

Conservation Research and Treatment Programs: Case Study of Ancient Boat Site in Rembang Regency

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Abstract

The ancient boat was made around the 7th century A.D. It was found on July 26, 2008 at 07.30 p.m. at Punjulharjo Village, Rembang Regency, Central Java Province, Indonesia. The boat site is covered by soil as deep as two metres and is located at the southern of coastline with a distance of 0,5 to 1 km. When the ancient boat was found, the shape of the boat was still intact. Size of the boat is 15 metres length and 5 metres width. Not only the shape is relatively intact but also the disclosure of data of the archipelago's unique technology could be held within this boat that was almost complete. *Tambuku* is the type of palm fibre rope, pegs was used in the boat and other components that have never been encountered before is really a remarkable data essential for the development of maritime archaeology, especially in Indonesia. The ancient boat has important value for history, science, technology, and culture. As an important cultural asset and potential, its existence must be well managed and sustainable by optimizing *in situ* conservation.

Conservation research should be conducted to identify the ancient boat such as the kind of materials for making a boat, condition of boat materials, the site condition of the boat, and environmental condition. Conservation method should be based on the results of diagnosis in the laboratory as well as in the field.

In situ conservation is another important approach to preserve the ancient boat, which simultaneously give positive impacts to tourism aspects and development to the region.

1. Introduction

The finding of an ancient boat found on July 26, 2008, in the Punjulharjo Village, Rembang Regency, Central Java Province, Indonesia has significant value for the history, science, technology and maritime State of Indonesia. The condition of the boat is that it is still relatively intact and shows characteristics of the archipelago boat in terms of materials, shapes, sizes, and technology. Radiocarbon dating tests were conducted in 2009 at the University of California on the sample of fibers used as a binder of boat parts and indicate the boat is aged to approximately 660-780 AD (Siswanto, *et al.* 2010).

Rembang Regency is located in the north eastern part of Central Java Province, latitude is 111 °, 00' - 111 °, 30' E and 6 °, 30' - 7 °, 00' S. It is a very complete topography of coastal areas, lowlands, highlands and mountains, the soil type consists of Mediterial, Grumosal, Alluvial, Andosal

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and Regasal. Rembang Regency has an area of 1014.08 km², and flanked on the north Java Sea and the North Kendeng Mountains in the south (Kusumastuti, *et al.* 2010). Location of the ancient boat is about 0,5 to 1 km at the southern coastline.

The main ingredient of the ancient boat components are the hardwood materials. The nature of the properties of the wooden materials are derived from living things. It has a fibrous and cellular structure composed of cellulose, lignin, resins, sugar and some other hydrocarbons, that can be categorized as organic materials.

As a solid matter, it has many pores and channels in its body, which, in its green state, are mostly filled with water. When freshly cut, wood has plenty of water, it starts drying out it when left in the open air. This loss of water continues until it reaches the stage where the moisture retained is in the equilibrium with the atmosphere.

Wood is hygroscopic and as a result its cell walls have the capacity to absorb moisture when atmospheric conditions are wet, and to release it out when conditions are dry. When wood has lost all its free water, which is the water held by its pores and channels, its water content is in equilibrium with the atmosphere.

Wood is also anisotropic, which means that the capacity for elongation and shrinking is not the same in the three directions of its cut: longitudinal, radial, and tangential. The unequal gain and loss in these three sides of the wood also result in distortion. Wood stabilizes in moist conditions (Agrawal 1977:9, 72-73).

As an organic material, wood normally decays under combined biological and chemical degradation when buried in earth; it may, however, survive prolonged exposure to extreme dryness or wetness. In shipwreck sites, the wooden components of the hull and small artifacts of wood often survive in good condition, albeit thoroughly waterlogged. Successful conservation of wooden artifacts is dependent upon one's knowledge of wood structure and types. Trees are divided into two broad categories: hardwoods and softwoods. Hardwoods are classified as angiosperms, which refers to broadleaf trees which are usually deciduous. Angiosperms are referred to as 'porous' woods because they have vessel pores. In many instances it is equally important that a wooden object's species type is identified in order to successfully conserve the waterlogged wood.

Through the loss of moisture, freshly cut, sound wood will generally experience a radial shrinkage of 3-6 percent, a tangential shrinkage of 5-10 percent, and a longitudinal shrinkage of about 0.5 percent. Proper conservation treatments can control the amount of shrinkage experienced by waterlogged wood during drying. In practice, a particular conservation technique is often selected because it is known that the treated wood will shrink a desired amount. The manner in which a plank of wood was originally sawn from a log will have an effect on how the plank, or an object manufactured from the plank will shrink (Hamilton 1999 :1,22-24) after undergoing any conservation treatment. In most environments the

primary factors for the degradation of wood include: (1) physical action (changes in temperature, fluctuations in relative humidity), (2) insect attack, and (3) fungal decay. Fungal decay can be eliminated as long as the wood is kept in an environment with a relative humidity of less than 65 percent. In anaerobic waterlogged environments, however, wood undergoes profound chemical changes and alterations that result in a significant loss of strength while retaining overall shape.

