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PREFABRICATED WOOD I-JOIST: *Araucaria hunsteinii* FLANGES AND ORIENTED STRAND BOARD WEB WITH L-BUTT JOINT

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ABSTRACT

I-joist is a modern wood product that can be used as a housing construction material such as roof and floor systems. It is a system that consists of flanges and web components, and both have to work together as a system in order to match the strength property of solid wood beam. This system was obtained by using Araucaria hunsteinii as solid wood flange and oriented strand board (OSB) web material with L-butt joint. The results showed that the average value of modulus of rupture (MOR) was 23.2 MPa and the average value of modulus of elasticity (MOE) was 11,454.0 MPa. In all cases, failures in the I-joist specimens studied were either in tension or in compression and failure occurred at the web joints. The L-butt jointing techniques encourage to the usage of off-cuts from related wood-based industries thus leading to the optimum utilisation of timber.

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. 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 fast-growing wood species such as *Acacia mangium* and *Araucaria hunstenii*. 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).

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 and introducing of forest plantation species (*Araucaria spp.*), more structural members are being made of these materials as substitute to common 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 L-butt joints of wood composite.

OBJECTIVE

The main objective of the study was to determine the strength properties of wood I-joist made from *Araucaria hunsteinii* flanges and OSB web material with L-butt joint.

MATERIALS AND METHODS

In this study, a total of 6 specimens of I-joists were tested in bending (Figure 4.1). The I-joists were prepared using OSB web and two types of solid flanges (*Araucaria hunsteinii* and *Diptrocarpus spp*). Both web types were end jointed using L-butt joints.

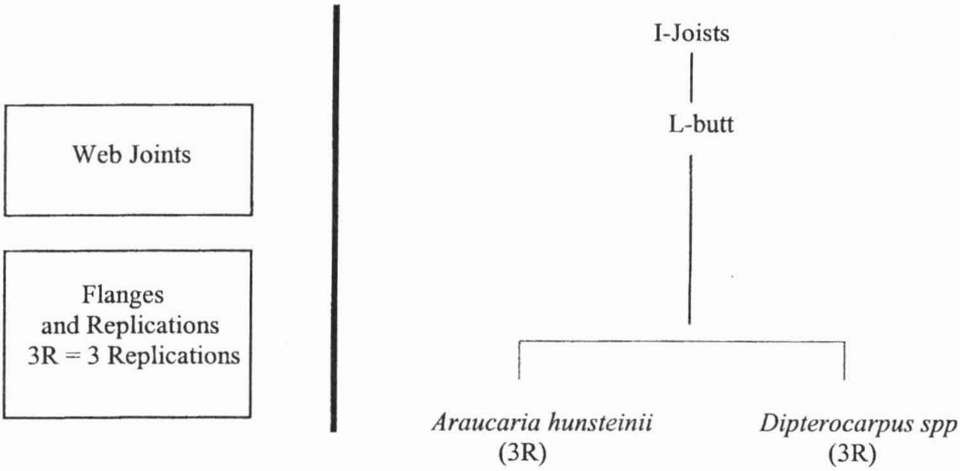


Figure 4.1 I-Joist Samples

Preparation of I-Joists

Figure 4.2 shows the flow chart for the preparation of I-joist specimens. Each set of I-joist consists of web and flange components. These components were assembled and formed into an 'I' shape (Figure 4.3).

