THEORETICAL ESTIMATION OF MECHANICAL PROPERTIES OF PLYWOOD-SHEATHED SHEAR WALL WITH COMBINED USE OF ADHESIVE TAPE AND WOOD DOWELS

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Abstract. Shear walls often function as elements that provide resistance to horizontal external forces exerted on wooden frames. Many shear walls with superior strength performance have been developed for this purpose. Amidst this backdrop, we have attempted to develop a shear wall that, in addition to strength performance, decreases the time and labor required for disposal. More specifically, the authors proposed a novel "metalless" shear wall: a shear wall in which industrial double-sided adhesive tape is used to attach plywood to the framework. Also, wood dowels are used as supplementary connectors with the aim of enhancing strength performance. Unlike conventional shear walls that use nails and metal fixtures, separation at the time of disposal is unnecessary, and therefore, disposal time and labor of the wall are anticipated to be significantly decreased. Thus, this study involved demonstrating and verifying a method of theoretical analysis for the mechanical performance of these kinds of shear walls toward in-plane shear force. Specifically, this study derived a method to estimate the mechanical behavior (load-deformation angle relationship) of plywood-sheathed shear walls based on shear performance obtained from double shear tests of joint specimens with the combined use of adhesive tape and wood dowels. Also, the validity of the method was experimentally verified. The results showed that the method proposed in this study was able to estimate the mechanical behavior and mechanical properties of the newly proposed shear wall, and the validity of the method was confirmed.

Keywords: Mechanical properties, theoretical estimation, shear wall, adhesive tape, wood dowel.

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INTRODUCTION

Improvements in mechanical performance are regularly demanded of wooden structures adopted in residential homes. In particular, in Japan, where disasters such as earthquakes and typhoons occur frequently, interest is great in mechanical performance toward external force exerted in the horizontal direction. This interest was further heightened following the massive damage caused by the Great East Japan Earthquake in 2011. Also, in recent years, not only mechanical perspectives but also life cycle assessments have been considered. In residential home and equipment design, there is demand not only for basic performance such as durability and thermal and sound insulation but also for designs that decrease the amount of time and labor required for disassembly and disposal. These two points—improvements in mechanical performance and low environmental burden—will be important in the field of wooden residential construction in the future.

The development of "metalless" structural elements, which do not use metal parts such as nails and metal fixtures, is one way to lower the environmental burden. Currently, nails and metal fixtures are used to enhance mechanical performance of the various structural elements of wooden buildings. However, at the disposal stage, the metal must be separated from the wood, which requires a great deal of labor, time, and cost. Metalless structural elements, conversely, can decrease the amount of time and labor required for this disposal. The authors proposed the novel method of using adhesive tape and wood dowels to mount plywood on the framework of shear walls. Plywood-sheathed shear walls are widespread structural elements for wooden structures. And, because large quantities of nails are generally used in these walls, they involve the aforementioned time and labor for disposal issue. We therefore attempted to decrease the environmental burden by using adhesive tape and wood dowels in place of joining by nails thereby decreasing separation time and labor at the time of disposal.

Aiming to apply this joining method to shear walls, Fukuta et al (2013) investigated the shear performance of joints using adhesive tape and wood dowels. The shear performance obtained in that study was not inferior to that of conventional nail joining. Plywood-sheathed shear walls that use the proposed adhesive tape and wood dowel joining method can therefore be expected to exhibit sufficient mechanical performance. In addition, from the results of the in-plane shear force test actually conducted using plywood-sheathed shear walls, Fukuta et al (2015) were able to infer that, even in the case of combined use of adhesive tape and wood dowels, the walls possessed sufficient mechanical performance for use as structural elements of wooden residential homes.

