Factors Affecting the Glue Strength of Finger-Joints in Commonly Used Timber Species in Sri Lanka

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Abstract
Finger- jointed timber production plays a vital role in furniture industry in the world. However, issues related with the strength of the joints, fixing time, timber species and glue types etc, are still not fully investigated in Sri Lanka. This research evaluated the effects of commonly available glue types, timber species, and time allowed to fix the joints on the strength of finger joint. The response variables measured for the tension tests. Data were gathered using Universal Testing Machine. One way ANOVA was used per each timber species to analyze the data. It was found that the glue type, timber species and time allowed to fix the joints directly affect the glue tensile strength. Furthermore, the highest tensile strength was recorded in Polyvinyl Acetate (PVA) SWR glue with the allocated time period of 4 hours.

Keywords: Finger Joint, Glue Strength, Polyvinyl Acetate Glues, Timber Production
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Introduction

Off-cut wood is currently one of the wastes dumped by sawmills as they fail to fully utilize the wood supply. Waste sawn timber material of furniture factories and short length of sawn timber are common problems in the timber industry in Sri Lanka. However, some of these wasted woods are used to fuel kiln dried boiler. Joining timber is another option in utilizing waste timber. 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 (BSI, 2014).

Finger joint is a sustainable, eco-friendly and economically valuable concept for furniture industry. It ensures the sustainable utilization of small wood cut pieces which removed as waste (Sandika et al, 2017).

The finger joint timber manufacturing is considered to be a viable solution for minimizing the waste generation in furniture manufacturing activities. Type of glues applied for the joining process of finger joint is one of the key factors which determine the strength of the product. However, a comprehensive study on the factors affecting the strength of finger-jointed hardwood species has not yet been conducted in Sri Lanka. Therefore, the effect of type of glue type on the strength of finger-jointed timbers was investigated by using three Polyvinyl acetate (PVA) adhesive types mostly used in Sri Lanka.

Polyvinyl resin emulsions are thermoplastic. In emulsified form, the PVAs are dispersed in water and have a consistency and non volatile content generally comparable to thermosetting resin adhesives. PVA's are marketed as milky-white fluids for use at room temperature in the form supplied by manufacturers, normally without additives or separate hardeners. SWR, SH and Speedx are mostly used three bonding materials in Sri Lanka.

Materials and Methods

Samples were cut from seasoned planks (Average moisture content 12 %) of five mainly used timber species in Sri Lanka. The wood species, Mahogany (*Swietenia macrophylla*), Pine (*Pinus caribaea*), Teak (*Tectona grandis*), Kumbuk (*Terminalia arjuna*) and Jack (*Aartocarpus heterophyllus*) were obtained from defects free sawn woods. Eight finger jointed samples were made for each timber species. The size of each replicate was 6 mm x 20 mm x 300mm and they were used for tension tests.

The vertical finger jointed samples were made by using 13 mm finger-joint length cutters. Polyvinyl acetate (PVA) adhesive SWR, SH and Speedx were used as bonding materials (Glue types). Samples which were placed in normal room temperature showed good structural performance compared to hot and wet conditioned (Vivek et al, 2016). According to the technical details of manufactures, bonding time range was 1-2 hours for SWR, 4-6 hours for SH and 1.5-2 hours for Speedx adhesives. In this study, the tensile strength were measured in one

hour, two hours, three hours and four hours time periods.

The testing was done under both laboratory and manufactory conditions according to the regulations of the standard on BS EN 15497:2014 and BS 373:1957.

Data were analyzed by using one way ANOVA per each timber species at 0.05 significant level to find the effects of glue type and time period on glue tensile strength (Table 1).

Table 1: Analyzed results by ANOVA Procedure

After 4 hrs	Sum of Squares	df	Mean Square	F	Significance
Between Groups (SWR,SH, Speedx)	463.093	2	231.547	65.937	0.000
Within Groups	94.815	27	3.512		

Results and Discussion

Calculated average RH percentage and ambient temperature were 79 % and 25.5^{0}C respectively. As shown in Figure 1, higher mean tensile strength values were recorded from five timber species which were bonded after 4 hours. Out of five timber species, the highest mean tensile strength was recorded in Jack followed by Mahogany and Pine and the least strength was recorded in Teak. Moderate mean tensile strength level was recorded in Kumbuk.

