Repair technique for wooden fishing boats using fibreglass

Sunardi, Sukandar, E Sulkhani Y, M A Rahman
Marine and Fisheries Faculty, Universitas Brawijaya, Malang, Indonesia.
Email: sunardi@ub.ac.id

Abstract. Almost all fishing boats operating in Indonesia are made of wood. The hulls of wooden boats are exposed to heat everyday and float in seawater, a combination which can cause parts of the boat's hull to be quickly damaged. One type of damage that occurs all the time is the attachment of fouling organisms (animals and marine plants) which encrust the hull of the boat; therefore, the hull should be careened once a week, as otherwise resistance will increase, reducing the speed and increasing fuel consumption. Fibreglass is a composite material which is strong, weather resistant and easily formed. This composite material can be applied as a coating material for wooden boats to overcome weathering and repair leaks. This applied research directly practiced a method to repair wooden boats by coating with 2 layers of fibreglass. The stages included the removal of all fouling and other coatings (e.g. paint) and contamination, drying and repairs, coating with two layers of fibreglass, followed by finishing. The results showed that the use of fibreglass to repair wooden boats can be a very effective technique with the following advantages: boards of boat hulls that are immersed in water do not decay, so that there is less likelihood of leaks developing; the technique reduces outlay because maintenance costs of fishing boats are reduced; boat maintenance will be easier because it is only necessary to clean the fouling attached to the hull; longer boat life and greater hull strength, as protection with fibreglass can strengthen old wooden construction elements and enable them to last longer.

1. Introductions
Some traditional fishermen have started using fibreglass boats now and have abandoned their wooden boats for various reasons. One reason is the increasing cost of wooden boats, often related to the scarcity of timber [1], while another reason is the greater difficulty of maintaining and repairing wooden boats compared to fibreglass boats. However, in some areas fishermen still continue to use wooden boats because wooden boats prove to be very strong and more comfortable to use when fishing in bad weather conditions compared to fibreglass boats; furthermore, timber is still abundant in many areas of Indonesia.

Fibreglass has several advantages as a primary construction material and as a coating or sheathing material; it is light-weight, easy to waterproof, easy to form, and (if properly used) resistant to damage caused by contact with sea water and the marine environment more generally [2]. Fibreglass is also being used in the construction of some types of wooden boats in Indonesia, in particular hulls with a composite construction such as laminated wooden boats. Laminated wooden hull construction uses wood, which is generally layered and jointed using special glue such as epoxy or resorcinol [3]. The basic purpose of laminated wood construction systems is to create a construction from easily formed thin layers of various types of wood which, when joined together, should to produce a hull with superior strength. In general, laminated construction systems are considered as a superior type of
construction both in terms of manufacturing techniques and in terms of maintenance [4]. Fibreglass sheathing of wooden boats, including canoes, can extend their life and reduce maintenance [5].

This research aimed to combine the advantages of fibreglass with traditional techniques in order to repair wooden boats, so that the wooden boats could continue to operate in seawater, resisting the destructive effects of the natural marine environment for a much longer time. The technique of repairing wooden boats with fibreglass laminating has proven effective, with coated wooden boats surviving for more than 10 years now, with few repairs and relatively low maintenance.

2. Methods
The materials used to laminating wooden boats with fibreglass were: wooden fishing boats, liquid resin, chopped strand mat (CSM), powder, colouring paint, catalyst liquid. The method used to repair the fishing boats with fibreglass comprised the following stages: Examination of the boat hull → Drying of the boat → Cleaning of the boat hull → Replacement of lost and damaged wood plates → Carpentry/boatbuilding → Fibreglass layer 1 → Fibreglass layer 2 → Attach nails → Caulking → Finishing

The method used in this study was a descriptive case study method based on observation and participation. The factors observed and described included the damage that occurs in wooden boats, as well as the repair methods used. In the first stage, various types of damage that can occur were described and analysed based on the causes and consequences of damage to wooden ships. The second stage of the research was conducted by directly repairing wooden boats (case studies) with fibreglass lamination. The results of the improvements were described sequentially and analysed for their advantages compared to conventional wooden boat repairs.

