EARTHQUAKE RESPONSE ESTIMATION OF WOODEN HOUSE WITH NEW BRACE FASTENER

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ABSTRACT: A new type brace fastener which fastens the end of a diagonal wood brace to the end of column is developed for Post and Beam construction wooden houses. Since the brace fastener contains high damping rubber, it absorbs a displacement between the end of a wood brace and a column, damage of wood around wood screws is able to be prevented. On shake table test of a wood frame with a wood brace fastened by the new brace fasteners, the new brace fastener showed higher seismic performance in comparison with normal brace fastener especially under large earthquake motion. Moreover, by means of earthquake response analysis of two-storied wooden house, it was confirmed that the new brace fastener showed good seismic performance.

KEYWORDS: Wooden house, Brace fastener, High damping rubber, Shake table test, Earthquake response analysis

1 INTRODUCTION

Wooden houses play an important role to preserve human life and property. They need to bear repeated large earthquakes and to be in use even after large earthquakes. However, once wood is subjected to a force, a decline of stiffness occurs. Therefore, shear stiffness of shear walls subjected to an earthquake is considered to decline, which means wooden houses are hard to resist the repeated large earthquakes.

From the expressed reason, authors have been developed a new brace fastener which fastens the end of a diagonal wood brace to the end of column for Post and Beam construction wooden houses. Since the brace fastener contains high damping rubber, it absorbs a displacement between the end of a wood brace and a column, damage of wood around wood screws is able to be prevented. Therefore, the brace fastener minimizes the decline of stiffness, moreover damping force by the high damping rubber is produced.

2 OUTLINE OF THE NEW BRACE FASTENER

The new type brace fastener, as shown in Figure 1, consists of a L-shaped steel normal brace fastener, a steel plate and a high damping rubber with 5mm thick. The high damping rubber glues a L-shaped normal brace fastener and a steel plate together. The L-shaped normal brace fastener is fastened to the end of a column with nine 75mm long wood screws installed at the end of a brace fastener

Figure 1: New developed brace fastener

Picture 1: Wood brace fastened by the new fastener

Picture 2: New brace fastener installed at the end of a brace
wood screws and the steel plate is fastened to the end of a wood brace with six 45mm long wood screws. In addition to the wood screws, four 45mm long wood screws which fasten the L-shaped fastener and a wood brace directly are added for fail-safe considering exfoliate of high damping rubber. Picture 1 shows a wood frame with double wood braces which are fastened by the new brace fasteners at the ends of braces as shown in Picture 2.

3 SHAKE TABLE TEST
Shake table test of a wood frame specimen with a wood brace fastened by the new brace fasteners was performed to evaluate its seismic performance.

Figure 2 shows test result of a wood frame with double wood braces fastened by the new brace fasteners. Maximum drift and shear force under 50% of JMA Kobe were 3% and 13kN, respectively. In a series of this test, a test of a wood frame with double wood braces fastened by normal brace fasteners was also performed. Figure 3 shows the result under 50% of JMA Kobe wave. The maximum drift was 5.6%, it is 1.9 times as much as the drift with the new brace fastener. The use of the new brace fastener is effective especially under relatively large earthquake motion.

4 EARTHQUAKE RESPONSE ANALYSIS
Earthquake response analysis of two-storied wooden houses was carried out to examine the seismic performance of the new brace fastener under earthquake motions.

For the analysis model, five ratios of existing wall length to required wall length in the Building Standard Law in Japan(Re) were set. Moreover, four ratios of second floor area to first floor area(Rs) were also considered to the analysis model.

Analysis result under JMA Kobe wave is shown in Figure 4. Maximum response drift on each floor of analysis models with wood braces fastened by the new brace fasteners are conservative in comparison with the one fastened by normal brace fasteners at any Rs and Rf. Especially at Re=1.0(minimum wall length under the Building Standard Law in Japan), the response drift of the first floor with the new brace fasteners is from 35% to 39% of the one with normal brace fasteners. The new brace fastener showed relatively good seismic performance especially in lower Re case.

5 CONCLUSIONS
A new type brace fastener which fastens the end of a diagonal wood brace to the end of column is developed for Post and Beam construction wooden houses. On shake table test of a wood frame with a wood brace fastened by the new brace fasteners, the new type brace fastener showed higher seismic performance in comparison with normal brace fastener especially under large earthquake motion. Moreover, by means of earthquake response analysis of two-storied wooden houses, it was confirmed that the new brace fastener showed good seismic performance.