Research activities and conservation planning of the ancient boat is based on national and international regulations as follows:

a. According to *The Law of The Republic of Indonesia number 11 of 2010* concerning items of Cultural Property especially in the article 76. Article 76 has been mandated in paragraph 1 -3.

In the paragraph first it mentions that maintenance is done by conserving of cultural heritage to prevent and overcome the damage caused by natural influences and- /- or human actions. In the second paragraph it also mentions that the maintenance of cultural heritage referred to in paragraph 1 may be performed at the original location or elsewhere, after first being fully documented.

In the third paragraph it mentions that the treatment is referred to in paragraph 1 is carried out with the cleaning, preservation, and repairing the damage with respect to the authenticity of the form, layout, style, material, or workmanship of the cultural heritage.

b. The In *UNESCO 2001 Convention on The Protection of The Underwater Cultural Heritage*, Paris, France comprises of:

- Acknowledging the importance of underwater cultural heritage (UCH) as an integral part of the cultural heritage of humanity and a particularly important element in the history of peoples, nations, and their relations with each other concerning their common heritage.
- Realizing the importance of protecting and preserving the UCH and that responsibility therefore rests with all States.
- Convinced of the importance of research, information, and education to the protection and preservation of UCH.
- Convinced of the public's right to enjoy the educational and recreational benefits of responsible non-intrusive access to in situ UCH, and of the value of public education to contribute to awareness, appreciation and protection of that heritage.

c. According to the first article concerning the fundamental principles in the *ICOMOS Charter on the Protection and Management of Underwater Cultural Heritage (1996)*, Sofia, Bulgaria it mentions:

- The preservation of UCH in situ should be considered as a first option.
- Public access should be encouraged.
- Non-destructive techniques, non-intrusive survey and sampling should be encouraged in preference to excavation.
- Investigation must avoid unnecessary disturbance of human remains or venerated sites.
- Investigation must be accompanied by adequate documentation.

2. Materials and Methods

The artifact of the ancient boat at Punjulharjo village is a very important cultural heritage and it is the object of cultural heritage that must be protected. Therefore, the ancient boat Punjulharjo Site should be developed into a maritime cultural landscape area to be conserved and used for fertilization of national pride and character development of the nation, as well as the public welfare.

In order to get a better understanding of degradation and deterioration problems of the ancient boat, a thorough intensive investigation has been conducted, both in the field as well as in the laboratory.

In situ observations were made to study the types of deterioration agents that could be visually observed.

To determine the type of material making of the ancient boat should be conducted laboratory research.

The materials and equipments required to research are:

Chemicals: PEG 400 and 4000, aquadest, Ethanol, *Ethylene Diamine Tetra Acetic Acid* (EDTA). Tools in the field: Thermohygrometer, pH meters, salinity meters, scalpel. Tools for conservation experiment in the laboratory: Scales, tray, soaking tub, shaker, pH sticks, hot plate with stirrer, glassware and so on.

In the conservation research of the ancient boat in Rembang Regency, the following procedures of work will be done:

1. Field observations
 - a. Observation of the environment
Observations carried out on soil environment, and water.
 - b. Climate measurements.
 - c. Observation of the damage level and deterioration boat.
Direct observation should be done on the object and recorded the damage that occurs and the factors that influence it.
 - d. Sampling
Soil and wood materials should be taken for further analysis.
2. Laboratory experiments
 - a. Cleaning wood samples
Wood samples have been taken are grouped according to estimates by type of wood. Each timber is cleaned with caution because the condition is very soft. Cleaning is done with plain water assisted by hand and brush.
 - b. Desalination sample
Clean samples that have been soaked in fresh water to remove salt dissolved. In order to the end result does not change the color of the wood, then the samples were stored in EDTA solution.
 - c. Chemical test for wood dimension stabilization
The chemical used is a Polyethylene Glycol (PEG). The reason of using the PEG in the experiments, because it is the most effective result over other materials. Variations in the concentration of PEG 400

usage was 20%, 30%, 40% (Cahyandaru, *et al.* 2010), and continued by PEG 4000 on the outer layer of the wood. Research on the effectiveness of the use of PEG 4000 is still ongoing at Borobudur Conservation Research Laboratory, Magelang.

3. Results and Discussion

The results of microscopic tests conducted by the archaeological office in Yogyakarta and the Faculty of Forestry Gadjah Mada University on the structure of ancient boats have identified three types of wood *Scorodocarpus borneensis*, *Palaquium javense*, *Eucalyptus alba*, and the rope fibers.

