INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Technological Change and Modernisation in Design and Construction of Country Crafts Operating in Coastal and River Waters

Dr. B. V. Ramalingeswara Rao
Academic Coordinator, Indian Maritime University, Visakhapatnam Campus, India
Y. Sudheer
Scientist, Indian Maritime University, Visakhapatnam Campus, India
N. Ananth Kumar
Technical Assistant, Indian Maritime University, Visakhapatnam Campus, India

Abstract:
Traditional boat building is strongly backed by the basic knowledge of craftsmanship of local carpenters and the knowledge has been passed from father to son. Most of the traditional boats are built in temporary yards and sheds erected by the carpenters wherever they found suitable place for construction of a boat mostly close to banks of the river. There are no proper designs, no periodic surveys, rules and regulations were also inadequate for the traditional boats which are operating in coastal and river waters. Hence there are accidents due to one or more reasons as stated above. There is a need to focus on the design aspects combined with a detailed study to improve the design and construction of the traditional boats where the accidents can be minimized.
In this paper an attempt has been made to study the traditional boat building activities in India by examining the technical aspects of mechanized and non-mechanized country boats. Since country crafts have complex curved nature, obtaining the hull geometry is a difficult task, in order to overcome the difficulty Faro Focus 3D Laser Scanner is used to scan the existing hull forms, which is used to generate the data offsets, lines plan etc...In this paper two case studies has been presented the first one discusses about the mechanized and non-mechanized country crafts which are distributed into set wise, highlighting the best design among them. The second one highlights the conversion of material change from wood to steel focusing on stability aspects. Based on the case studies, existing hull form(s)of better characteristics has been selected and slightly modified to make the country crafts much more efficient.

Keywords: *Traditional boat building, Faro focus 3D laser scanner, material, hydrostatics and stability...*

1. Introduction

The craft of making these vessels are traditionally passed on from generations within the families who have mastered the art. Historically, a rich maritime tradition exists in Indian sub-continent which is evident from the various types of vessels found today ranging from the Dhows of Gujarat to Chinese boats and nets of Kerala to sailing vessels of Bengal /North east, which also ply on the Ganges and Brahmaputra. Traditional Boats are generally used for are: Fishing, Small Cargo Handling, Passenger carriers in rivers, channels, & Tourism etc. These boats are classified as Un-powered or human powered boats (which are propelled by human effort), Sailing Boats (which are solely propelled by sails), Machined boats (which are propelled by means of electric motors).
Based on the growing environmental effects and deforestation, there is a need to convert the hull material from wood to Steel/FRP. In this paper an attempt has been made to study on the different country boat designs found throughout the country. As a part of an ongoing project in SMDR, team of project personnel has travelled across India by examining the technical aspects of mechanized and non-mechanized country crafts including design and construction practices.

2. Material of Construction

To build traditional boats [1] wood is the common raw material used for construction. The kind of wood differs on the basis of parts of the boat. The cordages like coir ropes or nylon ropes too, are functioning as raw materials for building a craft. Copper nails, iron nails, bolts and nuts and wooden pegs are used for clamping. Wood is used as a raw material for applying in different processes like building, Fastening, Sewing, Caulking, Coating, Sails etc. are used.
The types of wood available in Andhra Pradesh, Assam, Odisha, Kerala, Goa, West Bengal, Karnataka and Gujarat are tabulated below:

S.No	Local Name	Scientific Name
1	Circini karra	Anogeissuslatifoleawall
2	Cinntha karra	Albizziastipulata
3	Grannari karra	Acquiciaca nilotica
4	Thella Maddi	Terminalia Arjuna
5	*Mamidi karra*	*Magnifera indica*
6	*Teak*	*Tectona grandis*

Table 1: Wood used for boat building in Andhra Pradesh

S.No	Local Name	Scientific Name
1	*Teak wood*	*Tectona grandis*
2	*Arcini*	*Meliadubia*
3	*Chakunda*	*Albyzziastipulaat*
4	*Salwood*	*Shorea robusta*

