UNIVERSITI PUTRA MALAYSIA

BENDING PERFORMANCE OF I-JOISTS FROM JOINTED ORIENTED STRAND BOARD (OSB) WEB AND LAMINATED VENEER LUMBER (LVL) FLANGES

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By

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This work is dedicated to
my parents and my loving wife.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science.

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Chairman : **Mohd Ariff Jamaludin, Ph.D.**

Faculty : **Forestry**

An I-joist is a system that consists of flanges and web components. Both components have to work together as a system in order to match the strength property of solid wood beam. This study was carried out with the objective of obtaining the strength properties of I-joist made from 3 types of jointed oriented strand board (OSB) web (Finger, L-butt and Nail plate) and 2 types of flanges (solid wood and laminated veneer lumber).

Specimens with LVL flanges were found to be almost as strong as specimens with solid flanges. Both materials exhibited non-significant differences in strength properties as an I-joist system because the modulus of rupture (MOR) values of I-joist in this study were not significantly affected by the material of the flange either solid wood or LVL. Among the three types of joints, the I-joist specimen with finger jointed web was the strongest. The weakest joint was made-up of I-joist specimen with nail plate jointed web.

The modulus of elasticity (MOE) of I-joist systems used in this study did not show any significant difference. The analysis of MOE showed that there was no significant difference between the I-joist specimens with solid and LVL flanges of finger jointed web compared to L-butt jointed web, and finger jointed web compared to nail plate jointed web.

It was observed that failures in all of the I-joist specimens studied were either in tension or in compression. For specimens of finger and L-butt joints, the failure occurred at the web joints. But for nail plate joints, the failure occurred at the location between two adjacent nail plates connections.

OSB web can be produced from the off-cuts of tertiary processing mills that use OSB for other consumer products. Hence, the full use of off-cuts would consequently increase the recovery rate and the net profit. This study could lead to the utilisation of wood residues from an OSB plant as an alternative raw material for the production of web component in I-joists system.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

PRESTASI LENTURAN GELEGAR 'I' DARIPADA WEB PAPAN TATAL BERORENTASI (OSB) DAN BEBIBIR KAYU VENIR BERLAPIS (LVL)

Oleh

WAN MOHD NAZRI WAN ABDUL RAHMAN

Februari 2000

Pengerusi : **Mohd Ariff Jamaludin, Ph.D**

Fakulti : **Perhutanan**

Gelegar 'I' adalah sistem yang terdiri daripada komponen bebibir dan web. Kedua-dua komponen ini hendaklah bekerja sebagai satu sistem supaya ianya dapat menyamai sifat kekuatan rasuk kayu pejal. Ujikaji ini dijalankan bagi memperolehi sifat kekuatan gelegar 'I' yang diperbuat daripada 3 jenis sambungan web (jari, hujung-L dan plat paku) menggunakan OSB dan 2 jenis bebibir (kayu pejal dan kayu venir berlapis).

Spesimen yang terdiri daripada bebibir kayu venir berlapis menghasikan kekuatan yang hampir sama dengan spesimen yang terdiri daripada bebibir kayu pejal. Kedua-dua bahan ini menunjukkan tiada perbezaan ketara bagi sifat kekuatan dalam sistem gelegar 'I', kerana nilai modulus kepecahan (MOR) dalam ujikaji ini tidak menunjukkan perbezaan ketara yang disebabkan oleh bebibir kayu pejal atau pun kayu venir berlapis. Di antara ketiga-tiga jenis sambungan,

spesimen gelegar 'I' dengan web bersambungan jari adalah yang paling kuat. Spesimen gelegar 'I' dengan web bersambungan plat paku pula menunjukan kekuatan yang paling lemah.

Kekuatan lentur bagi sistem gelegar 'I' juga tidak menunjukan perbezaan yang ketara. Analisis modulus kekenyalan (MOE) menunjukkan bahawa tiada perbezaan ketara di antara spesimen gelegar 'I' dengan bebibir kayu pejal dan kayu venir berlapis bagi sambungan jari dibandingkan dengan sambungan hujung-L, dan sambungan jari dibandingkan dengan sambungan plat paku.

Daripada pemerhatian didapati kegagalan hanya berlaku dalam tegasan atau mampatan bagi semua spesimen gelegar 'I'. Spesimen gelegar 'I' dengan sambungan jari dan sambungan hujung-L menunjukkan kegagalan berlaku pada sambungan. Tetapi bagi sambungan plat paku, kegagalan berlaku di antara dua sambungan plat paku yang bersebelahan.

