Factors Affecting on the Glue Strength Utilized in Finger Joint Timber Production: A Study in Timber Manufacturing Industry

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ABSTRACT

The finger joint timber production plays a vital role in timber manufacturing industry in todays world as well as in Sri Lanka. There are much more issues and conflicts in using glues for finger joint production process related with the strength of the joint, fixing time, timber species and so on. This study evaluated the effects of glue type, timber species, and allocating time period to fix the joints on the strength of finger joint. The response variables measured for the tension tests were tensile strength and percent wood failure. Data were gathered in an experimental observations using Universal Testing Machine. Descriptive analysis and Split Plot Design have been used to analyze the data. It was found that the glue type, timber species and allocating time to fix joints directly affected on glue tensile strength. Furthermore the highest tensile strength was recorded in Fevicol SWR glue, Jak & Mahogany wood species and allocating time period was after 4 hours.

KEYWORDS: Finger Joint Timber Production, Glue Strength, Split Plot Design, Timber Manufacturing Industry

INTRODUCTION

Finger jointing is a method to create a long piece of wood from short pieces, by gluing and clamping. In finger jointing, timber pieces cuts into 8*4*2, 6*3*2 ... etc (inches) pieces.

The bending strength properties of off-cut by applying a jointing make special cut called finger cut, using a machine are useful to fix those pieces.

This study was undertaken to determine the strength properties of finger cut by applying glue on a jointing system, which utilizes the finger-jointed techniques to minimize the waste in timber jointing process.

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Many studies have been conducted by finger joint unit, which focused on the finger joints to determine the effects of finger orientation to finger jointed strength properties. Even though normally manufacturing process goes to cutting a whole tree, the finger joint process save trees through a sustainable and eco –friendly approach.

LITERATURE REVIEW

The process of joining wood pieces longitudinally by the use of fingered end joints has been recognized as a profitable way for minimizing waste and upgrading load by many woodworking concerns in recent years. Finger-jointed stock can be made to customer specifications so that a minimum waste of material on the part of users results.

Strength properties, appearance, and durability of product are the major factors in designing a finger-joint process. If finger-jointed stocks are properly made, they will have moderate tensile strength, high bending strength, and compression strength equal to or greater than that of hard wood. The development of overlaid lumber in recent years should increase the acceptance of

finger-jointed stock for use in exposed areas. Applications which require great dimensional stability is particularly suitable for finger-jointed stock. (Chiang, 1964)

Even so performance and minimum production requirements for finger joints are regulated in standards like a similar difficulty comes up with the joining. This is because for internal and external quality control only the bending strength and mode of failure of few randomly taken finger joint samples are determined in destructive tests. This also results in the fact that structural timber with features responsible for poor finger joint strength can reach the customers (Katzengruber, Jeitler, Brandner & Schickhofer, 2005).

The strength of finger-joints manufactured with phenol resorcinol formaldehyde (p.r.f.) should be compared with those manufactured with two different mixtures. The resins had to provide a stronger finger-joint without sacrificing any of the positive qualities of p.r.f. such as stiffness, durability and minimal creep. All the test specimens were manufactured according to the glue manufacturer's instruction sheet on a normal production line as it was felt that test specimens manufactured under laboratory conditions would give a false impression of the strengths that could be expected from commercially prepared finger-joints. (Rensburg, Burdzik, Ebersöhn & Cillié, 1987)

In their experiment, Spencer Brady and the group performed experiment as a 23 factorial experiment with six replicates for each of the eight specimens. They tested the effects of the three factors on the tensile strength of a wood glue bond between two pieces of pine (Brady et al., 2009).

RESEARCH PROBLEM

The finger joint timber manufacturing is a good solution for the waste occurs in the furniture manufacturing activities, Glue which is applied in the jointing process in finger joint is one of the dominant factors occurs upon the product strength. There are so many factors identified as related factors to that strength. But a comprehensive study was not carried out to identify the affecting factors on the glue strength. Therefore in this study, it is tried to find the factors that effect to the glue strength.

METHODOLOGY

The data has been collected by using a judgmental sampling method. In this study, independent variables are chosen as glue type, allocating time period and timber species.

Graphs and Bar charts are used to identify which level of each factor gets the highest tensile strength. Data are analyzed using hypothesis testing and split plot design (ANOVA) to find the effects of each factor affect on glue tensile strength.

DATA COLLECTION AND ANALYSIS

Primary data has been collected from experimental observations using Universal Testing Machine (UTM). 120 observations were collected through a practical experimental procedure using UTM by selecting a sample using the judgment sampling technique.

The mean glue tensile strength of glue types with time for Jak timber is represented in Figure 1.