Table 2: Wood used for boat building in Assam

S.No	Local Name	Scientific Name
1	*Ambagacho*	*Mangifera indica*
2	*Arcini*	*Meliadubia*
3	*Teak*	*Tectona grandis*
4	*Salwood*	*Shorea robusta*
5	Paldhua	Erythryna indica

Table 3: Wood used for boat building in Odisha

S.No	Local Name	Scientific Name
1	*Aini / Aangili*	*Artocarpushirsus*
2	*Mullumurukku*	*Erythrinastricta*
3	*Chakka / Jack*	*Mangiferacaesia*
4	*Mavu*	*Mangifera indica*
5	*Teak*	*Tectona grandis*

Table 4: Wood used for boat building in Kerala

The wood necessary to construct teppas, padavas and navas in Andhra Pradesh are available in Srikakulam and Rajahmundry forest areas and Palakonda hills. In Odisha, different types of wood are used for different varieties. Among them Teak (*Tectona grandis*) is known for its quality, strength and buoyancy. So, it is considered as best wood for boat building. Wood used as building material in Assam is available from nearest forests (kochu village, near Assam) and submerged wooden logs along the river during floods. The most predominantly used material in Assam is Sal wood (*Shorearobusta*) with tin sheathing. In Kerala aini/aangili material is mostly used for construction. In Goa mango (*mangiferaindica*) and Jackfruit (*Artocarpusintegrifolia*) timber is chosen for construction of dugouts. In west Bengal material used is babla wood (Acacia Nilotica). In Gujarat Malaysian salwood is mostly used for country crafts construction.

3. Construction Practices

The traditional boat building technology differ in different places, as it is purely relay on the availability of raw material, labour and master carpenter and builder's interest. So far in our study we found that there are numerous types of boat designs are there among those some are most predominant designed boats used for fishing and transportation in states of Andhra Pradesh, Orissa, Assam, Kerala and West Bengal etc., are:

- Stitched Plank built and
- Nailed Plank built boats

Stitched-plank and Nailed-plank built boat type of construction observed in Andhra Pradesh. Unseasoned wood is mostly used for this type of construction. The wooden planks are shaped to the required size and are joined together with a grass and stitched with a silk thread (nylon rope) as shown in the figure 1, through the holes drilled in both the planks.

Figure 1: Representation of stitched boats showing X-pattern stitching in longitudinal and transverse direction.

To keep the hull water tight and the holes left after stitching are filled with coconut fibre. The same procedure is also followed in many regions like Kerala and Tamil nadu etc. They apply coal-tar over the stitched portion for better sealing. Caulking is carried out during planking and after planking. These types of stitching joints are observed both longitudinally and transversely. Nailed plank built boat construction observed in areas of Orissa, Assam and West Bengal (see Figure 2).

Figure 2: Representation of Nailed Plank built boat "DINGHY", West Bengal and taking scan of craft model using 3D laser scanner.

Timber nails are used during hull construction by placing the planks side by side in desired position and for strengthen cotton is used during nail planking. To provide water tight a resin is applied on all the joins with a mixture of coal tar and castor oil throughout the boat. Maintenance is carried whenever required.

4. Case Study on Existing Country Craft Hull Form(s)

A case study has been carried by analysing different existing country craft hull forms of mechanised/non-mechanised categorisation found across India, and are distributed into Set A, B, and C with length ranges of 5.43 m to 17.46 m. This paper mainly focuses on analysing the hydrostatics and stability aspects, to know the best design and also by comparing the stability analysis for each set which is tabulated in the tables 6, 7, & 8 below. The results obtained gives the way to decide the best design which has better GM,GZ and Deck edge immersion angle.

