Weight Estimation

In this document, we explain the empirical formulae behind the excel sheet as an approach for weight estimation. An example is provided to explain step by step the weight estimation procedure.

Example

Estimate the lightship weight of a bulk carrier, L=153 m, B=25.6 m, T=8 m, D=13 m, and $c_B = 0.84$ The required deadweight is 25,000 tonnes. The following characteristics have been estimated:

- Main machinery characteristics: a diesel engine of a maximum continuous rate=6000 KW, and RPM=103.
- The length and the height of the superstructure are 20 m and 7 m respectively.
- The length and the height of the deckhouse are 7 m and 5 m respectively.
- The longitudinal center of buoyancy is 1% of the length abaft amidships.
- The double bottom height and the height of the engine room are 0.7 m and 5 m respectively.

• Solution Procedure:

As the three main divisions of the lightship weight are the structural weight, the machinery weight, and the outfitting weight; we will calculate each of these items separately.

1. Firstly, the structural weight is estimated using a formula based on Watson and Gilfillan approach:

$$W_S = KE^{1.36}[1+0.5(C_B-0.7)]$$

$$E = E_{hull} + E_{SS} + E_{dh} = L(B+T) + 0.85L(D-T) + 0.85\sum_i {}_i h_i + 0.75\sum_j {}_j h_j$$

Where C_B is the block coefficient at 80% of the depth. The factor K varies with the ship type and is shown in the follwing table. E is the equipment number; the third and the fourth terms related to the superstrcuture and the deckhouse dimensions respectively.

Ship type	*K mean*	*K range*	*Range of E*
Tankers	0.032	±0.003	1500 < E < 40 000
Chemical tankers	0.036	±0.001	1900 < E < 2500
Bulk carriers	0.031	±0.002	3000 < E < 15 000
Container ships	0.036	±0.003	6000 < E < 13 000
Cargo	0.033	±0.004	2000 < E < 7000
Refrigerator ships	0.034	±0.002	4000 < E < 6000
Coasters	0.030	±0.002	1000 < E < 2000
Offshore supply	0.045	±0.005	800 < E < 1300
Tugs	0.044	±0.002	350 < E < 450
Fishing trawlers	0.041	±0.001	250 < E < 1300
Research vessels	0.045	±0.002	1350 < E < 1500
RO-RO ferries	0.031	±0.006	2000 < E < 5000
Passenger ships	0.038	±0.001	5000 < E < 15 000
Frigates/corvettes	0.023		

Based on the main dimensions, the superstructure dimensions and the deckhouse dimensions, the equipment number is given as follows:

$$E = 153(25.6+8) + 0.85\times 153(13-8) + 0.85(20\times 7) + 0.75(7\times 5) = 5936.3$$

Let us take the mean value of the K factor, the steel weight of the vessel is then equal to:

$$W_S = 0.031\times(5936.3)^{1.36}[1+0.5(C_B-0.7)] = 4495 \text{ tonnes.}$$

2. Secondly, the machinery weight which is divided into main machinery weight and remainder weight. Following Watson and Gilfillan approach the main machinery weight is estimated based on the following formula:

$$W_{ME} = \sum_i 12(MCR_i / N_{ei})^{0.84}$$

Where i is the index of multiple engines each of a maximum continuous rate MCR_i and rpm N_{ei}.

$$W_{ME} = 12(6000/103)^{0.84} = 364.8 \text{ tonnes}$$

The remainder weight varies with the total plant maximum continous rate as follows:

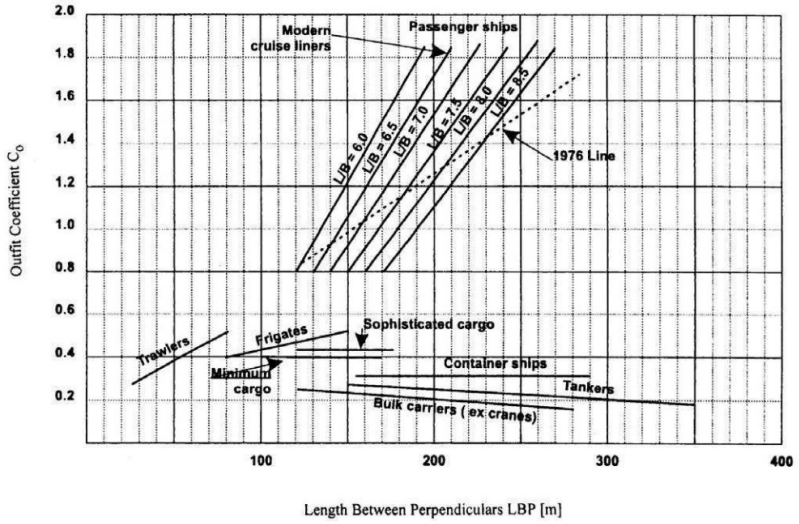
$$W_{rem} = c_m(MCR)^{0.7} = 0.69(6000)^{0.7} = 304.5 \text{ tonnes}$$

Cm=0.69 for bulk carriers.

3. Thirdly, the outfitting weight is estimated using the following formula:

$$W_o = C_0 LB$$

Where C_o is the outfitting weight coefficient is a function of the ship type and length and its values can be obtained from the following graph:



Then $W_o = 0.22 \times 153 \times 25.6 = 861.7$ tonnes.

4. Finally, the center of gravity is estimated based on the following:
   - The VCG of the basic hull can be estimated using an equation proposed by Kupras:
     $VCG_{hull} = 0.01D[46.6 + 0.135(0.81 - C_B)(L/D)^2]$ for $L > 120m$
     $VCG_{hull} = 5.99$ m
   - The vertical center of gravity of machinery is given as a function of the inner bottom height h_{db} and the height of the over-head of the engine room D' by Kupras:
     $$VCG_M = h_{db} + 0.35(D' - h_{db}) = 2.21 \text{ m}$$
   - The outfitting vertical center of gravity is proposed by Kupras:
     VCG_o = D+1.25+0.01(L-125) 125<L ≤ 250 m
     = 14.53 m
5. The lightship weight and its vertical center of gravity are obtained as follows:
   $$W_{light} = W_s + W_{ME} + W_{rem} + W_o = 6026 \text{ tonnes}$$
   $$VCG_{light} = \frac{Ws \times VCG_s + W_M \times VCG_M + W_o \times VCG_o}{W_{Light}} = 6.79 \text{ m}$$