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Wooden Boat Building For Sustainable Development

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Abstract:

Sound environmental practises are essential for sustainable development. The maritime industry is alive to it and has taken many initiatives. With the advent of new ship building materials like steel and more recently glass reinforced plastics coupled with the curbs on de-forestation traditional wooden boat building has declined. The use of steel and glass reinforced plastics (GRP) has increased. These materials however use significantly larger amount of energy in their production vis-à-vis traditional wood. Consideration of carbon sequestered in wood and dual advantages afforded by use of wood as a building material in reducing both carbon emission and energy consumption are discussed. To bring focus on the use of eco-friendly nature of wood, a case study of traditional boat building activities in India bringing out their problems and proposed solutions is presented. The overall "Green" impact of using of traditional wood over other materials is commented upon. In conclusion, requirement of governmental and institutional incentives for the same are suggested.

1.Introduction

There is growing public awareness on environmental aspects of every business activity. The maritime domain is also finding the focus of environmental studies slowly but surely. The realisation of the same is percolating into all aspects of the marine world be it ship building, is operation or disposal. The concept of Life-Cycle environmental cost of a ship is steadily gaining ground. This focus on environmental issues by the maritime fraternity has however been found to need greater impetus [1]. There are various aspects in the ship building-ship operation domain that can be improved or amended for enhanced environmental sustainability. This paper explores the traditional wooden fishing boats and the use of wood per se as ship building material as an eco-friendly option.

2.Wood

Wood is natural high-tech composite material. It is one of the strongest and most tenacious materials known. Its strength to weight ratio is higher than steel. It is also one of the first building materials used by man. The advent of newer materials has lead to neglect of wood. Environmental impact by using wood is the least of all materials. It is also a renewable resource. The environmental advantages of use of wood as a building material are brought out hereinafter.

2.1.Carbon Sequestration

The carbon contained within wood is atmospheric carbon dioxide made during the process of growth of trees. This carbon is integrated in basic hydro-carbon form in the wood. Thus carbon is stored or sequestered in the wood. There is an estimated 58.2 billion metric tons of carbon contained or sequestered in the forests, forest soils, and wood products in use in United States alone[2]. It has been further projected that the amount of carbon being sequestered annually in United States forests is 170 million tonnes. In comparison the total carbon emission due to world shipping fleet of approximately 866 million tonnes in 2010 and the same is projected to rise to 1103 million tonnes by 2020[3]. This comparison of the relative amount of carbon released by the world shipping fleet vis-à-vis carbon sequestered annually in US forests alone is indicative that use of wood as building material deserves a re-look. An innovative approach towards greater use of wood as a marine building material, in however limited manner, may have a significant contribution towards overall reduction in the carbon footprint of the maritime sector.

2.2.Building Materials- Comparative Carbon Consumption

The primary ship building material is presently steel, with others like wood, aluminium and glass reinforced plastics being used in much smaller quantities. A comparative table giving the carbon consumption in the production of these materials is placed at Table 1.

Material	**Net carbon emissions (kg C/metric)** [1]	**Net Carbon emissions including Carbon storage within material (kg C/ metric ton)**[2]
Framing Lumber	33	-457
Medium Density Fibreboard	60	-382
Steel	694	694
Aluminium	4532	4532
Plastics	2502	2502

Table 1: Net carbon emissions in producing 01 ton of material [1]

2.2.Energy Consumption

Wood for growth requires only solar energy and on conversion to lumber (i.e. ready to use wooden planks or sections) requires very little additional energy. This when compared to energy required for steel and its conversion for ship building and associated processes gives another perspective towards the ecologically friendly aspects of wood. A table giving the details of energy used in manufacture of steel plates and sections is shown in Table 2.

	Plate	**Sections**	**Pipes/tubes**	**Hot dip galvanization**	**Rail etc**
Energy	17.37	13.12	15.42	21.63	19.38
(GJ per tonne of Steel)					

Table 2 : Energy impact of Steel production (As per ISO 14040-World Steel Association) [4]

[1] Life assessment inclusive of processing and transportation
[2] Carbon content of 49% assumed for wood

2.3.Production Aspects

Lumber grade wood has a higher strength to weight ratio than that of steel. Further fabrication of wood does not use high energy consuming processing like gas welding, cutting, high pressure forming presses etc.. It primarily uses low technology and relatively lesser energy intensive processes like conversion-sawing, cutting and forming. Further in the context of small ship or boat building, these are traditional crafts which are inherently low consumers of energy. An additional aspect is disposal; the disposal of fibre glass boats and steel vessels is fraught with ecological implications. Wooden boats at the end of their life are easily broken down into recyclable wooden components and the same are also easily bio-degradable.

