Investigation of the Best Joint Type for Combining of the Finger Jointed Timber Panel in Board Production

C. K. Muthumala, S. De Silva, P. L. A. G. Alwis, and K. K. I. U. Arunakumara

Abstract Waste sawn timber material in furniture factories and short length of sawn timber are serious problems in timber industry. To further suggest ways to minimize the waste, by applying a jointing system, this paper utilizes the finger-jointed techniques. Using this method, waste timber planks, trimmings and edgings can be used as finger-jointed boards and furniture in sustainable way. Finger joint technique is also used to eliminate wood defects which weaken the strength of sawn wood planks. Finger joint technology is used in structural and non-structural applications. Furniture mainly belongs to non-structural category. This study was conducted to **i**nvestigate the best joint type for combining of the finger-jointed timber panel in board production. Shear test was done to determine the most suitable joint type which could be employed in combining two finger-jointed timber panels. Shear test was performed for Pine—*Pinus carebaea* (soft wood) and Teak—*Tectona grandis* (Hard wood) timber types. Clear specimens, butt-jointed and tongue and groove were tested in the shearing apparatus. Eight test specimens of each timber specimens were used to obtain shear strength perpendicular to grains with 0.5 mm/min loading rate was applied using a Universal Testing Machine. Shear strength of Teak specimens with tongue and groove is higher than Teak specimens with butt joint, because bonding area of the tongue and groove specimens is higher than bonding area of the butt-jointed specimens. Specimen part with tongue of Pine is weaker than corresponding part of butt-jointed Pine specimen due to small cross-sectional area of tongue. So, Shear strength of Pine specimen with butt joint is greater than Pine specimen with tongue and groove.

C. K. Muthumala (✉)
State Timber Corporation, Rajamalwatta Road, Battaramulla, Sri Lanka

S. De Silva
Department of Civil and Environmental Engineering, Faculty of Engineering, University of Ruhuna, Hapugala, Sri Lanka

P. L. A. G. Alwis
Department of Agricultural Engineering, Faculty of Agriculture, University of Ruhuna, Mapalana, Sri Lanka

K. K. I. U. Arunakumara
Department of Crop Science, Faculty of Agriculture, University of Ruhuna, Mapalana, Sri Lanka

R. Dissanayake et al. (eds.), *ICSBE 2020*, Lecture Notes in Civil Engineering 174,
https://doi.org/10.1007/978-981-16-4412-2_23

Keywords Finger joint · Joint types · butt joint · Tongue and groove · Shear test

1 Introduction

Timber, one of the oldest and natural building materials is extensively used world-wide in furniture and construction industries. When it is employed in construction and furniture manufacturing industries, off-cut and shorter sections are unavoidable wastes which are often dumped. However due to the fact that timber is a limited resource, any sort of dumping is a matter of great concern [6]. Joining pieces of off-cuts and shorter sections together to make finger joint boards is identified as another alternative use of timber wastes.

Finger joints are described as interlocking end joints formed by machining a number of similar tapered symmetrical fingers in the ends of timber members using a finger joint cutter and then bonded together [2]. Finger joint is recognized to be sustainable, eco-friendly and economically viable technique which minimizes the waste generation in furniture manufacturing and construction activities [8]. Though the technique is relatively new to Sri Lanka the State Timber Corporation (STC) has produced finger joints worth Rs. 5.2 and 7.1 million respectively for the year 2018 and 2019 [7]. When combining finger-jointed timber panels together to make finger-jointed boards, it is important to investigate the best joint type suitable for making finger-jointed boards. Main objective of this study is to investigate the best joint type for combining of the finger jointed timber panel in finger-jointed board production.

2 Methodology

Shear test was done to determine the most suitable joint type which could be employed in combining two finger-jointed timber planks. Wood samples taken from matured Teak (*Tectona grandis*) and Pine (*Pinus carebaea*) trees (30–40-year age) were collected from Boossa timber complex of the State Timber Corporation in Sri Lanka. Specimens were prepared from defects free, heart wood pieces with straight grain in breast height portion with eight replicates for each test. The highest mean tensile strength was obtained from PVAc-SWR glue type used in finger joint production in Sri Lanka [5]. Hence PVAc-SWR glue type was used to combine two timber pieces together. Standard size of shear perpendicular to grain test specimen is 50 × 50 × 50 mm (2 × 2 × 2 inch) (with 1 inch L or T section) as shown in Fig. 1. Timber samples were seasoned to reduce moisture content down to 12%. This study was conducted at wood laboratory in State Timber Corporation, Battaramulla, Sri Lanka. All the tests were performed according to BS 373:1957 [1].