As for existing research pertaining to mechanical performance estimation of plywood-sheathed shear walls, Tuomi and McCutcheon (1978) are well known for blazing the trail of theoretical analysis. They deduced a method of estimating the maximum load of shear walls by applying shear performance of nail joining to the slip between plywood and framework of shear walls when in-plane shear deformation occurred in plywood-sheathed shear walls. After their research, many researchers attempted the theoretical estimation of mechanical behavior of plywood-sheathed shear walls joined with nails. Hirashima (1981), eg, theoretically estimated nonlinear mechanical behavior of plywood-sheathed shear walls by reflecting the nonlinear behavior of the relationship between the load and displacement of parts joined with nails (Easley et al 1982; McCutcheon 1985; Schmidt and Moody 1989). Also, a simplified method of expressing them was proposed (Kamiya 1981). These studies assumed the framework to be a rigid body, but Gupta and Kuo (1985) conducted a derivation that took flexural deformation of the framework into account. Furthermore, these theoretical derivations expanded the range of application to all cases imaginable: Sugiyama and Matsumoto (1993a, b, 1994) derived nonlinear behavior of plywood-sheathed shear walls in cases in which there was an aperture, Murakami and Inayama (1999) in cases in which nails were arranged in complex patterns, and Källsner and Girhammar (2009) in cases in which the framework was anchored to the foundation. Unlike these studies, this study is an example of theoretical derivation of nonlinear behavior in a case using a joining method different from joining by nails.

FORMULATION OF MECHANICAL BEHAVIOR OF SHEAR WALLS

Mechanical Model

To arrive at the relationship between force and deformation of plywood-sheathed shear walls with adhesive tape and wood dowels as the joining implements, let γ be the deformation angle of the shear wall when a certain external force P_W acts on the shear wall. Assume γ to be the sum of the deformation angle of the shear wall caused by the slip between the plywood and the framework γ_S and the deformation angle of the plywood γ_P as shown in Eq (1):

$$\gamma = \gamma_S + \gamma_P \tag{1}$$

In this study, in the four-sided outer perimeter of the joined region of the shear wall shown in Fig 1, the authors refer to the regions joined in the horizontal direction (upper and lower sides) as the horizontally connecting part (HCP) and the regions joined in the vertical direction (left and right sides) as the vertically connecting part (VCP). Considering the relationship between deformation angle γ_S and external force P_W, assuming the surface material is a rigid body, this study shows a method for calculating the resistance corresponding to the slip between the surface material and framework independently for each bonding region as follows:

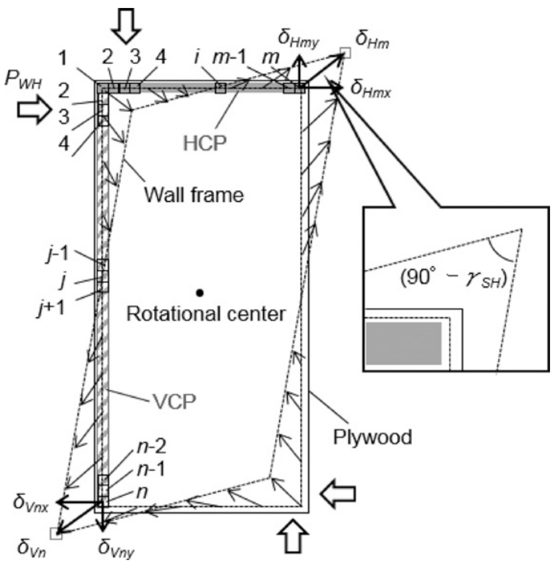

Figure 1. Appearance of deformation of framework by an external force (HCP, horizontally connecting part; VCP, vertically connecting part).

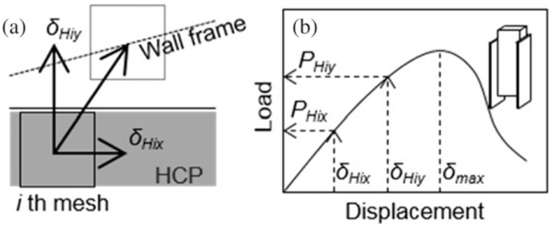

Figure 2. Calculation method for mesh displacement and resistance (HCP, horizontally connecting part).

Relationship between Load and Deformation Angle in Horizontally Connecting Part

First, the authors derived the relationship between load P_{WH} that acts on one side of an HCP of the joined region and deformation angle γ_{SH} in plywood-sheathed shear walls. The authors assumed the deformation caused by the slip between the plywood and framework was produced in the center of the rigid-body plywood. The authors divided the joined region into a mesh containing m units (Fig 1) and took displacement of the edge as δ_{Hm}. Displacement of each unit of the mesh can be thought of as dividing displacement components into the horizontal and vertical directions as shown in Fig 2a. If displacement of the ith unit of the mesh is δ_{Hi}, then the authors can express its horizontal component as δ_{Hix} and its vertical component as δ_{Hiy} ($1 < i < m$). Then, because the horizontal component of displacement δ_{Hix} is for any unit of the mesh, the relationship of displacement δ_{Hm} of the edge and displacement δ_{Hix} of the ith unit of the mesh is

$$\delta_{Hix} = \delta_{Hmx} \tag{2}$$

Also, vertical component δ_{Hiy} can be expressed as Eq (3) from the geometrical relationship of Fig 1:

$$\delta_{Hiy} = \left(2 \times \frac{i}{m} - 1\right) \times \delta_{Hmy} \tag{3}$$