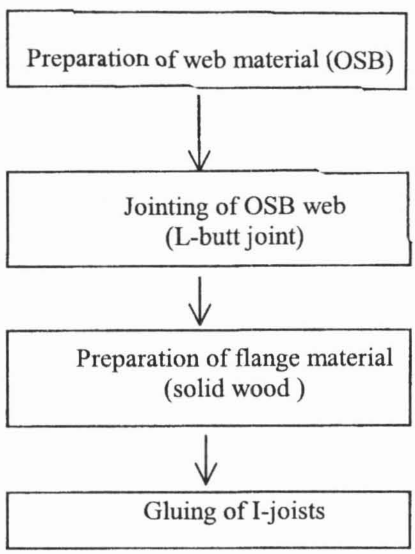


Figure 4.2 Flowchart for the Preparation of I-Joist Specimens

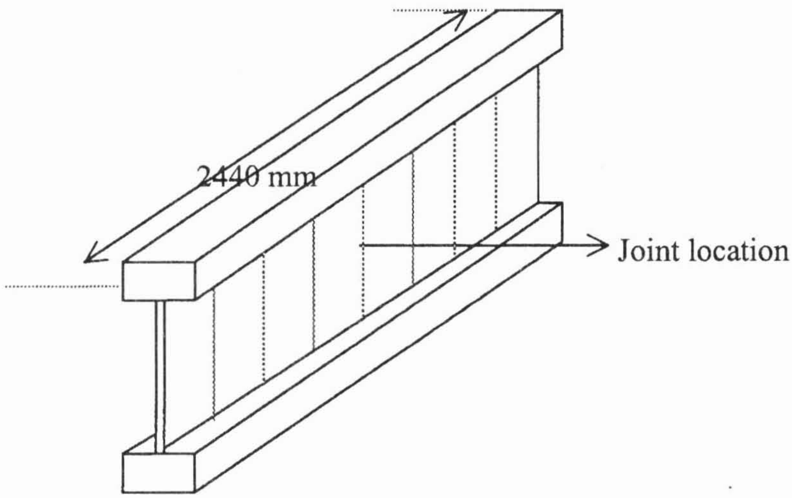


Figure 4.3 I-Joist Sample Showing the Location of Joint in the Web

L-Butt Joints

The L-butt joints in this study were joints that were partially jointed both across and along the grain forming an L-shape. The size of the L-shape was 58.5 mm x 58.5 mm x 58.5 mm. The L-butt joints were similar to any butt joints but having a wider contact area. It was intended that the L-shape profile would take advantage of the resistance provided by the alternate crossing grains of the OSB.

I-Joist Flanges from Solid Wood

The solid wood used in this study was purchased from a local supplier. The *Araucaria hunsteinii* solid wood were grooved at 2440 mm (8 ft) lengthwise of 10 mm x 12 mm and assembled onto the OSB web to form an I-joist. The groove was cut in the centre on the wide face of the flange.

I-Joist Fabrication

The I-joists used in this study were constructed using *Araucaria hunsteinii* as flanges and OSB as a web, glued together with a PRF adhesive. Each set of the I-joist consisted of 7 jointed OSB web. The length was arbitrarily fixed at 8 feet. The PRF adhesive was spread in the groove by using thin veneer and brush. The PRF adhesive was used because of its fast-setting characteristics and exterior exposure durability. Pressure must be applied while the adhesive was still tacky to achieve adequate bonding. I-joist specimens were clamped in beds with the pressure supplied by screwing at 6 MPa to 7 MPa. I-joist specimens were left to cure at room temperature for 2 days.

Destructive Testing of I-Joist Samples

I-joists were destructively tested by bending under third-point loading over a 2310 mm span. Each I-joist was tested in bending on a universal testing machine. The load point was placed symmetrically at the centre of the span. The load should be applied continuously with a uniform rate of cross-head movement throughout the test. The speed of testing was 6.6 mm per minute to achieve failure within 300 ± 120 s as recommended in BS 5820. The specimens were continuously loaded to achieve failure. The MOE was obtained based on deformation and load measurement. Load and displacement readings were taken at suitable intervals to plot a graph of load versus deformation.

RESULTS AND DISCUSSION

MOE and MOR of I-Joist

The flexural strength of a material is normally expressed by the MOR. When the results of the two treatments were compared, I-joist specimens with *Araucaria hunsteinii* flanges performed almost as strong as specimens with *Dipterocarpus spp.* flanges.

Table 5.1 Strength Properties of the I-Joist from *Araucaria spp.*and *Dipterocapus spp*

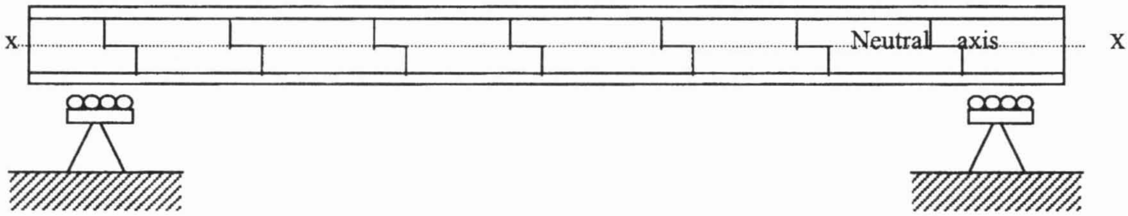
Number of sample	Max. Load (Kgf)	MOE (MPa)	MOR (MPa)	MOR (MPa) Average
AO -1	916	11,218	17.5	23.2
AO -2	1426	9,646	24.2	
AO -3	1300	13,500	24.8	
KO -1	1488	10,844	28.4	24.0
KO -2	1103	15,988	21.0	
KO -3	1176	10,826	22.4	

AO – I-joist from Araucaria flanges and OSB web
KO – I-Joist from Keruing flanges and OSB web