Figure 2, clearly shows that mean glue tensile strength of SWR was increased considerably against the time compared to the other two glue types. When considering three glue types, the highest mean tensile strength was recorded in SWR glue and the least was SH glue.

Tensile Strength values of SWR varied from 10.83 N/mm^2 up to 19.33 N/mm^2 and 7.50 N/mm^2 up to 10.83 N/mm^2 in Speedx. Tensile Strength values of SH varied from 3.33 N/mm^2 up to 8.25 N/mm^2 (Table 2)

According to Figure 1 and 2, the highest mean tensile strength can be obtained from Jack and Mahogany with SWR glue and allocating time period (fixing time) of 4 hours.

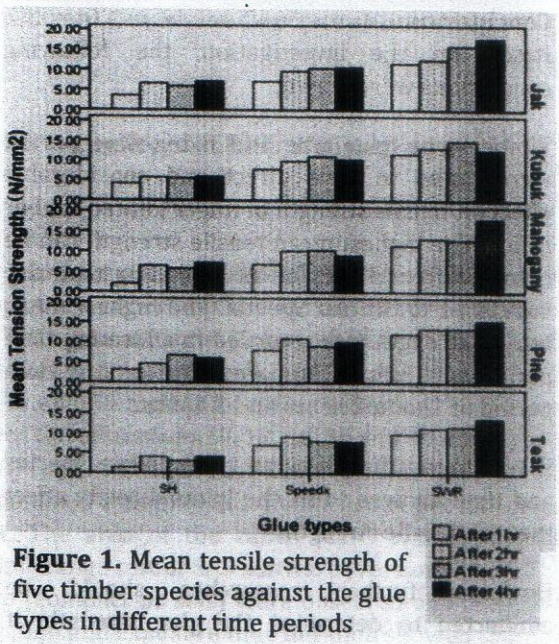

Figure 1. Mean tensile strength of five timber species against the glue types in different time periods

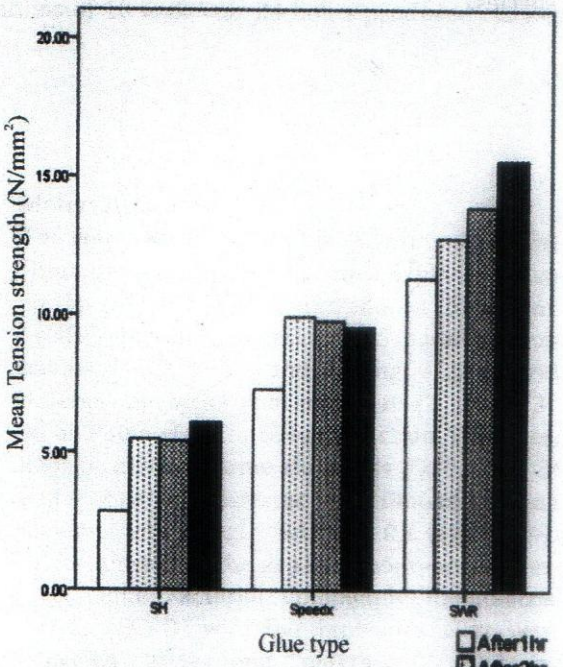

Figure 2. Mean tensile strength against the glue types in different time period

Table 2: Descriptive details in tensile strength of three glue types

Adhesive type	*No.of pieces*	*Mean*	*Std. Deviation*	*Minimum*	*Maximum*
SH	08	6.1000	1.52490	3.33	8.25
Speedx	08	9.5667	1.16852	7.50	10.83
SWR	08	15.6083	2.61614	10.83	19.33

Conclusions

Based on the investigation, the following conclusions were drawn.

Timber type, glue type and fixing time period were found to have direct and considerable effect on tensile strength of finger jointed timber solids. The highest mean tensile strength can be obtained from SWR glue as a bonding material, compared to SH and Speedx. The highest mean tensile strength was recorded in allocating time period of 4 hours, compared to allocating time period of 1hour, 2 hours and 3 hours.

It was found that the glue type, timber species and time allowed to fix the joints directly affect the glue tensile strength.

However further researches should be conducted to determine the glue strength of other adhesive types and the other timber species.

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