From this, the deformation angle γ_{SH} of the HCP of the joined region can be expressed as Eq (4) using edge displacements δ_{Hmx} and δ_{Hmy}:

$$\gamma_{SH} = \frac{2\delta_{Hmx}}{H} + \frac{2\delta_{Hmy}}{L} \tag{4}$$

By applying the relationship of the slip and shear load of the joints to respective displacement components δ_{Hix} and δ_{Hiy} (this relationship is expressed as $P_J = f_J\ (\delta_J)$), the authors calculated resistance P_{Hi} for the ith unit of the mesh (Fig 2b). The horizontal component P_{Hix} and vertical component P_{Hiy} with respect to resistance can be expressed as follows using the relationship between load and slip ($P_J = f_J\ (\delta_J)$) that can be obtained in shear testing of the joint:

$$P_{Hix} = \begin{cases} f_J(\delta_{Hix}) & \left(\sqrt{\delta_{Hix}^2 + \delta_{Hiy}^2} \le \delta_{max}\right) \\ 0 & \left(\sqrt{\delta_{Hix}^2 + \delta_{Hiy}^2} > \delta_{max}\right) \end{cases} \tag{5}$$

$$P_{Hiy} = \begin{cases} f_J(\delta_{Hiy}) & \left(\sqrt{\delta_{Hix}^2 + \delta_{Hiy}^2} \le \delta_{max}\right) \\ 0 & \left(\sqrt{\delta_{Hix}^2 + \delta_{Hiy}^2} > \delta_{max}\right) \end{cases} \tag{6}$$

Here, δ_{max} was used as displacement at maximum load in the shear test of the joint (Fig 2b). In Eqs (5) and (6), resistance becomes zero when mesh displacement δ_{Hi} reaches δ_{max}.

Next, the authors considered rotational moment around the center of the surface materials at the ith unit of the mesh. Considering the left-turning moment as under load P_{Hix} and the right-turning moment as under load P_{Hiy}, the sizes of the respective moments are expressed in Eqs (7) and (8).

$$M_{Hix} = P_{Hix} \times \frac{H}{2} \tag{7}$$

$$M_{Hiy} = P_{Hiy} \times \left(2 \times \frac{i}{n} - 1\right) \times \frac{L}{2} \tag{8}$$

Because M_{Hix} and M_{Hiy} are balanced at this time,

$$\sum_{i=1}^{m} M_{Hix} = \sum_{i=1}^{m} M_{Hiy} \tag{9}$$

The authors determined the combination of values of δ_{Hmx} and δ_{Hmy} that satisfy Eq (9) by numerical calculation and obtained the relationship of the horizontal and vertical components of the slip between plywood and framework in the HCP. This concept is the same as that of Kamiya's research but differs from that of Tuomi's, in which the displacement at the corners of the framework was held to follow the diagonal direction of the plywood.

Conversely, resistance P_{WH} at this time becomes as in Eq (10):

$$P_{WH} = \frac{\sum_{i=1}^{m} M_{Hix}}{H} = \frac{m}{2} \times f_J(\delta_{Hmx}) \tag{10}$$

Here, because γ_{SH} can be expressed in terms of δ_{Hmx} and δ_{Hmy} based on Eq (4) and δ_{Hmx} can be expressed as δ_{Hmy} based on Eq (9), P_{WH} can be expressed by γ_{SH} in Eq (10). The relationship is expressed as $P_{WH} = f_{WH}\ (\gamma_{SH})$.

