

C++ Programming

Ch. 12 Application to Shipbuilding

Spring 2014

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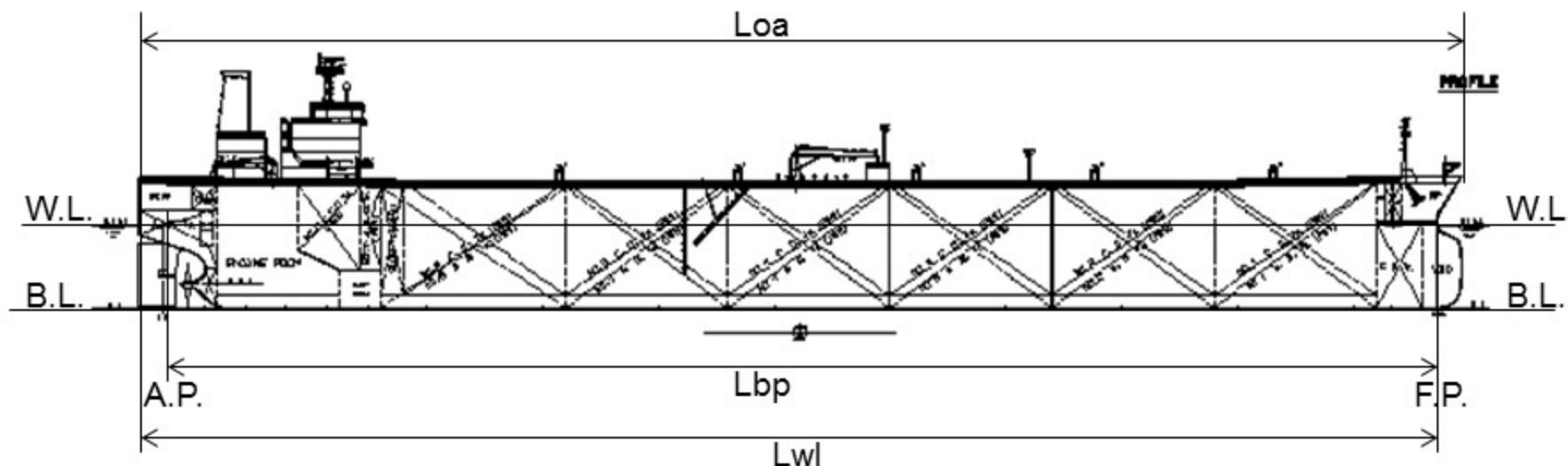
Ch. 12 Application to Shipbuilding

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- ☑ Main Terminology
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Main Terminology

- Principal Dimensions (1/2)



- ☑ LOA (Length Over All) [m]: Maximum Length of Ship

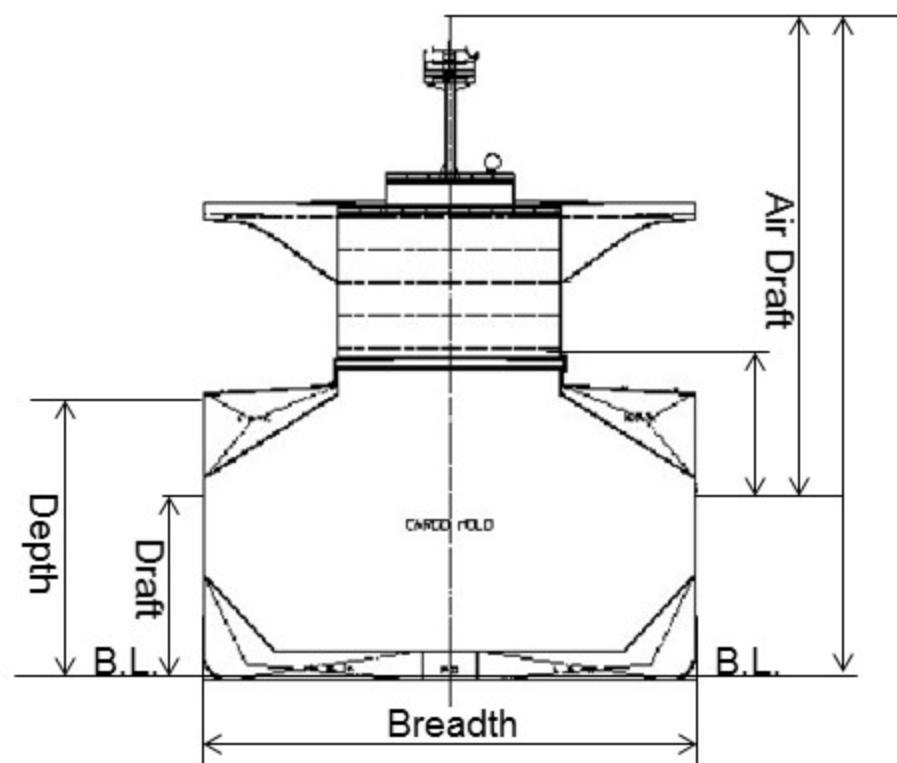
[m]

