Laminated mahogany and teak wood as construction materials for fishing vessels

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Abstract. The significant increase of Teak wood price causes the high price of fishing vessels made from intact Teak wood so that it is necessary to replace the Teak wood as the main material in fishing vessels. The traditional construction of fishing vessels has negative impact such as decreasing quality of the material due to heat treatment of wood, so that laminated wood technology with cold treatment is one solution to maintain and strengthen wood material. Mahogany wood is one of the woods that can be used as an alternative material for fishing vessels according to the Indonesian Classification Bureau, but some people assume that Mahogany is not suitable as an alternative for Teak wood due to differences in the durability of wood in seawater, so the research will be conducted on lamination of Mahogany and Teak as a material to build fishing vessel. This study carried out tensile and bending tests in accordance with ASTM standards for laminated material. Based on the results of test, the laminate material of Mahogany and Teak has an average tensile strength of 96.56 MPa, bending strength of 72.38 MPa and specific gravity of 0.82 gr/cm². According to the regulations of the Indonesian Classification Bureau the laminate material of Mahogany and Teak meets minimum tensile strength and bending strength, equivalent with Strength Group II-III and can be used for the entire construction section of the fishing vessel. From the economic aspect it is estimated that the cost to build a 3 GT fishing vessel around IDR 44,927,656 (USD 3,160).

1. Introduction
Currently, the manufacturing of wooden fishing vessels still using solid Teak wood as raw materials. Teak wood is more expensive than the other woods that are used in boat building [1]. While in Indonesia there are various types of wood that are more abundant and cheaper than Teak wood, one of which is Mahogany wood [2].

According to Biro Klasifikasi Indonesia (BKI), it is allowed to use mahogany as a material for wooden ship construction. Mahogany wood is classified as Strength Group II-III. A whole part of Mahogany cannot be used for the entire construction of the wooden boat because the Durability Group is only a Durability Group III so that the solid Mahogany is only allowed to be used for constructions that not always interact with seawater [3]. Although BKI allowed using mahogany as raw material of wooden boat, the use of mahogany is not as much as Teak in Indonesia due to doubts by producers and consumers about the strength and durability of mahogany wood.

Mahogany wood has disadvantages, those are easy to experience deformation and shrinkage. The disadvantages can be overcome by the lamination method that has been done by some researches. With the use of epoxy resins, Mahogany lamination can maintain the shape of the hull and gain strength up to the equivalent of Strength Group I wood.
The last research proved that Mahogany lamination using epoxy had 115 MPa of the tensile strength, while the tensile strength of solid Mahogany is only 90.83 MPa and the Teak wood only 97.1 MPa [4]. To perfect the research, it is felt necessary to provide additional reinforcement to the construction made of Mahogany wood with wood which has proven to be stronger and more durable than Mahogany. Teak wood is wood that has a Strength Group I and Durability Group 1 and is expected to increase the durability of Mahogany lamination by making Teak wood as the outermost coating of Mahogany lamination material because the durability of Teak wood has been proven to be good for parts of construction that come in direct contact with seawater [5]. Therefore, it is necessary to conduct a research by adding a layer of Teak wood on Mahogany wood laminate.

2. Methodology
This research is motivated by the use of alternative wood substitutes for solid Teak and the application of lamination technology where the material chosen for research is Mahogany and Teak Wood. The study begins with the formulation of the problem regarding the method of making ships with these materials as well as technical analysis and economic analysis. After that, collecting literature related to problems and problem solving in research and surveys to obtain information about the current conditions in the construction of fishing vessels made from whole wood. Material testing is carried out to get the results of bending strength and tensile strength which will be used to consider the feasibility of the material in accordance with BKI [6]. The results of the material testing are used for construction calculations on the Mahogany 3GT laminated vessel. After testing and surveying, prototyping is carried out to obtain comparative data on the production process between the shipbuilding method with lamination technology and the shipbuilding method using solid wood [7]. From prototype shipbuilding also obtained data on shipbuilding productivity with lamination technology and costs related to the construction of laminated vessels which will be used as calculation factors in the economic analysis of the construction of Mahogany and Teak laminated fishing vessel 3 GT.