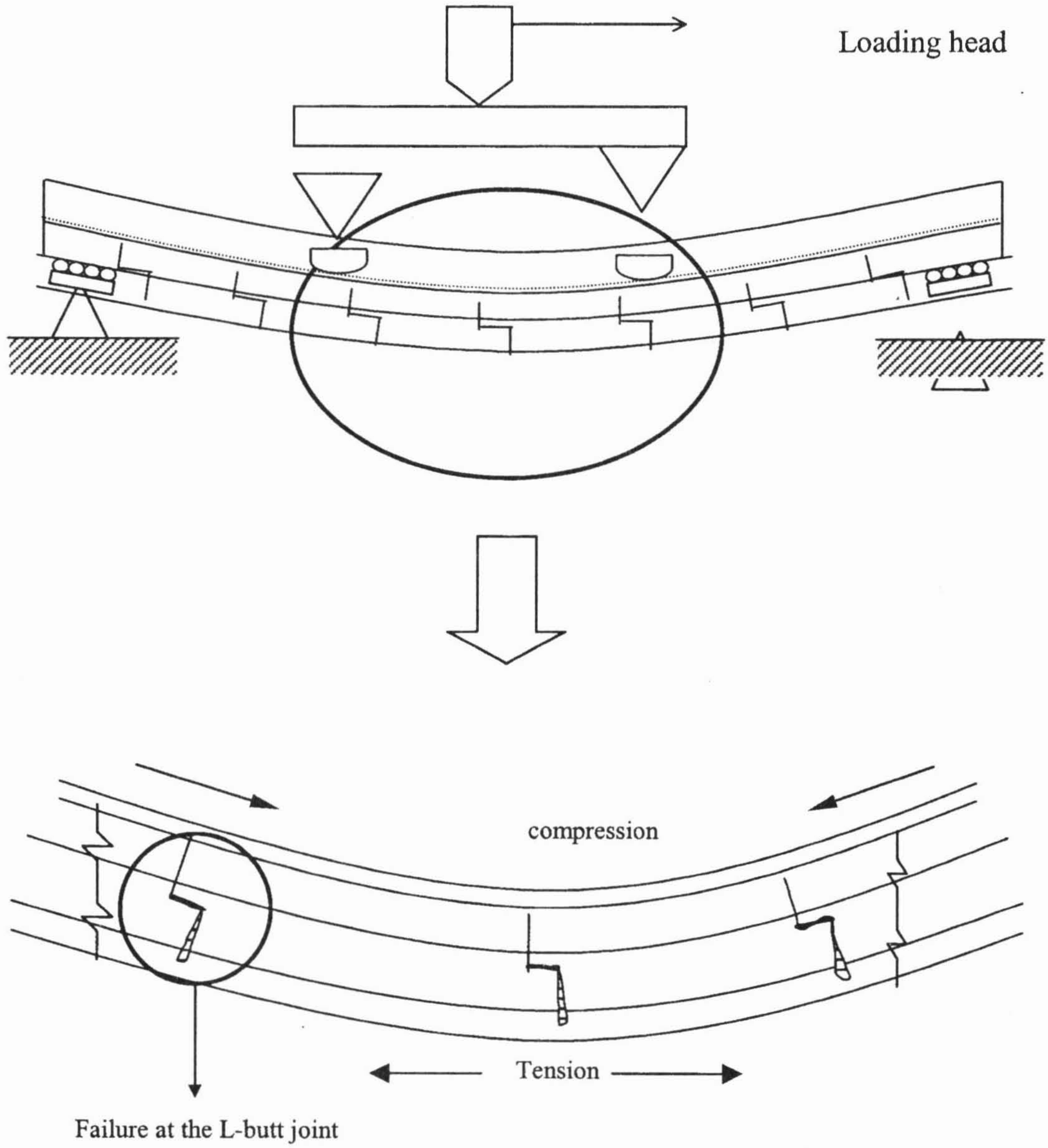
The MOE was computed by assuming that the deflection of all of the I-joist specimens arised from flexural deformation. The result showed that the highest value of MOE was 15,988 MPa for the I-joist with Keruing flanges, and the lowest was 9,646 MPa for the I-joist with Araucaria flanges (Table 5.1).

Failure in I-Joists with L-butt Joints

All the I-joists with L-butt jointed web failed at the glue line between the edges of the butt especially at the lower portion. It was observed that the L-butt joint located at the bottom of the web experienced tension and was the most separated (split), while the edges of the butt at the upper part (in compression) were the least separated (Figure 5.1). This was because the joint failure was governed more by a failure near the L-butt joint which was within the tension zone. According to Chu (1987), a lap joint with glue had little strength in tension because of the effect on the glue line which caused failure at the joint.



(a) Before Loading



(a) Upon Loading

Figure 5.1 Failure at the L-butt Joint of an I-Joist System

CONCLUSION AND RECOMMENDATIONS

Conclusion

As a conclusion to this study, specimens with *Araucaria hunsteinii* flanges performed almost as strong as specimens with *Dipterocarpus spp.* solid flanges. Both species exhibited non-significant differences in properties as an I-joist system because the MOR values of I-joist in this study were not significantly affected by the material of the flange whether it was *Araucaria hunsteinii* or *Dipterocarpus spp.*. The bending strength of the I-joist system also did not show any significant difference. It is important to understand that an I-joist is a system, and it cannot act as an individual element. The large flange area located away from the neutral axis is efficient because the flanges are placed at the point of maximum stresses, and the OSB web satisfactorily resists load as long as it has adequate shear strength.

Failures in all the I-joist specimens in this study were either in tension or in compression. The failure that occurred below the neutral axis was tension, while the compression failure occurred above the neutral axis.

Recommendations

There is a need to further this study in order to improve the I-joist system which involves different wood species, types of wood composite, gluing and jointing techniques and types of adhesive. This is because I-joists offer many advantages compared to solid sawn timber such as consistent dimensions with greater spanning capability, lighter weight, easier to handle and faster to install. I-joists also allow holes to be easily made in the web, provide flat floors and ceilings and make residential framing cost-effective.

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