CAD-CAM and Marine Design Laboratory Spring 2024

PRELIMINARY SHIP DESIGN PARAMETER ESTIMATION

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Owner's Requirements (Post Panamax PCC carrier)

→ Given Data:

Design capacity	25000 dwt, 8000 PCTC
Design Speed	20 Knots = 10.288 m/s
Route	China - Europe (through New Panama Canal) sector

1. Understanding the Modifications

Given Base Model Data (Drive Green Highway)

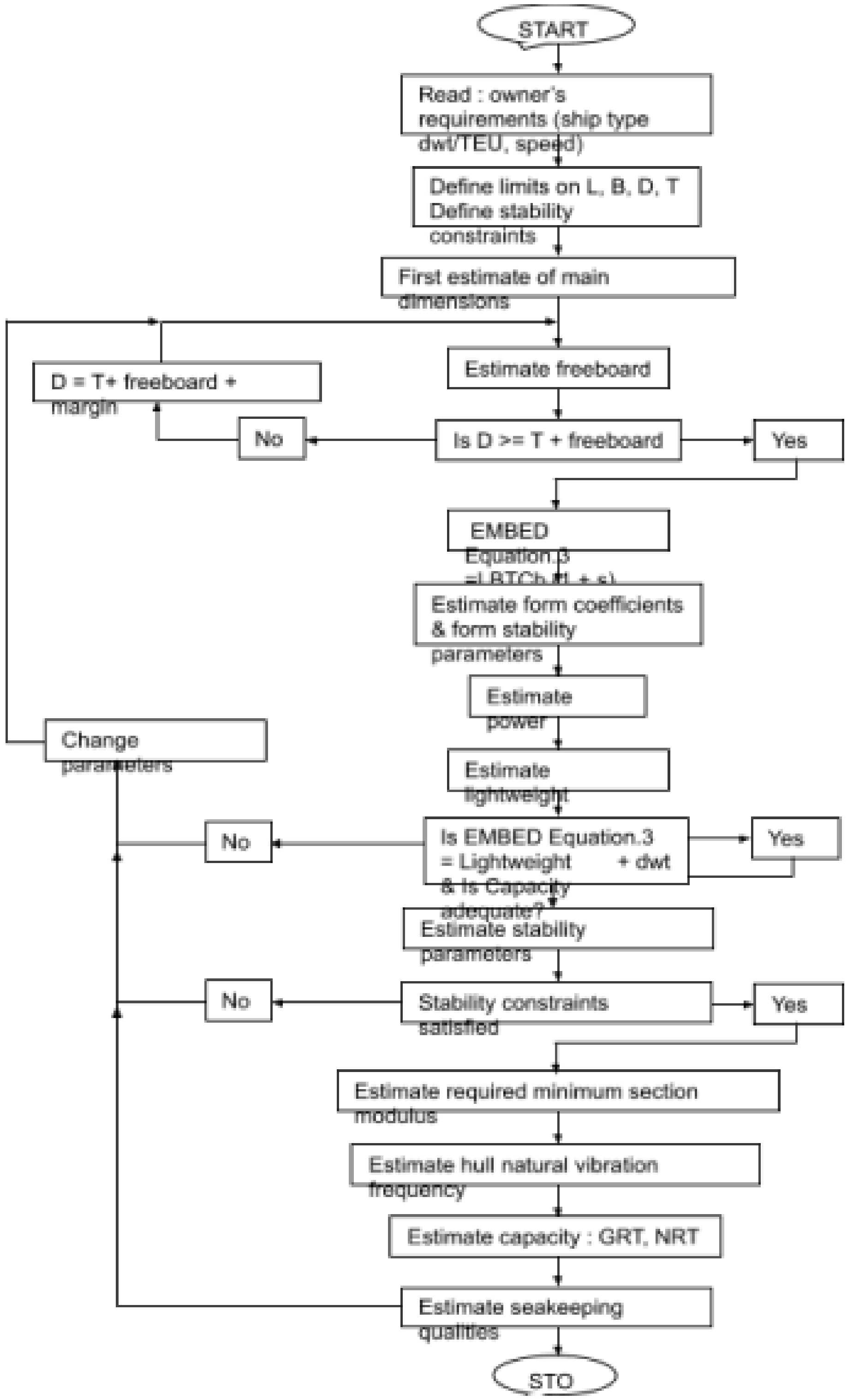
- Deadweight (DWT) = 20,034 tonnes
- Capacity = 7,500 cars
- Service Speed = 20 knots
- Length (LOA) = 199.99m
- Breadth = 37.50m
- Draft (Scantling) = 9.9m