2.4

The above factors bring out the inherent environmental advantages that wood has as a building material. In this background the applicability to ship building with specific attention towards wooden boat building activities in India is addressed. There are two case studies that have been undertaken. First is on State of Kerala; Kerala has a large amount of fishing trawler activity and also a significant amount of traditional wooden crafts used for tourism in the backwaters and other water-bodies. Second case study is done at Visakhapatnam, in the state of Andhra Pradesh. This is a state with a large coast line and subsequently a large coastal fishing industry. This fishing industry has traditionally used wooden boats however there appears to be a move away from the wooden boat industry towards other materials due to a multiplicity of reasons. This case study may be representative of the other states/ regions of India due to similarity of socio-economic and geo-political factors.

3.Case Study 1 – Kerala

Kerala has a coastline of 600 km and navigable backwaters of almost the same length. Traditionally the coastal waters were used only for fishing. There was no coastal cargo movement. Backwaters were used for cargo, passenger movement as well as fishing. Over the years cargo and passenger movement through backwaters have come down. Today tourism industry with its houseboats has emerged as a major user of backwaters. There are around 1500 houseboats operating in Kerala backwaters. Out of these 1500, nearly

thousand of the boats are operating in Alapuzha (Alleppey) district. The present case study focuses on the wooden houseboats, registration and building industry in Alapuzha region

3.1.Houseboats Of Alapuzha

The houseboat industry in its initial stages, in late 1990's, used traditional wooden cargo vessels (Kettu Vallams), converted by adding basic amenities. The Kettu Vallams were round bilge type wooden sailing vessels with 'U' shaped midship. The planks and frames were tied together. The boats were open type with thatched roof for protection from weather.

3.1.1

The houseboats now are decked. The boats are propelled by inboard engines and screw propellers. Sails are no more used. The boats have modern amenities and onboard sewage treatment or holding facilities. Two bath attached bedrooms, a galley and sit out is the most common configuration. Also, the breadth has been increased to accommodate larger bedroom.

Figure 1 : Typical High End Houseboat

The main particulars of the houseboat are at Table 3.

No.	Parameter	Value
1.	Length overall	22 to 30m
2.	Breadth extreme	4.5 to 6m
3.	Depth	1.4m
4.	Draft	0.5m
5.	Displacement	17 to 25 tons
6.	Life of Boat	10 years
7.	Total cost	Rs. 30,00,000/- to 1,00,00,000/
8.	Speed	06 Knots

Table 3 : Main particulars of Kerala Houseboats

3.1.2.

Houseboat Construction. Present houseboats are flat bottom boats. The boats are transversely framed. The frame spacing is 360mm. The planks connected to frames with copper nails. Underwater portion of the hull is coated with coal tar and a copper/ aluminium sheathing. Size of planks and structural members are at Table No. 4.

No.	Parameter	Material	Size
1.	Keel	Aini[3]	230 x 180mm
2.	Frames	Aini / Poon[4]	75 x 60 mm
3.	Shell planks	Aini for underwater / Poon	25 mm
4.	Deck beam	Poon	75 x 60 mm
5.	Deck plank	Plywood	16mm
6.	Superstructure	Plywood	10mm
7.	Roof	Thatched	-

Table 4 : Structural details

Figure 2: Hull Planking

[3] Aini – *Artocarpus Hirsutus Lamk. [7]*

[4] Poon – *Calophyllum Inophyllum Linn.[7]*

Figure 3 : Hull Bottom In way of Engine Girder

Figure 4: Typical Forward End Construction

Figure 5:Aft End Construction

Figure 6 : Deck Beams

3.1.3

Registration of Houseboats. All boats mechanised boats operating in Kerala inland waters are to be registered with Kerala Port Department. Before 2010 registration of boats in Kerala was done based on Travancore Cochin Canal Act and was done by Mechanical

Engineer of Irrigation Department. Due to recent fatal accidents, Kerala Government has bought out new regulations in 2010 (Kerala Inland Vessels Rules, 2010). The rules give details of drawings to be prepared, safety and operation requirements.

