4.5 – Trapezoidal Loading Equation

The magnitude of the load per foot on the keel line can be calculated by two equations. These two equations cover half of the keel line. Using the “Center of the Blocks” as the dividing line, the governing equations are as shown below:

At the end of the keel line closest to the LCG:

Load per Foot = \( \frac{W}{L_{\text{keel}}} + 6 \times \frac{W \times e}{(L_{\text{keel}})^2} \)

At the end of the keel line farthest from the LCG:

Load per Foot = \( \frac{W}{L_{\text{keel}}} - 6 \times \frac{W \times e}{(L_{\text{keel}})^2} \)

Where:

- \( W \) = Ship Weight in Long Tons
- \( L_{\text{keel}} \) = Keel bearing length (distance from first keel block to last keel block)
- \( e \) = Distance from centerline of keel bearing length to vessel LCG (See Figure 4.10)

This analysis is called the “Trapezoidal Load Distribution” and can be used for most typical dockings to determine the load on the blocks and dry dock and to develop pumping plans for floating dry docks.
Trapezoidal Load Distribution is derived from eccentrically loaded column formula:

\[ \frac{P}{A} \pm \frac{Mc}{I} \]

The analysis assumes the ship is infinitely stiff and the blocks are all of uniform size, materials, and spacing. It also assumes that 100 percent of the load goes into the keel blocks.

**These equations are not valid if:**

- The longitudinal strength of the ship is impaired due to damage or cutting.
- The blocks are not all constructed similarly.
- The block spacing is not uniform.
- The bearing area varies on top of the block (bar keel at one end, etc.)
- The vessel over hangs the keel blocks by more than twice its molded depth.
- The ship has a large initial hog or sag and the keel line is built straight.
- A floating dock is not dewatered according to the trapezoidal results.

The load on any one block is equal to the portion of the trapezoidal load directly over that block (from centerline of the gap between blocks aft to centerline of the gap between blocks forward). See figure below.

**FIGURE 4.11**
EXAMPLE – TRAPEZOIDAL LOADING

Given:

- \( W = 3000 \text{ LT} \)
- LCG = 185’ FWD of SRP
- Distance between SRP and aft face of first keel block = 65’
- \( L_{\text{keel}} = 250’ \)

Determine “e”:
- \( e = (250’/2 + 65’) - 185’ = 5’ \)

Calculate Loads:

\[
\text{Load (LT/Ft)} = \frac{W}{L} +/-(6 \times W \times e) / L_{\text{keel}}^2
\]

At the end closest the LCG (In this case it is the AFT portion of the Keel Line):

- Load = \( 3000 \text{ LT} / 250’ + (6 \times 3000 \text{ LT} \times 5’) / 250’^2 \)
- Load = 12 + 1.44 = 13.44 LT / Ft. Aft

At the end farthest from the LCG (In this case it is the FWD portion of the keel line):

- Load = \( 3000 \text{ LT} / 250’ - (6 \times 3000 \text{ LT} \times 5’) / 250’^2 \)
- Load = 12 – 1.44 = 10.56 LT / Ft. Fwd.