Relationship between Load and Deformation Angle in Vertically Connecting Part

Continuing from the previous section, the authors derived the relationship of load P_{WV} that acts on one side of the joined region, VCP, and shear angle γ_{SV}. In the same way as in the previous section, the authors divided this joined region into a mesh of n units as shown in Fig 1. If the edge displacement is δ_{Vn}, the horizontal displacement δ_{Vjx} of the jth unit of the mesh is

$$\delta_{Vjx} = \left(2 \times \frac{j}{n} - 1\right) \times \delta_{Vnx} \tag{11}$$

Also, because vertical displacement δ_{Vjy} at the jth unit of the mesh is the same as for any unit of the mesh,

$$\delta_{Vjy} = \delta_{Vny} \tag{12}$$

From the previous equations, the deformation angle γ_{SV} of the joined region VCP can be expressed as Eq (13) by using VCP edge displacements δ_{Vnx} and δ_{Vny}:

$$\gamma_{SV} = \frac{2\delta_{Vnx}}{H} + \frac{2\delta_{Vny}}{L} \tag{13}$$

Next, resistance P_{Vjx} and P_{Vjy} at the jth unit of the mesh in the VCP become Eqs (14) and (15), similar to Eqs (5) and (6).

$$P_{Vjx} = \begin{cases} f_J(\delta_{Vjx}) & \left(\sqrt{\delta_{Vjx}^2 + \delta_{Vjy}^2} \le \delta_{max}\right) \\ 0 & \left(\sqrt{\delta_{Vjx}^2 + \delta_{Vjy}^2} > \delta_{max}\right) \end{cases} \quad (14)$$

$$P_{Vjy} = \begin{cases} f_J(\delta_{Vjy}) & \left(\sqrt{\delta_{Vjx}^2 + \delta_{Vjy}^2} \le \delta_{max}\right) \\ 0 & \left(\sqrt{\delta_{Vjx}^2 + \delta_{Vjy}^2} > \delta_{max}\right) \end{cases} \quad (15)$$

Moments M_{Vjx} and M_{Vjy} around the center of the surface material at the jth unit of the mesh are expressed as Eqs (16) and (17); because they are balanced, they become as expressed in Eq (18).

$$M_{Vjx} = P_{Vjx} \times \left(2 \times \frac{j}{n} - 1\right) \times \frac{H}{2} \quad (16)$$

$$M_{Vjy} = P_{Vjy} \times \frac{L}{2} \quad (17)$$

$$\sum_{j=1}^{n} M_{Vjx} = \sum_{j=1}^{n} M_{Vjy} \quad (18)$$

Concerning Eq (18), we obtained a combination of values of δ_{Vnx} and δ_{Vny} that satisfied Eq (9) by numerical calculation and determined the relationship of the horizontal and vertical components of the slip between plywood and framework in VCP. Conversely, resistance P_{WV} at that time became as in Eq (19):

$$P_{WV} = \frac{\sum_{j=1}^{n} M_{Vjx}}{H} = \frac{1}{4}\sum_{j=1}^{n} \left\{ f_J\left(\left(2 \times \frac{j}{n} - 1\right) \times \delta_{Vnx}\right) \times \left(2 \times \frac{j}{n} - 1\right)\right\} \quad (19)$$

Here also, the relationship of P_{WV} and γ_{SV} is expressed as $P_{WV} = f_{WV}(\gamma_{SV})$, just as for Eq (10).

Shear Deformation of Plywood

In the previous section, we assumed the plywood to be a rigid body and determined the relationship of the slip between the plywood and framework with the load produced by it. However, the plywood was actually shear distorted. If we assume the relationship of plywood shear deformation γ_P and external force P_W shows linear behavior in the range in which deformation of the shear wall is supposed, the relationship becomes as expressed by Eq (20):

$$\gamma_P = \frac{P_W}{LTGN} \quad (20)$$

Here, L and T mean width and thickness of the plywood, respectively, G means elastic shear modulus of plywood, and N means number of plywood used for the shear wall.

