Middle-East Journal of Scientific Research 15 (3): 398-402, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.15.3.259

Investigation on the Strengths of T-Shape Joint

Abdollah Najafi

Asistant Professor, Wood and Paper Science and Technology,
Islamic Azad University, Chalous branch, P.O. Box: 46615/397, Chalous, Iran

Abstract: In this research, Tests carried out to determine withdrawal and shear strengths on wood dowel joint. Dowels were obtained from Hornbeam (*Carpinus betulus*) that their diameter and length were 10 and 80 mm, respectively. T form joints were made from blocks of Beech (*Fagus oreintalis*). Samples were conditioned to 10 and 15% moisture content. Effects of joint plane (tangential or radial page) and diameter of dowel embedment size (equal and 0.5 mm less than diameter of dowel) and conditioned moisture content (10 and 15%) were investigated. Results indicated that in 15% conditioned moisture content withdrawal strength insensibly reduced. Also diameter of embedment has strongly affected on the withdrawal strength as strength increased in 0.5 mm less than diameter of dowel. plane of joint has meaningfully affected on withdrawal strength too.

Key words: Joint · Dowel · Joint plane · Moisture content · Withdrawal strength · Shear Strength

INTRODUCTION

In wooden structures, joints are one of the most important parts of structure [1-3]. Joints provide continuity to the members and strength and stability to the structure. The strength and stiffness of joints used in wooden structures will determine the structure's strength [2, 3]. It is important for joints to be designed in a proper way, so that they can carry loads safely in service conditions without excessive deformation or failure [2]. Fortunately, one of the main advantages of wood as a structural material is that structural elements can easily be connected with a wide range of fasteners joints may entirely consist of wood members. Joints are critical links between elements of a structure and maintain load path continuity and provide structural rigidity [3].

Perhaps, dowel joints are the most popular method of joining members together in wood frame construction for example cabinet or furniture making [4]. The strength of these joints is somewhat limited relative to the strength of the joints members, so unless they are properly designed, they may be the weakest part of a furniture frame [2]. In a furniture frame, dowel joints may be subjected to axial, shear, tensional and bending forces [3]. An example of dowel joint which is often highly loaded is two pin side rails to back post joint in a common side chair. It can be seen a side frame of a typical chair in Figure 1 [3].

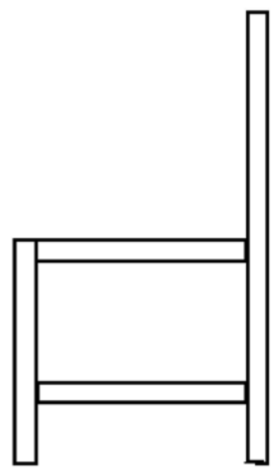

Fig. 1: Side frame of a typical chair

Modernized versions of common joints have developed over time to speed manufacturing or accommodate new materials. A dowel joint is by-product of industry. They make quick work of joinery by eliminating time-consuming fitting of joined elements and are alternatives that should find an appropriate place in every woodwork's repertoire [5]. A dowel is a solid cylindrical rod, usually made of wood. Dowel rod is employed in numerous, diverse applications. It is used to as structural reinforcement in furniture and cabinet making. Dowel rod is often cut into short lengths before using [5].

Corresponding Autor: Abdollah Najafi, Wood and Paper Science and Technology, Islamic Azad University, Chalous branch, P.O. Box: 46615/397, Chalous, Iran.

The wooden dowel rod used in woodworking applications is commonly cut into dowel pins, which are used to reinforce joints and support shelves and other components in cabinet and furniture making. Some woodworkers make their own dowel pins, while others purchase precut dowel pins that are typically available in assorted lengths and diameters.

Dowel-based joinery typically employs fluted dowel pins. A fluted dowel pin has a series of parallel grooves cut along its length. The fluting provides channels through which excess glue (which is used to secure the dowel pin in its hole) can escape as the dowel is inserted, thereby relieving the force that might otherwise split the wood when the assembled pieces are clamped together. A well-made dowel joint is as strong as a mortise and tenon joint [5]. It is often used instead of the mortise and tenon joint if cost is a consideration in the assembly of the work.