3. Results and Discussions
3.1 Material Test Result
From the results of tensile tests that have been carried out on the test specimens, the average elongation and Fault values will be shown, as shown in Table 1.

| No | Specimen | Sch | W (mm) | T (mm) | L0 (mm) | CSA (mm²) | Elongation (mm) | Fultimate (KN) |
|----|----------|-----|--------|--------|---------|------------|----------------|---------------|
| 1  | TR 1     |     | 23.70  | 6.60   | 64      | 156.42     | 32             | 14.0          |
| 2  | TR 2     |     | 24.00  | 6.20   | 64      | 148.80     | 24             | 14.6          |
| 3  | TR 3     | Parallel | 24.69 | 6.55   | 64      | 161.72     | 27             | 16.2          |
| 4  | TR 4     |     | 23.40  | 6.37   | 64      | 149.06     | 28             | 15.4          |
| 5  | TR 5     |     | 24.20  | 6.40   | 64      | 154.88     | 32             | 14.2          |
|    | Average: |     | 28.6   |  |         | 14.88      |                |               |

The test results of the Mahogany laminated material with Teak obtained maximum tensile values up to broken test specimens in accordance with the load graph obtained from the Universal Testing Machine [8]. Specimen 1 (TR 1) withstand a tensile load of 14 kN. Specimen 2 (Tr 2) withstands a tensile load of 14.6kN. Specimen 3 (Tr 3) holds a tensile load of 16.2 kN. Specimen 4 (Tr 4) holds a tensile load of 15.4 kN, and Specimen 5 (Tr 5) holds a tensile load of 14.2 kN. Similar test has been conducted for bamboo laminated material for fishing boats as well [9,10].
From the results of tensile tests that have been carried out on the test specimens, the elongation and fault values can be calculated, as shown in Table 2.

**Table 2. Bending test result**

| NO | Code | W (mm) | T (mm) | CSA (mm²) | L (mm) | L span (mm) | F_{ult} (KN) | Def (mm) |
|----|------|--------|--------|-----------|--------|-------------|--------------|---------|
| 1  | TK 1 | 24.86  | 20.20  | 502.1     | 610    | 480         | 1.4          | 15.5    |
| 2  | TK 2 | 25.19  | 20.30  | 511.4     | 610    | 480         | 1.6          | 14.8    |
| 3  | TK 3 | 24.90  | 20.24  | 504.0     | 610    | 480         | 1.5          | 14.7    |
| 4  | TK 4 | 25.03  | 20.19  | 505.4     | 610    | 480         | 1.4          | 15.4    |
| 5  | TK 5 | 24.77  | 20.16  | 499.0     | 610    | 480         | 1.4          | 14.7    |

Average: 1.46 15.10

The test results of Mahogany wood laminated material with Teak with aligned fiber direction arrangement obtained maximum bending value until the test specimen is broken [11]. Specimen 1 (TK 1) withstand a bending load of 1.4 kN. Specimen 2 (TK 2) holds a bending load of 1.6 kN. Specimen 3 (TK 3) holds the bending load 1.5 kN. Specimen 4 (TK 4) holds a bending load of 1.4 kN, and Specimen 5 (TK 5) holds a bending load of 1.4 kN.

3.2 Mechanical Properties of Tensile Test

From the tensile test results, the mechanical properties of Mahogany and Teak wood laminates can be calculated. From these calculations, the stress, MoE and Strain values obtained from the results of the tensile testing have been carried out. Details of the mechanical properties’ calculation of Mahogany and Teak laminates can be seen in Table 3.

**Table 3. Mechanical properties of tensile strength**

| No | Specimen | Stress (MPa) | MOE (Gpa) | Strain (%) |
|----|----------|--------------|-----------|------------|
| 1  | TR 1     | 89.50        | 15.28     | 37.50      |
| 2  | TR 2     | 98.12        | 19.14     | 32.81      |
| 3  | TR 3     | 100.17       | 19.54     | 32.81      |
| 4  | TR 4     | 103.32       | 18.40     | 35.94      |
| 5  | TR 5     | 91.68        | 13.41     | 43.75      |

Average: 96.56 17.15 36.56

For the calculation of mechanical properties based on tensile testing, it was found that TR1 specimens had tensile strength of 89.50 MPa and strains of 37.5%, TR2 specimens had tensile strength of 98.12 MPa and strains as large as 32.81%. TR3 specimens had tensile strength of 100.17 MPa and strain of 32.81%. TR4 specimen has a tensile strength of 103.32 MPa and strain of 35.94% and TR5 Specimen has a 91.68 MPa tensile strength and Strain of 43.75%. From all the test results obtained an average tensile strength the average is 96.56 MPa, the average MoE is 17.5 GPa, and the average strain is 36.56%. From the calculation result of tensile test analysis, it can be determined for stress-strain graph of each tensile testing specimen to see the characteristics of the test specimen.