Relationship of Load and Deformation Angle of Shear Wall

First, the authors considered load P_W at the time when deformation angle γ_S of the shear wall was produced by the slip between plywood and framework. Figure 3 shows the relationship of P_{WH}–γ_{SH} and P_{WV}–γ_{SV} obtained by Eqs (10) and (19). Here, the authors extracted the value of the load at the deformation angle γ_S. In addition, resistance P_W of the shear wall at the deformation angle γ_S can be calculated by multiplying row numbers N_H and N_V (eg $N_H = 4$, $N_V = 4$ in Fig 5 of HCP and VCP by the extracted load values and then summing them, as in Eq (21):

$$\begin{aligned} P_W &= P_{WH} \times N_H + P_{WV} \times N_V \\ &= f_{WH}(\gamma_S) \times N_H + f_{WV}(\gamma_S) \times N_V \end{aligned} \quad (21)$$

Next, the P_W–γ relationship of the shear wall can be determined by adding shear deformation

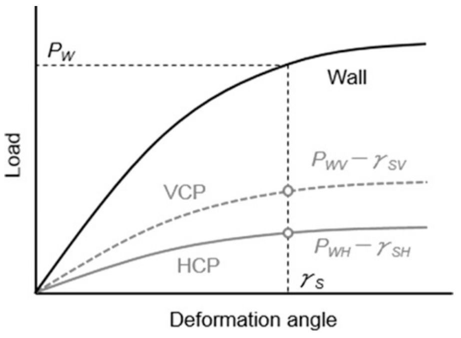

Figure 3. Calculation method for the P_W–γ_S relationship of shear walls (VCP, vertically connecting part; HCP, horizontally connecting part).

angle γ_P (Eq 20) of the plywood at the time of load P_W to γ_S in the P_W–γ_S relationship obtained by Eq (21).

MATERIALS AND METHODS

Joint Shear Test

The authors conducted double shear tests (Fig 4a) to determine shear performance of joints with the combined use of adhesive tape and wood dowels. Details of the tests are indicated in Fig 4b. Japanese cedar (*Cryptomeria japonica* D.DON) was used as the base material, and Japanese cedar structural plywood (4-ply, 12 mm thick) was used as the side panels. Two types of acrylic resin double-sided adhesive tape were used (Toyo Ink Co., Ltd., Tokyo, Japan): R230 and DF5680A, with nonwoven fabric and polyolefin foam as their respective base materials. In addition, the authors used wood dowels made of beech (*Fagus crenata* Blume), 10 mm in diameter and 36 mm long with a knurled surface. There were three joining methods: one using a combination of R230 and wood dowels (specimen symbol T1D), one using a combination of DF5680A and wood dowels (T2D), and another (N) mounted with nails (CN50) without adhesive tape (Fig 4b). Three specimens were prepared using each joining method, for a total of nine specimens. Specimens using adhesive tape were pressed immediately after tape application for 10 s at 1.0 MPa. Holes 9.5 mm in diameter were subsequently drilled, and wood dowels were driven into them. As shown in Fig 4a, in the double shear tests, load P was applied downward in the vertical direction from the upper surface of the base material, and slip displacement δ_J of the base material and side panel when the load was applied was measured.

Shear Wall Horizontal Load Test

Horizontal load tests were conducted on plywood-sheathed shear walls to verify the estimation method of mechanical performance derived herein. A shear wall specimen is shown in

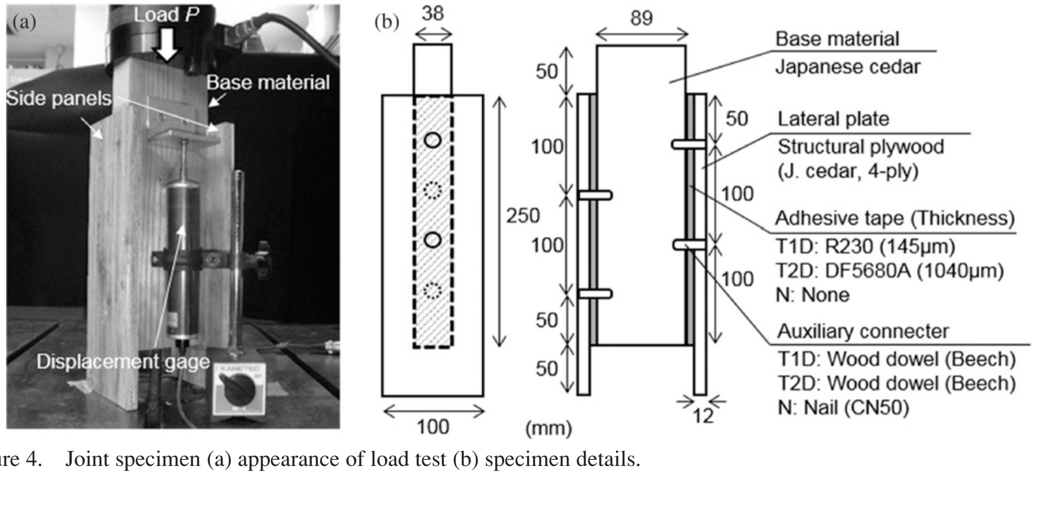

Figure 4. Joint specimen (a) appearance of load test (b) specimen details.

