Chapter 7
Conceptual Design of a Mini Houseboat for Local Inland Water Use

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7.1 Introduction

A houseboat is a boat that has been designed or modified to be used similarly as a home. It is a floating structure with a high load-carrying capacity and can accommodate numbers of people. Some houseboats are not motorized, because they are usually moored, kept stationary at a fixed point and often tethered to land to provide utilities. For a typical motorized one, the outboard engine is preferable to support for slow cruising on inland waters, offered the space and comfort as a home (Reymala 2012).

Over the years, houseboats have built an eco-tourism attraction with accessibility to many areas. Due to the deck size, hull shape and arrangement, a houseboat can carry a load almost similarly like a floating cabins. This new experience attracted and gained demands in tourism sector recently. The attraction of simplicity and the originality provided by the houseboat operator brought impressive feedback from tourists. They loved slow and leisurely movement in short term period more than the monotonous trip of the other typical boat shuttles and services. Malaysia, as a tropical country

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A. Ismail et al. (eds.), *Materials and Technologies for Future Advancement*,
Advanced Structured Materials 193,
https://doi.org/10.1007/978-3-031-38993-1_7

surrounded by beautiful rainforest and inland waterways unescapably follows this trend of demand. Local tourists extended their interest to travel and explore the attractions offered by this new experience houseboat trip. Most of the existing houseboats in Tasik Kenyir and Tasik Banding have an overall length ranging from 15 to 25 m suitably to accommodate between 20 to 30 persons each trip. Depending on the duration, season and trip arrangement, the price of rental varies from RM1800 to RM 6500 per night. This existing situation creates restrictions especially for small groups and families to enjoy the similar experience with slight lower budget. As an alternative, there is a potential to explore the smaller size of houseboat with more flexible trip arrangement and affordable rental. The conceptual design for this so-called mini houseboat was initiated for this project. Hull form assessment is one of the main agenda for hull selection based on the mission requirement. The final outcome of the 3D rendered conceptual design was developed by taking into consideration of essential elements such as comfortability, safety as well as ergonomics.

7.2 Literature Review

A houseboat is a built structure that lies on the water surface, thus uniquely creates sensations portrayed by the moving water below and views surrounding them. To suit the role of the houseboat as a unique recreational experience and vacation styles on water, the hull is the most crucial design consideration in order to provide sufficient buoyancy for required overall weight and remain seaworthy in any common condition. Comparing to the floating house, the major difference between houseboat designs is the capability of self-moving and maneuverability (Merrington 2004). Since they are not intended to be kept stationary at fixed locations, they are mostly motorized and only moored using dock lines when necessary (Wang and Xu 2021). Most of the houseboats range in length from 15 to 25 m, and could be more in some countries like United States, as shown in Fig. 7.1. Commonly with shallow draft feature, they have living quarters in the superstructure, maximizing the windows for light and ventilation. These houseboats typically have broad decks, which provides an ideal space for home-looked design and arrangement. Although facilities and amenities selection inside are more compacted compared to a normal house, they combine the roominess and comfort of the houseboat with the convenience of so called cabin cruiser. This cabin built on the hull varies from single level up to three tiers deck to equipped vacation-need facilities such as beds, kitchen, bathroom, refrigerator, television room, living room, dining room and other recreational spaces.

In Malaysia, houseboats are receiving a lot of attention as new style of vacation among foreign and local tourists. Inland water such as Kenyir lake, Pedu lake and Banding lake is the most preferable operation area due to its suitability in terms of calm water and large size, surrounded by natural ambiance as well as spectacular flora and fauna. In common practice, the houseboat owners or operators are entirely responsible during the operation, including helmsman and tour guide. This

Fig. 7.1 Houseboats in Tasik Temenggor, Royal Belum, Perak (Holly Bluff Marina 2022)

scenario gained more attention and demand among tourists, with a peaceful experience throughout their houseboat vacation trip. According to Amarudin (2022), Kenyir lake recorded a significant increased numbers of visitors experiencing the houseboat trip. The growing numbers of tourists has reached more than ten thousands since 2010, which is showing that this activity becomes increasingly popular.