- A.P.: After perpendicular (normally, center line of the rudder stock)
- F.P.: Inter-section line between designed draft and fore side of the stem, which is perpendicular to the baseline

- ☑ Lf (Freeboard Length) [m]: Basis of freeboard assignment, damage stability calculation
 - 96% of Lwl at 0.85D or Lbp at 0.85D, whichever is greater
- ☑ Rule Length (Scantling Length) [m]: Basis of structural design and equipment selection
 - Intermediate one among (0.96 Lwl at Ts, 0.97 Lwl at Ts, Lbp at Ts)

Main Terminology

- Principal Dimensions (2/2)



- **B (Breadth) [m]:** Maximum breadth of the ship, measured amidships
 - B_{molded} : excluding shell plate thickness
 - B_{extreme} : including shell plate thickness
- **D (Depth) [m]:** Distance from the baseline to the deck side line
 - D_{molded} : excluding keel plate thickness
 - D_{extreme} : including keel plate thickness
- **Td (Designed Draft) [m]:** Main operating draft
 - In general, basis of ship's deadweight and speed/power performance
- **Ts (Scantling Draft) [m]:** Basis of structural design

- **Air Draft [m]:** Distance (height above waterline only or including operating draft) restricted by the port facilities, navigating route, etc.
 - Air draft from baseline to the top of the mast
 - Air draft from waterline to the top of the mast
 - Air draft from waterline to the top of hatch cover
 - ...

Main Terminology

- Weight and COG (Center Of Gravity)

[ton]

- Weight of water displaced by the ship's submerged part

(DWT) [ton]: Cargo payload + Consumables (F.O., D.O., L.O., F.W., etc.) + DWT Constant
= Displacement - Lightweight

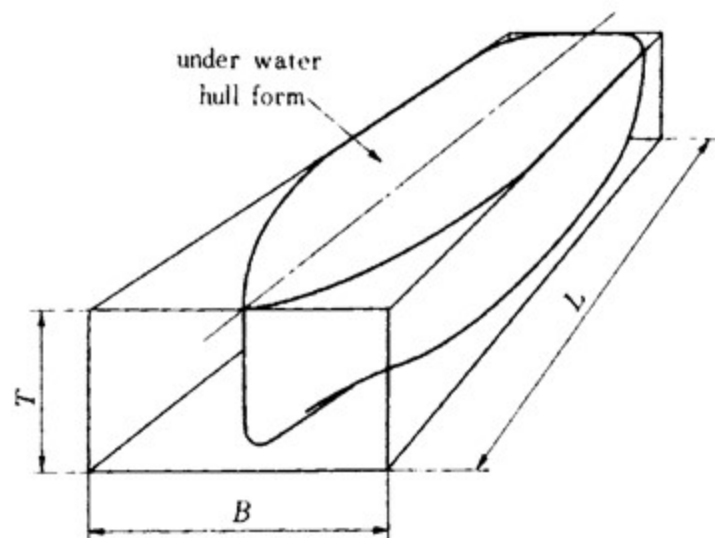
- ☑ Cargo Payload [ton]: Weight of loaded cargo at the loaded draft
- ☑ DWT Constant [ton]: Operational liquid in the machinery and pipes, provisions for crew, etc.

(LWT) [ton]: Total of hull steel weight and weight of equipment on board

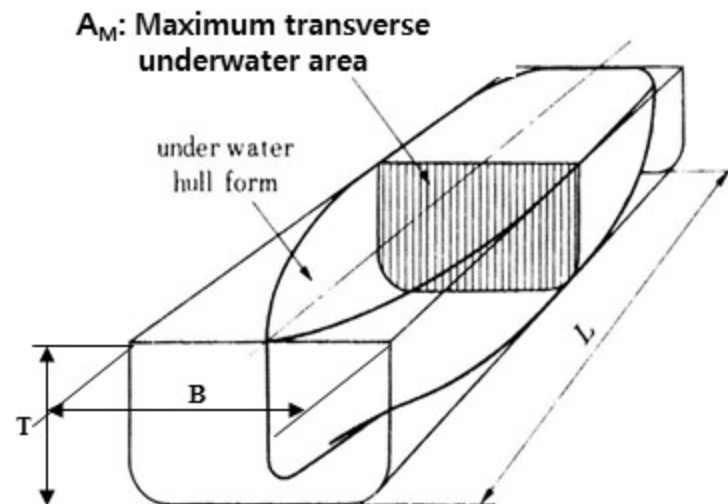
- ☑ Trim: difference between draft at A.P. and F.P.
 - $\text{Trim} = \{\text{Displacement} \times (\text{LCB} - \text{LCG})\} / (\text{MTC} \times 100)$
- ☑ LCB: Longitudinal Center of Buoyancy
- ☑ LCG: Longitudinal Center of Gravity