Web OSB boleh dihasilkan daripada bahan reja dari kilang pemprosesan peringkat ke tiga yang menggunakan OSB untuk barangan pengguna. Penggunaan sepenuhnya bahan reja akan dapat meningkatkan kadar pulangan dan keuntunggan. Ujikaji ini boleh merintis penggunaan sisa kayu daripada kilang OSB sebagai bahan alternatif bagi menghasilkan komponen web dalam sistem gelegar 'I'.

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LIST OF ABBREVIATIONS

FRIM	Forest Research Institute of Malaysia
I	Moment of Inertia
LSD	Least Significant Difference
LVL	Laminated Veneer Lumber
MC	Moisture Content
MOR	Modulus of Rupture
MOE	Modulus of Elasticity
MPa	Mega Pasca
N	Newton
OSB	Oriented Strand Board
PRF	Phenol Resorcinol Formaldehyde
Z	Section Modulus

CHAPTER I

INTRODUCTION

The forest industry has contributed significantly towards the socio-economic development of Malaysia. However, due to limited natural resources today, the trend is to change from solid wood to wood composite which encourages the use of small diameter logs, juvenile wood and variety plantation species of wood. The use of solid timber for structural purposes may not last for long. The properties of alternative lumbers such as plywood, laminated veneer lumber (LVL), oriented strand board (OSB), particleboard and glulam need to be understood fully, so that proper utilization can be achieved to ensure efficient product design and safety to the users.

Conventionally, prefabricated wood I-joists were constructed with solid sawn lumber flanges and plywood web. This was followed by I-joists produced from some of the newer wood products, for example, LVL has been used for flanges and OSB for web materials (Breyer, 1993).

Various types of structural components can be produced with the combination of wood composite materials. These wood composite structural components typically consist of large numbers of separate pieces that must be jointed together for the complex structural components of the whole system. The advantage of I-shapes compared to the solid section is that higher bending moments and stiffness can be achieved with the minimum use of the material. Wood I-joists also gain efficiency by using web materials that are strong in shear. Plywood and OSB panels can be used also in other high shear applications such as horizontal diaphragms and shearwalls, in addition to being used as web materials in fabricated wood I-beam (Breyer, 1993).

Wood I-joists span much longer than traditional joists. OSB is as strong if not stronger than plywood. The engineered lumber almost always does a better job than its "natural" composition. Engineered-wood products are generally more stable and reliable than traditional wood products. In many cases, they are also cheaper. Engineered wood I-joists with OSB web provide a high quality support system that minimizes deflection and eliminates floor squeaking (Corper, 1998).

1.1 Problem Statement

Many research studies on the performance of connections between solid timber members have been done and specifications on the appropriate use of this material have been established world wide. But, with the advent of wood composites, more structural members are being made of these materials as substitute to solid timber. End jointing of wood composite such as OSB to produce longer structural member is one of the greatest problems in engineering. Furthermore, there is insufficient published information on these structural joints of wood composite.

Environmental concerns go hand in hand with any building material selection. The environmental advantages of engineered wood products become evident when wood is compared to other building materials. These advantages are resource renewability and efficient use of available resources. Due to the lack of natural resources, building material manufacturers have now diversified their products from solid wood products to engineered wood products such as I-joists. There is a possibility that off-cuts from the fabrication of products such as audio box, table top and cabinet can be used for the fabrication of other value-added products such as I-joist and parquet flooring. Consequently, the productivity and recovery of the mill can be increased.

1.2 Objective

A preliminary experiment done on pieces of OSB panels connected with either nail plate, L-butt or finger joints showed that the nail plate provided the strongest connection. It is envisaged that this type of joint will also provide the strongest connection when used as the web of an I-joist system. Therefore, the main objective of the study was to determine the strength properties of wood I-joist made from 3 types of jointed web (finger, L-butt and nail plate) from OSB and 2 types of flanges (solid wood and LVL).

The specific objectives of the study were as listed below:

1. To determine the strength properties [modulus of elasticity (MOE) and modulus of rupture (MOR)] of the I-joist system with jointed OSB web (finger, L-butt and nail plate).
2. To determine the strength properties (MOE and MOR) of I-joist flanges (solid wood and LVL).
3. To determine the possible modes of failure in I-joist during static bending.

CHAPTER II

LITERATURE REVIEW

2.1 The Use of I-Joists

A prefabricated wood I-joist is a structural member manufactured using sawn timber or structural composite lumber flanges and structural panel web, bonded together with exterior exposure adhesives, forming "I" cross-sectional shape. These members are primarily used as joists in floor and roof construction (Anon., 1997).