According to the 2013 BKI regulation on "Rules for Small Vessels up to 24 m" which stipulates the permitted stress of plywood or laminate material, it states that the laminate to be used as construction material must have a minimum tensile strength value of 42,169 MPa [12]. Meanwhile, according to Figure 1 the results of testing all specimens of Mahogany and Teak wood laminate have tensile strength values above the conditions determined by BKI where the tensile strength results of each specimen have passed the minimum tensile strength limit.
3.3 Mechanical Properties of Bending Strength

From the results of bending testing can be calculated and obtained deflection values, bending strength and MoE from bending test data results for laminated Mahogany and Teak wood. At the time of conducting the bending test to measure deflection, it requires sufficient precision due to the necessity to observe deflection based on the sound of specimen cracks. For details on the calculation of bending test results can be seen in Table 4.

| No | Code | MOR (MPa) | MOE (Gpa) |
|----|------|-----------|-----------|
| 1  | TK 1 | 68.1      | 7.1       |
| 2  | TK 2 | 78.7      | 8.4       |
| 3  | TK 3 | 77.1      | 8.3       |
| 4  | TK 4 | 66.8      | 7.0       |
| 5  | TK 5 | 71.1      | 7.6       |
|    | Average: | 72.4 | 7.7 |

In accordance with the table above for specimen TK1 has a bending strength of 76.2 MPa with MoE of 6.08 Gpa. Specimen TK2 has a bending strength of 86.08 MPa with MoE of 6.71 Gpa, Specimen TK3 has a bending strength of 65.30 MPa with MoE of 5.13 GPa, TK4 Specimen has a bending strength of 73.96 MPa with MoE of 6.15 Gpa, and TK5 Specimen has a bending strength of 82.74 MPa with MoE of 6.88 GPa. In accordance with the calculation of bending test results obtained an average bend strength of Mahogany and Teak laminate material is 76.86 MPa with an average MoE of 6.19 GPa.
Minimum bending strength required by BKI is 71.098 MPa. Not all bend strength values of tensile test specimens are not fulfilled, but if taken an average strength value of all average tensile strengths of 72.38 MPa, Mahogany and Teak laminated material meet the minimum bending strength requirements for strong conditions bend minimum according to BKI. For a comparison of the bending strength of each specimen can be seen in Figure 2. Specimen's bending strength Figure 2.

3.4 Eligibility for use of Mahogany and Teak Lamination Material

3.4.1 Plywood strength group
In BKI Volume XIV regulations "Rules for Non-Metallic Materials 2014 Edition" the Strength Group of laminated material is divided into two namely the F1 Strength Group and the strong F2 group. For wood laminated material, the Strength Group F1 has a tensile strength above 40 MPa while the Strength Group F2 has a tensile strength of less than 40 MPa with a minimum tensile strength of 30 MPa. Based on the results of testing Mahogany and Teak laminated material has an average tensile strength of 96.56 MPa which means this material is included in the category of F1 Strength Groups where this material is allowed as material for the structure of shipbuilding support.

3.4.2 Wood strength group and durability group
In BKI Regulation Volume VI of 2013 concerning "Rules for Small Vessels up to 24 m" wood material that is allowed to be used as shipbuilding material is material with a minimum of Strength Group III and Durability Group III. For Strength Group I more than 650 kg/mm² or more than 63.74MPa with a minimum specific gravity more than equal to 0.9gr/cm³, Strength Group II 450kg/mm² up to 650 kg/mm² or equivalent to 44.13-63.74 MPa with specific gravity between 0.6-0.9gr/cm³. Strength Group III 300 kg/mm² up to 450 kg/mm² or equivalent to 29.42 MPa - 44.13 MPa with a specific gravity of 0.4-0.6gr/cm³. Mahogany and Teak laminated material has an average tensile strength of 96.56 MPa with a specific gravity of 0.82 gr/cm³ so that although it has a tensile strength equivalent to Strength Group I woods, in terms of its specific weight equivalent to Strength Group II wood, Mahogany and Teak wood laminated material equivalent to Strength Group II Wood. For durability group of laminated material According to BKI is durability group which is owned by wood with the lowest durability group namely Mahogany wood so that this material has Durability Group III.