Required Design Changes

- Deadweight (DWT) = 25,000 tonnes (+4,966 tonnes)
- Capacity = 8,000 cars (+500 cars)

- Speed = 20 knots (No change)

<u>We are Following this road map</u>



3. Calculation:

$$\frac{L_{\text{new}}}{L_{\text{old}}} = \left(\frac{DWT_{\text{new}}}{DWT_{\text{old}}}\right)^{\frac{1}{3}}$$

L(new) = new ship length
L(old)= original ship length
(199.99m) DWT(new) = 25,000
tonnes DWT(old) = 20,034 tonnes

Distance of desire Route = ~24,000 Km
L(New) ~ 215 m
B(Breadth) ~ 40 m
D(Depth) ~ 41 m
T(Draught) ~ 10.65m

Stability Constraints:-

→ Froude number:-

$$Froude\ Number = \frac{V}{\sqrt{gL}}$$

Fr(new) = 0.224

Since $0.15 \le F_n \le 0.32$ this is in the range,

$$C_B = C_P \cdot C_M$$

→Block Coefficients

$$C_B = C_{VP} \cdot C_{WP}$$

where C_p: Longitudinal prismatic coefficient

and C_{VP}: Vertical prismatic

coefficient

$$C_P = \frac{\nabla}{A_M \cdot L} \qquad C_{VP} = \frac{\nabla}{A_{WP} \cdot T}$$

$0.15 \le F_n \le 0.32$ as
$C_B = -4.22 + 27.8\sqrt{F_n} - 39.1F_n + 46.6F_n^3$

= 0.71

→ **<u>Midship Area Coefficient</u>:**

$C_M = \left[1+(1-C_B)^{3.5}\right]^{-1} = 0.987$

→ **<u>Prismatic Coefficient</u>:-**

Cp = 0.71935

- Waterplane Area Coefficient :

We estimate CWP using the empirical relationship for bulkers given as :

$$C_{WP} = C_b / (0.471 + 0.551 * C_b)$$

=0.823465

$A_M = C_M$*B*T = 420.462

$A_{WP} = C_{WP}$*B*T =350.80 m^2

∇ = 65028.9 m^3

C_P = 0.71935

C_{VP} = 17.406

→ **<u>Displacement</u>:**

- ρ = 1.025 kg/ m^3
- Free board = ~12 m
- Volume displacement(Δ) =CB×L×B× T×ρ(1 + s) Here s = 0.008

= 67122.310 tonnes

- Underwater Volume :

Δ = L * B * T * Cb

⇒ △ = 65028.9 m3

- Estimation of Volumetric Displacement :

All the parameters above have been estimated , so displacement can now be easily estimated.

∇ = L * B * T * Cb* 1. 032

= 67109.82

- <u>Estimation of Dead Weight</u>:

Table: Typical Deadweight Coefficient Ranges

Vessel Type	$C_{cargo\ DWT}$	$C_{total\ DWT}$
Large tankers	0.85 – 0.87	0.86 – 0.89
Product tankers	0.77 – 0.83	0.78 – 0.85
Container ships	0.56 – 0.63	0.70 – 0.78
Ro-Ro ships	0.50 – 0.59	–
Large bulk carriers	0.79 – 0.84	0.81 – 0.88
Small bulk carriers	0.71 – 0.77	–
Refrigerated cargo ships	0.50 – 0.59	0.60 – 0.69
Fishing trawlers	0.37 – 0.45	–
where $C = \dfrac{Cargo\ DWT\ or\ Total\ DWT}{Displacement}$		

→ **Deadweight (DWT)**

- **Cargo DWT:** 25,000 tonnes
- 8000 Cars:- 16000 tonnes
- **Fuel Oil:** 10% of displacement = 6157.66 tonnes
- **Fresh Water:** 0.1 tonnes/person/day × 23 people × 24 days = 55.2 tonnes
- **Crew and Effects:** 5% of DWT = 1,250 tonnes

Total DWT = cargo dwt + crew and effect (5% of total dwt) + Fresh water + Fuel Oil

cargo dwt = 25000 + 16000 -1250 - 6157.66 = 33592.34 tonnes

Therefore, $C = \dfrac{Cargo\ DWT\ or\ Total\ DWT}{Displacement}$

= 0.5166

→ <u>**Fresh Water:**</u>

Weight of Fresh Water = 0.1 * (No. of person) * endurance

= 0.1 * 23 * 24 = 55.2 tonnes

Where ,

Fresh water for 23 people onboard and estimated journey of 24 days with

20 knots speed and approximate consumption of 0.1 tonnes of fresh water per person per day is equal to = 55.2 tonnes.