Figure 3: Dinghy, West Bengal

4.1.1. Set A – Lengths (5.43, 5.62, 5.79 and 6.02 m) of four boats at various locations in India

Figure 4: Dugout Canoe, Goa

Figure 5: Nava, Narasapur

Figure 6: Kettuvalam, Kerala

4.1.2 Set B – Lengths (7.22 and 7.95 m) of two boats at various locations in India.

Figure 7: Fishing Boat, Porbandar

Figure 8: Padava, Bheemili, Visakhapatnam

4.1.3 Set C– Lengths (9.53, 13.35, 16.10 and 17.46 m) of four boats at various locations in India.

Figure 9: Fishing Trawler, Beypore

Figure 10: Murrivallam, Kerala

Figure 11: Fishing Trawler, Visakhapatnam

Figure 12: Fishing Trawler, Okha, Gujarat

4.2. Dugout Canoe

This type of boat is found in Goa coast line. It is typically a non-mechanized country boat used for fishing purposes.

4.3. Construction Material

Mango (mangifera indica) and Jackfruit (*Artocarpus integrifolia*) timber is chosen for construction of dugouts.

4.4. Construction Process

Dugouts [2] are variously known as ***'Ponjal', 'Ponayo'*** and ***'Vodem'*** built from a single log. A Centre line is marked on the log, which helps to cut the timber into the required shape and size. After that the log is kept in water for a fortnight and dried in shade. When the log is wet scooping is done for bringing the required edges by using chisels and axes. Mostly 2 to 3 persons are engaged in this task for 10-20 days.

S. No.	Particulars	Values
1.	Length overall	6.02 m
2.	Breadth Extreme	0.84 m
3.	Depth	0.45 m
4.	Draft	0.206 m
5.	No. of Persons	1 – 2
6.	Fish Catch Capacity	150 kgs
7.	Life of Boat	2 - 3 years
9.	Total cost	55,000/- INR

Table 5: Main particulars of Dugout Canoe

Figure 13: Dugout Canoe, Goa.

In the similar way, Study on hull form(s) of different lengths is carried by set wise distribution [3], and its hydrostatics, Stability analysis and the results were presented at Table no.6, 7 and 8.

Parameters		**Kettuvallam (Non-Mechanized)**	**Dinghy (Non-Mechanized)**	**Nava (Non-Mechanized**	**Dugout Canoe (Non-mechanized)**
Boat Building Areas		**(Churuyap, Vypin), Kerala**	**(Balagarh), West Bengal**	**(Narasapur), East Godavari, A.P.**	**(Betul), Goa**
LOA (m)		5.43	5.62	5.79	6.02
Breadth (m)		0.83	1.52	1.32	0.84
Depth (m)		0.38	0.41	0.61	0.45
Draft (m)		0.195	0.242	0.217	0.231
Construction Material		Wood	Wood	Wood	Wood
Carrying Capacity	No.of Persons	01 Person	01 Person	01 Person	01 Person
	Fish Catch/ Cargo(in Kgs)	150	250	250	250
Displacement (T)		0.31	0.626	0.561	0.600
LCG (m)		2.33	2.621	2.716	2.772
VCG (m)		0.271	0.259	0.283	0.177
GM (m)		0.160	0.554	0.349	0.321
Max. GZ		0.060 m @ 31.8	0.208 m @32.7 ^{o}	0.212 m @45.5 ^{o}	0.177 m @51.8 ^{o}
Deck Edge Immersion angle		17.5 ^{o}	11.5 ^{o}	31.4 ^{o}	27 ^{o}
Purpose of operation		Inland Fishing	Inland Fishing	Inland Fishing	Inland Fishing

Table 6: Hydrostatics & Stability: Set A

From the above Table 6, on comparing the GM, GZ and Deck edge immersion angle of the four non - mechanized country crafts had come to the conclusion that Dinghy in West Bengal is the better design in this length range, since it has sufficient GZ, GM values and for Boats Dugout Canoe, Nava and Kettuvallam, slight varying in the hull form like increasing the breadth to increase their GM values is suggestible.

