Formulación para el modelo matemático del plan de estiba

$$Fn = VB.\frac{0{,}5144}{(9{,}8\cdot L)^{0.5}} \qquad \text{(ec. 67)}$$

$$\text{CP} = 8.0606 \times Fn^2 - 5.6199 \times Fn + 1.517 \qquad \text{si} \qquad \text{Fn} \leq 0{,}35$$

$$\text{CM} = 1 - 0{,}0622\ Fn^{0{,}792} \text{ (Fórmula de M. Meizoso)}$$

$$CB = \frac{0{,}14}{Fn} \cdot \frac{{}^{Lpp}/_{B}+20}{26} \qquad \text{(Fórmula de Schneekluth)}$$

$$CB = CM \times CP \quad \text{(ec. 71)}$$

Variables dimensionales

$$\nabla = \text{CB} \cdot \text{L} \cdot \text{B} \cdot \text{T}$$

$$PB = 0{,}0114\ \cdot VB^3\ \cdot TPM^{0{,}55}$$

$$\text{HDF}_1 \geq \frac{3 \cdot (B + T + 10)}{100}$$

$$\Delta = 1{,}025 \cdot \nabla$$

Cálculo del Peso en rosca, PR

$$PR = P_{acero} + P_{eqipo} + P_{maquinaria}$$

$$P_{acero} = 0{,}01665 {L_{pp}}^{1{,}5} \cdot B \cdot D^{0{,}5} \cdot\ (1 + CB)$$

(Fórmula García Garcés para portacontenedores con $70 < L_{pp} < 170$ m)

$$P_{equipo} = 0{,}33 \cdot L \cdot B$$

$$P_{maquinaria} = P_{motor} + P_{rmp} + P_{oecm} + P_{le}$$

$$P_{motor} = \begin{Bmatrix} 2{,}5 + 9{,}5\left({}^{MCO}/_{N}\right)^{0{,}91}\ para\ motor\ de\ 4T\ en\ línea + reductor \\ 6 + 6{,}9\left({}^{MCO}/_{N}\right)^{0{,}96}\ para\ motores\ de\ 4T\ en\ V + reductor \end{Bmatrix}$$

$$P_{rmp} = 0{,}63 \cdot MCO^{0{,}7}$$

$$P_{oecm} = 0{,}03 \cdot V_{cm}$$

$$V_{cm} = 0{,}85 L_{cc} \cdot B(D - HDF1) \cdot CB$$

$$P_{le} = Kne \cdot l_{eje}\left(5 + 0{,}0164 L_{pp}\right) \quad se\ supone\ Kne = 1\ (una\ sola\ línea\ de\ eje)$$

Cálculo del arqueo

$$GT = (0{,}2 + 0{,}02 \log(VC + Vol)) \cdot (VC + Vol)$$

$$VC = L_{pp} \cdot B \cdot D \cdot CBD$$

$$CBD = CB + 0{,}35\frac{D-T}{T}(1-CB)$$

$$\text{Vol}=\sum_{i=1}^{6}\text{Vol}_i$$

$$Vol1 = Vol_{toldilla} + habilitación = 9{,}1B \cdot ET2$$

$$Vol2 = Vol_{castillo} = 2\ lmpp \cdot B$$

$$Vol3 = Vol_{guardacalor} = 1000$$

$$Vol4 = Vol_{puente} = 350$$

$$Vol5 = Vol_{escotillas} = 0{,}85(L - ET2) \cdot B$$

$$Vol6 = Vol_{brusca} = 0{,}012\ L \cdot B^2$$

$$Coef = -1{,}3975 \cdot Fn + 1{,}4339$$

$$PB = 0{,}0114 \cdot \text{VB}^3 \cdot \Delta^{0{,}55} \cdot Coef$$

$$\text{TPM} = \Delta \text{ - PR}$$

$$L_{cc} = \begin{cases} -8 \cdot 10^{-10} \cdot PB^2 + 0{,}0002 \cdot PB + 18{,}705 & si\ PB \leq 120.000\ kW \\ 32 & si\ PB\ > 120.000\ kW \end{cases}$$