The typical houseboat design ideally consists of a hull that is partially submerged in water which allows the boat to move in the water with required speed and maneuverability. There are two major types of hull form design, the one with a mono hull that is curved and shaped to move through the water efficiently. The other has a pontoon base type that is wider in the water and contains at least two hull extrusions into the water, similarly with the feature of catamaran. This design is considered concerning on the bigger reserve buoyancy for more weight required but sacrificing cruising speed and less manoeuvrability through water. This design provides more deck space for the cabin above or within 'twin's' hull and therefore better flexibility on the general arrangement. In faster single curved hulled boats, sleeping and living quarters are included in the hull of the boat, similarly like a yacht. The pontoon base design mostly creates shallower draft at corresponding displacement (Merrington 2004).

Advantages from both types of design are listed and taken into consideration to produce the new conceptual design. The pontoon based type potentially could be improvised to achieve as much as possible catamaran look and features. By having advantages of catamaran over a mono hull in terms of wider layout, excellent stability and less wetted surface area, the conceptual design of a smaller size the so-called mini houseboat would be the main option (Hidayah and Radam 2014). Hull form variations were developed based on mission requirement and individual assessment were further performed in this project.

7.3 Research Methodology

The project was initiated with the development of potential hull forms. The overall flow of the project can be referred in Fig. 7.2. Based on the main dimensions and type of hull required, variations of hull form were developed by using a 3D modelling software, Maxsurf Bentley. Assessment of individual hull forms then is carried out to comply the mission and operation requirement. Parameters such as length of overall (LOA), shallow depth and draft, distance between both hulls and total displacement are among the crucial factors in finalizing the hull form. The hull form selected must ensure to provide sufficient reserve buoyancy to support the required total weight of the houseboat. At the same time, decision for deck width must be sufficient to accommodate the required cabin. Factors such as wetted surface area for less resistance, and height of freeboard for better stability also need to be borne in mind during hull form consideration. All these considerations are made based on assessment of the hydrostatics data produced. Hydrostatics particulars of each potential hull form were evaluated individually to determine the most suitable one, in terms of displacement required at acceptable design draft, sufficient depth and adequate deck area for cabin and equipment/outfitting arrangement. A decision matrix as suggested by (Jack 2022) was used to compare, evaluate and decide the most suitable one. Initial list of typical weights to be accommodated onboard were considered once the conceptual design of hull form has been finalized. There is a wealth of outsourcing information available such as catalogues and brochures for equipment and weight consideration. The maximum displacement based on hydrostatics result is the main reference in considering the total of potential weights. The total weight proposed ideally should be within the allowable displacement determined at a design draft. For the final outcome, a general arrangement drawing was produced to give the overall view of space and equipment distribution onboard. On top of that, a three-dimensional design by using Rhinoceros was developed for better visualization purpose as a proposed conceptual design of the mini houseboat.

7.4 Results and Discussion

As far as the conceptual design is concerned, the selection of a suitable hull form and main dimensions are the most important stage for the project. The hull form assessment based on the variations developed crucially needs to be considered to meet the initial mission and operation requirements. To propose the new concept of a houseboat for a smaller group of tourists having similar experience, with more affordable and flexible trip, new mission requirements were initially stated as given in Table 7.1. Based on a literature research made earlier, for the new requirement of the mini houseboat concept, the possible range of length overall is from 7.5 to 10 m. This is the common length for leisure boat activities involving between 6 and 8 persons. This range of numbers is an acceptable number for a small group of tourists

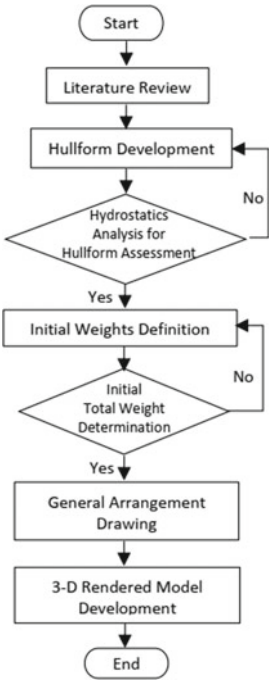


Fig. 7.2 Flowchart of the overall project

as well as a family. Similarly with the other existing houseboat operation, slow and leisure trip with speed from 6 to 8 knots is their preference. The conceptual design of the mini houseboat is also preferably having shallow depth, to give more flexibility for the area of operation. Not only lake, but the route of trip could also be extended to shallower water depth areas such as natural swamps and river mouths for new experience.