Some researches have been carried out on joints of configuration [4, 6, 7]. Although doweled joints are vastly used in furniture and cabinet frame, in Iran, these are a little information about its withdrawal and shear strength. The subject of this study is to obtain initial information concerning the withdrawal and shear strengths of dowel joint to understanding effective parameters on the strengths.

MATERIALS AND METHODS

The tests were carried out on T-type samples of dried (straight grain and free from defects beech wood (*Fagus orientalisLipsky*)). As it is seen in Figure 2 the size of T-type samples were 52 x 100 mm as a rail attached to a post 52 x 140 mm in size. This is close to the size of joint one might use putting together a chair or a stool. The holes of rail and post of samples were made for supporting in universal machine test by screws.

In general ready-made dowels are available to buy pre-cut to sizes. As usual, they are made from tough, strong, crack/split resistance and short grained woods like hornbeam. In this study dowels used were cut from hornbeam (*Carpinus betulus*). The dimensions of pre-cut dowels were 80 mm in length and 10 mm in diameter, respectively. They are designed chamfered at either end to make them easier to insert. In addition to these factors, effects of joint planes (tangential or radial) and diameter of dowel embedment size (equal and 0.5 mm less than diameter of dowel) were experimented too. Polyvinyl acetate (PVAc) glue was used for the assembly of the joints used in this study. The glue used was white carpentry glue (meshad glue) that it's the best carpentry glue in Iran, with a constant value for all samples. The glue was applied both to the dowel and to the embedment hole to ensure complete coverage so that any variations in strength could be attributed to assembly conditions. After gluing, each joint was clamped up with just enough pressure to bring the rail shoulder into contact with the face of the mortise for not more than 1 min while the excess glue was removed. After assembled, sampled put in two conditioner rooms (different circumstance for example relative humidity and room temperature), samples were conditioned to reach to two level of EMC (equivalent moisture content), 10±1 percent and 15±1 percent moisture content, respectively. Identify Codes of all treatments indicate in Table 1. For shear testing, the test sample was fitted with a cast aluminum alloy rule plate to support the post member of the joint while the horizontal rail member was loaded by crosshead, which was raised 1.2 mm min-1 during the test [3].

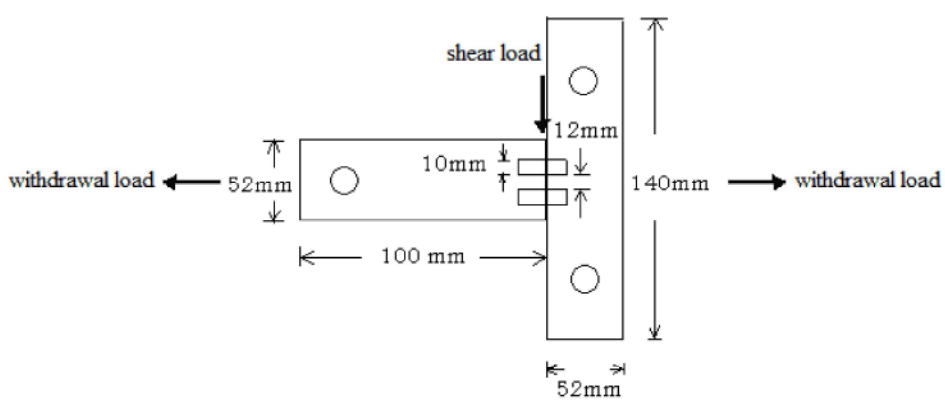

Fig. 2: Diagram showing geometry of the samples

Table 1: Identify Codes of all treatments

Joint plane	EMC (%)	Embedment hole size	Identify Code
Tangential	10	equal	T0%10
		0.5 mm smaller	T0.5%10
	15	equal	T0%15
		0.5 mm smaller	T0.5%15
Radial	10	equal	R0%10
		0.5 mm smaller	R0.5%10
	15	equal	R0%15
		0.5 mm smaller	R0.5%15

RESULTS AND DISCUSSION

The mean withdrawal and shear loads with standard deviations of means are given in Table 2. Two planes of joint and two levels of moisture content and two diameters of embedment holes indicate in each row.

The results for withdrawal and shear loads were analyzed statistically to isolate the effects due to joint sides, moister content and embedment hole of dowels. Analysis of variance with a 0.05 level of confidence show in Tables 3 and 4.