3.4.3 Allowed use for construction
In BKI Regulation Volume VI of 2013 concerning "Rules for Small Vessels up to 24 m" the ability to use materials for each construction part has been determined based on the specific gravity of the material [13]. Because Mahogany and Teak laminated material have a specific gravity of 0.82 gr/mm³, this material is allowed to be used as construction material for all parts of the ship. For details of the permissibility of using Mahogany wood lamination material can be seen in Table 5.

| Construction       | Specific Gravity (g/cm³) | Status   |
|--------------------|--------------------------|----------|
| Keel               |                          | Allowed  |
| Stem               |                          | Allowed  |
| Floor              | 0.7                      | Allowed  |
| Frame              |                          | Allowed  |
| Transom beams      |                          | Allowed  |
| Shell              |                          | Allowed  |
| Sheer plank        | 0.56                     | Allowed  |
| Reinforced deck beams |                      | Allowed  |
### Construction Specific Gravity (g/cm$^3$) Status

| Item            | Specific Gravity (g/cm$^3$) | Status |
|-----------------|-----------------------------|--------|
| Beam knees      |                             | Allowed|
| Carlines        |                             | Allowed|
| Engine Mounting |                             | Allowed|
| Deadwood        |                             | Allowed|
| Deck            |                             | Allowed|
| Deck Longitudinal | 0.45                      | Allowed|
| Shelves         |                             | Allowed|

#### 3.5 Scantling For 3 GT Fishing Vessel

The calculation of the construction size was obtained based on the 2013 Biro Klasifikasi Indonesia (BKI) Volume VI regulations on "Rules for Small Vessels up to 24 m" [13]. The calculation is done based on Section 1 D about cold-molded in BKI Volume VII 2013. On the results of the determination of the construction of laminated wooden vessels. The results of the calculation of the size of the construction of Mahogany and Teak laminated teams of 3 GT can be seen in Table 6.

**Table 6.** Construction scantling for 3GT fishing vessel

| Item         | Area | Height | Width | Thickness |
|--------------|------|--------|-------|-----------|
| Keel         | All  | 90 mm  | 148 mm|           |
| Stem         | All  | 75 mm  | 75 mm |           |
| Chine lock   | All  | 20 mm  | 50 mm |           |
| Bottom Shell | > 0.4 L ÷ fore | 12 mm  |       |
|              | < 0.4 L ÷ aft  | 12 mm  |       |
| Side Shell   | > 0.4 L ÷ fore | 12 mm  |       |
|              | < 0.4 L ÷ aft  | 12 mm  |       |
| Deck         | All  | 27 mm  |       |           |
| Bulkhead     | > 0.4 L ÷ fore | 17 mm  |       |
|              | < 0.4 L ÷ aft  | 15 mm  |       |
| Floor        | All  | 56 mm  | 44 mm |           |
| Frame        | All  | 40 mm  | 50 mm |           |

**Table 7.** Boat's volume

| Part      | Volume |
|-----------|--------|
| Shell     | 0.089  |
| Floor     | 0.137  |
| Frame     | 0.112  |
| Transom   | 0.069  |
| Bulkhead  | 0.125  |
3.6 Economic Analysis

The main material costs calculated in the construction of Mahogany and Teak Laminated Fishing vessel 3 GT are the costs of wood materials, the cost of the need for epoxy resin glue, and materials other than the main material of laminated wood used on ships. Raw material costs are calculated to determine the Prime Cost:

3.6.1 Wooden material cost

The price of wood used in the construction of Mahogany and Teak laminated fishing vessel 3GT can be seen in Table 8 and for detailed calculation of volume calculation of wood needs can be seen in Appendix H. Determination of waste material is based on the evaluation of prototype ship construction where the amount of waste material is 55%. Mahogany wood needs are 0.504 m$^3$ at a price of IDR 1,549,212.27, people's Teak wood needs are 0.260 m with a price of IDR 1,783,241.28 and TPK Teak wood needs are 0.909 m$^3$ with a price of IDR 8,843,394.37. The total cost of Wood material needs in the construction of Mahogany and Teak laminated fishing vessel is IDR. 12,175,847.8.

| Name       | Applied (m$^3$) | Waste Material | Needs (m$^3$) | Price/m$^3$ | Total (IDR)   |
|------------|----------------|----------------|--------------|-------------|---------------|
| Mahogany   | 0.325          |                | 0.504        | 3,072.23    | 1,549,212.2   |
| Common Teak| 0.168          | 55%            | 0.260        | 6,862.64    | 1,783,241.2   |
| TPK's Teak | 0.587          |                | 0.909        | 9,725.67    | 8,843,394.3   |