The variation of hull forms were developed and assessed in determining the most suitable one to be used as the conceptual design. The hydrostatics data produced was mainly used as main reference in analyzing the most suitable hull form for the mini houseboat concept. Variation of hull forms and the individual hydrostatics data can

Table 7.1 Mission requirements of mini houseboat

Particulars	Parameters
Length overall (LOA)	7.5–10 m
Number of passenger	6–8 person
Cruising speed	7–8 knots (typical houseboat)
Displacement	3.5–4 tonnes
Cabin for overnight stay	
Limited depth (with shallow draft)	

be referred in Figs. 7.3, 7.4, 7.5, 7.6 and 7.7. The Maxsurf Modeller software was used for the hull form development and hydrostatics analysis.

The length of overall is firstly highlighted so that the range is not too small to cater approximately 6–8 passengers but at same time, not too long to meet the 'mini' houseboat concept. Out of 5 hull forms developed, the first three, hull 1, hull 2 and hull 3 are potentially restricted the deck space for cabin arrangement and superstructure with an initiated overall length less than 10 m. hull 4 and hull 5 with length of overall 10.5 m were prioritized to accommodate conveniently the superstructure,

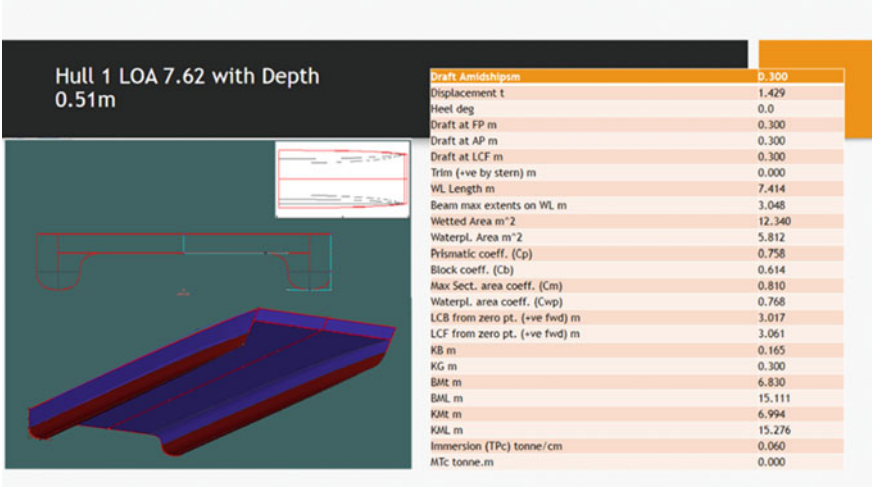


Fig. 7.3 Hull 1 design and hydrostatics particulars at design draft

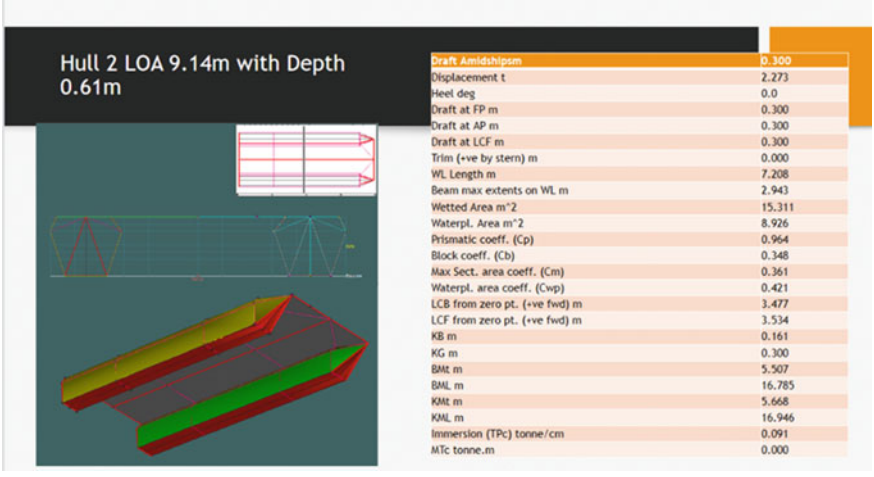
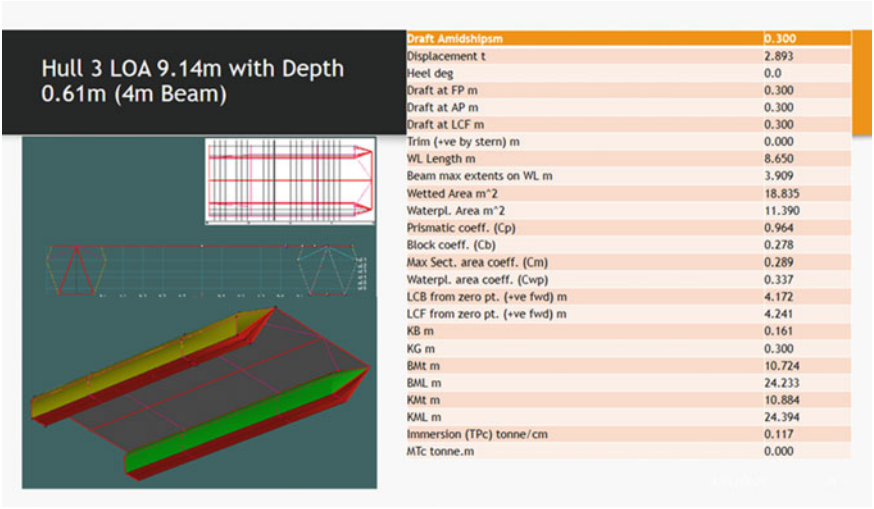
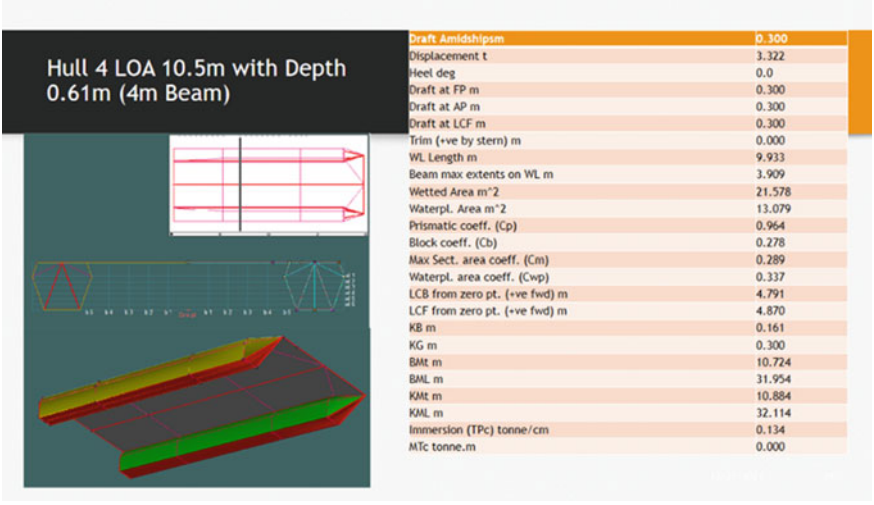


