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목재 트러스 접합부의 toothed metal plate 접합과 plywood gusset plate 접합에 관한 연구

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Study on Metal Plate Connections and Plywood Gusset Plate Connections for Light-Frame Wood Truss Tension Joint

Jae-Kyung Cha[*2]

요 약

본 연구는 잣나무 간벌재를 이용한 plywood gusset plate 접합과 toothed metal plate 접합에 대하여 인장력을 가해 조사하였다. plywood gusset plate 접합에 있어서는 합판과 부재 사이를 상온 경화제(초산 비닐 수지)로 접착한 후 6d 못으로 접합한 형태와 단지 합판만을 사용한 형태의 plywood gusset plate 접합 사이의 기계적 특성 차이를 조사했다. toothed metal plate 접합은 plywood gusset plate 접합보다 인장력에서 좋은 behavior를 보였다. 또한 접착제를 가한 plywood gusset plate 접합은 접합제를 가하지 않은 형태보다 큰 하중 지지력을 보였다.

1. INTRODUCTION

For light-frame wood truss construction, fasteners such as nails, bolts, and metal plate connectors are used. Rigid connections of prefabricated laminated frames and arches can also be obtained by using these. Nails are used when the loads are relatively small, and other types of structural connec-tions such as bolts are used for larger loads. The bolts are essentially fixed in position by the metal side plates. Therefore, the only movement permitted is that allowed by the clearance between the bolt holes.

The significant mechanical fastener of modern times is the toothed metal plates. Metal plates in which teeth have been punched out are made of light gage galvanized steel plates in a variety of sizes and tooth patterns. They support the almost unlimited variety of components that can be assembled with plates and dimension lumber. Metal plate connections (MPCs) used primarily for the fabrication of light-frame wood truss, are normally not assumed to provide moment resistance. So these conne-ctors are designed to transmit axial forces and shear between connected members. As a result, most metal plate research has been focused on performance under axial load and how these connections are affected by various tests and environmental variables.[2, 4, 8] Corvella etal. tried to develop theoretical model to predict MPC joint stiffness under axial tension.

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* 2. 국민대학교 임업대학 College of Forestry, Kookmin University, Seoul 136-702, Korea

Nail connections between plywood and lumber are very common in structural work. Since plywood is commonly available in thickness 12mm and less, the bearing of head end of the nail in the plywood can become the weakest element of such joints. The objective of this study was to investigate the joint assembly on MPCs compared with plywood gusset plate connections. The another objective of this study was to investigate the effect of adhesive applied to plywood gusset plate connection between plywood and lumber. This paper is only limited to plywood gusset plate connections and MPCs subjected to axial tension only.

2. MATERIALS AND METHODS

A test matrix was used to compare the two types of truss plate to connect wood member to wood member as shown in Table 1. Lumber was used representing a narrow ranges of specific gravity(SG). These lumbers were 4 cm by 8cm Korean pine thinning lumber. Each piece for wood member was cut into 40 cm long samples and 2 cm long SG block was cut from the center of the each samples, leaving two end-matched piece 19 cm long to be joined with an MPC and plywood gusset plate connections to form the test specimens. All specimens were cut to avoid knots in the area of the end joint. The pieces were tightly butted and held in alignment to produce test specimens that were straight with no gap.

Table1. Specimens for truss plate joint types

plate type	treatment	no of test	Specific gravity mean	SD**
PGPC*	no adhesive	10	0.427	0.031
	adhesive	9	0.418	0.020
MPC	no adhesive	10	0.418	0.035

*PGPC : plywood gusset plate connection
**SD : standard deviation

The metal plates used in this study were gangnail GN20 plates. The metal plates were obtained from the U.S. retailers. They were made of 20-gauge plate galvanized steel and were 7 cm wide and 9 cm long, with an average tooth density of 1.27 teeth per square centimeter. One tooth is punched from each opening. Average tooth length was 0.9 cm. All test samples fabricated and conditioned in the same manner. MPCs were manually pressed by cold press one at a time to full uniform contact between plate and wood, giving a total of 80 effective teeth per member (40 teeth per side). The sketch of fabricated MPC specimen is shown in Fig.1 Plywood