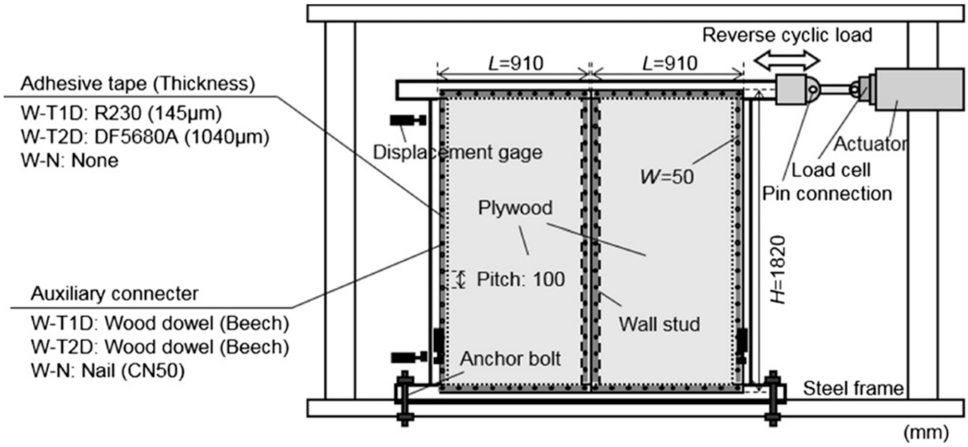

Figure 5. Shear wall specimen and horizontal loading test method.

Fig 5. As in the joint test specimens in the previous section, the specimens were made of Japanese cedar (cross section dimensions 105 × 105 mm) for the framework and Japanese cedar structural plywood ($T = 12$ mm, $L = 910$ mm, and $H = 1820$ mm) for the surface material. As shown in Fig 5, the same three types of joining methods as used for the joint specimens were used to join the plywood with the framework. Width W of the adhesive tape was 50 mm. Clamps were used to press the adhesive tape joints of framework and plywood. However, pressing was only applied to the peripheral parts of the shear wall and not to the stud parts. Three specimens were prepared for each of the test conditions, for a total of nine pieces.

The test was conducted in accordance with the test standardized by Japan Housing and Wood Technology Center (2008) to calculate rigidity and allowable shear capacity of vertical and horizontal structures. Figure 5 shows an overview of the test. The foundation of each specimen was fastened to the test machine with anchor bolts; one end of the beam was attached to a hydraulic actuator. Reverse cyclic load was applied here. The loading sequence consisted of nine cyclic steps with three identical cycles. The deformation angle amplitudes of each of the cyclic steps were ±1/450, 1/300, 1/200, 1/150, 1/100, 1/75, 1/50, 1/30, and 1/10 rad. The test was conducted until the applied load become 80% of maximum load after reaching the maximum load.

RESULTS AND DISCUSSION

Shear Behavior of Joints

Figure 6 shows the relationship of δ_J and shear load P obtained through the double shear tests of the joints. The thin lines trace the experimental results from the three specimens, and the thick

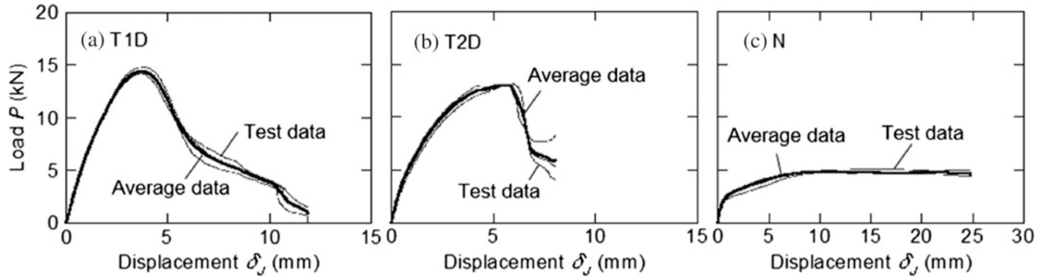

Figure 6. Relationship of shear load and slip of joint specimen.

lines trace the average loads at various displacements for the three thin lines. As Fig 6 shows, the maximum load of the T1D and T2D specimens was nearly 2.5-3 times that of the *N* specimens. However, shear load dropped notably after reaching maximum load. In contrast, for the N specimens, after reaching maximum load, almost no drop in shear load was observed accompanying the increase in slip displacement.

