Analytical Study on Seismic Performance of Beam-to-Column Connections

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1. Introduction

As a result of the damage to steel bridges experienced during the Kobe Earthquake in 1995, Japanese seismic design codes were changed from elastic design to plasticity design. While the design guidelines for the columns were reviewed, the guidelines for beam-to-column connections were not clearly outlined due to lack of sufficient researches. Experiments were undertaken thereafter and valuable data of the beam-to-column connections were collected. However, the experiments had limitations and therefore it was necessary to undertake simulations by using finite element analysis methods. In this study, analysis is undertaken with an aim of gathering data on the seismic performance of beam-to-column connections under cyclic loading and observing the effects of various parameters. In this paper, the effects of parameters such as width-thickness ratio parameters and breadth-width ratio are investigated.

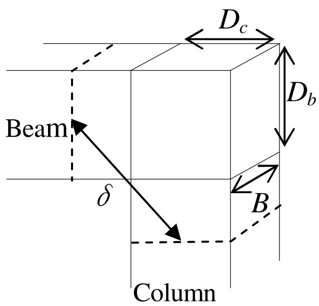

Fig.2. 1 Beam-to-Column Connection

2. Target Structure

The beam-to-column connection of a simple L-shaped frame was the target structure of this study as shown in Fig.2.1. The dimensions of several models were calculated so as to vary the parameters such as R_R and R_F and B/D_c.

3. Analysis Model

The validity of the model and program used in this study was verified in previous research[1]. Initial deflection was input in accordance with Japanese Highway Design Codes. Residual stress was input as shown in Fig.3.1. Meshing was done appropriately to ensure accuracy and efficiency of the analysis. A half model was utilized in the analysis as shown in Fig.3.2. Parametric analysis was then undertaken on a lot of models.

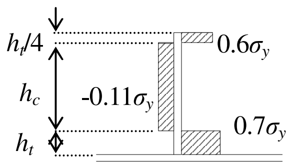

Fig.3.1 Longitudinal residual stress

4. Loading Conditions

Loading on the beam end at an angle of 35 degrees to the perpendicular was input. This load would ensure that the moment distribution at the connection was similar to the one experienced during an earthquake. Displacement measures were taken from the loading point and the corner displacement as shown in Fig.2.1. The latter was used as the measure of ductility for the connection.

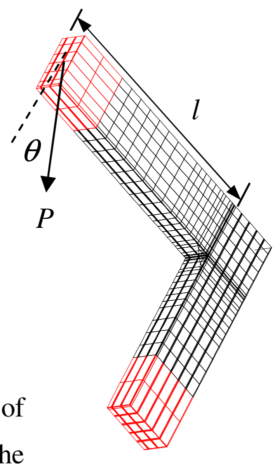

Fig.3.2 Analysis Model

5. Analysis Results

Fig.5.1 shows an example of the jack load - corner displacement relationship. Deformations of the connection after loading are shown in Fig.5.2. To compare the effects of parameters on the seismic performance, normalization of P_{max} and δ_m with P_y and δ_y was undertaken.

KEYWORDS: Beam-to-column connection, Seismic Performance, Parametric Analysis
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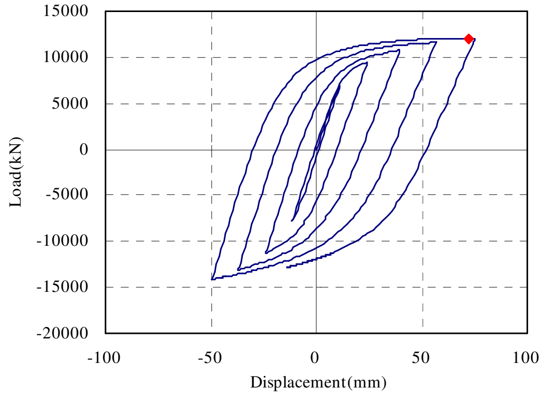

