

# Mechanical characteristic of laminated beam of teak wood with sengonusing connector

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**Abstract.** Wood as construction material which is provided by nature is decreasing if the usage is not controlled. Several kinds of wood which are often used for construction material are teak wood and sengon wood. One alternative combines wood with good quality and deficient quality, such as combination of teak wood and sengon wood as laminated beam. This research is to know flexural load of perpendicular layered connection of teak wood and sengon wood with bolt and nail connector. The teak wood was placed at the bottom and the sengon wood was at the top. Dimension of wood beam test specimen before laminated was 60 x 100 x 800 mm, after being laminated was 120 x 100 x 800 mm with 2 variations of connector of bolts and nails. Each connector was made in 3 test specimens. The bolt diameter size was 7 mm, the nail size was 5 mm, the length was 150 mm and the range of each connector was 160 mm. Installation of connector was carried out parallel for each specimen test, so that there were 4 connectors in each laminated beam. The flexural load of laminated beam test specimen of teak wood with sengon wood using nail connector is bigger 19.2 % than laminated beam using bolt connector although the diameter is smaller. The use of laminated beam with nail connector becomes alternative substitute of whole beam.

## 1. Introduction

Wood and bamboo are construction materials which are provided by nature that are able to be regenerated. Bamboo as a green material can reduce the effects of global warming needed for the sustainability of the environment and the earth is back green and comfortable as a place of human life and nature [1].

The use of wood as construction material has been applied long before development of science and steel and concrete construction technology. However, until at present wood is still in demand in construction work, considering wood has several advantages such as having high specific strength, light, easy to be gained, and in certain regions, the price is relatively cheap as well as the implementation is easy to be done [2].

Request for wood as construction material is always getting up from year to year, whereas the ability to provide wood is diminishing. One of the solutions of this problem is by combining wood with good and deficient quality. Therefore, it is necessary to be developed composite wood product as construction material by using raw material of low quality wood from fast growing wood types [3].

For construction need, it must be adequate in toughness or strength of bearing the burden that might arise, the selected wood must also be adequate in its stretch. The wood connection is very important in construction with material of good wood in form of house, building, bridge or tower. In



the process, upright connection is easier to be made than other connections. The connection is also functioned to drain force or burden to other parts. According to Sucahyo dan Agustina, a building, besides it needs proper design, thus emphasis on wood connection at its building is able to make the use of wood more effective and efficient [4].

Reviewed from mechanical planning, wood construction has difference from other constructions such as reinforced concrete or steel. On wood construction, there is a limitation of deformation or displacement on its connection in which the limitation of connection displacement is allowed until 1.5 mm. For the connector, there are several kinds of them, namely adhesive connector (epoxy), cotter pin, nail, and bolt. Effectiveness of each connector is divergent, it depends on each character of the connectors in which the effectiveness of adhesive connector can reach 100 percent, cotter pin 60 percent, nail 50 percent and bolt 30 percent [5].

However, the bolts and the nails are connectors that are often used in gluing each connector on wood because they are easy to be obtained and in the implementation, they are also relatively cheap and easy. The strength of a connection which uses bolts and nails is affected by its diameter, quantity, types of base material used as well as connection model used. Hence, it is necessary to be observed how big the flexural strength load is able to be held by the lamination beam of teak wood with sengon wood by using connector of nails and bolts.

## 2. Literature review

One of wood characters as natural material is hygroscopic, adaptation with surrounding condition, wood can absorb and release water inside it. Various studies have been conducted about the relation between water content and wood strength, Haygreen and Bowyer state that high water content inside wood is inversely proportional with wood strength, because value of water content becomes one of important parameters to be concerned in relation to wood in taking the load [6]. The result test of density and water content of sengon wood which was done by Affan and friends, The average of water content is as big as 17.23 %, based on the wood quality of type B. The average of density is as big as 0.48, based on class of wood strength included in class III [7].

Research on flexural strength review of combination laminated beam between sengon wood and teak wood with glue adhesive of epoxy member, flexural strength results of laminated beam, variation 1 (thickness of teak wood is 10mm, sengon wood is 80mm) is as big as 13.95 MPa, laminated wood beam 2 (thickness of teak wood is 20mm, sengon wood is 60mm) is as big as 17.37 MPa, Laminated wood beam, variation 3 (thickness of teak wood is 30mm, sengon wood is 40mm) is as big as 18.76 MPa, and laminated wood beam, variation 4 (thickness of teak wood is 40mm, sengon wood is 20mm) is as big as 21.19 MPa [3].