3. Results
3.1. Identification of damage to wooden boat hulls
3.1.1. Fouling on the hull. A crusty fouling layer on the hull is caused by sea animals and plants which attach to the hulls of wooden boats (Figure 1). If the fouling is not removed, it will get thicker and cause the resistance of the boat to increase, so that the speed of the boat will be lower.

![Figure 1. Example of fouling organisms forming a crust on the hull](image)

3.1.2. Weathering of the hull. One cause of damage to boat hulls is the frequent (often continuous) exposure to the elements, especially heat and light from the sun and sea water that can enter the pores
of the wood. Both will accelerate decay of the wood and damage to the boat (Figure 2). If wood damaged by weathering is not immediately replaced, the vessel will be likely to leak; furthermore, wood which has become porous due to weathering will increase the resistance and reduce the strength of the boat.

3.1.3. Broken hull board. This damage is caused by the collision of boat construction with coral, port walls, underwater obstructions, and so on (Figure 3). If not repaired immediately such damage will cause the boat to leak.

3.1.4. Holes and scratches on the hull of the ship. Wooden hulls can be damaged (Figure 4) by abrasion from coral reefs and stones, heat and light from the sun and heavy loading on the boat hull due to wave action.
3.2. **The technique of repairing wooden boats with fibreglass lamination.**

The repair of wooden boats through laminating with fibreglass has been proven to be able to protect the hull from the various types of damage mentioned above. Fibreglass lamination of wooden boats is the process of coating wooden boats by gluing fibreglass to the hull of the boat. The purpose of this lamination is to protect the hull of the wooden boats from water seeping into the boat and to strengthening the construction, including the joints between the hull boards. Fibreglass laminating with a two-layer technique adds around 0.5 centimetres to the thickness of the hull of the boat. The composition of the constituent layers of the fibreglass lamination is shown in Figure 5. The process of fibreglass lamination on traditional wooden boats begins with drying and cleaning of the boat's body, fibreglass lamination and ends with refinement with painting.

3.2.1. **Drying the hull.** Before a laminated wooden fishing vessel can be laminated with fibreglass, it is vital that it should be thoroughly dry, as any trapped moisture will cause the wood to rot inside the laminating. In addition, the water content in the wood will damage the fibreglass layer and prevent the fibreglass layer and the wood from binding properly, even if the moisture is only present in very small amounts. For small boats (Figure 6), the hull must be dried at least 3 days before the lamination process is carried out. Larger boats will take longer. The fouling layer should be removed before drying as it will trap moisture.
3.2.2. Cleaning the hull of boat. The purpose of cleaning the boat hull (Figure 7) is to remove any material attached to the wood, so that the fibreglass lamination in the next stage can glue tightly and perfectly. This generally includes the remaining paint and putty that is still attached to the hull of the boat, as well as any remaining fouling still encrusting the hull.

3.2.3. Lamination Fibreglass with Chopped Strand Mat (CSM). Two layers of fibreglass laminate (resin-CSM-resin-CSM-resin) will increase the thickness of the boat by around 3 mm (Figure 8). This fibreglass laminate will make the hull of the boat impermeable and protect the boat from the danger of water seepage into the construction of the boat, and causing leaks. In addition, the fibreglass laminate will strengthen the connection between the hull boards and the overall construction of the boat.
3.2.4. **Tacking the fibreglass laminate to the wooden hull.** Tacks (short nails with large heads) of the 1 cm size were used to strengthen the bond of the fibreglass laminate to the wooden hull, and placed at distances of 20-30 cm (Figure 9). The purpose of this nailing is to strengthen the fibreglass layer on the hull so that there is no possibility of a layer of fibreglass becoming detached from the wooden hull of the boat. To avoid making holes that would cause the boat to leak this must be done while the fibreglass is still wet, and the nails must be covered with a layer of resin.

3.2.5. **Layering putty mixture and smoothing.** Once dry, the fibreglass is covered with a putty mixture. This was made using a mixture of talc and resin with enough catalyst added. Once dry, the surface of the boat's hull needs to be polished (Figure 10), after which the hull surface will be very hard and smooth.
3.2.6. Painting and finishing. The final outer layer was a special paint with a mixture of colour pigments and resins which were mixed with additive to make the surface of the boat shinier and not easily dirty (Figure 11). This special paint mixture will discourage the attachment of fouling organisms which can encrust the hull of the boat; the fouling organisms that do attach can generally be cleaned off quite easily. The results of boat repair work with other fibreglass extensions that were carried out in Lekok, Pasuruan Regency, East Java Province, are shown in Figures 12-14.
4. Discussion
Fibreglass laminating to repair traditional wooden vessels can benefit fishermen as follows.