Fig.5.1 Cyclic Loading Response curve

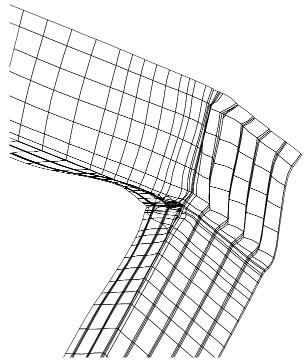

Fig.5.2 Deformation of connection

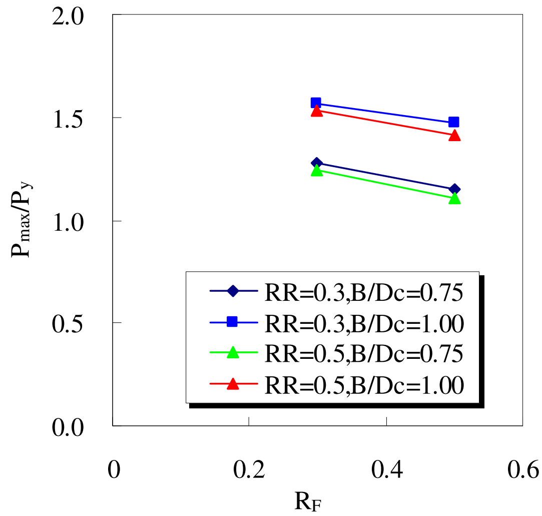

Fig.5.3 Effects on Strength

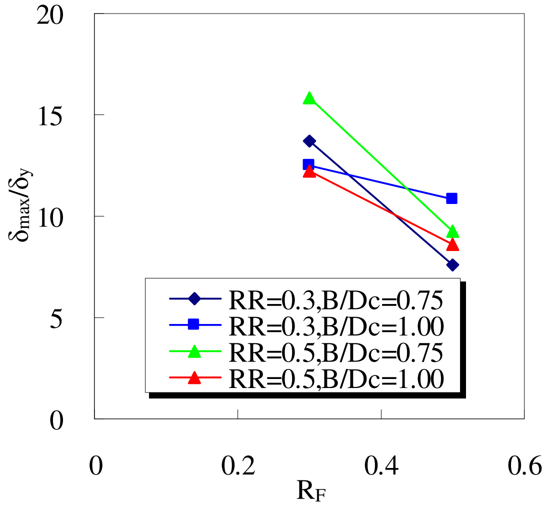

Fig.5.4 Effects on Displacement

$$\sigma = \frac{M}{W} + \frac{N}{A} \qquad \sigma = \frac{P \cdot \cos\theta \cdot l}{W} + \frac{P \cdot \sin\theta}{A} = P\left(\frac{\cos\theta \cdot l}{W} + \frac{\sin\theta}{A}\right) \qquad P_y = \sigma_y\left(\frac{\cos\theta \cdot l}{W} + \frac{\sin\theta}{A}\right)^{-1} \quad \textbf{(Eq.5.1)}$$

$$\tau = \frac{M}{2D_b t_w} - \frac{N}{4D_b D_c t_w} \qquad \tau = \frac{P \cdot \cos\theta \cdot l}{2D_b t_w} - \frac{P \cdot \sin\theta}{4D_b D_c t_w} = P\left(\frac{\cos\theta \cdot l}{2D_b t_w} - \frac{\sin\theta}{4D_b D_c t_w}\right) \qquad P_y = \tau_y\left(\frac{\cos\theta \cdot l}{2D_b t_w} - \frac{\sin\theta}{4D_b D_c t_w}\right)^{-1} \quad \textbf{(Eq.5.2)}$$

The yield loads P_y of flanges and corner plates were derived using Eq.5.1 and 5.2 respectively. The least of the two was used as the minimum value.

The normalized values of P_{max} and δ_m for all the models are shown in Fig.5.3 and Fig.5.4. There was a clear difference in P_{max}/P_y and δ_m/δ_y depending on R_R, R_F and B/D_c. The biggest changes in P_{max}/P_y were caused by B/D_c followed by R_F and the least effect was by R_R. Changes in δ_m/δ_y were observed with changes in R_F. The effects of R_F were observed more in models with *B/Dc*=0.75 than those with *B/Dc*=1.00.

6. Conclusion

In this study, the effect of parameters such as R_R, R_F and B/D_c on the seismic performance f beam-to-column connections was investigated by finite element analysis. From the results, it was found that an increase in width-thickness ratio parameter R_F led to a decrease in ultimate strength and ductility. Furthermore, it was also noted that the effect vary with the values of *B/Dc*.

7. References

1. Tanaka, K., Ono, K., Nishimura, N., Miyata, R., Maina, V. and Nara, S.: Experimental Study on Seismic Performance of Steel Rigid Frames; 2007 Proc. of JSCE Kansai Chapter, 2007.