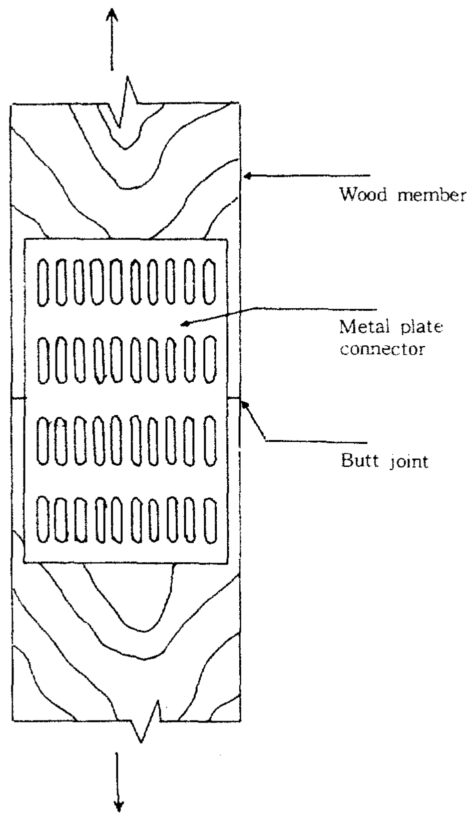

Fig. 1. Sketch of metal plate connection system

with 12 mm thick were cut to 8 cm wide and 10 cm long used to connect the wood-to-wood members for glued and unglued specimens by using 6d galvanized nail. Nail spacing was used to avoid unused splitting of the wood. Splitting greatly reduces the strength of a connection. So two pairs of nails were present in the upper member and two pairs of nails were present in the lower member. The nails were full penetrations of one side plywood and members. Room temperature setting adhesive(Polyvinyl acetate)was applied to all adhesive treatment specimen bandline for plywood gusset plate connections between members and plywoods.

The specimen was attached to the testing machine with universal joints to eliminate potential moments produced by misalignment. The load was applied by screw-driven crosshead testing machine. Tensile forces were applied parallel to the longitudinal plate dimensions. A machine's platen speed of 5 mm/min, was applied to load until failure. The load-displacements were continuously recorded to failure with an X-Y recorder.

3. RESULTS AND DISCUSSION

Any specimen which contains more than one nail provides an load-displacement curve which makes it difficult to separate vari-ables affecting response. Therefore, data analysis focused on the axial load at the location of joints. Under pure axial loads were assumed to to be uniformly distributed over the length of the specimen between load points. A sample of the load-displacement characteristics for the joint is shown in Fig.2 All joints exhibited a nonlinear load-displacement behavior beyond the initial elastic response. 0.4mm displacement has historical precedence. The 2.5mm displacement has been recommended to eliminate gap and friction test variations. The 3.2mm displacement is based on the international conference of Building Officials requirement(5). Ultimate load defines an ultimate factor of safety. Therefore, all truss plate type joints were compared at each other four different displacement levels 0.4mm, 2.5mm, 3.2mm, and ultimate load.