1. Technical aspects:
   - With a fibreglass coating, the boat hull board that is immersed in water does not thus reducing the risk of leaks.
   - When fibreglass coated, the maintenance of the boat will be less onerous because fouling organisms will not form a hard crust on the hull; although there will still be a need to wipe off some fouling organisms, these should be relatively easy to wipe off.
   - The boat's speed will be higher with the same power because of the smooth surface of the boat, the absence of a crust of attached fouling organisms and of water seeping into the hull of the boat.
   - Once fibreglass coated, the boat is protected from the detachment of boards during fishing operations at sea and the life of the boat can be extended by many more years.
   - With fibreglass coatings, the fishermen can save costs because maintenance cost of fishing boats is reduced.

2. Economic aspects (relative costs):
   - Cost of traditional wooden boat repair methods:
     The average cost of maintaining/repairing a wooden boat with principle dimensions length over all = 12 meter, breadth = 2 meter and draught = 1 meter, is around IDR 3,000,000.00 every 4 months, or IDR 9,000,000.00 every year.
   - Cost of fibreglass laminating wooden boat repair methods:
     The costs of repairing the boat using the fibreglass laminating method over a total surface area of 36 m² are:
     - Materials costs: IDR 400,000.00/m², total costs = IDR 14,400,000.00
     - Labour cost for 6 labourers over 5 days @ IDR 500,000 = IDR 3,000,000.00
     - Overhead costs: IDR 2,000,000.00
     - Total costs: IDR 19,400,000.00

Based on results achieved to date, the repair of wooden fishing boats with this fibreglass lamination method can last up to 8 years. The total repair of fishing boats with traditional methods for 8 years would be IDR 72,000,000.00. This shows that it should be much more cost effective to repair these boast with the fibreglass laminating method.
5. Conclusion
Based on the results of this case study on repairing wooden boats with a fibreglass lamination method, the method used has advantages over repairs with traditional repair methods. Technically, the results from repairing wooden ships with fibreglass laminating are generally more durable than using traditional methods. From an economic point of view, repairing wooden boats with fibreglass lamination methods is more expensive initially, but in the long run it is more cost-effective as repairs and maintenance are reduced. The disadvantage of repairing wooden boats with fibreglass lamination is the need for special expertise for workers, as each stage of repair requires special expertise and skills in the field of fibreglass lamination.

Acknowledgements
The authors thank the LPPM Universitas Brawijaya and Ministry of Research, Technology and Higher Education of the Republic of Indonesia for funding this community service study entitled "Fibreglass Laminates to repair wooden fishing vessels in Ujung Pangkah District, Gresik Regency." Thanks also to Universitas Brawijaya, in particular the Faculty of Fisheries and Marine Science, for all the support provided.

References
[1] Sreeja M, Ajith P and Edwin L 2006 Cheaper boats, cleaner waters Fish. Chimes 26 47–9
[2] Balasubramanyan R 1971 Experiments with fibre-glass sheathing as a protection against marine wood-boring organisms Fish. Technol. 8 60–4
[3] Putra G L, Sunaryo J and Prayogo G 2015 Analisa Sifat Mekanik Komposit Vinyl Ester Berpenguat Serat E-Glass Tipe Multiaxial Dengan Metode Vartm Untuk Aplikasi Pada Lambung Kapal Cepat Proceeding Seminar Nasional Tahunan Teknik Mesin XIV (SNTTM XIV) vol 08 (Banjarmasin) pp 1–10
[4] Sutrisno, Andrianto R and Pribadi T W 2012 Produksi Kapal Ikan Tradisional dengan Kulit Lambung dan Geladak Kayu Laminasi serta Konstruksi gading dan Geladak Aluminium J. Tek. ITS 1 98–103
[5] Baiju M V., Edwin L, Pravin P, Meenakumari B and Baiju M 2013 Fiberglass Reinforced Plastic (FRP) Sheathed Canoes for North East Hill Regions J. Mar. Biol. Assoc. India 55 87–90