Mechanical behavior of shear walls is calculated in the next section using these shear test results for the joints. However, it is necessary to convert the P–δ_J relationship indicated by the thick line in Fig 6 to the P_J–δ_J relationship that serves as the basis for estimating mechanical behavior of shear walls. That is expressed as Eq (22) with joint area A_S of the joint specimens and area A_J per single mesh unit of the shear wall specimens:

$$P \times \frac{A_J}{A_S} = P_J = f_J(\delta_J) \qquad (22)$$

This serves as the basis for estimation of mechanical behavior of plywood-sheathed shear wall (ie the P_W–γ relationship).

Mechanical Behavior of Shear Walls

Figure 7 shows a W-T1D specimen as an example of the results of the horizontal load tests on shear walls. In addition, the envelope curve in the direction of applied force when the final force is applied is based on mechanical behavior such as those given in Fig 7. The thin line in

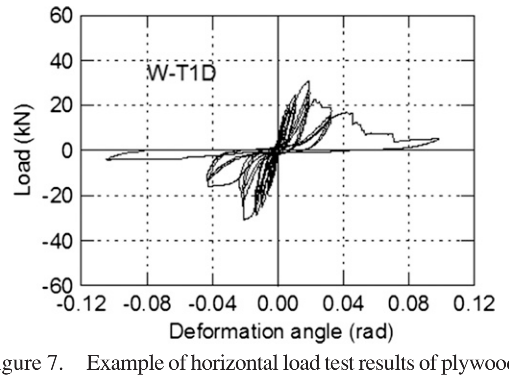

Figure 7. Example of horizontal load test results of plywood-sheathed shear walls.

Fig 8 shows the envelope curves of all specimens. W-T1D and W-T2D had maximum load comparable with W-N (25-30 kN). Therefore, the adhesive tapes and wood dowels appear to be useful as connecters. According to Fukuta et al (2013), maximum load of joint specimens with the adhesive tapes and wood dowels was double that of specimens with only the tapes, which means the contribution of ones on maximum load is half-and-half. The result appears to apply to the case of the specimens W-T1D and W-T2D. Along with verifying the estimation method by comparing these envelope curves and the theoretical values used to estimate them, this section adds some discussion concerning the mechanical properties of shear walls with adhesive tape.

The thick dotted line in Fig 8 is the result of calculating according to the estimation method proposed herein. These calculation results are based on the experimental results of Fig 6, and it can be confirmed that they reflected the mechanical behavior of the joints. This shows that the theoretical values and experimental values for the W-N specimens not only show satisfactory agreement in the elastic region but extend to the plastic region as well. However, the degree of agreement for the W-T1D and W-T2D specimens, which used adhesive tape, was low, resulting in a quite excessive estimation.

The experimental values for W-T1D and W-T2D specimens were therefore much smaller than the estimated values. Considering this, we confirmed that the plywood began separating from the studs at the outer surface at the stud parts of the specimens when the shear deformation angle reached about 1/75 rad. The cause is believed to be the significant impact of insufficient bonding pressure between the studs and the plywood when the specimens were fabricated as previously stated. In other words, the joining of studs by adhesive tape was hardly effective.

Taking this into account, row number N_V for the VCP was set at 2 for Eq (21), and calculation was performed without estimating resistance at the stud parts. The results are indicated by the thick solid line in Fig 8. Estimated

