SECTION 2

FORM COEFFICIENTS

Introduction

Form coefficients are *ratios* that numerically compare the ship's underwater form to that of regular shapes having the same major dimensions as the ship.

They are primarily used at the design stage, prior to construction, to predict factors such as resistance to forward motion that the ship will experience during operation. Such information is then used to estimate the ship's power requirements for the desired service speed.

Block coefficient is a ratio that is considered in the calculation and assignment of a ship's freeboard.

Learning Objectives

On completion of this section the learner will achieve the following:

1. Understand the term *Coefficient of fineness of the water-plane area* (C_W).
2. Understand the term *Block coefficient* (C_B).
3. Understand the term *Midships coefficient* (C_M).
4. Understand the term *Longitudinal prismatic coefficient* (C_P).
5. Complete simple calculations on (1) to (4) above.

2.1 Coefficient of Fineness of the Waterplane Area (C_W)

Is defined as the *ratio of the ship's water-plane area (WPA) to the area of a rectangle having the same length (L) and breadth (B) of the ship at the waterline in question.*

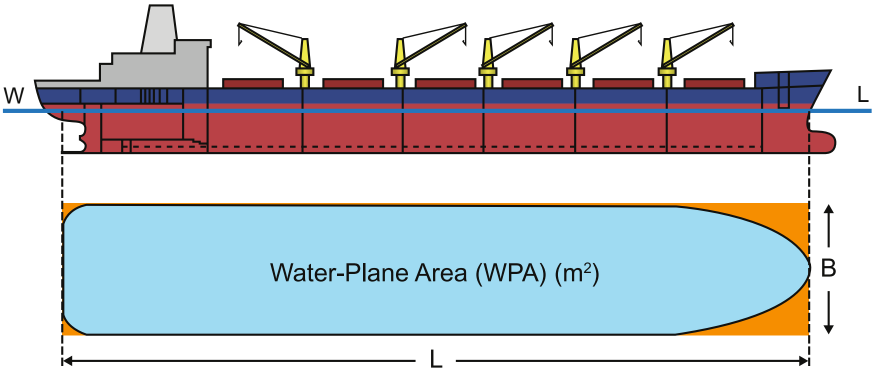

Figure 2.1

$$C_w = \frac{WPA}{L \times B}$$

Since the ship's WPA is less in area than the rectangle formed around it, *the value of C_W must always be less than 1.00.*

Example 1

A ship has a length and breadth at the waterline of 40.1 m and 8.6 m respectively. If the water-plane area is 280 m^2 calculate the coefficient of fineness of the water-plane area (C_W).

Solution

$$C_w = \frac{WPA}{L \times B} = \frac{280}{40.1 \times 8.2} = \mathbf{0.812}$$

Note that the answer has no units; it is simply a comparison of one area to another!

2.2 Block Coefficient (C_B)

The block coefficient (C_B) of a ship is the *ratio of the underwater volume of a ship to the volume of the circumscribing block.*

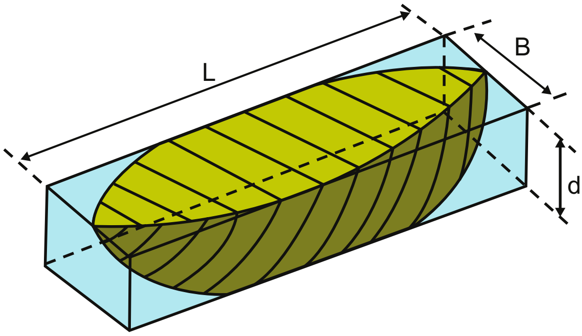

Figure 2.2

$$C_B = \frac{\text{Volume of displacement}}{L \times B \times d}$$

Therefore: $$\text{Displacement}_{\text{Ship}} = (L \times B \times d \times C_B) \times \rho$$

Since the ship's volume of displacement is less than the volume of displacement of the surrounding block, *the value of C_B must always be less than 1.00.*

Example 2

A ship floats at a draught of 3.20 m and has a waterline length and breadth of 46.3 m and 15.5 m respectively. Calculate the block coefficient (C_B) if its volume of displacement is 1800 m^3.