→ Fuel Oil:

- ρ = 0.87 t/m^3
- Weight of the fuel oil = 10 % * of the volume of the ship * ρ

=0.1 * 215 * 40 * 11 * 0.87

= 8230.2 tonnes

Note: In the following expression we are taking the fuel to occupy 10% of total volume and based on which we have calculated the fuel oil weight

→ Crew:

Weight of crew of fresh Water = 0.17 * 23 = 3.91 tonnes

→ Total DWT = cargo dwt + crew and effect (5% of total dwt) + Freshwater + Fuel Oil

= 33592.6 + 3.91 + 55.2 + 8230.2

= 41881.91 tonnes

• Estimation of Light Weight

→ LightWeight = Steel Weight + Outfit Weight + Machinery Weight + Margin → Steel Weight:

$$W_{st} = 0.007\ L_{pp}^{1.759}\ .\ B^{0.712}\ .\ D^{0.374}$$

= 3006.116885 tonnes

→ **Outfit Weight:**

Outfit Weight = 0.36 * L * B = 3096 tonnes

→ **Machinery Weight:**

- **Power Estimation:-**

$$\frac{SHP}{V_0^3} = 0.5813\left[DWT/1000\right]^{0.5}$$

=> SHP = 30095.637 kW

- **Machinery Weight** =BHP/10 + 200 tonnes

= 2696.53 + 200 tonnes=2896.534 tonnes

→ **<u>Light Weight</u>:**

Lightweight = Steel Weight + Outfit Weight + Machinery Weight = 3006.11 + 3096 + 2896.534 = 8998.651 tonnes

- **Estimation of Total Weight:**

Total weight = Deadweight + LightWeight

= 41881.91 tonnes + 8998.651 tonnes

= 50880.561 tonnes

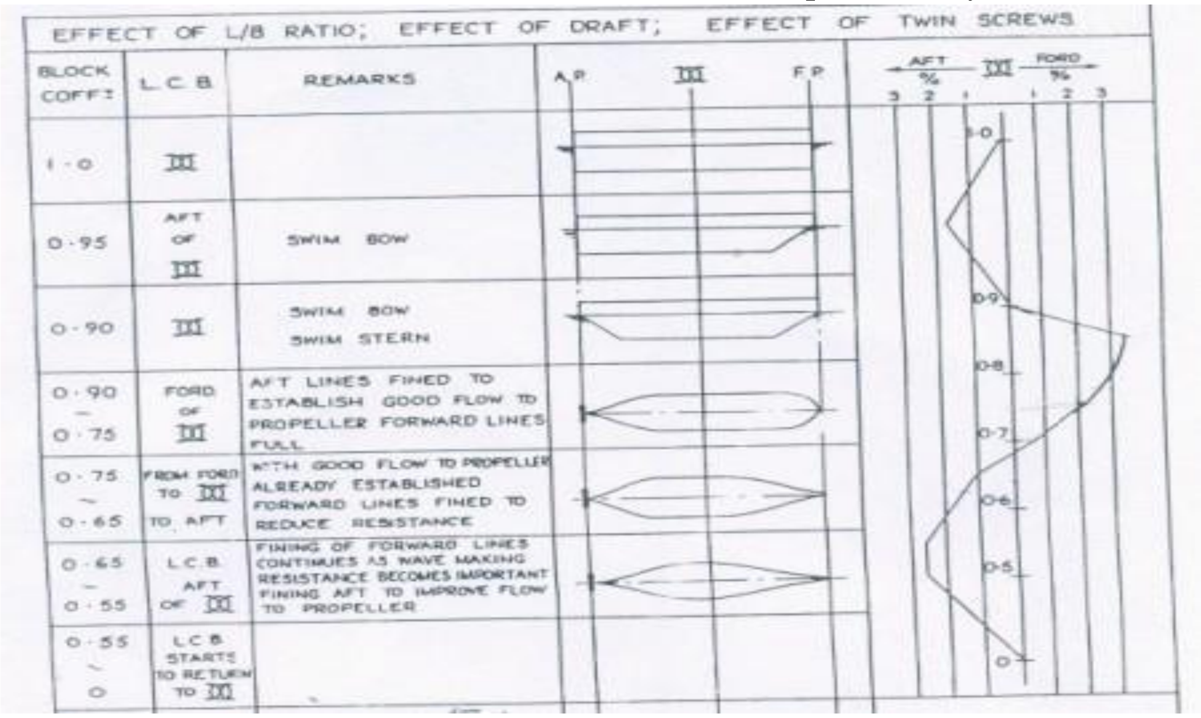
→ Parallel Middle body:

midship = 107.4 m toward aft

Pmb = 15 % of Lpp = 32.25

- Length of Aft hull 91.275m and length of Forward hull is equal to 91.475 m

Reference of the calculation is taken from the data provided by Sir.