The increased joint withdrawal load resulting from a decrease in diameter of embedment hole and side of joint are obvious in Table 1 and was confirmed by the results obtained from analysis of variance in Table 3. But, there were no statistically significant differences between the variations on shear strength of joint (Table 4). It can be concluded that withdrawal strength is dependent upon moisture content of wood [1]. But in this study conditioned moisture content do not have any influences on withdrawal strength of joint. The moisture content of wooden blocks in T-form joint results were excluded from the analysis because of, after joints were assembled, the samples were located in two different circumstances and moisture had no enough time and could not penetrated into wooden blocks. The withdrawal load of a joint is determined partly by the bond area, on the 2 faces of T- form joint where the glue is stressed in shear when the joint is loaded in withdrawing and partly by diameter of embedment hole were specified. It can be seen in Figure 3. In this figure can be seen effect of embedment hole size on withdrawal load. When diameter of embedment hole is smaller than diameter of dowel, joints needed more load in withdrawing. Figure 4 shows effect of plane of connection on withdrawal load. Based on Table 3 there was statistically significant difference on plane of connection. It can be concluded that anatomical variations have influence on withdrawal load of joint. There are several pits on radial side of connection and glue can be penetrated in pits. No statistically significant differences between the variations on shear strength of joint (based on Table 4) can represent the fact that shear strength in joints can be affected by other factors, such as shear strength of bond area and so on. It can be seen in Figures 5 and 6.

Table 2: Mean breaking loads with standard deviation of means

Joint plane	Tangential				Radial			
EMC	10%		15%		10%		15%	
embedment hole size	Equal	0.5 mm smaller	Equal	0.5 mm smaller	Equal	0.5 mm smaller	Equal	0.5 mm smaller
Withdrawal load (kN)	6.57 (0.48)	10.49 (1.02)	4.69 (0.45)	10.68 (0.94)	7.24 (0.9)	10.83 (0.32)	7.10 (0.77)	11.87 (0.69)
Shear load (kN)	6.74 (1.62)	6.93 (1.14)	5.76 (0.22)	6.81 (0.71)	6.64 (0.96)	5.93 (0.50)	7.05 (1.16)	7.35 (0.96)

Values in parentheses are standard deviation of means

Table 3: Analysis of variance (ANOVA) results in Withdrawal load

Source of variations	Sum of Squares	df	Mean Square	F	Sig.	Level of Significance
Plane of connection	7.970	1	7.970	14.560	0.002	*
Penetration hole size	125.172	1	125.172	228.686	0.000	*
EMC	0.230	1	0.230	0.420	0.526	ns
plane × hole	0.901	1	0.901	1.646	0.218	ns
plane × EMC	2.503	1	2.503	4.572	0.048	*
hole × EMC	3.945	1	3.945	7.207	0.016	*
plane × hole × EMC	0.302	1	0.302	0.551	0.469	ns

ns: not significant

*statically significant with a 0.05 level of confidence

Table 4: Analysis of variance (ANOVA) results in shear load

Source of variations	Sum of Squares	df	Mean Square	F	Sig.	Level of Significance
Plane of connection	0.198	1	0.198	0.200	0.660	ns
Penetration hole size	0.255	1	0.255	0.258	0.619	ns
EMC	0.199	1	0.199	00.201	0.660	ns
plane × hole	1.017	1	1.017	1.028	0.326	ns
plane × EMC	3.169	1	3.169	3.203	0.092	ns
hole × EMC	1.313	1	1.313	1.327	0.266	ns
plane × hole × EMC	0.008	1	0.008	0.008	0.929	ns