Clear specimens, butt-jointed and tongue and groove were tested in the shearing apparatus as illustrated in Fig. 2. Eight test specimens of each timber specimens were

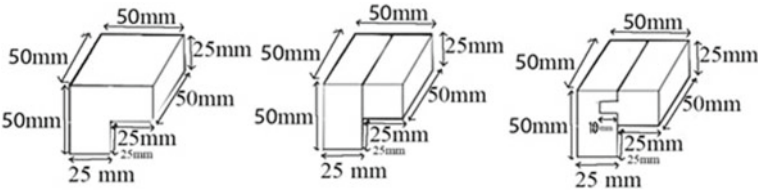

Fig. 1 Specimens for shear test

Fig. 2 Shearing tool used for the shear test

used to obtain shear strength perpendicular to grains. 0.5 mm/min loading rate was given using UTM.

The number of specimens prepared in each set (three joint types and two timber types) for shear measurements are given in Table 1 (Fig. 3).

Equation 1 was used in calculating the shear strength.

$$\text{Shear Strength Capacity} = \frac{\text{Maximum load act on sample}}{\text{Shear Area}} \tag{1}$$

Table 1 Specimen details for shear test

Joint type	Timber types	Number of specimens
Clear specimen	Teak	08
	Pine	08
Butt joint	Teak	08
	Pine	08
Tongue and groove	Teak	08
	Pine	08

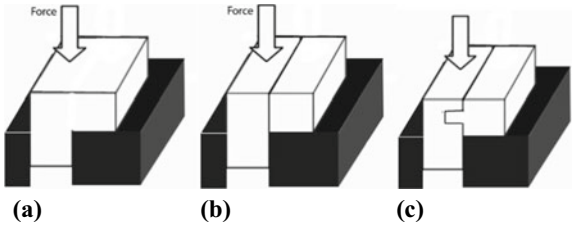

Fig. 3 Loading set-up for shear test. **a** Clear specimen. **b** Butt-jointed specimen. **c** Specimen with tongue and groove

3 Results and Discussion

Average shear strength of different joint types are shown in Table 2.

Failure modes of the Teak and Pine timber specimens are shown in Figs. 4 and 5.

Table 2 Average shear strength of different joint types (N/mm^2)

Joint type	Pine	SD	Teak	SD
Clear specimen	2.373	1.21	2.720	0.10
Butt joint	2.453	0.50	1.587	0.52
Tongue and groove	1.640	0.35	1.840	0.31

SD Standard deviation

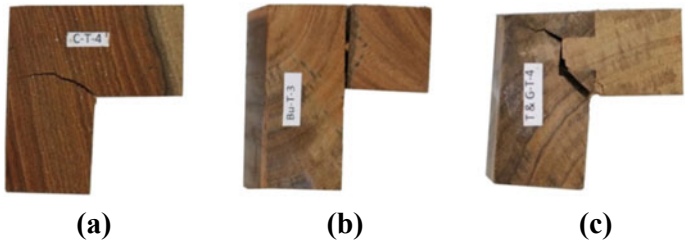

Fig. 4 Failure modes of shear test in teak **a** clear; **b** butt; **c** tongue and groove

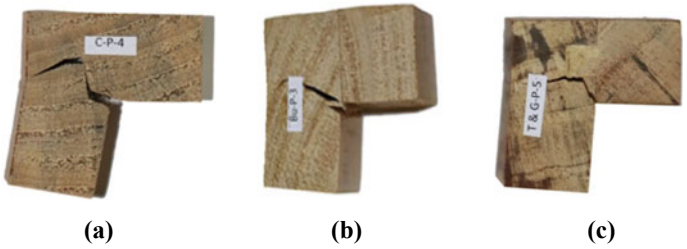

Fig. 5 Failure modes of shear test in pine **a** clear; **b** butt; **c** tongue and groove

According to Table 2, Shear strength of clear wood specimens shows the highest strength values than specimens with butt-jointed and tongue and groove jointed. Considering the butt joint and tongue and groove joint, clearly shows that, butt-jointed specimens of Pine (soft wood) has the highest shear strength rather than clear specimens and tongue and groove-jointed specimens.

Figure 6 depicts that butt-jointed Teak specimens shows the lowest shear strength. That means, when combining two timber planks of Teak, it is not suitable to use a butt joint. Mean shear strength value of Tongue and groove joint of Teak is higher than Butt joint of Teak. But Mean shear strength value of Tongue and groove joint of Pine is lesser than Butt joint of Pine. So, when two timber planks combining together, Butt joints are suitable for softwood species like Pine and tongue and grove joints are more suitable for Teak (Fig. 7).