The test of wood flexural strength is made into two models, they are flat landscape and vertical landscape. The beam sizes of flat landscape and vertical landscape are the breadth (b) 130 mm, the height (h) 150 mm, and the length (L) 1000 mm. The testing object is connected with 2 inch long nails, diameter of 0.3 cm. The research result is found that vertical landscape has stronger value of flexural strength than flat landscape. It is because of the sticky strength of nails in holding the wood. If it is nailed from the side, the sticky strength is except from the wood that holds back, the nails also hold beam when it is pressed. Differed from flat landscape, it is only held with its wood, because nails are mounted parallel to wooden holder. The strength of wood does not depend on the number of nails. Because in the testing of vertical landscape, the wood with distance of 9 cm has stronger strength [8].

## 3. Research methodology

The research methodology is an experiment in laboratory which the goal is to know flexural load of laminated beam of teak wood and sengon wood by using bolt and nail connector.

Dimension of testing object before lamination was 60 mm x 100 mm x 800 mm, the dimension after lamination was 120mm x 100mm x 800mm, it was made in vertical manner layered parallel to fibre with difference of wood quality I using teak wood at the bottom and wood II using sengon wood

at the top. The lamination of teak and sengon wood used bolt connectors which were made in three testing objects and using nail connectors which were made in three testing objects.



**Figure 1.** Laminated beam between teak wood at the bottom and sengon wood at the top

The connectors used are bolts and nails with 150 mm length dimension, 7 mm bolt diameter and 5 mm nail. Making the holes by drilling then it was installed connectors which were appropriate with its dimension. The number of connectors were 4 points for each testing object, the range of each point was 160 mm. On installation of nail connectors left 30 mm length from in front of testing object, thus, the it was conducted bending of nail tip in the same direction as beam, so that the connector was stronger to bind the both beams, on the bolt was given nut lock ring. The testing in this research was flexural strength of laminated beam.



**Figure 2.** Nail instalation



**Figure 3.** Bolt instalation



**Figure 4.** Settingup of flexural testing

The flexural testing is used one point loading, the beam is then loaded at its centre point until failure to get relationship load – deflection.

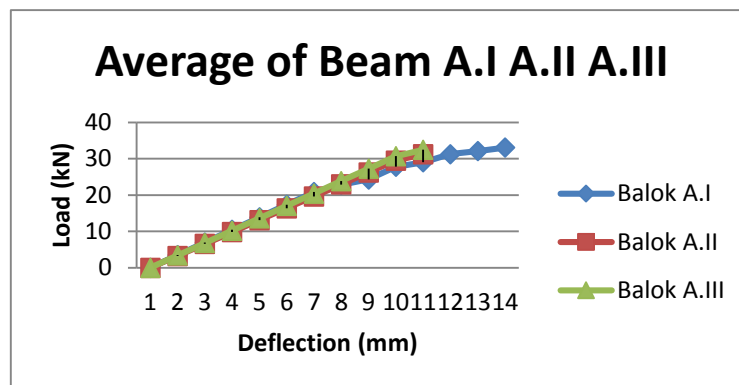
## 4. Results and discussion

### 4.1 Flexural testing of laminated beam with bolt connector ( A )

The result of flexural testing of teak wood and sengon wood with bolt connector , the dimension ( 120 x 100 x 800 ) mm, the range of each 4 bolt connector on each testing object is 160 mm. The beam of teak wood and sengon wood with bolt connector (A.I), (A.II), and (A.III), obtains the result of beam flexural load as follow :

**Table1.** The beam average results of bolt connector (A.I), (A.II), and (A.III)

Load Average and maximum Deflection of Beam with Bolt Connector(A)					
No	Code	Maximum Load (KN)	Average Load (kN)	Maximum Deflection (mm)	Average Deflection (mm)
1	A.I	33.11		39	
2	A.II	31.25	32.29	39.01	35.34
3	A.III	32.50		28	



**Figure 5.** Average result of laminated beam of bolt connector (A.I), (A.II), and (A.III).

The average of maximum load of laminated beam using bolt connector (A) is as many as 32.29 kN and maximum deflection is 35.34 mm.