ns: not significant

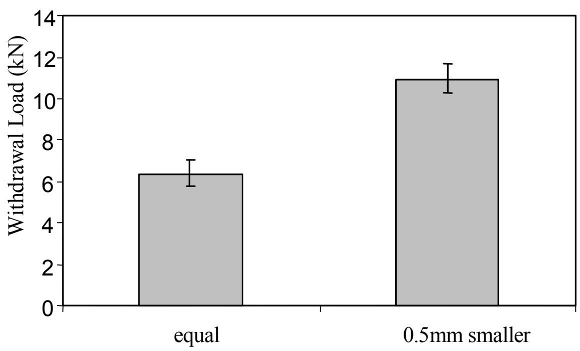

Fig. 3: Effect of embedment hole on withdrawal load

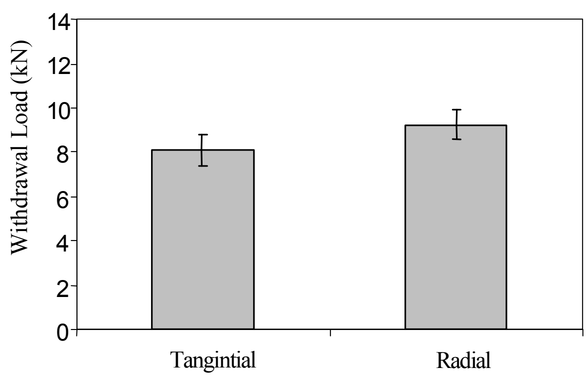

Fig. 4: Effect of plane of connection on withdrawal load

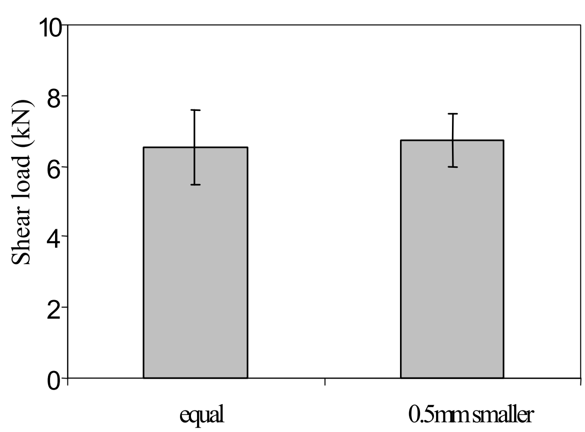

Fig. 5: Effect of embedment hole on shear load

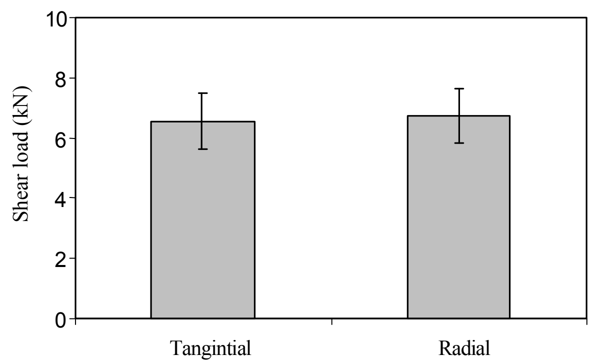

Fig. 6: Effect of plane of connection on shear load

CONCLUSION

The following conclusions could be drawn from the results of the present study:

- The results of an ANOVA indicated that the embedment hole and plane of connection had significant effects on the withdrawal strength of joint.
- When diameter of embedment hole is smaller than diameter of dowel and the plane of connection is radial, joints needed more load in withdrawing.
- In this study, there were no statistically significant differences between the studied variations on shear strength of joint and this can be represent the fact that shear strength in joints affected by other factors.

REFERENCES

1. Bodig, J. and B.A. Jayne, 1993. Mechanics of Wood and Wood Composites. Krieger Publishing Company, Florida.
2. Eckelman, C.A., 1979a. Strength design of furniture. Timber-Tech, Inc. Lafayette, Indiana.
3. Eckelman, C.A., 2004. Engineering Design of Furniture, Purdue University. USA.

4. Eckelman, C.A., 1971. Bending strength and moment-rotation characteristics of two-pin moment-resisting. Forest Products Journal, 21(3): 35-39.
5. Noll, T., 2002. Woodworker's Joint Book, The Complete Guide to Wood Joinery. Apple Press Company, Sheridan House.
6. Eckelman, C.A., Y.Z. Erdil and J. Zhang, 2002. Withdrawl and bending strength of dowel joints construction of plywood and oriented strandboard. Forest Product Journal, 52(9): 66-74.
7. Zhang, J., 2002. Direct Withdrawal strength of single staple joints in pine plywood. Forest Product Journal, 52(2): 86-91.