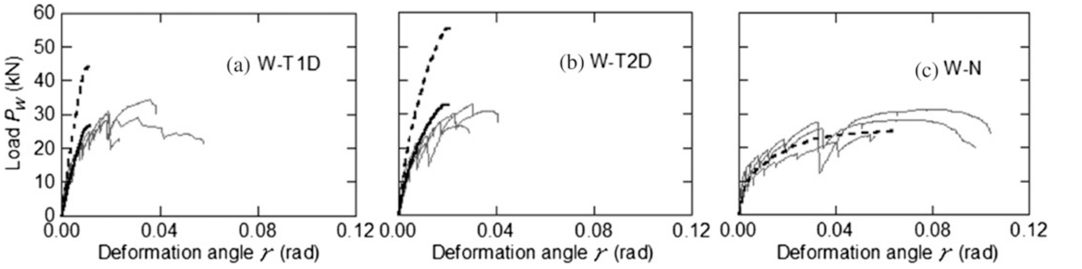

Figure 8. Comparison of theoretical and experimental results of plywood-sheathed shear walls. The thin line indicates experimental results, and the thick dotted line and thick solid line indicate theoretical results at $N_V = 4$ and 2, respectively.

results generally showed good agreement with experimental results near the elastic region and yielding point. This suggested the validity of the estimation method proposed herein. Additionally suggested was the possibility of showing mechanical behavior with superior strength performance if the poor bonding of the studs and plywood was improved.

Mechanical Property of Shear Walls

The authors found that the mechanical behavior of plywood-sheathed shear walls could be accurately estimated near the elastic region and yielding point from the load to deformation angle relationship as shown in Fig 8. In this section, the estimation precision for the estimation method shown in this study is investigated in detail by comparing the mechanical property calculated from experimental and estimated values for the load to deformation angle relationship shown in Fig 8. Mechanical properties of shear walls were obtained by applying the perfect elastoplastic model established by construction inspection/certification institutions such as the Japan Housing and Wood Technology Center. Eleven mechanical properties were thus obtained: resistance at deformation angle 1/120 rad $P_{1/120}$, initial stiffness K, yield resistance P_y, yield deformation angle γ_v, maximum load P_{max}, deformation angle at maximum point in load γ_{max}, ultimate resistance P_u, ultimate deformation angle γ_u, ductility factor μ ($=\gamma_u/\gamma_v$), and structural characteristics factor D_s ($=1/(2\mu - 1)^{1/2}$). The authors determined these properties from the estimated and experimental envelope curves in Fig 8 and determined each ratio of estimated value to experimental value. Figure 9 shows the means and standard deviations of these ratios. According to Fig 9, the ratios for many of the property values are near 1.0, suggesting the validity of the estimation method. Mechanical properties at the initial loading period such as $P_{1/120}$ and K were overpredicted slightly. In addition, resistances near breaking points such as P_y, P_{max}, and P_u were underpredicted slightly. Deformation indicated good agreement for deformation angles γ_y and γ_v near the yielding point. Conversely, for deformation angles near γ_{max}, the breaking point, and γ_u, at which deformation greatly increased, the ratio was significantly less than 1.0. Estimation precision also became lower for ductility factor μ and structural characteristics factor D_s, which were deeply involved with these properties. In other words, estimations concerning toughness were not always good. This was particularly noticeable for W-T1D. One possible reason for this is that behavior after reaching maximum load cannot be estimated well. Improvement of the precision of γ_u estimation is an issue. Thus, although

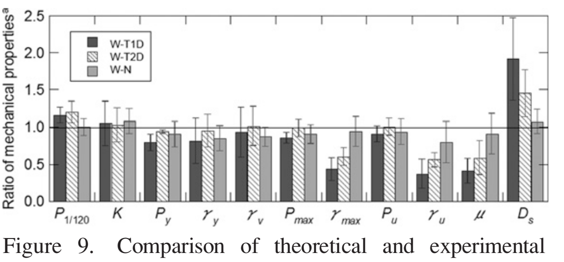

Figure 9. Comparison of theoretical and experimental values of the shear walls. [a]Ratio of theoretical estimated value to experimental result (theoretical value/experimental value).

issues remain with precision in the plastic region, the estimation method for mechanical properties of shear walls shown in this study can be regarded as effective particularly in the elastic region.

CONCLUSIONS

The authors proposed a method of theoretically estimating the mechanical performance of plywood-sheathed shear walls. When theoretical values were compared with experimental values in detail, satisfactory precise estimates of mechanical behavior and maximum load were obtained in the elastic region, which demonstrates the validity of the proposed theoretical estimation method for the mechanical behavior of shear walls. In the future, it may become necessary to fully understand mechanical performance related to, eg, repeated load applications supposed for an extended period of time or wet environments, for the practical application of shear walls that use adhesive tape as joints.

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