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Super Yatch Design Study for Malaysian Sea (Langkawi Island)

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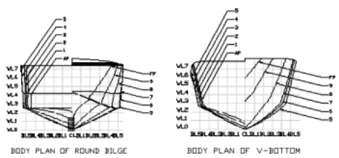
Graphical abstract



Abstract

Malaysia as a country surrounded by water has a huge economic and geographical potential in the development of super yacht industry in South East Asia. There is lack of super yacht design study specifying to Malaysian marinas and seas. Most of the super yacht operates in Malaysia were built and bought directly from oversea, and chartered by foreign companies. It is hence the purpose of this study to survey on Malaysian sea water, particularly Langkawi Island, to introduce a design methodology in producing a preliminary design of super yacht that suits Langkawi Island, and serves as a guideline for future super yacht design for Malaysian sea in different marinas. Suitable dimensions of super yacht were derived by using dimensional relationship via statistical method. Two types of hull form designs (round bilge and V-bottom hull) were designed using Maxsurf Pro software. Resistance analysis on the two hull forms were carried out using Savitsky Pre-Planing and Compton methods via MaxsurfHullspeed software, and stability performance of the two hull forms was analyze using Hydromax software. V-Bottom hull form is found to have better resistance performance as compared to round bilge hull form, and both hull forms are found to be in stable conditions and comply with IMO requirements.

Keywords: Malaysian sea; super yacht design; dimensional relationship; round bilge; V-bottom

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1.0 INTRODUCTION

The term "Super Yacht" as according to Larsson and Eliasson,[1]began to appear at the beginning of the 20th century when wealthy individuals constructed large private yachts for personal pleasure. Early luxury sailing yachts include Americas Cup classic J class racers like S/Y (sailing yacht) Endeavour and Sir Thomas Lipton's S/Y (sailing yacht) Shamrock. The term super yacht often refers to expensive privately owned yacht which is professionally crewed and is also known as a luxury yacht.

After the last decade, the number and popularity of large private luxury yachts increased. Luxury yachts are particularly bountiful in the Mediterranean and Caribbean Seas. As according to Yacht Report Group,[2] average of super yachts around the world is 100-160 meters, while in Malaysia, due to the lacks of well-developed plans given in the yacht industry, the range ofsuper yacht building is widely difference from 10 meters to over 100 meters. In this study, focus is on the super yacht length range from 24-35 meters, suitable for Malaysian sea water, particularly Langkawi Island.

2.0 RESEARCH METHODOLOGY

In this paper, Langkawi Island was taken as the area of study for super yacht design. Environmental limitation in Langkawi sea and marinas were first surveyed. Existing super yachts main dimensions operating in Langkawi were gathered, and statistical formula were introduced in finalizing the optimum principal dimensions of the new design of the Malaysian super yacht.

Maxsurf Pro software was being used in the design of the new hull form of the Malaysian super yacht. Two hull forms were created in the research–round bilge and V-bottom hull forms. The two hull forms were then analyzed in stability performance via MaxsurfHydromax software and resistance performance using Savitsky Pre-Planning and Compton methods via MaxsurfHullspeed software. Their results were compared and discussed.

3.0 MALAYSIA SEA CONDITIONS AND MARINA SURVEYS

3.1 Malaysian Sea Conditions

Langkawi Island is the focused location in the study because it has full facilities for super yacht such as berthing and marinas. As per the survey done at the Meteorology Departments of Survey and Mapping Malaysia, the tidal stations of Langkawi Island is located at Jeti Telok Ewa. The tidal information is shown in Table 1 to 3. From the table shown, the highest sea level is 4.01 m and the lowest sea level is 0.44 m, while the mean sea level is 2.30 m.

This gives guidance in designing the depth of the super yacht that is suitable to be operated in Langkawi. The tidal of the sea is important in deciding the suitable draught of super yacht with relates to the length of the ship using the T/L relationship and T/B relationship.