Solution

$$C_B = \frac{\text{Volume of displacement}}{L \times B \times d} = \frac{1800}{46.3 \times 15.5 \times 3.2}$$

$$C_B = \mathbf{0.784}$$

Example 3

A ship has length 200 m and breadth 18 m at the waterline. If the ship floats at an even keel draught of 7.56 m in water RD 1.012 and the block coefficient is 0.824 calculate the displacement.

Solution

$$\text{Displacement} = \text{Volume of displacement} \times \text{Density}$$

$$\therefore \quad \text{Displacement} = (\text{Length} \times \text{Breadth} \times \text{draught} \times C_B) \times \text{Density}$$

$$\therefore \quad \text{Displacement} = (200 \times 18 \times 7.56 \times 0.824) \times 1.012 = \mathbf{22695\ t}$$

2.3 Midships Area Coefficient (C_M)

The midships coefficient (C_M) of a ship at any draught is the ratio of the underwater transverse area of the midships section to the product of the breadth and draught (the surrounding rectangle).

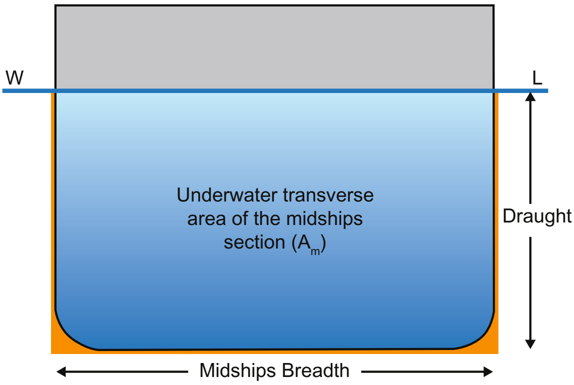

Figure 2.3

$$C_M = \frac{\text{Underwater transverse area of midships section } (A_m)}{\text{Breadth} \times \text{Draught}}$$

$$C_M = \frac{A_m}{B \times d}$$

Similarly, *the value of C_M must always be less than 1.00.*

This coefficient may be used to determine the *prismatic coefficient (C_P).*

Example 4

A ship floats at a draught of 4.40 m and has a waterline breadth of 12.70 m. Calculate the underwater transverse area of the midships section if C_M is 0.922.

Solution

$$C_M = \frac{A_m}{B \times d}$$

$$0.922 = \frac{A_m}{12.70 \times 4.40}$$

$$0.922 = \frac{A_m}{55.88}$$

$$0.922 \times 55.88 = A_m = \mathbf{51.521\ m^2}$$

2.4 Longitudinal Prismatic Coefficient (C_P)

The longitudinal prismatic coefficient (C_P) of a ship at any draught is the *ratio of the underwater volume of the ship to the volume of the prism formed by the product of the transverse area of the midships section and the waterline length.*

$$C_P = \frac{\text{Volume of displacement of ship}}{\text{Volume of prism}}$$

$$C_P = \frac{\text{Volume of displacement of ship}}{\text{Waterline length} \times \text{Area of midship section } (A_m)}$$

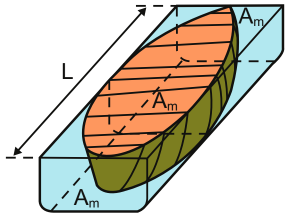

Figure 2.4

This coefficient gives an indication of how much the ship's form changes at the ends. Similarly, *the value of C_P must always be less than 1.00.*

Example 5

A ship has the following details:

Draught 3.63 m;
Waterline length 48.38 m;
Waterline breadth 9.42 m;
C_M 0.946;
C_P 0.778.

Calculate the volume of displacement.

Solution

The formulae are:

$$C_M = \frac{A_m}{B \times d} \qquad C_P = \frac{\text{Volume of displacement}}{L \times A_m}$$

Starting with:

$$C_M = \frac{A_m}{B \times d} \qquad 0.946 = \frac{A_m}{9.42 \times 3.63}$$

$$A_m = 0.946 \times 9.42 \times 3.63 = 32.348 \text{ m}^2 \quad \text{and;}$$

$$C_P = \frac{\text{Vol. of displacement}}{L \times A_m} \qquad 0.778 = \frac{\text{Vol. of displacement}}{48.38 \times 32.348}$$

Vol. of displacement $= 0.778 \times 48.38 \times 32.348 =$ **1217.6 m³**

It should be noted that for most courses only knowledge of the *Coefficient of fineness of the water-plane area (C_W)* and the *Block coefficient (C_B)* is required.