The field test results indicate waterlogged wood in visually fragile condition. Fragile condition can be observed directly as the hardness of the wood components are relatively low. This was tested by the pressure of our thumb nails showed deep imprints; as well as the bond between a loose wood fiber. It is indicated by wooden damage that are cracked, broken, and split (Suranto 2010).

There are two main factors of degradation and deterioration processes on the components of the ancient wooden boat that it was due to the influence of internal and external factors:

a. Internal Factors

Natural properties of waterlogged wood include the material quality and structure of the wood. This will determine the resistance of the object's interactions with environmental factors.

b. External Factors

External factors are environmental conditions where underwater archeological remains are located, both for still being in sea water and having been excavated (Cahyandaru, *et al.* 2010)

Based on the process, the degradation that occurs on the waterlogged wood can be grouped into four: the process of mechanical damage, physical damage, chemical deterioration and biotic deterioration.

Fluctuations in humidity and temperature can cause both chemical and biological damage. Fluctuations of humidity can cause the dissolution of salts, and high temperatures can cause rapid chemical reactions. Moisture can accelerate chemical reactions that cause the decomposition of organic material, especially an ancient boat.

The ancient wooden boat has long been submerged in salt water, soaking of the boat has been going since the seventh century. As a result of soaking the wood moisture content increased even reaching the water-saturated conditions. Water saturated conditions lead to the development dimension and the timber having the water volume at maximum levels, even reaching the level of swelling of the wood.

Swelling of the wood until it reaches maximum volume indicates a disintegration of the wood components. Disintegration of wood

components take place at various levels, both at the tissue level, cellular, and in the level fibrils, even at the chemical level. Disintegration of wood components will carry consequences for the form of wood that has been missing all the basic properties of wood. Its chemical properties, physical properties, mechanical properties, and natural durability properties have been degraded so that the trait has been detached from the timber, unless the nature of the structure still exists (Suranto 2010).

Disintegration at the tissue level can be seen from the presence of cracks, breaks, and even splits on various timber for boat preparation. For example, a part of the timber separated from the ancient boat.

Disintegration at the cellular level can be seen from the fragility of wood in the longitudinal direction on a variety of wood making up the boat.

Disintegration at the level of the chemical can be proven through further research activity of organisms to analyze the chemical properties of wood using the equipment in the laboratory. More generally, the disintegration of the chemical components of wood can be seen from the texture of wood. Wood that has disintegrating components can be seen in acute texture, namely that the wood does not have the ability to reflect light again, the wood is not shiny. In other words, the timber as part of the components of the boat looked bleak (Suranto 2010).

Based on the above data, the right technology for the handling of an ancient boat in Rembang Regency is the technology of preservation and dimensional stabilization of wood technology.

The growth of fungus appeared in the field observations. Fungus is microorganism that have no chlorophyll and so can not make their own food. Therefore to survive it rides on other living things, in this case a boat whose condition is already fragile as a medium for the growth of fungi. Hyphae into the wood fiber so that the wood becomes softer.

Marine worms is a marine borer organism that can degrade the quality of wood to be softer.

Based on the results of laboratory tests conducted by the Centre for Conservation of Borobudur, Magelang, Central Java, Indonesia in 2010 are as follows.

Based on field measurements showed the following results i.e: outside temperature. 24,8°C (at 6 a.m) -31,4(at 11.30 a.m), outside humidity: 59 -85%, wind speed 1,6 -27,4 km/h, in temperature 24,8 °C - 34,5 °C.

While based on the results of laboratory studies on the water content of wood before treatment is equal to 326%, after immersion in PEG 20% moisture content to 106%, after immersion of PEG was increased to 30% moisture content to 54%, and levels of immersion in PEG 40% moisture content to 18% as an equilibrium moisture content. Its experiment of immersion duration is four weeks.

Table 1. The observation of the condition of the wood components of an ancient boat. (Kusumastuti, *et al.* 2010)

No.	Parameter	Results
1.	Fungi	80%
2.	Crack	> 30%
3.	Humidity	100%
4.	Hardness	Very soft

Table 2. The results of chemical analysis of soil samples (Kusumastuti, *et al.* 2010)

No.	Parameters are analyzed	Samples (%)	
		S1	S2
1.	SiO ₂	89,30	77,63
2.	Ca	1,60	1,60
3.	Mg	1,46	1,95
4.	Al	2,58	2,49
5.	Fe	1,79	1,34
6.	SO ₄	3,07	3,07
7.	Cl	0,79	0,99

Remarks:

S1: grayed soil samples

S2: yellowish soil samples

Results of measurements of soil permeability indicate that the soil around the boat has a low permeability with rate speeds of between 10^{-3} - 10^{-5} is in the form of fine sand.