Parameters		Fishing Boat, (Mechanised)	Padava (Mechanised)
Boat Building Areas		(Porbandar), Gujarat	(Bheemili), Visakhapatnam,
LOA (m)		7.22	7.95
Breadth (m)		1.6	1.71
Depth (m)		0.9	0.93
Draft (m)		0.379	0.372
Construction Material		Wood	Wood
Carrying Capacity	No.of Persons	4 Persons	5 Persons
	Fish Catch/ Cargo	400 Kgs	450 Kgs
Displacement (T)		1.685	1.39
LCG (m)		3.29	3.647
VCG (m)		0.52	0.634
GM (m)		0.094	0.156
Max GZ		0.099@46.4 Degrees	0.097 @50.9 Degrees
Deck Edge Immersion angle		28.9 Degrees	32.4 Degrees
Resistance (KN)		0.9 @ 7 HP 1.1 @ 9 HP 1.2 @ 10HP	0.80 @ 7 HP 1.00 @ 9 HP 1.10 @ 10HP
Speed in Knots		7.26 7.60 7.80	7.82 8.42 8.74
Purpose of operation		Offshore Fishing	Offshore Fishing

Table 7: Hydrostatics & Stability: Set B

From the above Table 7, on comparing the GZ, GM, and Deck edge immersion Angle of the two mechanized country boats had come to the conclusion that Padava in Visakhapatnam is the better design in this length range, since it has sufficient GZ, GM and has a large deck edge immersion angle. It is observed that for fishing boat, Porbandar slight varying in the hull form like increasing the breadth to increase their GM values and deck edge immersion angle.

Parameters		Fishing Trawler	Fishing Boat	Fishing Trawler	Fishing Trawler
Boat Building Areas		Beypore, Kerala	Alappuzha, Kerala	Fishing Harbour, Visakhapatnam	Okha, Gujarat
LOA (m)		9.53	13.35	16.1	17.46
Breadth (m)		3.27	2.4	5.1	5.71
Depth (m)		1.68	1.14	3.84	3.66
Draft (m)		0.898	0.45	1.601	1.506
Construction Material		Wood	Wood	Wood	Wood
Carrying Capacity	No.of Persons	5	10	8	8
	Fish Catch/ Cargo (in tonnes)	1	1.5	12	16
Displacement (T)		5.965	3.80	37.643	50.76
LCG (m)		4.763	6.33	6.946	6.87
VCG (m)		1.496	0.72	1.752	1.75
GM (m)		0.512	0.836	1.682	1.206
Max GZ		0.118 m @39.1 (Deg.)	0.350 m @ 48.2 (Deg.)	1.102 m @ 65.5 (Deg.)	1.015 m @ 66.4 (Deg.)
Deck Edge Immersion angle		28.8 (Deg.)	34.3 (Deg.)	44.9 (Deg.)	40.3 (Deg.)
Resistance (KN)		1.80 @ 14 HP	2.20 @ 19.8 HP	9.40 @ 90 HP	13.40 @ 140 HP
Speed in Knots		7.33	8.66	9.00	10.00
Purpose of operation		Inland Fishing	Inland Fishing	Inland Fishing	Inland Fishing

Table 8: Hydrostatics & Stability: Set C (Mechanised)

From the above Table 8, on comparing the GZ, GM & Deck edge immersion Angle of the four mechanized boats had come to the conclusion that Fishing Trawler in Visakhapatnam is the better design in this length range, since it has sufficient GZ, GM and has a large deck edge immersion angle. It is observed that for fishing boats of Gujarat, Kerala and Beypore, slight varying hull forms like increasing the breadth to increase their GM values and deck edge immersion angle is suggestible.

5. Case study on conversion of material change from wood to steel, Beypore, Kerala

Beypore port is one of the oldest ports in Kerala from where trading was done to the Middle East. Beypore port is a Sub-port of Kozhikode port and is situated approximately 10 km south of Kozhikode.

Location: Fishing Trawler constructing place, River Chaliyar, Beypore, Kerala.

Figure 14: Fishing Trawler, Beypore.