Fig. 7.4 Hull 2 design and hydrostatics particulars at design draft



Draft Amidships m	0.300
Displacement t	2.893
Heel deg	0.0
Draft at FP m	0.300
Draft at AP m	0.300
Draft at LCF m	0.300
Trim (+ve by stern) m	0.000
WL Length m	8.650
Beam max extents on WL m	3.909
Wetted Area m^2	18.835
Waterpl. Area m^2	11.390
Prismatic coeff. (Cp)	0.964
Block coeff. (Cb)	0.278
Max Sect. area coeff. (Cm)	0.289
Waterpl. area coeff. (Cwp)	0.337
LCB from zero pt. (+ve fwd) m	4.172
LCF from zero pt. (+ve fwd) m	4.241
KB m	0.161
KG m	0.300
BMt m	10.724
BML m	24.233
KMt m	10.884
KML m	24.394
Immersion (TPc) tonne/cm	0.117
MTc tonne.m	0.000

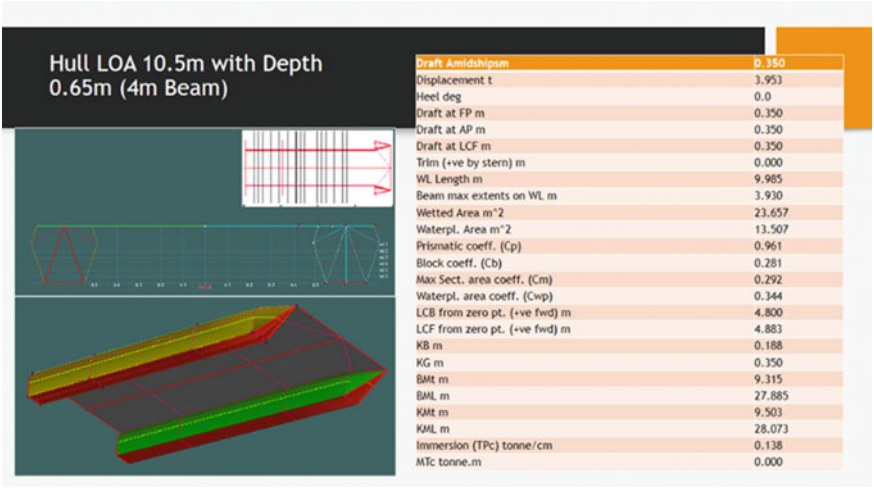
Fig. 7.5 Hull 3 design and hydrostatics particulars at design draft



Draft Amidships m	0.300
Displacement t	3.322
Heel deg	0.0
Draft at FP m	0.300
Draft at AP m	0.300
Draft at LCF m	0.300
Trim (+ve by stern) m	0.000
WL Length m	9.933
Beam max extents on WL m	3.909
Wetted Area m^2	21.578
Waterpl. Area m^2	13.079
Prismatic coeff. (Cp)	0.964
Block coeff. (Cb)	0.278
Max Sect. area coeff. (Cm)	0.289
Waterpl. area coeff. (Cwp)	0.337
LCB from zero pt. (+ve fwd) m	4.791
LCF from zero pt. (+ve fwd) m	4.870
KB m	0.161
KG m	0.300
BMt m	10.724
BML m	31.954
KMt m	10.884
KML m	32.114
Immersion (TPc) tonne/cm	0.134
MTc tonne.m	0.000

Fig. 7.6 Hull 4 design and hydrostatics particulars at design draft

with optimized width from 3 to 4 m. Concerning the mission requirement of shallow depth and draft, the depth decided for hull 5 improvised the variations proposed earlier in hull 1–4. Although an attempt was made to achieve as low as possible the depth, those designs could not provide sufficient draft to maximize the required displacement. A design with too low depth creates a restriction on the draft to have better reserve buoyancy, as well as freeboard height. Crucial evaluation between



Draft Amidships m	D.350
Displacement t	3.953
Heel deg	0.0
Draft at FP m	0.350
Draft at AP m	0.350
Draft at LCF m	0.350
Trim (+ve by stern) m	0.000
WL Length m	9.985
Beam max extents on WL m	3.930
Wetted Area m^2	23.657
Waterpl. Area m^2	13.507
Prismatic coeff. (Cp)	0.961
Block coeff. (Cb)	0.281
Max Sect. area coeff. (Cm)	0.292
Waterpl. area coeff. (Cwp)	0.344
LCB from zero pt. (+ve fwd) m	4.800
LCF from zero pt. (+ve fwd) m	4.883
KB m	0.188
KG m	0.350
BMt m	9.315
BML m	27.885
KMt m	9.503
KML m	28.073
Immersion (TPc) tonne/cm	0.138
MTc tonne.m	0.000