Total Wood Material Cost 12,175,847.8

3.6.2 Epoxy resin material cost

Epoxy resin glue used in the construction of Mahogany and Teak laminated Fishing vessel in this study uses Propan EWA-135 which has a price of IDR 110,000.00. Coverage area is an area that can be fulfilled by 1 kg of epoxy resin glue based on the amount used in the construction of Mahogany and Teak laminated fishing vessel which is 0.5 m$^2$/kg. The cost of glue per m$^2$ is calculated based on the weight of glue used in the area of square meters gluing obtained at 0.5kg/m$^2$. Detail calculation of glue requirements can be seen in Table 9.

| Name        | Amount     | Unit     |
|-------------|------------|----------|
| Price/kg    | 110,000.00 | IDR      |
| Coverage Area (m$^2$/kg) | 0.5        | m$^2$/kg |
| Cost/m$^2$  | 55,000     | IDR/m$^2$|
| Weight per-m2| 0.5        | kg/m$^2$ |
| Total Area  | 100.2      | m$^2$    |
3.6.3 Fastener material cost

In addition to wood and epoxy resin, other materials are needed as fasteners which serve to strengthen the connections in the ship’s modules. These materials are nails, studs, screws, bolts, and O-rings. For details on the cost of fastener raw materials for making Mahogany and Teak laminated fishing vessel 3 GT can be seen in Table 10 with a total cost of IDR 1,348,500.

| Name                  | Qty | Unit | Price  | Total      |
|-----------------------|-----|------|--------|------------|
| Nail                  | 5   | Kg   | IDR 18,500.00 | IDR 92,500.00 |
| Stud Bolt M12         | 8   | pcs  | IDR 90,000.00 | IDR 720,000.00 |
| Screw                 | 1   | pack | IDR 250,000.00 | IDR 250,000.00 |
| Bolt M12              | 44  | Pcs  | IDR 4,000.00 | IDR 176,000.00 |
| O Ring                | 44  | kg   | IDR 2,500.00 | IDR 110,000.00 |
| **Total Fasteners Cost:** |   |      |               | **IDR 1,348,500.00** |

3.6.4 Coating cost

Painting of Mahogany and Teak laminated fishing vessel uses 3 types of coatings namely primary coat, topcoat, and anti-fouling. Painting is assumed to only be carried out on the outer layer of the hull [14]. The cost of paint at the primary coating stage is IDR 294,666.67, the anti-fouling fee is IDR 111,822.22, and the cost of top coating is IDR 835,377.78. The total cost of painting the Mahogany and Teak laminated fishing vessel 3 GT is IDR 835,377.78. Detailed calculation of painting needs in the construction of Mahogany and Teak laminated fishing vessel 3GT can be seen in Table 11.

| Name            | Coating Area | Application (L/m2) | Use (L) | Price  | Total       |
|-----------------|--------------|--------------------|---------|--------|-------------|
| Primer coating  | 35.52        | 9                  | 3.95    | 100,000| 394,666.67  |
| Anti Fouling    | 11.84        | 9                  | 1.32    | 85,000 | 111,822.22  |
| Top Coating     | 23.68        | 9                  | 2.63    | 12,000 | 328,888.89  |
| **Total Coating Cost:** |               |                     |         |        | **835,377.78** |

3.6.5 Variable cost

Variable costs are costs incurred in every ship construction outside the cost of basic materials. Items included in the variable costs are consumables and related services needed for the construction of Mahogany laminated fishing vessels and 3 GT teak. Details of variable costs can be seen in Table 12.

| Category     | Name | Qty | Unit | Price  | Total   |
|--------------|------|-----|------|--------|---------|
| Consumable   | Thinner | 5   | liter   | IDR 25,500.00 | IDR 127,500.00 |
### Table 13 Fixed cost

| Name               | Qty | Unit  | Price      | Total     |
|--------------------|-----|-------|------------|-----------|
| Jig                | 1   | Set   | IDR 1,400,000.00 | IDR 1,400,000.00 |
| Planner Machine    | 1   | Pcs   | IDR 13,000,000.00 | IDR 13,000,000.00 |
| Hand Saw           | 2   | Pcs   | IDR 60,000.00     | IDR 120,000.00   |
| Hand Planner       | 1   | Pcs   | IDR 300,000.00    | IDR 300,000.00   |
| Hammer             | 2   | Pcs   | IDR 50,000.00     | IDR 100,000.00   |
| Chisel Tools       | 2   | Pcs   | IDR 60,000.00     | IDR 120,000.00   |
| C Clamp            | 18  | Pcs   | IDR 60,000.00     | IDR 1,080,000.00 |
| F Clamp            | 8   | Pcs   | IDR 80,000.00     | IDR 640,000.00   |
| Span Screw         | 1   | Pcs   | IDR 120,000.00    | IDR 120,000.00   |
| Stainless Knee     | 40  | Pcs   | IDR 8,000.00      | IDR 320,000.00   |
| **Total Fixed Cost**: |     |       |             | IDR 17,200,000.00 |