Table 3. Salt content of wooden components on an ancient boat (Kusumastuti, *et al.* 2010)

No.	Phase	Salinity	pH	Temperature	Remarks
	Sea water	>1,641 ppt			Chemical analysis
Desalination Process					
1	1 th	1,641 ppt	7,67	20 °C	Salinity meter
2	2 nd	1,517 ppt	6,18	24,2 °C	
3	3 th	1,045 ppt	6,90	22,7 °C	
4	4 th	427,3 ppm	6,59	24,4 °C	
5	5 th	326,8 ppm	6,90	24 °C	
6	6 th	276,1 ppm	6,65	24,9 °C	
7	Tap water	239,6 ppm	6,51	24,8 °C	

Therefore, treatment programs of ancient boat should be done by the following method:

a.Desalination

Desalination should be done, because the wood in the sea water contains very high levels of salt. Salinity can disrupt the process of conservation, if not removed. Desalination process is carried out by immersing the waterlogged wood in plain water or mineral-free water. Soaking is done in stages with running water, so that the soluble salts can be removed from the soaking tub. Desalination is done until the soaking water is not saline. Salinity can be monitored with a measurement tool or with the analysis of levels of chloride (Cl^-). The most damaging salt is sodium sulfite.

b.Cleaning

Cleaning is done simultaneously with desalination. During the cleaning, water continues to flow so it carries away salt impurities. Common impurities in the waterlogged wood is soil / mud, sand and other impurities. Impurities in the form of soil or sand are relatively easy to clean manually. The surface is very soft wood and because of this during cleaning one should use a soft tool like a paintbrush. Careful cleaning by hand can also be done because the surface of the skin of the hands can touch and feel the part that is still dirty, and the required pressure level can be set with professionally attuned touch. Wood is often found under the sea overgrown with corals and marine animals (sea crabs, marine worms). Corals are extremely hard, harder than artifact. Therefore, in situ cleaning of the wood must be done manually with caution. The use of chemicals can harm the object if not careful. Manual cleaning is assisted by means of a scalpel, needle, taper pliers, small hammer and others in a very careful manner so as to not damage the object.

c.Impregnation and Stabilization

The process of impregnation and stabilization is needed in the conservation of waterlogged wood in situ. Impregnation is the process of inserting chemicals into the cell structure of wood so that it is filled by the chemical and free water pushed out from the cell, so the wood becomes more stable. The chemical used is Polyethylene Glycol (PEG) 400 as well as 4000 with the formula $\text{H}_2\text{OCH}(\text{CH}_2\text{OH})_2\text{CH}_2\text{OH}$.

Before implementation of soaking one must first prepare a watertight soaking tub. Due to high cost for ancient boat conservation at this moment their is limited state budget in Indonesia to make and appropriate shell or soaking tub for the boat. So the chosen alternative is in situ conservation, because to transfer the object to another place to make the shell is very expensive.

Besides explanation above, in 2011 will be made the preparation of Master plan of Ancient boat sites and Area Preservation and Development Punjulharjo surroundings. Master plan preparation purposes is an ancient boat handling, and preparing the Grand Design Museum Ancient Boat Punjulharjo. This activity will be conducted by Regional Government of

Central Java Province, Indonesia in the three terms level i.e. short term, medium term, and long term.

4. Conclusions

Based on experiments that have been done in order to conserve the ancient boat in Rembang regency can be summarized as follows:

- a. Water affects the condition of the boat where it is located on sandy soil with low permeability rates and high salinity.
- b. The existence of both temperature and humidity fluctuations. Outside temperature is 24.8 °C in the morning and temperature reached until maximum is 31.4 °C at noon. The air humidity showed inverse ratio with the air temperature. If the air temperature increases, then the humidity goes down.
- c. Results of observations indicate that the condition of the boat is very serious level of damage. The wooden components of the boat is very soft, and it is very suitable as a medium for the growth of fungi. In addition there are also other organisms of fungi namely marine worms (Marine borer). Marine worms is that the longer an animal borer will decrease the strength of the wood itself. Condition of the wood has cracks more than 30%. Wood cracking was evident on the first layer.
- d. Conservation methods used are desalination, cleaning, impregnation and stabilization.
- e. Development and utilization of sites Punjulharjo boat is done in three terms: short term, medium term, long term



Figure 1. Condition of the ancient boat on November 2008, by Waluyo Agus P.



Figure 2. The boat was covered by wet cotton flannel. This photo was taken by Waluyo Agus P. on the last September 2011.



Figure 3. Environment of Punjulharjo ancient boat site on the last September 2011. It was taken by Waluyo Agus P.

5. Bibliography

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