Fig. 7.7 Hull 5 design and hydrostatics particulars at design draft

lower depth (with shallow draft) and displacement requirement is needed, thus hull 5 gives an acceptable range of depth at 0.65 m and displacement nearly 4.0 tonnes (3.95 tonnes). Comparing to earlier hull 1, hull 2 and hull 3, although the size of LOA (7.6–9 m) and depth (0.5–0.6 m) suits within the range, the corresponding maximum displacement gained at appropriate draft is just less than 3 tonnes. The ideal concept of the mini houseboat with all basic facilities and equipment for up to 8 people requires at least 3.8–4 tonnes for full load displacement. With appropriate depth and draft, this range of displacement potentially could also provide better flexibility and stability in considering more than one deck of superstructure. With adequate control of weight and vertical center of gravity (VCG) distribution, a two-tiers deck was proposed for this conceptual design of the mini houseboat. Table 7.2 shows the decision matrix used to relatively compare the variations of the hull form design. The criteria specified are mainly based on the mission and operation requirements identified earlier. Though, weightage is specified to rate the importance and priority of the requirements. As a rating factor, weightage 1.0 is the most important, thus main dimensions selection, convenience of cabin and total displacement provided are in the list. Those criteria signify the compliance of initial mission requirements and success of the ideal mini houseboat.

The flexibility of the construction process also is preferable as a criteria of selection, but it is considered as the least important with weightage of 0.5. Out of 5 hull form designs, although the criteria of shallow depth and draft rated as the lowest, hull 5 still gained the highest in total of 12.5 and is considered as the winning concept. Its lowest criteria is still acceptable since it is categorized as the least important in considering the conceptual design. With additional of 0.5 m depth height from 0.6 m (hull 4) to 0.65 m (hull 5), it is still acceptable to operate in typical shallow water if necessary. With moderate score of main dimensions selection, the design provides

Table 7.2 Decision matrix for hull form conceptual design of mini houseboat

Criteria	Weightage	Hull 1		Hull 2		Hull 3		Hull 4		Hull 5	
Main dimension	1.0	3	3	2	2	2	2	2	2	2	2
Number of passenger	0.8	2	1.6	2	1.6	3	2.4	3	2.4	3	2.4
Convenience cabin for overnight stay	1.0	1	1	1	1	2	2	3	3	3	3
Shallow depth and draft	0.6	3	1.8	2	1.2	3	1.8	2	1.2	1	0.6
Total displacement	1.0	1	1	1	1	2	2	2	2	3	3
Hull fabrication process	0.5	1	0.5	3	1.5	3	1.5	3	1.5	3	1.5
Total with weightage			**8.9**		**8.3**		**11.7**		**12**		**12.5**

convenient cabin space for a maximum of 8 persons, a less-challenging process of hull fabrication and most importantly allows adequate buoyancy to maximize the total weight to be onboard.

Based on the allowable total displacement of 3.9 tonnes at 0.35 m draft for Hull 5 design, the initial weight breakdown has been considered and distributed as listed in Table 7.3. As a conceptual design stage, items and weight to be considered were based on the relevant reference of typical recreational boats. The prediction of weight is made by considering factors such as similar range of size and mission as well as relevant brochures and catalogues available in the market. There might be room for improvements in term of the accuracy once the design has been detailed out later.

The list of initial weight for this conceptual design was decided mainly based on the mission requirement as well as the basic needs and space for 8 persons such as:

(i) Light weight material of hull by using aluminum
(ii) High water resistance for superstructure by using wooden-looked cement fibre material planks
(iii) As minimum as possible power of engine for light weight and low cruising speed
(iv) Adequate cabin to cater for 8 persons
(v) Galley and convenience space for dining
(vi) Water closet and shower room
(vii) Fresh water tank
(viii) Space for recreational activities such as observation deck and water slide.

