Analytical Evaluation on High-rise building using Hybrid Buckling-restrained Braces

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1. Introduction

Having been developed to improve the drastic decrease of the internal strength due to the buckling of steel braces, buckling-restrained braces (BRB) were first designed in Japan in 1990. Since then, many other types of BRBs have been developed, mainly from the USA and Japan [1],[2]. BRB is a hysteretic damper that dissipates a large amount of energy through the accumulated plastic deformation in the case of a large deformation after steel core yields. BRB, however, shows elastic behavior against a load smaller than the yield load, and produces a minimal amount of energy dissipation, making it ineffective in a weak earthquake or in a wind load.

Thus, the development of a hybrid BRB (H-BRB), which has the BRB's energy dissipation capability not only against earthquake loads but also against wind loads, was required for high-rise buildings.

A time-history analysis of a 40-story building was performed in this study, using the properties of H-BRB, which was used in the structural test, and wind data which were acquired through a wind-tunnel test.

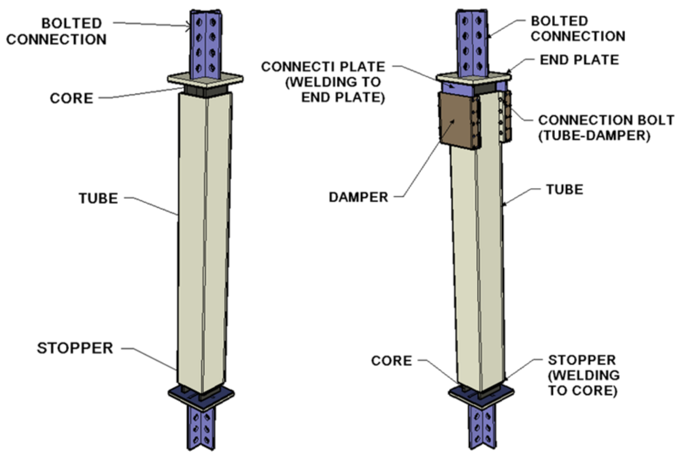


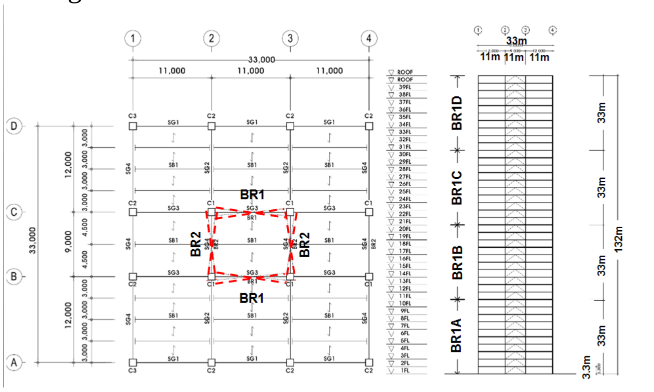
Figure 1 Comparison of BRB and H-BRB

2. Hybrid Buckling-restrained Brace System

H-BRB dissipates the energy produced by winds or minor earthquake within the elastic deformation, using the viscoelastic damper attached to the outer side of the tube, while the BRB dissipates the energy produced by large deformations, such as major earthquakes(Fig 1).

3. Analytical Study

The analysis model that was used for the evaluation of the wind-induced vibration control performance of H-BRB was a 40-story steel mixed-use building with a slenderness ratio of 4, a 33mx33m plane area, and a 132 m height.



(a) Typical Floor Plan (b) Elevation(x direction)
Figure 2 Plan and elevation of an analysis model

An analysis model was designed with identical conditions (design code = KBC 2005[3]; roof displacement limit = H/400). The equivalent damping ratio of the H-BRB testing model that was used in the design was 2%, a value that resulted from the test on the elastic region of the H-BRB testing model [4]. Drain-2DX was used in the study for time-history analysis [5].

The results of the wind-tunnel test by Daewoo E&C were used as the wind load data for the time-history analysis.

4. Results and Discussion

The analysis results are discussed herein based on the system comparison by brace type. The analysis results of NB-AL, BRB-AL, and H-BRB-AL are shown in Table 1.

Table 1 Comparisons of the roof responses according to brace types

	Roof displacement		Roof acceleration (mm/sec^2)		
	Max (mm)	Min (mm)	Max	Min	Absolute value
NB-AL	87.8 (0.778)	-6.40	133.9	-135.6	135.6 (0.969)
BRB-AL	112.9 (1.000)	-5.38	139.9	-137.0	139.9 (1.000)
H-BRB-AL	93.1 (0.825)	0.797	93.5	-99.1	99.1 (0.708)

(1) Displacement and acceleration at the roof

The maximum displacement of the rooftop floor, as can be seen in the analysis results, was reduced in the order of BRB-AL, H-BRB-AL, and NB-AL. Such a tendency is due to the fact that the buckling loads of the brace that were used in NB-AL, which was designed to have the same yield stress strength as BRB, is the largest among the three models.

(2) Hysteresis behavior of the 25-story brace

Shown in Fig. 3 is a comparison of the hysteresis behaviors of the braces of the systems caused by usable wind loads. The axial strength of H-BRB was between that of BRB and NB, showing that it is capable of dissipating energy, due to its damper.

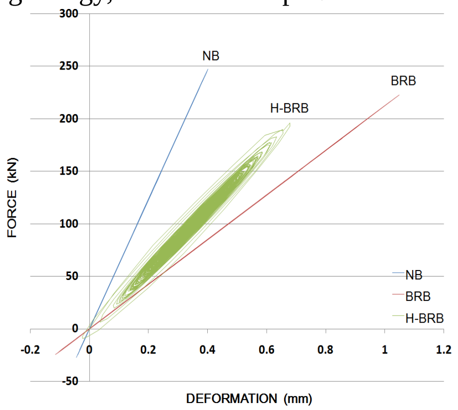


Figure 3 The force-deformation hysteretic loop of brace members at the 25th story

5. Conclusions

The results of the analysis of the 40-story steel building that was conducted in this study to evaluate the wind-induced vibration control performance of H-BRB are as follows:

(1) H-BRB is more effective for displacement control when designing wind loads than BRB is, as its core (the primary resisting component) is connected to its damper and tube (the secondary resisting component), which increases its lateral stiffness.

(2) The time-history analysis results based on the wind loads for the serviceability evaluation showed that the acceleration of H-BRB at the roof was 0.71 smaller than that of BRB, showing that the wind-induced vibration was improved in H-BRB.

(3) When designing BRB frames under the same conditions as those used for the steel-braced frames, H-BRB can improve both the lateral stiffness(the roof displacement) and the wind-induced vibration(the roof acceleration).

Acknowledgement

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