Main Terminology

- Hull Form Coefficients (1/2)



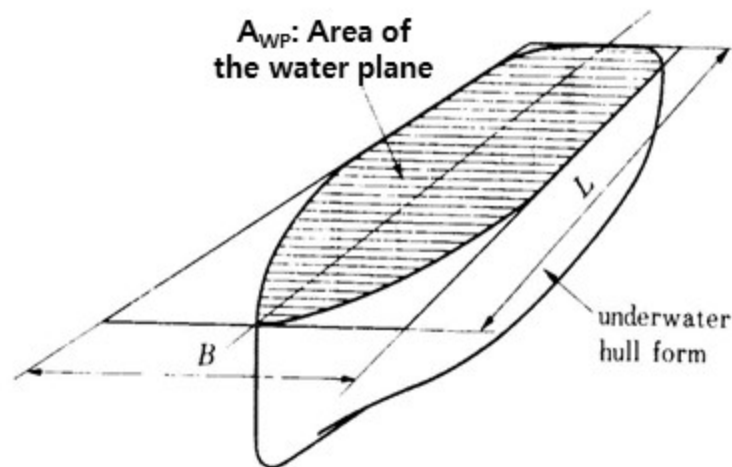
= Displacement / ($L \times B \times T \times \text{Density}$)
where, density of sea water = $1.025 \text{ [Mg/m}^3\text{]}$



- C_M (Midship Section Coefficient)
= $A_M / (B \times T)$
- C_p (Prismatic Coefficient)
= Displacement / ($A_M \times L \times \text{Density}$)

Main Terminology

- Hull Form Coefficients (2/2)



- C_{WP} (Water Plane Area Coefficient)
 $= A_{WP} / (L \times B)$

Main Terminology

- Speed and Power (1/2)

- ☑ **MCR (Maximum Continuous Rating) [PS x rpm]**
 - NMCR (Nominal MCR)
 - DMCR (Derated MCR) / SMCR (Selected MCR)

- ☑ **NCR (Normal Continuous Rating) [PS x rpm]**

- ☑ **Trial Power [PS x rpm]:** Required power without sea margin at the service speed (BHP)

- ☑ **Sea Margin [%]:** Power reserve for the influence of storm seas and wind including the effects of fouling and corrosion.

- ☑ **Service Speed [knots]:** Speed at NCR power with the specific sea margin

Main Terminology

- Speed and Power (2/2)

☑ DHP: Delivered Horse Power

- Power actually delivered to the propeller with some power loss in the stern tube bearing and in any shaft tunnel bearings between the stern tube and the site of the torsion-meter

☑ EHP: Effective Horse Power

- Required power to maintain intended speed of the ship

☑ η_D : Quasi-propulsive coefficient = EHP / DHP

☑ RPM margin

- To provide a sufficient torque reserve whenever full power must be attained under unfavorable weather conditions
- To compensate for the expected future drop in revolutions for constant-power operation

Main Terminology

- Tonnage

- ☑ **Tonnage: normally, $100 \text{ ft}^3 (=2.83 \text{ m}^3) = 1 \text{ ton}$**
 - Basis of various fee and tax
 - **GT (Gross Tonnage):**
 - **NT (Net Tonnage): Total sum of the volumes of every cargo space**
 - GT and NT should be calculated in accordance with "IMO 1969 Tonnage Measurement Regulation".
 - **CGT (Compensated Gross Tonnage)**
 - **Panama and Suez canal have their own tonnage regulations.**

