

Chapter 3

The Cargo Module

3.1 Overview

In all previous optimization approaches to containership design [1], [2], [3]; the carrying capacity (number of containers) is fixed during the design process. The number of containers a ship can carry is a function of the principal dimensions and the block coefficient of the ship. As these dimensions change during the optimization process, so do the number of containers.

The cargo module calculates the number of containers that can be stowed in the holds and on deck by employing stowage factors on the total available hold volume and the surface area on deck respectively. It then calculates the vertical center of gravity of the cargo.

The number of rows and columns of containers in a hold is an integer value. This makes the carrying capacity (number of containers) and hence the objective function discontinuous functions of the principal dimensions. This problem has been solved by using a linear response surface fit to the number of TEUs (Twenty-foot Equivalent Units) below and above deck.

3.2 TEUs below deck

We discretize the space available for container stowage in the lengthwise, beamwise and the depthwise directions. The product of the number of TEUs in each direction and a “Stowage factor” gives us the total number of containers that can be stowed.

$$TEU_{bd} = \left[\frac{Loa}{1.05 \times 6.1} \right] \times \left[\frac{B - (2 \times DBH)}{2.44} \right] \times \left[\frac{D - DBH}{2.44} \right] \times STW_{bd} \quad (3.1)$$

Where

- $\frac{Loa}{1.05}$ = The approximation for the length between perpendiculars (Lbp) that has been followed throughout this work.
- 6.1 = Length of a TEU in meters, equivalent to twenty feet.
- 2.44 = Width and the depth of a TEU in meters, equivalent to eight feet.
- DBH = Double bottom height is defined by the user. In this work, it is defined as 1.83 meters.
- TEU_{bd} = Number of TEUs below deck.
- STW_{bd} = Stowage factor for TEUs below deck averaged from data on twelve ships as shown in Table 3.1 on page .
- The expressions within the brackets indicate that the terms within are truncated to integer values.

The stowage factor accounts for the geometry of the hull form and the space available for container stowage after accounting for the space occupied by the container cell guides. We found that the number of containers below deck shows a dependence on the block coefficient when it is calculated by employing the stowage factor on the total available hull volume. The dependence has been accurately represented by expressing the stowage factor explicitly as a function of the block coefficient.

Division of the actual number of TEUs (TEUbd, actual as shown in Table 3.1) by the number of TEUs given by (3.1), denoted as TEUbd(3.1) in Figure 3.1, which is a function of the principal dimensions, would remove the dependence of the TEUs on the principal dimensions. Fig. 3.1 shows this ratio plotted against the block coefficient. The positive slope indicates the dependence of the number of TEUs on the block coefficient.

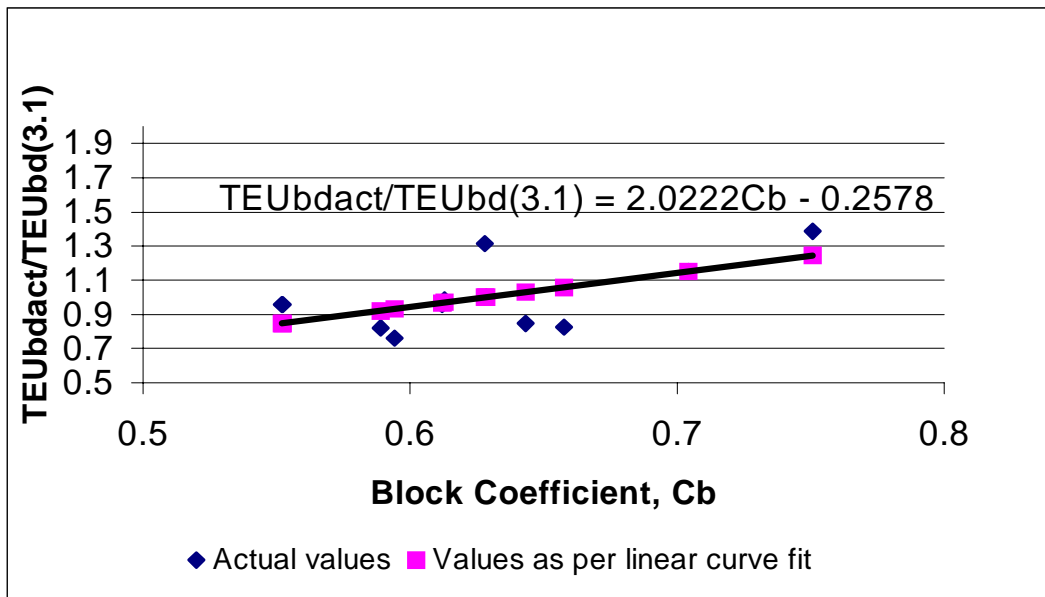


Fig.3.1: Dependence of TEUs below deck on Cb indicated by slope

To eliminate the slope we express the stowage factor as a function of Cb through a least squares fit using the twelve points in Table 3.1 as shown in Fig.3.2. The resulting equation is:

$$STWbd = (0.8479 \times Cb) - 0.0918 \quad (3.2)$$

Substituting (3.2) in (3.1) gives:

$$TEUbd_i = \left[\frac{Loa}{1.05 \times 6.1} \right] \times \left[\frac{B - (2 \times DBH)}{2.44} \right] \times \left[\frac{D - DBH}{2.44} \right] \times (0.8479 \times Cb - 0.0918) \quad (3.3)$$