Table 7.3 Initial weight estimation for conceptual design

Item	Weight (kg)
Hull structure	650
Superstructure	530
Railing/pillars	290
Engine (engine mercury 30HP)	51
Cabin 1	
Single tier 1 and 2 (mattress and Pillow)	44
Locker 1	8
Fan	3
Window 2	6
Window 2	6
Cabin 2	
Single tier 3 (mattress and pillow)	22
Locker	8
Window 1	3
Cabin 3	
Queen bed matteress and pillow	44
Fan	6
Window 2	6
Galley	
Refrigerator	36
Dine table & chair (8)	70
Stove	2
Hanging cabinet	13
Storage and sink	42
Fan	3
Window	3
Deck flooring	680
Anchor and rope + railing rope	11
Steering and gear	10
Wood blind	62
Fuel oil	40
Fresh water tank	450
Toilet	
Bowl	35
Toilet door	9
Sink	16
Mirror	5
Crew	75

(continued)

Table 7.3 (continued)

Item	Weight (kg)
Passengers × 8	600
Galley accessories	50
Safety equipment	30
Water slides	30
Total weight	**3949**

As a conceptual design, spaces with all necessary equipment and items have been modelled by using the Rhinoceros 3D software for better visualization and can be seen Fig. 7.8.

In terms of the powering requirement, the drag of the hull 5 was estimated using the Holtrop method. The speed was calculated from 2 to 8 knots. At 8 knots the total effective power is at 15.2 kW. If we consider a propulsive efficiency of 70%, the delivered power required for hull 5 will be at 21.7 kW which is equivalent to 29.1 horsepower as shown in Fig. 7.9.

As a whole, the overall arrangement of spaces proposed mainly prioritizing the restriction area of the mini houseboat and lighter weight of equipment, without compromising the minimum requirement of safety, comfortability and ergonomic factor. The arrangement and distribution proposed can be referred in the general arrangement drawing as shown in Fig. 7.10.