On the banks of River Chaliyar, Beypore, there is one of the oldest boat building yard in India. Before 15 years they used to construct wooden Trawlers, but after 1990 they started to construct steel trawlers. Hull is made up of steel and the wheel house is made of wood. Fishing trawlers length below 32 ft. were wooden trawlers and greater than 32ft length were steel trawlers. They construct trawlers for different states around India - Orissa, Tamilnadu and West Bengal.

The main particulars and the structural details of the Fishing trawler, Beypore, Kerala is shown in the Tables 9 and 10 below.

SNo.	*Particulars*	*Values*
1.	Length overall	9.53 m (31.26 ft)
2.	Breadth Extreme	3.27 m
3.	Depth	1.68 m
4.	Draft	0.85 m
5.	No. of Persons	4 - 6
6.	Voyage	5 - 8 days
7.	Storage Capacity	1 - 2 tonnes
8.	Life of Boat	10 years
9.	Engine Details	Make: 3 Cylinder Ruston Engine.

Table 9: Main Particulars of wooden fishing trawler, Beypore, Kerala

S No	Item	Material	Thickness in mm
1.	Keel	Wood	100
2.	Stem	Wood	100
2.	Frames	Wood	40X80
3.	Shell planks	Wood	38.10
4.	Deck Beam/Transverse	Wood	38.10
5.	Deck Longitudinal	Wood	25.40

Table 10: Structural Details:

5.1. Tracing of 3D Craft Model

In the case study the following area was focused upon; Beypore, Kerala. Visited boat building site to collect appropriate dimensions of the craft using "FOCUS 3D Laser Scanner". By locating the reference points the entire craft model can be scanned to get solid model of the craft. The data obtained after scanning, is in a form of three dimensional nurb surface, surface model saved in file format .IGES to further compatible in ship design software, after importing the lines plan of the boat can be generated.

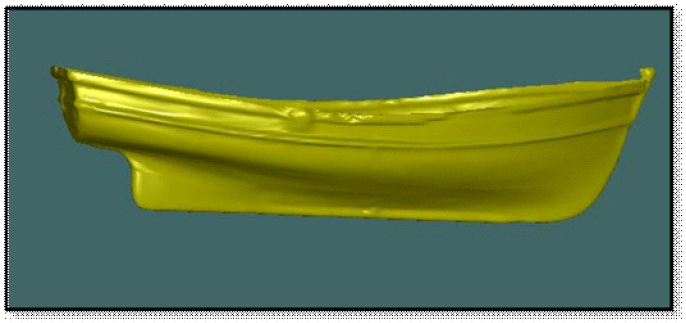

Figure 15: Represents the 3D View of Wooden Fishing Trawler

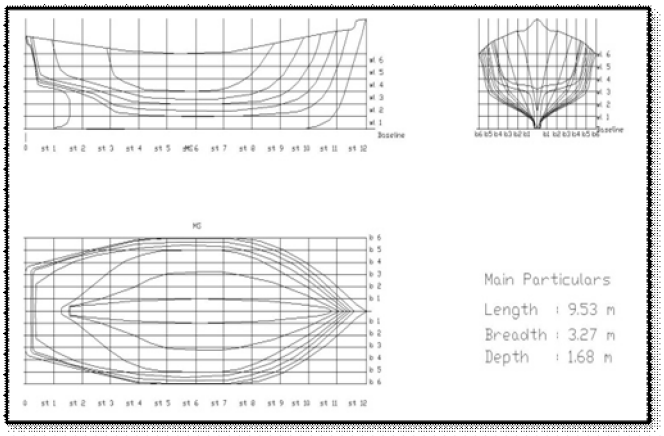

Figure 16: Lines Plan of Wooden" FISHING TRAWLER", Beypore, Kerala.