Cálculo del francobordo

$$\text{FB} = (\text{D-T}) \cdot 1000 > \text{FBM}$$

$$\text{FBM} = (\text{FBT} + C_1)\cdot C_2 + C_3 \text{ - } C_4 + C_5\ (\text{mm})$$

$$FBT = \begin{cases} e^{(-2.053+28.61/\text{L}+1.936\times\ln(\text{L}))} & si\ 50\ \leq L\ \leq 100 \\ e^{(-2.55-0.0061\text{L}+2.2378\times\ln(\text{L}))} & si\ 100\ \leq L\ \leq 150 \\ e^{(9.123-\frac{206.75}{L}+0.000419\times ln(L))} & si\ 150\ \leq L\ \leq 250 \end{cases}$$

(Alvariño Castro, 1997)

$$C_1 = 7{,}5\ (100 - L)\left(0{,}35 - {}^{ET}/_{L}\right) \qquad si\ L < 100\ m\ o\ ET < 0{,}35L$$

$$C_2 = \begin{cases} 1 & si\ CB\ \leq 0{,}68 \\ \dfrac{1.01 \times CB85D + 0.68}{1.36} & si\ CB\ > 0{,}68 \end{cases}$$

$$CB85D = 1{,}01CB$$

$$C_3 = \begin{cases} 0 & si\ D \leq \dfrac{\text{L}}{15} \\ \left(D - \dfrac{\text{L}}{15}\right) \cdot \text{R} & \text{si D} > \dfrac{\text{L}}{15} \end{cases}$$

donde

$$R = \begin{cases} \dfrac{L}{0{,}48} & si\ L < 120 \\ 250 & si\ L \geq 120 \end{cases}$$

$$C_4 = \mathrm{DE} \cdot \frac{\mathrm{POR}}{100}$$

$$DE = \begin{cases} 8.36 \cdot L + 149 & si\ 24 < L < 85 \\ 5.675 \cdot L + 378 & si\ 85 \leq L < 122 \\ 1070 & si\ L \geq 122 \end{cases}$$

$$\mathrm{POR}=0{,}26 + 58{,}9 \cdot \left(\frac{\mathrm{ET}}{\mathrm{L}}\right) + 42{,}9 \cdot \left(\frac{\mathrm{ET}}{\mathrm{L}}\right)^2$$

$$\mathrm{ET}=\mathrm{ET}_1+\mathrm{ET}_2$$

$$ET_1 = \begin{cases} -0{,}0065L^2 + 1{,}759L - 104{,}95\ \ si\ L \geq 100\ m \\ lmpp + 1\ \ si\ L < 100\ m \end{cases}$$

$$ET_2 = -0{,}0036L^2 + 1{,}0264L - 52{,}392$$

$$C_5 = \left(1 - \frac{50}{100}\right)(4{,}168L + 125)\left(0{,}75 - \frac{ET}{2L}\right)$$

$$BDCC = \begin{cases} 1{,}5 & si\ \ 0{,}1 \times B > 0{,}75 \\ 0{,}75 & si\ \ 0{,}1 \times B < 0{,}75 \end{cases}$$

Variables para el cálculo de slots

$$HSE = 0.22 \cdot L_{pp} + 0.28 \cdot D^{1.56} - 0.02 \cdot L_{pp}^{0.806} \cdot D^{1.1}$$

$$\theta = \tan^{-1}\left(\frac{(D-T)+HSE}{L - ET2 + 2 \cdot L}\right) = \tan^{-1}\left(\frac{(D-T)+HSE}{3 \cdot L - ET2}\right)$$

$$\mathrm{NCL_p}= \begin{cases} \mathrm{E}\left(\frac{\mathrm{L\text{-}lcc\text{-}ET1\text{-}(LG \cdot NG)}}{\mathrm{FCC}+\mathrm{DC_{1,p}}}\right) & \text{si} \quad \mathrm{MG_g}=\mathrm{MG_1} \\ E\left(\frac{\mathrm{L\text{-}lcc\text{-}ET1}}{\mathrm{DC_{1,p}}}\right) & \text{si} \quad \mathrm{MG_g}\neq\mathrm{MG_1} \end{cases}$$

$$\mathrm{NBCM} = ENTERO\left(\frac{lcc - ET2}{DC_{1p}}\right)$$

$$\mathrm{NBCAS} = ENTERO\left(\frac{ET1}{DC_{1p}}\right)$$

BSC = NCLp +NBCM + NBCAS