Table 1 The information of the tidal station

Station	Pulau Langkawi
Location	JetiTelokEwa
Latitude (N), Longitude (E)	06 25.9, 99 45.9
Height of Nearest BM, (m)	3.417

Table 2 Annual mean sea levels in meter

Langkawi Station(Month)	Sea Level (m)
Jan	2.15
Feb	2.06
Mar	2.13
Apr	2.24
May	2.28
June	2.22
July	2.3
Aug	2.2
Sept	2.14
Oct	2.18
Nov	2.08
Dec	2.03
Average	**2.17**

Table 3 Annual highest and lowest sea level

Langkawi Station (Month)	Sea Level	
	Highest (m)	Lowest (m)
Jan	3.83	0.61
Feb	3.82	0.55
Mar	3.88	0.48
Apr	3.9	0.81
May	3.66	1.06
June	3.58	0.99
July	3.84	0.91
Aug	3.86	0.66
Sept	3.82	0.44
Oct	4.01	0.67
Nov	3.82	0.69
Dec	3.55	0.69

3.2 Marina Surveys

Surveys were conducted on three marinas around Langkawi Island on the tidal at the berths that are suitable for super yacht to operate. Summary of the survey is shown in Table 4.

Table 4 Marinas at Langkawi

Marina	Notes
Royal Langkawi Yacht Club	The minimum depth of the berths that is close to shore is 3m and more than 10m on outer berths. The maximum length of the yachts on outer berth is 70m.
TelagaHarbour	The depth of water is from 3.5m to 4.5m. The marinas can accept up to 36m on landing dock and fuel dock.
Rebak Marina	The depth at the entrance of the berths is from 2m to 3m. It has 128 berths for vessels that are up to 35m.

As per the surveys, the average water depth is from 2 m to 3 m. This serves as a guideline for the suitable depth of super yacht design.

4.0 SUPER YATCH MAIN DIMENSION DETERMINATION

This section discussed on the determination of the main dimension of the Malaysian super yacht design. Relationship between the main dimensions of a ship (L, B, T, Δ, v, and Constant C) were derived and generalized.

4.1 Length / Displacement, L/ΔRelationship

In L/Δ relationship, Posdunine equation was being used. Posdunine, [3]introduced constant C (Equation 1) to show the relationship between length and displacement.

$$L = C\,[V / (V + 2)^2] \times \Delta^{1/3} \qquad \text{(Equation 1)}$$

Where,
V is the economical speed in knots
L is the length overall in meters
Δ is the displacement of the ship in tones

Table 5 shows constant C for nine super yacht designs operates in Langkawi Island with length of around 25 m to 35 m. The range of the constant C value varies from 6.818 to 8.581, and is being used as the second guideline for Malaysia super yacht design.

Table 5 Super yatch's particulars that are operates in Langkawi Island

Type ofSuper Yacht	L (m)	B (m)	T (m)	Δ (tonnes)	V(knots)	Constant,C
CHALLENGER 80'	24.30	6.10	1.80	62.5	17	7.649
FERRETTI 80' RPH	24.55	6.04	1.86	51.0	27	7.637
CANADOS 86'	26.48	6.40	2.00	75.0	29	7.175
MAIORA 31 m	31.07	6.80	2.35	126.0	22	8.581
AKHIR 100'	31.10	7.06	1.85	160.0	22	6.818
FALCON 102'	31.10	6.50	2.20	100.0	23	7.916
BENETTI 35 m	35.00	7.60	2.00	181.0	15	7.947
AZIMUT 116'	35.46	7.65	2.35	132.0	25	8.123

Table 6 shows the main dimension relationship from the nine super yachts statistical survey as in Table 5. These equations were later being used to finalize and optimize the final dimensions of the Malaysian super yacht design.