The use of prefabricated wood component has increased substantially in recent years. The most widely used form of these composite members is the wood I-joist, but box beams are also used. Wood I-joists are efficient bending members for two reasons. First, the cross section is an efficient shape. The most popular steel beams (W shapes and S shapes) have a similar configuration. The large flanges are located away from the neutral axis of the cross section, thus increasing the moment of inertia and section modulus. Second, wood I-joists are efficient from a material usage standpoint (Breyer, 1993). According to Samson (1985), LVL and solid wood are usually used as the flanges in I-joist fabrication. The flanges are grooved lengthwise and assembled to the plywood or OSB web to form an I-joist.

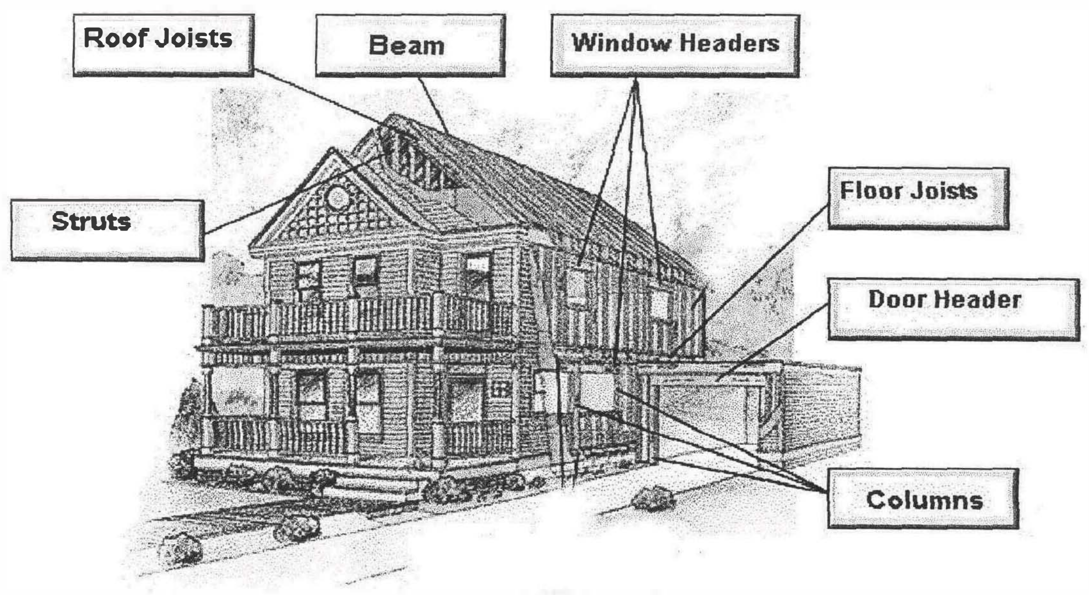
Prefabricated wood I-joists have gained wide acceptance in developed countries for repetitive framing applications. Web stiffeners for wood I-joists may be required to transfer concentrated loads or reactions in bearing through the flange and into the web. Prefabricated metal hardware is available for a variety of connection applications. Because of the slender cross section of I-joists, particular attention must be paid to stabilizing the members against translation and rotation (Breyer, 1993).

In the United States, all residential floors except concrete, are potential markets for I-joist. In 1994 this represented about US$3 billion of potential sales. By 2000, I-joists will have 40 to 50% of the market and the production will exceed 750 million feet (229 million m) per year. I-joist flanges, beams and headers in single and multi family homes consume over 80% of the LVL made in North America. The conversion of I-joist flanges from lumber and increased use in applications such as long span rafters have accelerated the growth of LVL. These engineered wood products also perform more predictably in service, reducing the number of callbacks for repairs and corrections (Walters, 1996).

2.2 I-Joists in Residential Structures

Wood trusses represent another common type of fabricated wood component. Heavy wood trusses have a long history of performance, but light wood trusses are more popular today. The majority of residential wood structures and many commercial and industrial buildings in the United States use some form of closely spaced light wood trusses (I-joists) in roof and floor systems (Breyer, 1993).

I-joists provide squeak-free floor for the life of a home. It is manufactured to resist swelling and shrinking, and feature an efficient "I" shape that enables I-joists to carry loads over long spans without sagging or loosening their connection to the plywood and floor finish. I-joists are also well suited for use as roof joists, especially in longer span such as cathedral ceiling designs common in today's residential buildings (Anon., 1999). Figure 2.1 illustrates the location of which I-joists are being used in residential structures.



Source: Anon., 1999.

Figure 2.1 Location of I-Joist in Residential Structures