars and seismic tests for the girders were performed to check the validity of the present equations used in the standard. The obtained girders were designed with shear span lengths of 1,200 mm, to investigate the validity of the shear capacity equation currently used for seismic evaluation. The original test girders were termed SG-1 and SG-2, respectively. Their flexural Q_{mu} and shear strengths Q_{su} were calculated using equations which

(a) (b) (c)

Figure 1. Existing building (a): comprehensive view of the test building; (b): concrete core boring; (c): cutting girder with a wire saw.

are provided in the standard JDBPA (2001). The failure modes of the members are very important factors for the seismic performance of existing buildings; therefore, valuating the strength of the RC members is necessary. Honeycombs were observed in girders; hence, one of the girders SG-2 was repaired using epoxy resin injection to investigate the effect of retrofitting.

3 Experimental Results

Fig. 2 (a), (b) depicts the relationships of the shear force Q with drift angle R in both the test girders. The calculated flexural and shear strengths of the original girders were 186 kN and 314 kN, based on the standard. The stiffness degradations for both the test girders were observed at the first loading cycle. In both girders, the peaks of the shear forces were measured at drift angle R = 1/200 rad. The maximum shear forces exceeded the calculated flexural strength and did not reach the calculated shear strength. Although the shear cracks progressed, the apparent strength degradations were not observed. Therefore, the main bars were estimated to be yielding. In contract, the hysteresis loops were of a slip - type from the initial stage. The bond slippage of the main bars from the concrete may have occurred because the reinforcement was a plain round bar, and the concrete strength was low. The maximum strength of the retrofitted girder was 1.07 times that of the original girder, although the girders before repair contained some honeycombs. Those values were much greater than the flexural strength calculated with current equations using the recommended material strength based on the standard (JBDPA, 2001). Fig.2(c) shows the comparisons between the observed envelope curves of the shear force responses and the shear strength calculated using material strength obtained by the material tests.

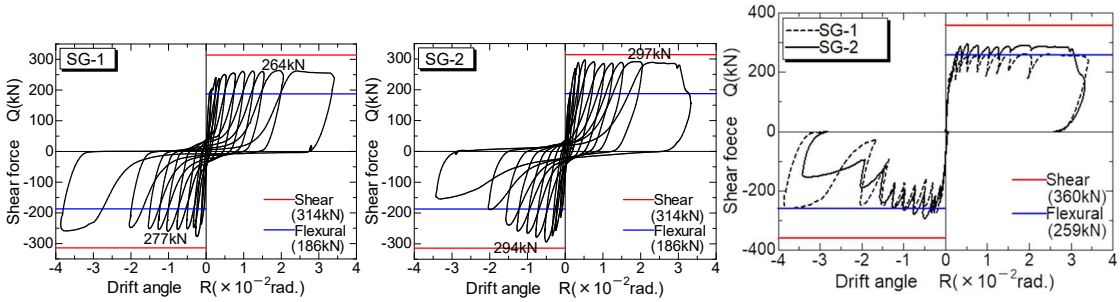

Figure 2. Shear force and drift angle response.

4 Conclusions

- The failure modes of the girders could be appropriately predicted through the method recommended in the standard. However, the phase of the bond slippage was observed in the hysteresis loops because of the plain round bars.
- Epoxy resin injection improved the seismic performance of the RC girders.
- The predicted flexural strengths were consistent with the observed maximum values.
- The researchers noted that the crack patterns of both the girders through the loadings were mainly shear failure modes.

References

Japan Building Disaster Prevention Association (JBDPA), (2001), Standards of seismic evaluation of existing RC buildings Revised Edition.