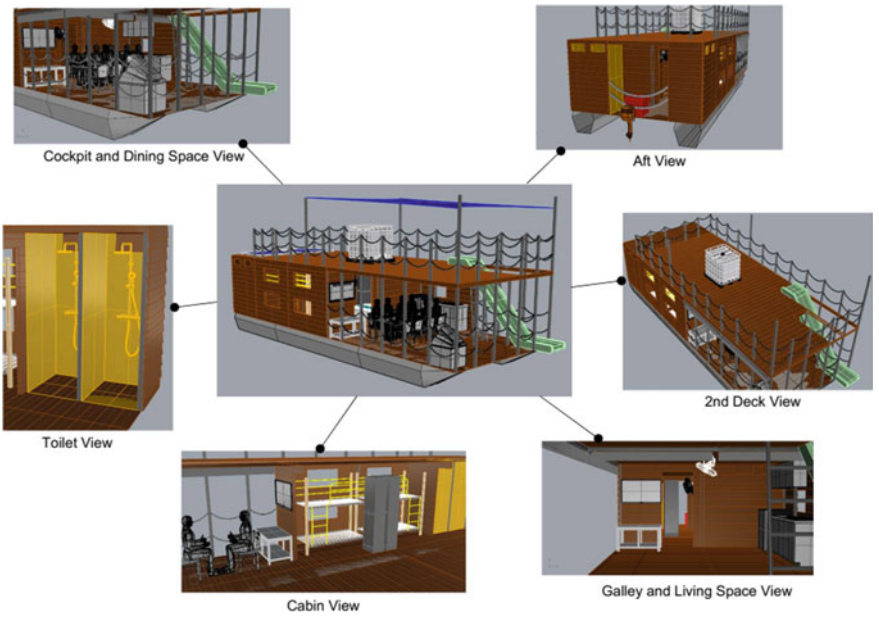


Fig. 7.8 3-dimensional views of conceptual design of mini houseboat

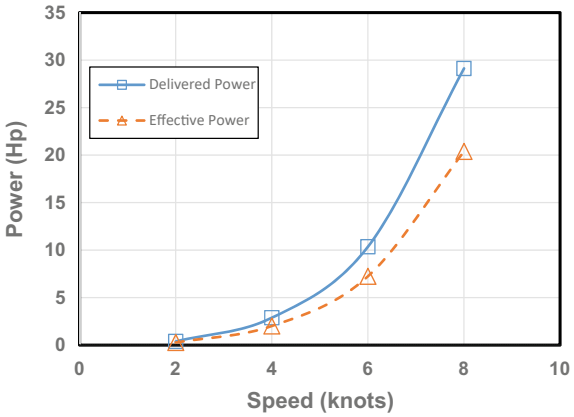


Fig. 7.9 The powering requirement for hull 5 from 2 to 8 knots

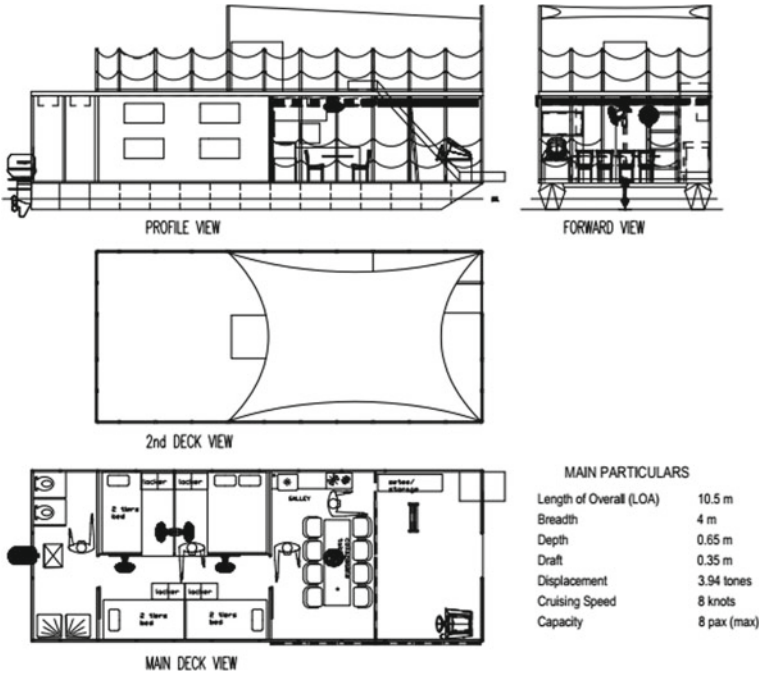


Fig. 7.10 General arrangement of conceptual design of mini houseboat

Table 7.4 Main particulars of conceptual design of mini houseboat

Particulars	Parameters
Length overall	10.5 m
Breadth	4.0 m
Depth	0.65 m
Design draft	0.35 m
Displacement (at design draft)	3.95 tonnes
Cruising speed	8 knots (approximately)
Capacity	8 persons

7.5 Conclusion

The conceptual design of a mini houseboat was completely developed as an alternative of existing houseboat with a larger size. Considering the restrictions as well as the mission and operation requirements, this new design not just caters for smaller size of tourists having similar experience, it also gives a more flexible trip with lower budget. They still can have a relaxing overnight trip with convenience cabin and facilities, more privacy close to nature trip and a safe adventurous tour. Concerning the mission and operation requirement, safety and ergonomics factors, Table 7.4 shows the main particulars for the conceptual design of the mini houseboat. This conceptual design potentially could be further detailed out for future research. Having the initial general arrangement drawing together with weight list, a detailed weight estimation could be performed next by taking into account the individual center of gravity. This will give a more convincing weight distribution and overall center of gravity for stability assessment purpose. Prior to that, scantling and structure weight calculation also need to be detailed out for the next preliminary design stage. Cost estimation and analysis then could be carried out later in determining the feasibility of this new concept of mini houseboat. The main factors to be highlighted at this stage include materials and equipment, man hours for construction and cost of operation such as fuel consumption, helmsman wages and potential rental fees.

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