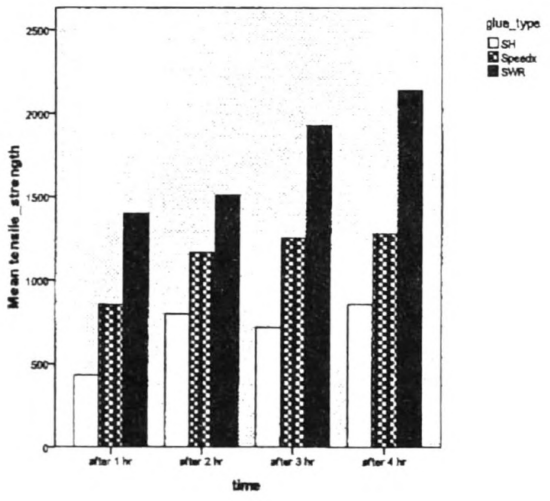

Figure 1: Glue Tensile Strength of Three Glue Types against the Time for Jak

According to the Figure 1, mean glue strength of Jak for Fevicol SWR was increased highly with the time. But comparing other glue types, Fevicol Speedx was increased slowly with the time and Fevicol SH was recorded least glue strength with time.

The glue tensile strength of timber types with time for Fevicol SWR glue is shown in Figure 2.

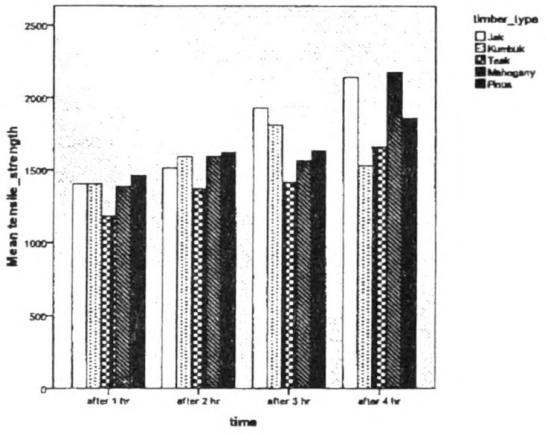

Figure 2: Glue Tensile Strength of Five Timber Types against the Time for Fevicol SWR

As indicated in Figure 2, the tensile strength using Fevicol SWR was continuously increased in Jak for four time periods. It was recorded the second largest growth in tensile strength in Mahogany. The tensile strength was existed average in Pinus and Kumbuk, and the least growth except after 4 hours was reported in Teak.

The glue tensile strength of timber types with Glue type is shown in Figure 3.

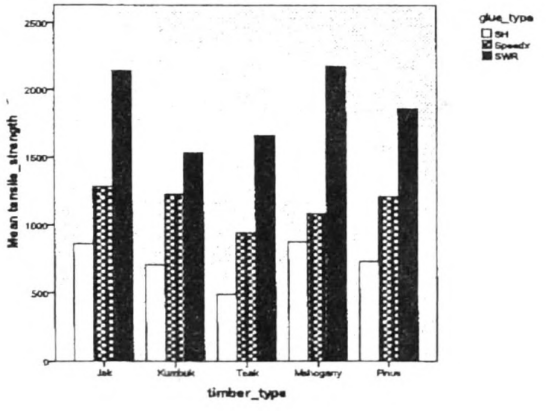

Figure 3: Glue Tensile Strength of Three Glue Type against Five Timber Types for After 4 Hours

Figure 3 depicts that the highest mean tensile strength was recorded in Fevicol SWR for all the five timber types after 4 hour. Moderate level tensile strength was recorded in Fevicol Speedx while the least tensile strength was recorded in Fevicol SH for all different timber types. Even in this time period, the highest mean tensile strength using Fevicol SWR was recorded in Jak and Mahogany while the least mean tensile strength was recorded in Teak.

Summary of test between subject effects of all factors was given in Table 1 in the purpose of checking the hypothesis mentioned below.

Main Treatment Effect
H_0: Mean of all glue types are equal.
H_1: At least one mean of glue type is differ

Subplot Treatment Effect
H_0: Mean of all allocating time periods are equal
H_1: At least one mean of time period is differ

Sub - Subplot Treatments Effect
H_0: Mean of all timber types are equal
H_1: At least one mean of timber type is differ

H_0: There is no interaction effect
H_1: There is an interaction effect

Table 1: ANOVA Table (Split Plot Design)

Source	F value	P value
Glue type	1518.11	0.001
Timber type	27.17	0.004
Time	38.16	0.007
Glue type*timber type	1.16	0.418
Glue type*time	2.90	0.110
Timber type*time	2.58	0.057
Glue type*timber type*time	3.20	0.003

According to the Table 1, the significant p values of main three factors less than 0.05. Hence, at least one mean of glue type, timber type, and allocating time period is not equal at 5% significance level. There are no interactions among glue type and time, timber type and time and also between glue type and timber type, since all the p values for those combinations are

greater than 0.05. But there is an interaction among three factors, because p value (0.003) is less than 0.05.