The ability of the adhesive to penetrate into wood species dependent and is generally greater for early wood than for late wood, especially in softwoods like Pine and for vessel elements in hardwoods [3]. Frihart et al., showed that some wood species, such as teak (*Tectonia grandis*), are hard to bond because they have oily extractives that limit the ability of the adhesive to come into contact with the wood and therefore provide a chemically weak boundary layer. Frihart and Hunt [4] reported

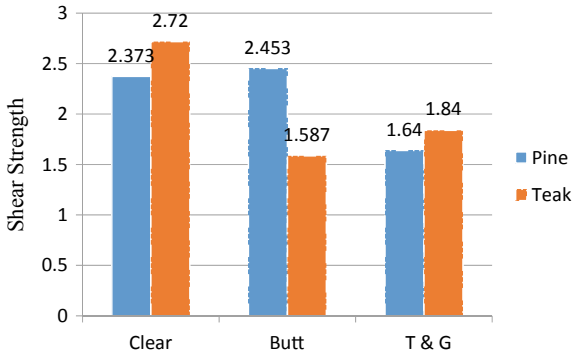

Fig. 6 Variation of shear strength versus joint types

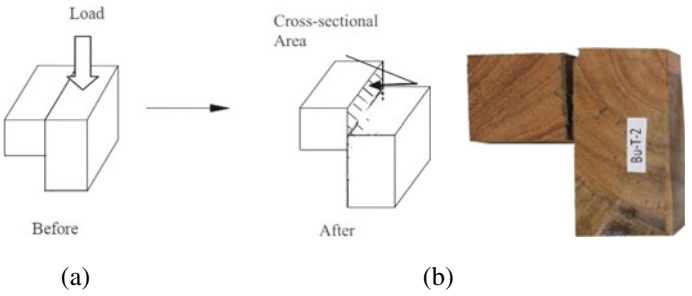

Fig. 7 Some failure mode of butt-jointed teak specimen. **a** Schematic diagram. **b** Tested teak specimen

that high-density woods are difficult to bond because the thicker cell walls and smaller diameter lumens, adhesives do not easily penetrate into the wood, limiting mechanical interlock to less than two cells deep. Much greater pressure is required to compress stronger, stiffer, high-density wood to bring contact between wood surfaces and adhesive.

Shear strength of Teak specimens with tongue and groove is higher than Teak specimens with butt joint. Because bonding area of the tongue and groove specimens are higher than bonding area of the butt-jointed specimens.

Specimen part with tongue of Pine is weaker than corresponding part of butt-jointed Pine specimen due to small cross sectional area of tongue. So Shear strength of Pine specimen with butt joint is greater than Pine specimen with tongue and groove.

4 Conclusion

Based on the results obtained from the study conducted, the following conclusions can be drawn.

Shear strength of Teak specimens with tongue and groove is higher than Teak specimens with butt joint, because bonding area of the tongue and groove specimens are higher than bonding area of the butt-jointed specimens.

Specimen part with tongue of Pine is weaker than corresponding part of butt-jointed Pine specimen due to small cross-sectional area of tongue. So, Shear strength of Pine specimen with butt joint is greater than Pine specimen with tongue and groove.

When two timber planks are combined together in finger-joint production, butt-joints are suitable for softwood species like Pine and tongue & grove-joints are more suitable for Teak.

References

1. British Standard Institution (1999) BS 373:1957, Methods of testing small clear specimens of timber. British Standards Institution, London
2. British Standard Institution (2014) BS EN 15497:2014. Structural finger-jointed solid timber—Performance requirements and minimum production requirements. European Committee for Standardization, B 1000 Brussels
3. Frihart CR, Wiedenhoeft AC, Jakes JE (2007) Wood bonding in the furniture industry and the effect of changing wood supply, In: Practical solutions for furniture and structural bonding. International workshop, Larnaka—Cyprus, 22–23 March 2007, TEI of Larissa, Department of Wood & Furniture Design & Technology, Terma Mavromichali, GR-43100 Karditsa, Greece
4. Frihart CR, Hunt CG (2010) Chapter 10: Adhesives with wood materials—bond formation and performance. In: Wood handbook—wood as an engineering material. General Technical Report, FPL-GTR-190. United States Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, WI, pp 10-1–10-24

5. Muthumala CK, De Silva S, Alwis PLAG, Arunakumara KKIU (2018) Investigate the most suitable glue type for finger-joints production in Sri Lanka. Res J Agric Forestry Sci 6(11):6–9
6. Muthumala CK, De Siva S, Arunakumara KKIU, Alwis PLAG (2020) Identification of joint efficiencies in 13 mm finger jointed timber species used in Sri Lanka. In: ICSBE 2018. LNCE 44. Springer, Singapore, pp 261–267
7. Performance Report (2019) Finance Division, State Timber Corporation
8. Sandika AL, Pathirana GDPS, Muthumala CK (2017) Finger joint timber products for effective utilization of natural resources: an analysis of physical properties. Economic factors and consumers' perception. In: International symposium on agriculture and environment, University of Ruhuna, Sri Lanka, pp 109–111