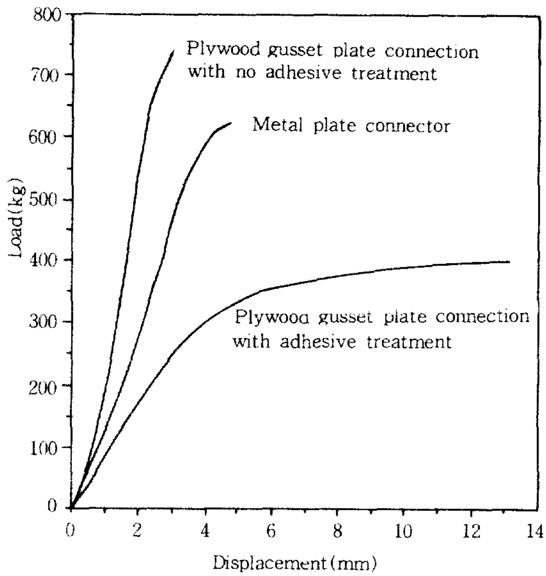

Fig. 2. Average load-displacement for various joint types

Average load values and standard deviations (SDs)at four displacement levels are summarized in Table 2. These comparisons also shown graphically in Fig.2 The comparisons of ratio of mean load of other joints to plywood gusset plate connection with no adhesive treatment are made in Table 3. Table 2 and Fig. 2 shows that the effect of adhesive layer is greater on strength at the plywood gusset plate conn-ections. At the 0.4mm displacement level and the ultimate load, adhesive treatment connection had about 85% increase in mean lateral loads compared with no adhesive treatment for plywood gusset plate connection. At the 2.5mm displacement level adhesive treatment connection had about 200% increase the mean lateral load compared with no treatment. MPCs had 56−87% increase in the mean lateral load compared with no adhesive treatment plywood gusset plate connection. MPCs had about 10% lower than that of adhesive treatment for plywood gusset plate connection. The displacement in a MPC joint explains why an increased allowable load is permitted when MPCs are used instead of plywood side members. MPCs are usually thin steel pla-tes(usually sheet metal), and consequently there is less length in which joint displacement can occur. Even for thicker metal plates, the tooth is probably held more rigidly and displacement is limited. The adhesive for plywood gusset plate connection contributing to change the ultimate load and stiffness was the manner in which the stresses was distributed along the length of bandline.

Table 2. Lateral-loads for various joint types

Joint type	Treatment		Load(kg)at4 deflection value 0.4mm	2.5mm	3.2mm	Maximum load(kg)	slip(mm)
PGPC*	no adhesive						
		X**	30.0	213.1	270.0	400.0	12.71
		SD***	9.64	53.52	50.71	48.77	1.54
	adhesive						
		X	55.7	645.7	--	740.0	3.02
		SD	7.32	202.14	−	146.9	0.64
MPC	no adhesive						
		X	50.0	364.3	504.0	623.8	4.71
		SD	24.78	112.08	199.67	90.38	1.63

*PGPC : plywood gusset plate connection
**X : average
***SD : standard deviation

All MPCs failed by tooth withdrawal. The observed failures were curvature bending of the nails for plywood gusset plate connection. Visual examination of failed surface for adhesive treated plywood gusset plate connection showed that most of the members surface covered with plywood surface. This means that the adhesive influences the tensile behavior for plywood gusset plate connection. Evaluation of load were based on the average of test values. The qualitative effects of treatment might be from a program relatively small test sample size. No attempts were made to closely examine the test data from a statistical view point because the sample size would make further judgement of the results from such an analysis in appropriate. The actual values of capacity were not of importance at this time, so it was necessary to complete test with various species and grade of wood, MCs, metal plate sizes, orientation and resin types for plywood gusset plate connection.

Table 3. Ratios of mean stength values of plywood gusset plate connection with no adhesive treatment to other joint

Joint type	Treat-ment	Load at 4 deflection value 0.4mm	2.5mm	3.2mm	Maximum load
PGPG*	adhesive	1.85	3.03	−	1.85
MPC	no adhesive	1.67	1.71	1.87	1.56

*PGPC : plywood gusset plate connection

4. CONCLUSIONS

MPCs shows a good tensile behavior over the plywood gusset plate connection for truss joint. The real benefit may depends on the fabication of truss joint. Addition of adhesive to the plywood gusset plate connection significantly alter the tensile beh-avior. Test results of adhesive treatment shows that the increase in lateral load compared with no adhesive treatment for plywood gusset plate connection. Additional testing is required to determine if this increase is applicable to other species, nail sizes, penetration, and metal plate sizes.

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