UNIVERSITI TEKNOLOGI MARA

PERFORMANCE AND FLEXURAL BENDING BEHAVIOR OF FINGER-JOINTED TROPICAL TIMBER ANALYZED BY EXPERIMENTAL AND NUMERICAL METHODS

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ABSTRACT

The finger joints are commonly used to join the timber planks in order to make long span beam. This technique is widely used in the manufacturing of glued laminated timber (glulam). In the glulam beam, this joint form the weakest point. Therefore, the right profile of finger joint is needed to have optimum performance of glulam. Currently there is no standard for specific measurement of fingers profile in the glulam manufacturing for Malaysian hardwood timbers. As Malaysian glulam industry is still new, the choice of finger profiles is limited to available finger joint cutter which mostly for furniture industries and currently being adopted for glulam manufacturing. The finger profile has many parameters namely finger length, pitch, slope, tip thickness, butt depth and tip gap. In order to evaluate the effect of the finger joint profiles on the finger joint strengths for different densities and species of Malaysian tropical timbers can be cumbersome as the densities of Malaysian timbers ranges from 400 kg/m^3 to 1300 kg/m^3. Therefore, this study develops model using finite element method. This study limits the investigation on the effect of finger joint length. America uses fingers of 25mm length. Japan uses 12mm length and Australia uses an average between 10-20mm lengths but 10mm length is preferred. These overseas timbers, the densities vary from 200 kg/m^3-600 kg/m^3 and yet their finger joint length also varies. This research investigates the finite element analysis of effect of finger lengths on finger jointed timber beams made from Malaysia tropical hardwood by varying finger joint lengths. The research was carried out in two (2) phases. In the first phase (Phase 1), the work was carried out experimentally by finger jointing the timber planks using two finger lengths (15mm and 25mm). A series of timber beams were made with vertical finger joints with different length of fingers namely 15mm and 25mm using Bintangor (804.4 kg/m^3) and White Meranti (783.33 kg/m^3) species from Strength group 5 (strength grouping based on Malaysian Standard MS 544 Part 2). Phenolic resorcinol formaldehyde (PRF) was used as adhesive to joints the parts together. The performances of finger-jointed beams were determined using bending test. Since the 25mm finger length shows consistently marginally higher MOR and MOE values compared to 15mm finger length for both densities, at this point of time, 25 or 15mm finger length can be used. The failure modes of the failed bending specimens were observed, and it was found that the failures were mostly in adhesive failure. In the second phase (Phase 2), finite element method was conducted using Abaqus/CAE program to model the behavior of the joints made in Phase I; and the results indicated a good agreement between experimental and numerical analysis in bending behavior. Therefore, the model is suitable to be used in predicting the performance of the jointed beam for other profiles.

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CHAPTER ONE
INTRODUCTION

1.1 Background of Research

Timber is a natural material with advantages related to recycling and a low carbon economy. However, as an engineering material it also has some disadvantages, related to natural variability, its strongly orthotropic nature and restricted sizes. Compared with other engineering materials, variability in mechanical properties is large, not only within species from different regions, but also within a single log or board. The coefficient of variation for strength can be in the range of 15-30% for structural timber from commonly used species (Serrano & Källander, 2005). The ratios of the stiffness parallel to the grain to the stiffness perpendicular to the grain is found to be in the range of 20-40, so this is another reason why engineered wood materials have been developed. The joining of smaller timber pieces to form larger components such as beams, or sheeting material will result in a product having more accurately defined dimensions and less sensitivity to moisture changes resulting in less distortion.

End jointing of sawn timber has been used extensively in order to authorize the use of single-piece construction since 1900s. It was used for construction of aircraft. In the beginning, the technique of end jointing used was a preliminary scarf joint as a means of bonding two pieces of timber end-to-end using adhesive. Due to end-grain bonding of timber has a low rate of structural capacity; the design of scarf-joint was developed. Beginning in about the 1950s, many researchers studied on the end-joint variations in order to produce a joint with appropriate structural capacity while not increasing the volume of timber that had to be machined (Hernandez, 1998).

As Adams (1980) studied, adhesive joints are designed to provide a continuous bond over as much surface as feasible whereas bolted or screwed joints applies pressure over a smaller area and the associated holes tend to weaken the structure. Modern adhesives work very well in compression, tension and shear; hence structural joints should be designed to take advantage of these properties. Figure 1.1 depicts a variety of common adhesive joints using thin glue lines and joints are clamped together while the adhesive cures to reduce air voids. This research work is concerned with adhesive bonding of timber joints, particularly finger joint connection.