RACKING PERFORMANCE OF SHEATHED SHEAR WALL FASTENED WITH NAILS AND SCREWS TOGETHER

Yasunobu Noda¹, Masahiko Toda², Takuya Fujiwara²

ABSTRACT: Almost all panels of sheathed shear walls are fundamentally fastened with a single type of fastener. However, a combination of different types of fasteners can be required in certain construction situations. In this study, the racking performance of a sheathed shear wall which composed of 30 mm-thick three-layered panels made of Todomatsu (Abies sachalinensis) was evaluated. The panels were nailed to the frame and screwed with each other using connecting members. The story deformation angle of the wall was predicted by modelling the rotational deformation of each panel at every loading level, and considering the relationship between the load and the slip of the nail and the screw, obtained from a single fastener shear test. The predicted relationship between the lateral load and the story deformation angle showed good agreement with that observed in the initial deformation region.

KEYWORDS: Nailed joint, screwed joint, combined joint, bearing wall.

1 INTRODUCTION

For the construction of conventional posts and beams in Japan, shear walls are important elements of consideration, as they resist seismic forces. Applying Tuomi assumption [1] or Kamiya’s equation [2], racking performance to sheathed walls can be predicted on the basis of load-slip performance of a single fastener. Murakami [3] also derived an advanced theory for asymmetrical nailed situations, which is well known in HOWTEC reference [4] as a typical analysis method. This study attempts to customise Kamiya’s equation for a combination of fasteners – nail and screws – used to fasten the same panel.

2 EXPERIMENTS

2.1 SHEAR TESTS OF SINGLE FASTENER

Single fastener shear tests of a nail (CN75) and a screw (Nedanotto ND5-70) were conducted. Shear test of single fasteners is shown in Figure 1. The main member was Todomatsu and the side member was 30 mm thick three-layer cross-laminated panel of Todomatsu. The end margin of faster was 25 mm. Loading protocol was determined as ±0.5, ±1, ±2, ±4, ±8, and ±25 mm. Five screws and 10 nails were employed as specimens for the test.

2.2 RACKING TEST OF SHEAR WALL

The shear wall specification is shown in Figure 2. Those panels were connected to the frame using CN75 nails at a pitch of 200 mm. And those panels were connected to each other using connecting member on the outside with screws from the inside. Loading schedule was determined as ±1/450, ±1/300, ±1/200, ±1/150, ±1/100, ±1/75, ±1/50 and ±1/15 rad of story deformation angle with 3 repeats. Three specimen were tested.

Figure 1: Specification of single fastener shear specimen.

Figure 2: Specification of shear wall specimen.

¹ Yasunobu Noda, Forest Products Research Institute, Hokkaido Research Organization, 1-10 Nishikagura, Asahikawa, Hokkaido, Japan. Email: noda-yasunobu@hro.or.jp
² Masahiko Toda and Takuya Fujiwara, Forest Products Research Institute, Hokkaido Research Organization, Japan.
3 THEORY

Regarding the sheathing panel as rigid body, shear deformation angle $\gamma$ of the wall depends on each fastener’s slip $\delta_i$ on each panel. Kamiya’s equation [2] defined moments $(M_x, M_y)$ obtained for components $x$ and $y$ of the slip $(x_i, y_i, \delta_i)$ of each fastener on the panel, focusing on each panel’s rotation. The equation can be further extended by taking into account the rotational centre of the panel as follows.

$$M_x = \sum x_i q_i (y_i - y_G) \tag{1}$$

$$M_y = \sum y_i q_i (x_i - x_G) \tag{2}$$

Here, $x_i$ and $y_i$ are of the x and y component forces of each fastener, $(x_i, y_i)$ is the coordinate of each fastener, and $(x_G, y_G)$ is the coordinate of rigidity centre of all fasters. The rigidity centre is derived from the equilibrium of component forces of all fasteners at every story deformation angle. $x_i$ and $y_i$ are obtained from $\delta_i$ as follows.

$$\delta_i = \sqrt{(\delta_i^2 + \delta_i^2)} \tag{3}$$

$$x_i = \frac{x_i}{\delta_i} f(\delta_i) , \quad y_i = \frac{y_i}{\delta_i} f(\delta_i) \tag{4}$$

$f(\delta)$ is applied to the observed curves in single shear test. For the equilibrium of the moment, lateral force $P$ of the wall can be expressed by resisting force $P_j$ and height $h_j$ of each panel, as follows.

$$P = \sum_j P_j h_j \sum h_j \tag{5}$$

Work subjected to lateral force, $P_j$, and total work of all fasteners, $tU$, in a panel, are defined as

$$pU_j = \frac{P_j h_j \gamma}{2} , \quad tU_j = \sum \frac{f(\delta_i) \delta_i}{2} \tag{6}$$

The relationship between $P$ and $\gamma$ can be obtained when $pU = tU$.

4 RESULTS

4.1 SHEAR TEST OF SINGLE FASTENERS

The results of the average of single fasteners shear test is shown in Figure 3. The maximum load of the screw was 1.37 times of the nail. The initial stiffness of the screw was higher than the nail.

4.2 COMPARISON BETWEEN OBSERVED AND CALCULATED RACKING PERFORMANCE OF SHEAR WALL

Figure 4 shows observed $P-\gamma$ curves enveloped. The Initial stiffness of predicted curve shows good agreement with observed curve. The obtained maximum loads are higher than the predicted. This could have been due to the friction of the edges of each panel in the actual experiment.

5 CONCLUSION

Kamiya’s equation can be developed to predict curve expressing the relationship between the load and the story deformation angle of sheathed shear wall in case of combined fasteners.

REFERENCES