Particulars	Wood	Steel
LOA (m)	9.53	9.53
Beam (m)	3.27	3.27
Depth (m)	1.68	1.68
Draft (m)	0.898	0.962
Displacement (t)	5.965	7.25
LCG (m)	4.763	4.96
VCG (m)	1.496	1.42
GM (m)	0.512	0.520
max.GZ	0.118 m @ 39.1^{o}	0.152 m @ 35.5^{o}
Deck edge immersion angle in (Deg.)	28.8	26.2
Resistance (KN)	1.80 @ 14HP	2.00 @ 16HP
Speed in Knots	7.33	7.33

Table 11: Stability Comparison between Wood and Steel fishing trawler, Beypore, Kerala

There is an increase in displacement by about 20% and an increase in resistance and power of about 12% for the same speed due to the increase in draft. Stability is found to be improved due to reduction in VCG.

5.2. Advantages and Disadvantages of Boats Built

In Steel Compared To Wood

- Advantages:
  - Long life.
  - Easy construction.
  - Repair & maintenance can be done easily
  - Safe in case of grounding.
- Disadvantages:
  - More weight.
  - High initial investment.

5.3. Advantages and Disadvantages of Boats Built in FRP compared to wood

- Advantages:
  - Do not absorb water, hence no change in buoyancy.
  - Light in [6] weight, easy to handle, excellent surf-riding capacity, less energy required for navigation.
  - Waterproof, non-corrosive, do not need drying.
  - Score over wooden crafts in durability, speed, loading capacity and maintenance.
  - Raw material easily available, a good substitute for wood.
  - Stronger than wood, more elegant and better-looking, permit complex constructions.
- Disadvantages:
  - Higher initial cost. Fabrication needs special skills.
  - Raw material, especially the resins, needs special storage.
  - Low resistance to abrasion.

6. Conclusion

This paper concludes by studying on the design and construction practices, of the traditional boats plying around the coastal and river waters of India. The first case study which is divided into set wise distribution (A, B, and C) which are categorised into mechanized and non - mechanized, suggests that the boats with better design of varying lengths is decided, if the boat has sufficient GZ, GM and large deck edge immersion angle. The second case study concludes that by converting wooden boat into steel, the optimal efficiency can be improved. From the case studies the below observations can be noteworthy:

- Construction: Construction standards are observed to be fair, but the traditional practices are being followed without precise standards.
- Structure: It is found that structural details [4], [5] are comparable with available strength requirements laid by international standards.
- Stability: It is observed that few vessels are not meeting the minimum stability Requirements as per international standards. Hence we suggest slight varying in the hull form like increasing the breadth to improve their stability.
- Conversion: Stability seems to be improved by conversion of wooden boats to steel due to reduction in VCG. However there is a need to increase the power due to increased draft.

7. Acknowledgements

This study is part of the Study Project “Study and modernisation of design and construction of country crafts operating in coastal and river waters" Sponsored by The Ministry of Shipping, Government of India awarded to Indian Maritime University, Visakhapatnam Campus.

We thank all the boat owners, builders & government organisations of Andhra Pradesh, West Bengal, Odisha, Assam, Kerala, Goa, and Gujarat for their support without which the study would not be successful.

8. References

i. Traditional Indian Shipping Building, Book by Rajamanickam, Victor G.
ii. Zeeshan A. Shaikh, Sila Tripati and Vasant Shinde, A Study of Traditional Boats of Goa Marine Archaeology Centre Department of Archaeology, Author version: Man Environ., vol.36; 2011; 79-87.
iii. List of Indian Timber Trees sources obtained from Wikipedia.
iv. IMO 2010, Surveyor’s Notebook for non-convention ships, Annex I and Annex III.
v. IMO, MSC 87/26/Add.2, ANNEX 29 - Safety Recommendations for Decked Fishing Vessels of Less than 12 Metres in Length and Undecked Fishing Vessels, chapter 3, Annex II and Annex IV.
vi. Food and Agriculture Organisation of United Nations - Corporate Document Repository, FAO Fisheries Technical Paper 321,Titled as Fishing boat construction: 2 Building a fibreglass fishing boat, prepared by Ned Coackley, Y. Bryn, Glan Conwy, Clwyd LL28 5SL, UK.