Main Terminology

- Conversion Factor between GT and CGT

船型(DWT) 船種	100— 4,000	4,000— 10,000	10,000— 30,000		30,000— 50,000	50,000— 80,000	80,000— 160,000	160,000— 250,000	250,000 이상	비 고	
Crude oil carrier	1.70	1.15	0.75		0.60	0.50	0.40	0.30	0.25	Single hull tanker	
	1.85	1.30	0.85		0.70	0.55	0.45	0.35	0.30	Double hull tanker	
Product carriers & Chemical carriers	2.30	1.60	1.05		0.80	0.60	0.55			Black product carrier White product carrier	
Bulk C+arriers	1.60	1.10	0.70		0.60	0.50	0.40	0.30		Chip carrier, Lumber Carrier, Car/bulk, Bulk/container, Open bulk	
Combined carriers	1.60	1.10	0.90		0.75	0.60	0.50	0.40		Ore/bulk/oil	
General Cargo Ships	1.85	1.35	1.00		0.75	0.60	0.50	0.40		Semi—container, Multi—purpose cargo	
Reefers	2.05	1.50	1.25								
Full container ships	1.85	1.20	10,000— 20,000	20,000— 30,000	0.75	0.65					
			0.90	0.80							
Ro—Ro vessels	1.50	1.05	0.80	0.70	0.65						
Car carriers	1.10	0.75	0.65	0.55	0.45						Ro—Ro/Container
L.P.G. carriers	2.05	1.60	1.15	0.90	0.80	0.70					
L.N.G. carriers	2.05	1.60	1.25	1.15	1.00	0.75					

船型(GT) 船種	100- 1,000	1,000- 3,000	3,000- 10,000	10,000- 20,000	20,000- 40,000	40,000- 60,000	60,000 이상	비고
Ferries	3.00	2.25	1.65	1.15	0.90			
Passenger ships	6.00	4.00	3.00	2.00	1.60	1.40	1.25	
Fishing vessels	4.00	3.00	2.00					Fishing vessel & Fish factory ship
Other non-cargo vessels	5.00	3.20	2.00	1.50				Tug & Supply vessel, Dredger, Ice breaker, Cable layer, Research ship, etc

註 : 100GT 이상 선박

Main Terminology

- Unit

- ☑ LT (Long Ton) = 1.016 [ton]
- ☑ SG (Specific Gravity) ➡ [ton/m³]
- ☑ SF (Stowage Factor) ➡ [ft³/LT]
 - e.g., SF = 15 [ft³/LT] ➡ SG = 2.4 [ton/m³]
- ☑ API (American Petroleum Institute) = (141.5 / SG) - 131.5
 - e.g., API 40 ➡ SG = 0.8251 [ton/m³]
 - cf. Actually, SG is density in SI system
- ☑ 1 [knots] = 1 [NM/hr] = 1.852 [km/hr] = 0.5144 [m/sec]
- ☑ 1 [barrel] = 0.159 [m³]
 - e.g., 1 [mil. barrels] = 159,000 [m³]
- ☑ 1 [PS] = 75 [kgf·m/s] = 75×10⁻³ [Mg]·9.81 [m/s²]·[m/s]
= 0.73575 [kW] (Pferdestärke, German translation of horsepower)
 - NMCR of B&W6S60MC: 12,240 [kW] = 16,680 [PS]
- ☑ 1 [BHP] = 76 [kgf·m/s] = 76×10⁻³ [Mg]·9.81 [m/s²]·[m/s]
= 0.74556 [KW] (British horsepower)

Ship Class (1/3)

☒ Class for Storing Ship Information

for storing ship information such as
principal dimensions
for calculating some values by using
principal dimensions of a ship

Ship Class (2/3)

☑ Requirements

- The class can represent principal dimensions (L, B, D, Td, Cb) and miscellaneous information (Cp, Cm, Vs, NCR, Displacement, Deadweight, Lightweight, Volume, Am, etc.) of a ship.
- Define functions for calculating displacement and lightweight of the ship as below.
 - Displacement = Volume * rho_sw
 - Lightweight = Displacement – Deadweight
- Define functions for calculating hull form coefficients (Cb, Cp, Cm, Cwp).
- Define a function for checking a maneuvering problem by using the following criteria.
 - The obesity coefficient should be less than or equal to 0.15.
 - The obesity coefficient = $C_b / (L / B)$
- Constant for calculation
 - rho_sw (seawater density) = 1.025 [ton/m³]

Ship Class (3/3)

☑ Ship: Deadweight 320,000 ton VLCC (Very Large Crude oil Carrier)

☑ Given Data

- $L = 320$ [m], $B = 60$ [m], $D = 30.5$ [m], $T_d = 20$ [m]
- Volume = 321,929 [m³]
- Deadweight = 320,000 ton
- $A_m = 1,197$ [m²], $A_{wp} = 17,560$ [m²]

☑ Find

- Displacement, Lightweight
- Hull form coefficients (C_b , C_p , C_m , C_{wp})
- Obesity coefficient