Table 6 Malaysian super yatch dimension equations

Relationship	Super Yacht's Dimensional Equation
Δ/L	Δ=9.017(L) – 164.2
B/L	B=0.136(L) + 2.695
L/B versus L	L/B=0.060(L) + 2.588
T/L	T =0.032(L) + 1.085
Δ/L^3	$\Delta=0.003(L^3) + 14.18$

In order to ensure that the designed super yacht can berth at the marinas of Langkawi Island, the length of the super yacht was being preset to 25.0 m. The finalized principal dimensions of the Malaysian super yacht is shown in Table 7 and two designs of Malaysian super yacht–round bilge and V-bottom, were designed using Maxsurf Pro software.

Table 7 Main dimensions of the Malaysian Super Yatch Design

Principal Dimensions	Value
Length, L (m)	25.0
Breadth, B (m)	6.095
Draught, T (m)	1.885
Block coefficient, C_B	0.40
Displacement, Δ (tonnes)	115.41

■5.0 MALAYSIAN SUPER YATCH HULL FORM DESIGN AND ANALYSIS

By using the super yacht dimension relation as in Table 6, two hull forms (round bilge and V-bottom) were designed. Body plans of the two hull forms and their stability assessment and resistance comparison were performed in the next subsections.

5.1 Round Bilge and V-Bottom Hull Form Designs

Figure 1 shows the body plan of the round bilge and V-bottom body plan designed using Maxsurf Pro design software.

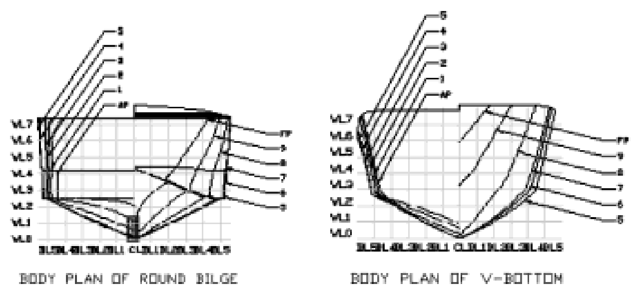

Figure 1 Body plan for round bilge and V-bottom hull form of Malaysian super yatch

5.2 Stability Assessment on Round Bilge and V-Bottom Hull Forms

MaxsurfHydromax software was being used in the assessment on the hull form of the designed Malaysian super yacht. GZ curve for round bilge hull form and V-bottom hull form are shown in Figure 2 and 3. From the figures, round bilge hull form is found to have the highest righting arm (GZ value = 0.927 m) at 52 degree and higher GM value than V-bottom hull form. This shows that the round bilge hull form is more stable at static sea condition compared to V-bottom hull form.

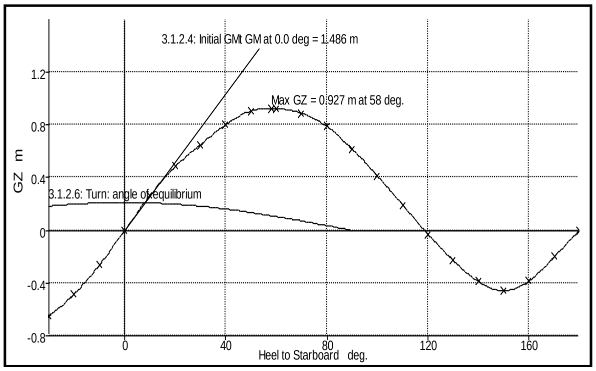

Figure 2 GZ curve of round bilge hull form

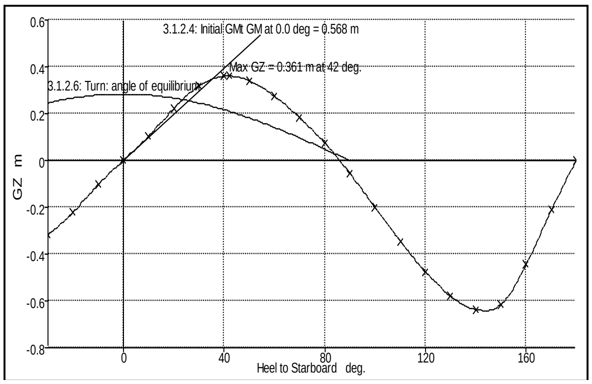

Figure 3 GZ curve for V-bottom hull form

In assessing the stability of the two hull forms, IMO A.749 (18) Code,[4] on Intact Stability were being used and shown in Table 8.