- **Stability Estimation:**

→ **Bilge Radius:**

$$R^2 = \frac{2(1 - C_M)B.T.}{4 - \pi}$$

$= 2.33\ (1 - C_M)\ B.T.$

R = 3.6m

→ **KB Calculation:**

Regression formulations are as follows :

$Kb/T = 0.90 - 0.36\ C_M$

$Kb = 5.80$ m

→ **Metacentric Radius: BM_T and BM_L**

Moment of Inertia coefficient C_I and C_{IL} are defined as

$$C_I = I_T / LB^3$$

Equations	*Applicability / Source*
$C_I = 0.1216\ C_{WP} - 0.0410$	D' Arcangelo transverse
$C_{IL} = 0.350\ C_{WP}^2 - 0.405\ C_{WP} + 0.146$	D' Arcangelo longitudinal
$C_I = 0.0727\ C_{WP}^2 + 0.0106\ C_{WP} - 0.003$	Eames, small transom stern (2)
$C_I = 0.04\ (3C_{WP} - 1)$	Murray, for trapezium reduced 4% (17)
$C_I = (0.096 + 0.89\ C_{WP}^2) / 12$	Normand (17)
$C_I = (0.0372\ (2\ C_{WP} + 1)^3) / 12$	Bauer (17)
$C_I = 1.04\ C_{WP}^2) / 12$	McCloghrie + 4% (17)
$C_I = (0.13\ C_{WP} + 0.87\ C_{WP}^2) / 12$	Dudszus and Danckwardt (17)

The formula for initial estimation of C_I and C_{IL} are given below

Equations for Estimating Waterplane Inertia Coefficients

$$B_{MT} = \frac{I_T}{\nabla} \qquad B_{ML} = \frac{K_L}{\nabla}$$

Therefore,

- Moment of area Coefficient:

$C_1 = 0.1216\ C_{WP} - 0.0410 =$ **0.05913**

$C_{IL} = 0.350\ C_{WP}^2 - 0.405\ C_{WP} + 0.146$ **= 0.04983**

$IT = LB^3 \times C_1$

IT = 1146666 m^4

$IL = BL^3 \times C_1$

IL= 19809169.05 m^4

-Metacentric Radius:

BM_T = IT/∇ = 17.633 m

BM_L= IL/∇ = 304.62 m

-Transverse Stability(GM):

The transverse stability (metacentric height) GM is:
KG/D = 0.53
KG/D = 21.73m
KMt = KB + BMt = 22.958 m
GM = KMt - KG =
GM = 22.958 - 21.73
GM = 1.228 m

-Longitudinal Centre of Buoyancy:

LCB = 109.65 m from AFT

-Longitudinal Stability:

$$GM_L \cong BM_L = \frac{I_L}{\nabla} = \frac{C_{IL}\ L\,B^3}{LBT\ C_B} = \frac{C_{IL}\ L^2}{T.C_B}$$

GML≅ BML =304.62 m

$$MCT\ 1\,cm = \frac{\nabla GM_L}{100\ L_{BP}} = \frac{L.B.T.C_B\ C_{IL}\ L^2}{100.T.\,C_B\,L} = \frac{C_{IL}\ L^2 B}{100}$$

MCT= 921.36 tonne-meters

-Centre of Mass:

VCG(hull)= 19.258m
LCG(hull)= LCGhull=0.52×215 = 111.8m

Power Estimation $\frac{SHP}{V_0^3} = 0.5813\left[DWT/1000\right]^{0.5}$

SHP = 30095.637 kW

Ac = V^3*(displacement)$^{2/3}$ / BHP
Ac = 490 for pcc

BHP = 26965.30 kW

Shaft Efficiency = BHP/SHP = 0.8959
= 90%

Maximum Continuous Rating (MCR) :

MCR = BHP*0.89
= 26965.30 * 0.89
= **23999.12 kW**

L	215	m
B	40	m
D	41	m
T	10.65	m
Freeboard	12	m
Speed(m/s)	10.28	m/s2
Design Capacity	8000 cars	25000 dwt
Density Water	1.025	m3
Froude Number	0.224	
Block Coefficient (Cb)	0.63	
MidShip Coefficient	0.97	
Prismatic coefficien t	0.65	
Displacement	596548.1544	tonnes
Bilge radius	5.546	m
Parallel MIddle Body	32.25	m
Length of Aft hull	91.275	m

Length of Forward hull	91.475	m

Kb	5.83	m
Cwp	0.77005	
C1	0.052638	
LCB	107.65 m from aft	m