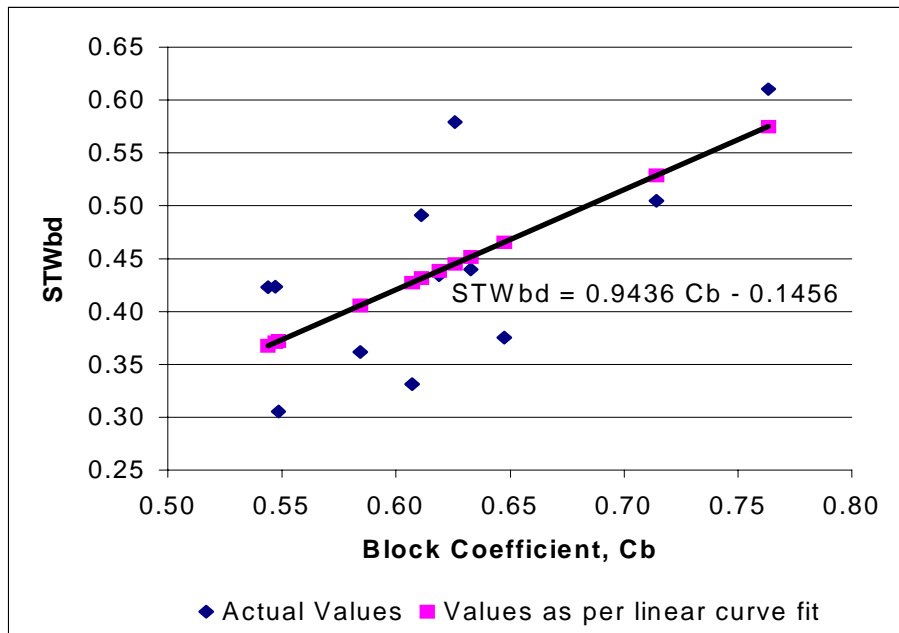


Figure 3.2: Expressing stowage factor below deck as a function of C_b

To verify that the dependence of the number of TEUs on the block coefficient has been accurately represented, we plot the ratio of the actual number of TEUs to the number of TEUs given by (3.3). Ideally the slope should be zero. Fig. 3.3 shows that the slope induced by C_b has been reduced significantly.

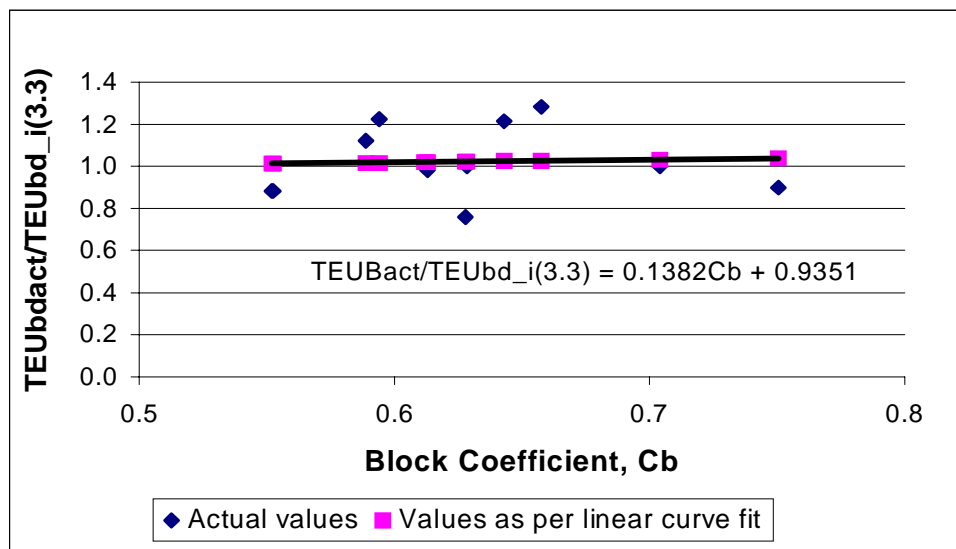


Figure 3.3: Reduction of slope induced by C_b on TEUs below deck