Table 8 Comparison of stability criteria using IMO A.749 (18) Code on Intact Stability

Code and Criteria	Round Bilge	Status	V-Bottom	Status
3.1.2.1: Area 0 to 30 (shall not be less than 3.151 m.deg)	10.819 m.deg	Pass	4.850 m.deg	Pass
3.1.2.1: Area 0 to 40 (shall not be less than 5.157 m.deg)	18.102 m.deg	Pass	8.290 m.deg	Pass
3.1.2.1: Area 30 to 40 (shall not be less than 1.719 m.deg)	7.283 m.deg	Pass	3.439 m.deg	Pass
3.1.2.2: Max GZ at 30 or greater (shall not be less than 0.20 m)	0.927 m	Pass	0.361 m	Pass
3.1.2.3: Angle of maximum GZ (shall not be less than 25.0 deg)	58.000 deg	Pass	42.000 deg	Pass
3.1.2.4: Initial GMt (shall not be less than 0.15 m)	1.486 m	Pass	0.568 m	Pass

5.3 Resistance Comparison Study

Two empirical formula (Savitsky Pre-Planing and Compton methods) were being used in the resistance analysis of the two hull forms for speed 13 to 17 knots. The analysis was carried out using MaxsurfHullspeed software with Savitsky Pre-Planing and Compton methods formularized and computerized.

Figures 4 and 5 show the differences in prediction between Savitsky Pre-Planing and Compton methods for round bilge and V-bottom hull form. In Figure 4, Savitsky Pre-Planing method predicted lower resistance at below 15 knots and higher resistance at above15 knots as compared to Compton method for round bilge hull. For V-bottom hull form, both Savitsky Pre-Planing and Compton methods predicted similar value of resistance in both design.

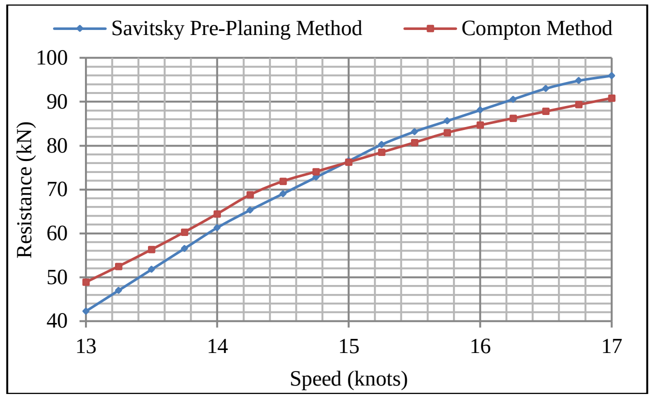

Figure 4 Resistance comparison of round bilge hull using Savitsky Pre-Planning and Compton methods

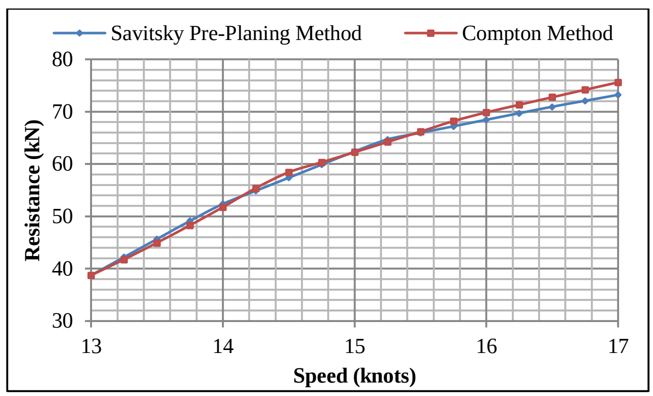

Figure 5 Resistance comparison of V-bottom hull using Savitsky Pre-Planning and Compton methods