Effects of timber types affect on glue strength compared pairs considering each timber type shown in Table 2 in the purpose of checking the hypothesis mentioned below.

Hypothesis
H_0: Effects of timber types are equal
H_1: Effects of timber types are not equal

Table 2: Multiple Comparisons of Timber Types

Timber species	Mean difference	P value
Jak-Kumbuk	68.13	0.208
Jak-Teak	283.75	0.000
Jak-Mahogany	53.96	0.434
Jak-Pinus	60.63	0.316
Kumbuk-Teak	215.63	0.000
Kumbuk-Mahogany	14.17	0.991
Kumbuk-Pinus	7.5	0.999
Mahogany-Teak	229.79	0.000
Mahogany-Pinus	6.67	1.000
Pinus-Teak	223.12	0.000

According to the Table 2, comparing Teak with all other four timber types separately, the effect on the tensile strength is different than to those four timber types (all p values less than 0.05) at 5% significance level. Considering other pairs Jak with Kumbuk, Jak with Mahogany, Jak with Pinus, Kumbuk with Mahogany, Kumbuk with Pinus and Mahogany with Pinus separately, the effect on glue tensile strength are similar of those pairs, since p values are greater than 0.05.

Effects of glue types affect on glue strength compared pairs considering each glue type shown in Table 3 in the purpose of checking the hypothesis mentioned below.

Hypothesis
H_0: Effects of glue types are equal
H_1: Effects of glue types are not equal

Table 3: Multiple Comparisons of Glue Types

Glue types	Mean difference	P value
SWR-Speedx	512.62	0.000
SWR-SH	1014.0	0.000
Speedx-SH	501.38	0.000

Considering the significant values in Table 3, it can be concluded that all significant values were less than 0.05. Therefore, effect of each glue type affect on glue strength in different from each other at 5% significance level.

Effects of allocating time periods to fix joints affect on glue strength compared pairs considering each time period shown in Table 4 in the purpose of checking the hypothesis mentioned below.

H_0: Effects of allocating time periods are equal
H_1: Effects of allocating time periods are not equal

Table 4: Multiple Comparisons of Allocating Time Period to Fix

Allocating time	Mean difference	P value
1hour-2hour	268.33	0.000
1hour-3hour	304.17	0.000
1 hour-4 hour	388.5	0.000
2hour-3hour	35.83	0.584
2hour-4hour	120.17	0.000
3hour-4hour	84.33	0.020

Considering the significance p values in Table 4, it can be identified that the effect of after 1 hour allocating time period to fix joints on the glue tensile strength was different than to the other allocating time. When comparing the 2 hour & 4 hour time periods and 3 hour & 4 hour time periods, the effects between those were also different at 5% significance level. But, the effects of after 2 hour & after 4 hour periods affect on the glue tensile strength was equal.

RESULTS AND DISCUSSION

According to the Split Plot Design, main effects (five timber species), three glue types and four allocating time are differ at the 5% significance level. There is no interaction among glue type & timber type, among glue type & time period, timber type & time period. But there is an interaction among glue type, timber type & time period. Multiple comparisons show that the

different entities in each factors effect on glue tensile strength in different way.

As a summary, the overall highest mean tensile strength of five timber species was recorded in Jak and Mahogany, secondly in Pinus and least strength was recorded in Teak. Moderate mean tensile strength level recorded in Kumbuk.

When considering about the glue type, the highest mean tensile strength was recorded in Fevicol SWR glue and the least is Fevicol SH glue. Then it can be said that the best glue type for the finger joints products is Fevicol SWR. Second recommendation on timber type is the best wood species for the products is Jak & Mahogany and the highest glue tensile strength can be achieved when the joints allocate more than 4 hours to fix.

CONCLUSION

There is a direct and considerable effect on tensile strength from the three factors; timber type, glue type and allocation time. Main effects of three factors effect on glue strength in different manner. There are no interactions among two factors effects to tensile strength but also there is an interaction between three factors.

The highest mean tensile strength can be obtained as Fevicol SWR glue, Jak & Mahogany timber species and allocating time period is after 4 hour. As the strength of the finger joint is a major problem in this sector, this research provides a solution for a current problem in the field of timber manufacturing industry.

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