SHIP FORM COEFFICIENTS

Mohd. Hanif Dewan, Chief Engineer and Maritime Lecturer & Trainer, Bangladesh.
COEFFICIENTS OF FORM

- Coefficients of form are dimensionless numbers that describe hull fineness and overall shape characteristics. The coefficients are ratios of areas or volumes for the actual hull form compared to prisms or rectangles defined by the ship’s length, breadth, and draft.
- Since length and breadth on the waterline as well as draft vary with displacement, coefficients of form also vary with displacement.
- Tabulated coefficients are usually based on the molded breadth and draft at designed displacement. Length between perpendiculars ($L_{bp}$) is most often used, although some designers prefer length on the waterline.
- Coefficients of form can be used to simplify area and volume calculations for stability or strength analyses.
- As hull form approaches that of a rectangular barge, the coefficients approach their maximum value of 1.0.
**BLOCK COEFFICIENT \((C_b)\)**

block coefficient \((C_b)\) is the ratio of the immersed hull volume \((\nabla)\) at a particular draft to that of a rectangular prism of the same length, breadth, and draft as the ship:

\[
C_b = \frac{\nabla}{LBd}
\]

where:

- \(\nabla\) = immersed volume, \([\text{length}^3]\)
- \(B\) = beam, \([\text{length}]\)
- \(d\) = draft, \([\text{length}]\)
- \(L\) = length between perpendiculars, \([\text{length}]\)
<table>
<thead>
<tr>
<th>Ship type block</th>
<th>coefficient $C_B$</th>
<th>Approximate ship speed (in knots)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barge</td>
<td>0.90</td>
<td>5 – 10</td>
</tr>
<tr>
<td>Bulk carrier</td>
<td>0.80 – 0.85</td>
<td>12 – 17</td>
</tr>
<tr>
<td>Tanker</td>
<td>0.80 – 0.85</td>
<td>12 – 16</td>
</tr>
<tr>
<td>General cargo</td>
<td>0.55 – 0.75</td>
<td>13 – 22</td>
</tr>
<tr>
<td>Container ship</td>
<td>0.50 – 0.70</td>
<td>14 – 26</td>
</tr>
<tr>
<td>Ferryboat</td>
<td>0.50 – 0.70</td>
<td>15 – 26</td>
</tr>
</tbody>
</table>
MIDSHIP SECTION COEFFICIENT ($C_m$)
The midship section coefficient ($C_m$) is the ratio of the area of the immersed midship section ($A_m$) at a particular draft to that of a rectangle of the same draft and breadth as the ship:

$$C_m = A_m / B \times d$$

Where,

- $A_m =$ area of the immersed portion of the midships section, [m$^2$]
- $B =$ beam, usually taken at the waterline, [m]
- $d =$ draft, [m]
WATERPLANE AREA COEFFICIENT ($C_w$)

The waterplane area coefficient ($C_w$) is the waterplane area divided by the length x the breadth.

So,

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

Where,

- $C_w$ = Waterplane Area (m²)
- $L$ = Length (m)
- $B$ = Breadth (m)
THE PRISMATIC COEFFICIENT \( (C_p) \)
The prismatic coefficient \( (C_p) \) is the underwater area, divided by the area of a midship section, times the length of the ship. It is an indication of hull fineness, and may be broken down into fore & aft components. This formula can be written as
\[
C_p = \frac{\nabla}{A_m} \times L
\]

where,
\[
\nabla = \text{immersed volume, [m}^3]\]
\[
A_m = \text{area of the immersed portion of the midships section, [m}^2]\]
\[
L = \text{length between perpendiculars, [m]}
\]
We Know,
\[ \nabla = C_b \times L \times B \times d \quad \text{and} \quad A_m = C_m \times B \times d \]

Now,
\[ C_p = \frac{\nabla}{A_m L} \]

So,
\[ C_p = \frac{C_b \times L \times B \times d}{C_m \times B \times d \times L} \]

\[ C_p = \frac{C_b}{C_m} \]
Some typical values are presented in the table below:

<table>
<thead>
<tr>
<th>Type of vessel</th>
<th>Block coefficient</th>
<th>Prismatic coefficient</th>
<th>Midship area coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude oil carrier</td>
<td>0.82–0.86</td>
<td>0.82–0.90</td>
<td>0.98–0.99</td>
</tr>
<tr>
<td>Product carrier</td>
<td>0.78–0.83</td>
<td>0.80–0.85</td>
<td>0.96–0.98</td>
</tr>
<tr>
<td>Dry bulk carrier</td>
<td>0.75–0.84</td>
<td>0.76–0.85</td>
<td>0.97–0.98</td>
</tr>
<tr>
<td>Cargo ship</td>
<td>0.60–0.75</td>
<td>0.61–0.76</td>
<td>0.97–0.98</td>
</tr>
<tr>
<td>Passenger ship</td>
<td>0.58–0.62</td>
<td>0.60–0.67</td>
<td>0.90–0.95</td>
</tr>
<tr>
<td>Container ship</td>
<td>0.60–0.64</td>
<td>0.60–0.68</td>
<td>0.97–0.98</td>
</tr>
<tr>
<td>Ferries</td>
<td>0.55–0.60</td>
<td>0.62–0.68</td>
<td>0.90–0.95</td>
</tr>
<tr>
<td>Frigate</td>
<td>0.45–0.48</td>
<td>0.60–0.64</td>
<td>0.75–0.78</td>
</tr>
<tr>
<td>Tug</td>
<td>0.54–0.58</td>
<td>0.62–0.64</td>
<td>0.90–0.92</td>
</tr>
<tr>
<td>Yacht</td>
<td>0.15–0.20</td>
<td>0.50–0.54</td>
<td>0.30–0.35</td>
</tr>
</tbody>
</table>
Let us solve some tutorial questions!