3.1.4

Wooden Houseboat Building Industry. Wooden houseboat / boat building is not an organised industry. Building is done by a head carpenter/shipwright. Workers are hired and space is rented as and when an order is placed. There are no construction drawings or arrangement drawings. Recent changes in regulations have made some of the drawings and safety arrangement mandatory for vessel registration. In recent years (especially in last one year) the houseboat industry has started moving from wood to steel. This trend had started much earlier in the fishing boat industry. The most commonly sited reason for this trend is strength, cost, non availability of wood, labour shortage and environmental issues. These reasons cited are due to lack of knowledge of wood and its engineering properties. The major finding emerging from the same is that wood is not promoted as an engineering material.

4.Case Study – 2: Visakhapatnam

4.1.

The entire coast line of the state of Andhra Pradesh is interspersed with traditional boat building activities. These function akin to a small or mini industry with a large component of traditional skills being used. In the case study the following areas were focussed upon;

- Visakhapatnam adjacent to the Visakhapatnam fishing harbour
- Kakinada
- Visakhapatnam; boat yard at Vadlapudi

4.2.Boat Building At Fishing Harbour

The wooden boat building at this site has being undertaken continuously since a long time. In the period; 2009-2012 boats were built at the rate of 15 to 20 every year. The primary features of the boats built here are tabulated in Table 5.

No.	Parameter	
1.	Length overall of the boat	16 feet
2.	Breadth extreme	4 feet
3.	Depth	3 feet 06 inches
4.	Dry weight of Boat (with out engine)	0.7 tons
5.	Displacement	1.2 tons
6.	Life of Boat	05 years
7.	Total cost (excluding engine)	Rs 17,000/-
8.	Speed (under engine power)	09 Knots

Table No. 5 : Main particulars of traditional wooden fishing boats; Visakhapatnam Fishing Harbour

4.3.Construction Materials

The boat building uses the following raw materials. The basic wood is mango tree wood (*Magnifera Indica*). Wood from acacia tree being of higher strength is used for keel, gunwale and capping pieces. Polypropylene rope is for securing the flat wooden planks. Jungle grass; indigenous to the area containing a binding sap; is used for imparting water tight integrity between planks.

4.4.Boat Building Process

The sequence of activities of wooden boat building is as follows :-

4.4.1.

All wooden bearers and planks are converted to required sizes. This is generally done at the saw mill and only minor conversion to fit to shape is undertaken at the boat building area.

4.4.2.

The keel bearer of acacia wood is laid out. Small diameter holes/ inserts are made on either side of the bearer to serve as securing recesses for the shipside planks

4.4.3

Shipside planks of mango wood; size 06 feet to 07 feet, 20 inch breadth & 01 inch thick are bent and shaped into required ship-side.

4.4.4

The formed wooden plank as above, are preliminarily secured to the keel by tying it with the keel plank.

4.4.5

Post tying of the wooden plank to the keel and forming of the planks into the boat shape, grass and sap are inserted into the gaps between the keel & plank and between adjoining planks. This activity is done under close supervision of the master craftsman since the same is essential for subsequent watertight integrity of the vessel. After adequate inserting of sap and jungle grass into all gaps is ensured, stitching of the planks to keel and then plank to plank is undertaken. Fig No. 7 refers.

4.4.6.

The foxle and aft board pieces are placed in position and then process at sub para (d) and (e) are repeated.

4.4.7.

Next activity is the placement of gunwale capping piece. The gun-whale capping piece securing is by the same processing of tying and stitching as adopted for keel and planks.

4.4.8.

The planks for thwart benches are then positioned. These are then secured by copper nails or wooden roves.