### Table 14. Direct labor cost

| Parts name | M³/Man Hour | Volume | Duration | Cost    |
|------------|-------------|--------|----------|---------|
| Shell      | 0.0025      | 0.089  | 35.5     | IDR 799,200.00 |
| Floor      | 0.0011      | 0.137  | 124.2    | IDR 2,795,364.65 |
| Frame      | 0.0007      | 0.112  | 160.3    | IDR 605,663.93  |
| Transom    | 0.0019      | 0.069  | 36.2     | IDR 815,246.28  |
| Bulkhead   | 0.0032      | 0.125  | 39.2     | IDR 881,926.64  |

3.6.6 Fixed cost

Fixed costs are costs used to procure materials that do not change in price due to production processes such as machinery and workshop facilities. In the construction of 3 GT laminated fishing vessel and Mahogany wood, machines and equipment as production support are needed which are included in fixed costs. For details on fixed costs, see **Table 13**.

3.6.7 Direct labor cost

Direct labor costs are calculated according to the number of hours of people needed in accordance with the man hour ship modules obtained from data obtained from the construction of prototype ships. The hourly labor rate is assumed to be IDR 22,500.00. In Table 14 it can be seen for the details of direct labor costs where the total cost required is IDR 16,808,340.63.
### Table 15. Prime cost

| Category          | Cost       |
|-------------------|------------|
| Wood Material     | IDR 12,175,847.92 |
| Fastener Material | IDR 1,348,500.00  |
| Glue              | IDR 5,512,757.22 |
| Coating           | IDR 835,377.78  |
| Variable Cost     | IDR 4,162,500.00 |
| Direct Labor Cost | IDR 16,808,340.63 |
| Prime Cost        | IDR 40,843,323.55 |

Mahogany and Teak laminated fish boat 3GT has a total construction cost of IDR 40,843,323.55. To estimate the selling price of ships in the market, the author determines the profit of selling ships at 15% of the total construction cost. With a sales profit of 15% of the cost of production, a profit of IDR 4,084,332.35. Estimated sales price per ship for Mahogany and Teak laminated fish boat is IDR 44,927,655.90. Calculation of the selling price of ships can be seen in Table 16.

### Table 16. Selling price

|                          | Cost       |
|--------------------------|------------|
| Prime Cost               | IDR 40,843,323.55 |
| Profit 15%               | IDR 4,084,332.35 |
| Selling Price            | IDR 44,927,655.90 |

### 4. Conclusions

Based on the technical analysis and economic analysis explained in the previous chapter, the following conclusions are obtained:

1. Based on the prototype development of the 3 GT laminated fishing vessel that has been built, the technical analysis and economic analysis that has been carried out in this research, shows that Mahogany and Teak wood lamination material can be used to build traditional 3 GT fishing vessels using the Cold Press Planking Method.

2. Based on the results of testing materials for Mahogany and Teak laminates, they have an average tensile strength of 96.56 MPa and a flexural strength of 76.56 MPa and a specific gravity of 0.82 gr/cm³ so that according to BKI regulations Volume XIV "Rules for Non-Metallic Materials 2014 Edition" and BKI Volume VII of 2013 on Rules for small vessels up to 24 m "Mahogany and Teak laminated materials meet minimum tensile strength and minimum bending strength, have a
Strength Group F1 for laminated wood, equivalent to wood with Strength Group II and Durability Group III, and can be used for all constructions of ship construction.

3. In terms of economics in terms of the results of the calculation of the prime cost with an estimated total profit of 15% of the Prime Cost, it is estimated that the cost of sales of 3 GT Mahogany laminated fishing vessel and Teak is required to cost IDR 44,927,655.90 or equal to some USD 3,160.

Acknowledgements
The author thanks to Dr. Wasis Dwi Aryawan as the Head of Department of Naval Architecture. Further, thanks are also conveyed to member of Laboratory of Ship Production Technology and Management, Department of Naval Architecture ITS Surabaya for the discussion and sharing the problem and solution.

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