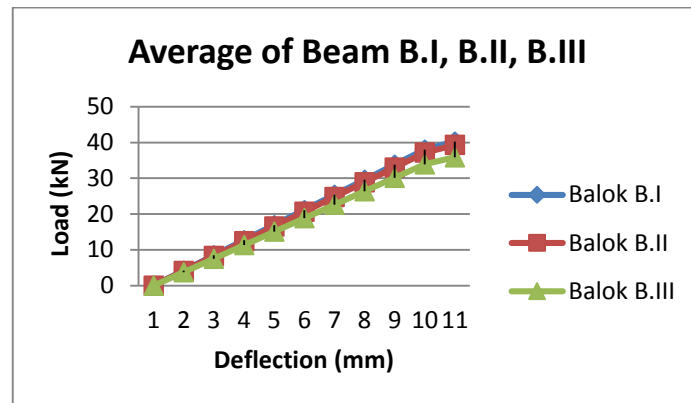
### 4.2 Flexural testing of laminated beam with nail connector ( B )

The testing results of laminated beam of teak wood and sengon wood with nail connector as on table 2, teak wood beam and sengon wood (B.I), (B.II), and (B.III), obtain the results of beam flexural load as follow:

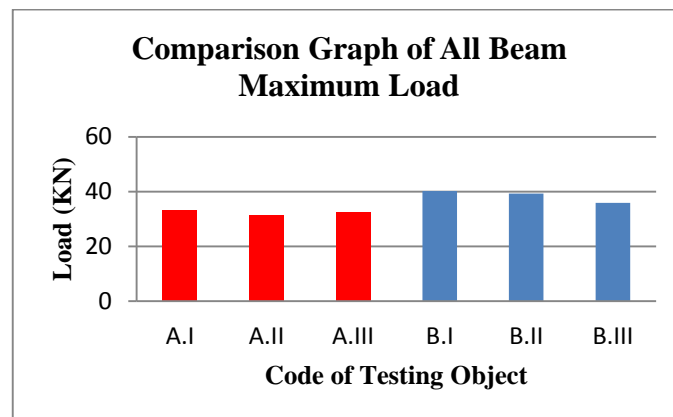
**Table 2.** The average result of laminated beam using nail connector (B.I), (B.II), and (B.III)

Average of Beam maximum Load of Nail Connector (B)					
No	Code	Maximum Load (KN)	Average Load (KN)	Maximum Deflection (mm)	Average Deflection (mm)
1.	B.I	40.26		35.16	
2.	B.II	39.32	38.49	31.3	31.85
3.	B.III	35.90		29.09	

The average of maximum load of laminated beam uses nail connector (B) is 38.49 KN and the average deflection is 31.85 mm.



**Figure 6.** Average result of laminated beam of nail connector (B.I), (B.II), (B.III)



**Figure 7.** Comparison of beam load of bolt connector (A) and nail connector (B)

It can be seen that the average results of every testing object beam of lamination beam of teak wood and sengon wood which uses nail connectors are bigger than lamination beam using bolt connector although the nail diameter is smaller than the bolt. It is because bending of the nail at the other end as the locking makes lamination beam more tightly rather than bolt which is locked by using nut, the increasing of flexural load strength on nail is as big as 19.2 % compared to flexural load on lamination beam of bolt connector. According to Rochman, 2012, the result of the flexural test of laminated beam of teak wood and sengon use epoxy adhesive is 15 KN, smaller than using a nail or bolt connector in this test.

#### 4.3 Failure pattern of beam



**Figure 8.** Failure Pattern of Lamination Beam using bolt connector.



**Figure 9.** Failure Pattern of Lamination Beam using nail connector

The failure of lamination beam of teak wood and sengon wood with bolt connector (A) occurs on testing object (A.II). it happens cracks under testing object at the maximum load 20.46 KN, because there is a wood defect. The failure of lamination beam of teak wood and sengon wood with nail connector (B) occurs on testing object (B.I). It is because there is a wood defect so that it happens cracks under testing object at the load reaching 27.57 KN, however, at the time it is given more load, it increases significantly, the testing object can still bear up at maximum load 40.26 KN.

#### 5. Conclusion

The result of this research proves that lamination beam of teak wood and sengon wood which is made in layered parallel to the fibre using bolt and nail connectors, the better testing object is by using nail connector (B) with average of flexural load as big as 38.49 KN, comparing to bolt connector (A) it obtains flexural load average only as big as 32.29 KN. It occurs that not only is the selection of wood species, but also installation of nails whose ends are bent in the same direction of testing object takes effect in bearing up lamination beam so that it is more tightly than bolt which is locked by nut. The damage of testing object (A.II) and (B.III) is gained because the texture of defective/cracked testing object on its wood beam.

#### 6. References

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