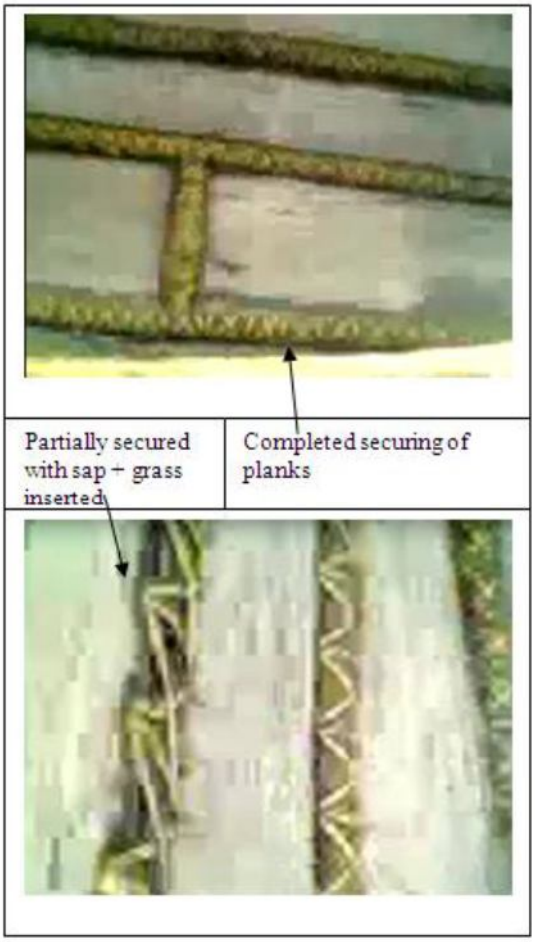

Figure 7 : Securing of planks in traditional wooden fishing boats

4.5.

The entire process of manufacture of the and the nuances involved therein are similar with the Kerala boat building though the type of craft is different, the specific areas of difference like use of jungle grass/sap is peculiar and hence elaborated. It may also be noted whilst the focus of the extant paper is on the concept of carbon advantage and not on the process of boat building hence certain areas are dealt with cursorily.

4.6.

The manufacture of the wooden fishing boat is undertaken usually by a team of 04 skilled workers with one or two of them being master craftsmen. A team will complete manufacture of one boat within 10 days. However since forming and shaping of wood may take more time, concurrent manufacture of atleast 3-4 boats together is undertaken. This also renders the entire boat building activity more economic.

4.7.

The boats thus manufactured are fitted with diesel engine coupled to a single propeller mounted on a long shaft. These engines may be new or re-furbished one. The boats thus manufactured have a service life of about 5 years. Every year the boats are hoisted on the beach for repairs and refurbishment of the wooden planking. This is undertaken usually in the monsoon season to coincide with the non-fishing periods. As part of annual repairs the plank securing arrangement is repaired/ refurbished.

4.8.

The building activities at the Visakhapatnam Fishing Harbour are however come to a stand-still for the last 10 months approximately. The wooden boat building activities are continuing at Kakinada for present. At Vadlapudi though expertise still exists to build wooden boats the main building activity has now shifted to GRP boats. The main factors towards the decline of the traditional wooden fishing boat industry are :-

4.8.1.Non-availability of Wood. The availability of wood is limited and governmental controls on cutting of wood have curtailed its availability and consequentially prices have also escalated.

4.8.2.Constraints in Availability of Skilled Manpower. The skilled manpower namely the traditional shipwright craftsmen adopt other lucrative trades.

4.8.3.Lack of sustained orders. Sustained and adequate orders are required to maintain entire boat building activity economically viable. Newer orders are flowing into GRP fishing crafts due to their larger dimensions, longer life and lesser maintenance requirements. This is despite the higher initial cost and non-awareness of adverse environmental impact of GRP crafts.

5.Emergent Issues Both From Case Studies

5.1.

The case studies bring out the following common factors that would go a long way in furthering this traditional industry with significant ecological advantages. The same are discussed in subsequent paragraphs with suggested measures and underlying rationale.

5.2.

Availability of Graded Lumber. The most commonly cited reason for moving away from wood is non-availability of wood. There are two aspects of this :-

5.2.1.Governmental Controls on Felling

Environment concerns have lead to governmental orders curbing felling of trees in forest areas. While the same is the correct step in short term, there is a need to assess the long term environmental advantages of use of wood as a building material. The studies presented at [2] bring out that harvesting of forests at intermediate intervals and the use of wood thereof has dual advantages of saving of energy (since wood is used in place of other materials that would require much greater amount of energy to produce) and harvesting of forest reduce the release of carbon by the deteriorating forest bio-mass and conserve it the wood that serves as carbon sink. In view of the same, regulatory and governmental bodies need to pro-actively promote use of wood as a building material with particular focus in those areas where the carbon footprint minimization would be the most. It suggested that traditional boat building be adopted as one of the industries wherein use of wood is promoted.