Figures 6 and 7 shows the differences in resistance prediction for round bilge and v-bottom hull form using Savitsky Pre-Planing and Compton methods. In both figures, round bilge hull shows clearly with higher resistance as compared to V-bottom hull form from speed 13 knots to 17 knots.

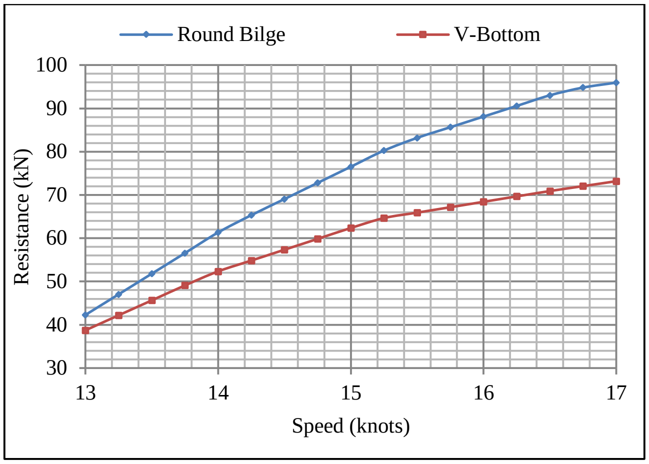

Figure 6 Resistance (kN) versus speed (knots) using Savitsky Pre-Planning method

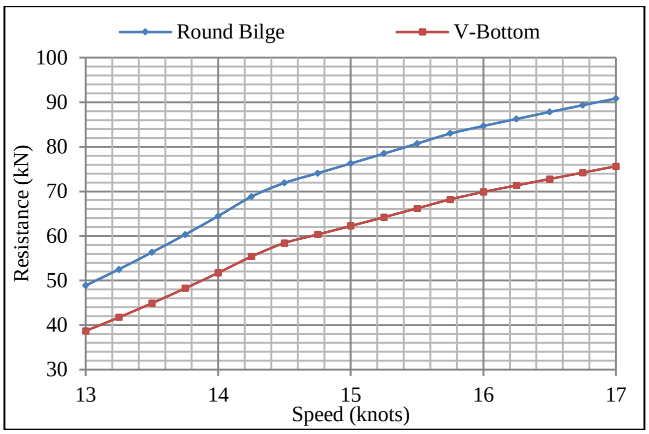

Figure 7 Resistance (kN) versus speed (knots) using Compton method

6.0 CONCLUDING REMARKS

A preliminary design process of a Malaysian super yacht for Malaysian sea, particularly in Langkawi Island, has been carried out in the study. Surveys were being made on Langkawi Island to determine the sea level and tidal conditions on the marinas of Langkawi Island, in order to determine the suitable draught dimension of the Malaysian super yacht design. Dimensional analysis via statistical method and Postitune constant C were being used in determining the suitable main dimensions of the Malaysian super yacht.

Two hull forms of the Malaysia super yacht were designed in the study–round bilge and V-Bottom hull. Stability of the two yachts were analysed using Maxsurf Hydromax software and checked with ISO A.749 (18) Code on Intact Stability, where both hull forms passed all the criteria in IMO requirement. Resistance of the yachts were predicted and compared using Savitsky Pre-Planning and Compton methods via Maxsurf Hullspeed software, where V-Bottom hull is found to have less resistance as compared to round bilge hull form.

Nomenclature

B	Breadth
Δ	Displacement
L	Length
T	Draught
v	speed

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