5.2.1.Non Availability Of Graded & Standardized Wood

In most developed nations wood is available in standard sizes [6] like steel sections and plates. The strength properties of these sizes are available in published for public use. The availability of graded lumber commercially as a building material duly standardized would go a long way towards the promoting of wood use as an ecologically friendly option.

5.3.1.Shortage of Skilled Work Force

Shortage of skilled work force is a real problem facing the traditional wooden boat building industry. The genesis lies in the fact that there are no structured training programmes for boat building. The traditional structures of apprentice-ship to master craftsmen have long broken down. In the existing technical educational institutions, timber engineering is not there in the curriculum of most engineering courses, in both graduate & diploma level. A related factor is also economic. The industry is not able to retain skilled workers who migrate to more lucrative trades.

5.4.Lack of Orders & Move towards other Building Materials

The lack of orders and move towards other materials have two common contributing factors. However before the same are addressed it is emphasized that the background economic activity per se, that tourism (Kerala) and fishing (Andhra Pradesh) is viable and there is a demand of newer boats. The contributing factor for lack of orders and move towards other materials is lack of application of modern design techniques to meet the demand of bigger and better boats of the costumer.

5.4.1.Application Of Modern Design

One of the factors that have emerged from both the case studies is that the boat designs are usually rule of thumb traditional designs. There are no professional designs being undertaken of wooden boats. This is due to lack of knowledge of wood and its engineering properties. Wood is not promoted as an engineering material. This is one of the reasons that this industry is losing out to the GRP fishing boats, since there are no design options available for longer and larger boats that the fishing community is now requires. Governmental intervention towards the same with contribution from research and academic institutions will go a long way in helping this traditional industry. Application of engineering will bring down the construction as well as operational cost.

5.4.2Monetary Incentives

The promotion of the traditional wood boat building as an activity that leads to net carbon and energy saving vis-à-vis other boat building materials like steel, aluminium and GRP may be considered by governmental bodies in light of the rationale brought out. The same would however be feasible if an incentive is provided to the boat builder or operator by means of waiver of tax/duties. Thus competitive cost solution would evolve for the buyer vis-à-vis other high energy and high carbon footprint building materials. The same may be by means of waiver of boat registration fees or a cash subsidy. The actual mechanism of such an incentive is however well beyond the purview of the extant paper which seeks only to draw attention to the concept of inherent eco-friendly nature of wood as a building material with particular reference to boat building

5.5.Organizational Improvements

The government can provide assistance for organising the wooden boat building sector. Boatbuilding parks inline with other industrial parks will help in changing the industry from an unorganised sector to an organised one. An organised industry will help in improving productivity.

5.6.Focussed Attention

The measures suggested for arresting the decline of traditional boat building need focussed attention. The decline of wooden fishing boat building & move towards GRP fishing boats in Andhra Pradesh and the trend towards steel tourist house-boats in Kerala will result in a loss of an existing practise that is environmentally sustainable, carbon friendly and low energy. This trend is also occurring in other regions of South Asia. Vietnam has recently embarked on a programme to change all wooden fishing boats into steel hull fishing boats [8]. There is thus a need to propagate the environmental advantages of wood use in the maritime sector world- wide and adopt measures to sustain the same.

6.Conclusion

The positive environmental impact that the use of wood as a building material has, by means of being a low energy material, a net carbon negative footprint and a renewable resource; gives credence to need for a greater attention to its use in maritime sector. The traditional wooden boat building activities in South Asia with particular reference to India are on decline. The reasons of the same are primarily lack of availability of graded structural lumber, skilled manpower and minimal application & adoption of modern engineering for improved designs that the market demands. Considering the positive environmental impact that the use of wood has, governmental and regulatory intervention for promotion of wood in small and traditional boat building is proposed to stem the decline that has set in.

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