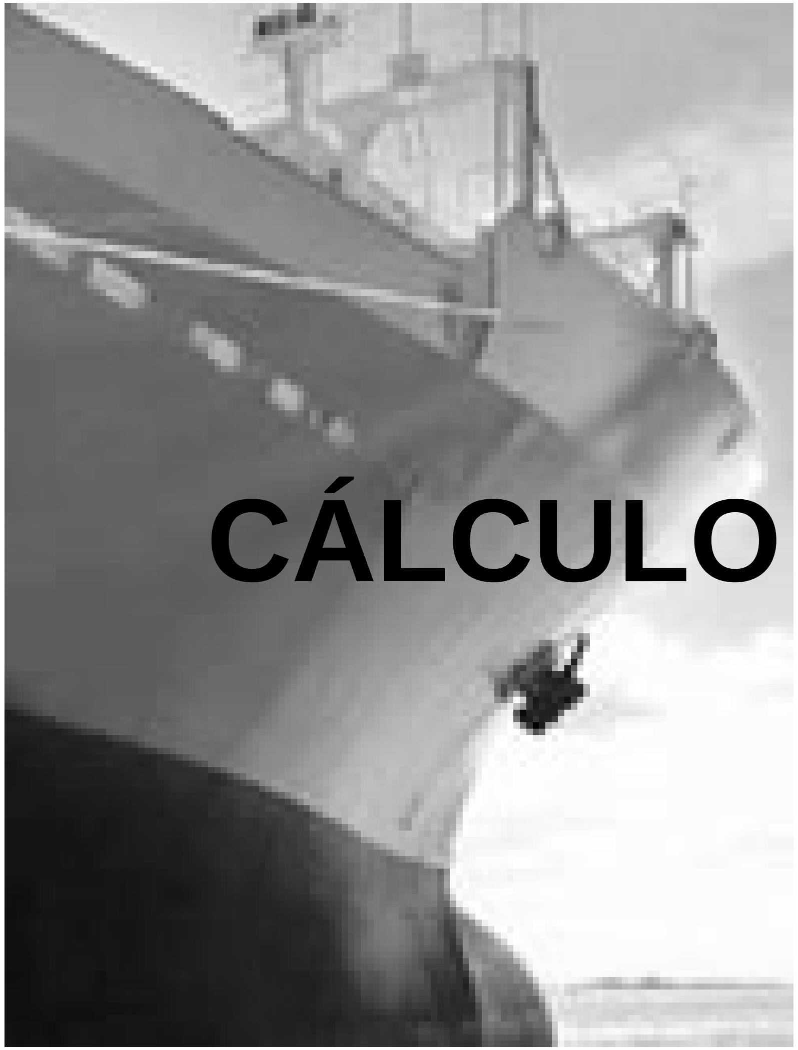


CÁLCULO DE DEFENSAS

Objetivos del uso de Defensas

- Proteger las estructuras de transferencia
- Absorber la energía de atraque
- Proteger a la nave de daños en el casco

Tipos de Defensa

<u>Bridgentone:</u>

- Cell Fender
- M Fender
- Arch Fender
- Cilindrical Fender
- Super Pot Fender
- Turtle Fender
- Seal Fender
- Corner Fender
- Cell Fender For Roll-On Roll Off Berth

Tipos de Defensa (Continuación)

<u>Fentek</u>

- **Super Cone Fenders**
- **Unit Element Fenders**
- **Parallel Motion Fenders**
- **Arch Fender**
- **Cilindrical Fender**
- **Pneumatic Fenders**
- **Foam FendersDonut Fender**
- **Shear Fender**
- **Whell Fenders**
- **Roller Fenders**

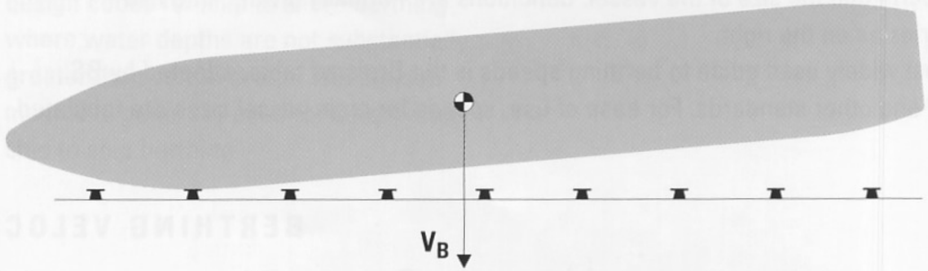
Diseño-Factores

- Peso del Barco
- Efectos del Agua Circundante
- Velocidad de Atraque
- Excentricidad y Punto de Atraque
- Efectos Angulares
- Limitaciones de tipo de atraque
- Limitaciones de los tipos de barco
- Limitaciones bajo condiciones naturales

Energía de Atraque

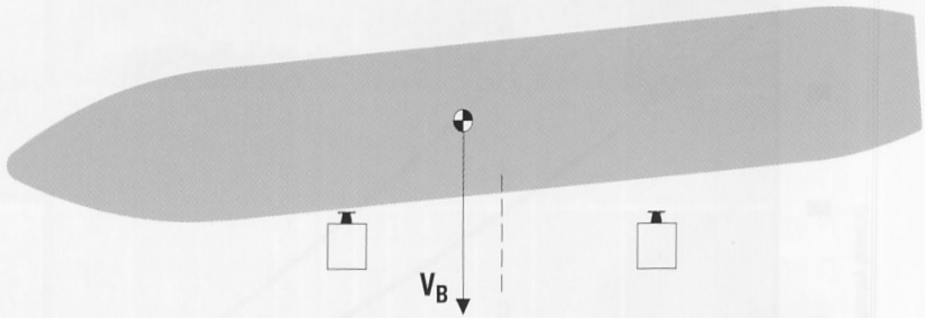
SIDE BERTHING

This is the most common method of approach along continuous quays. Berthing speeds are typically in the range of 150-300mm/s and berthing angles in the region of 5-15°, depending on ship size and berth



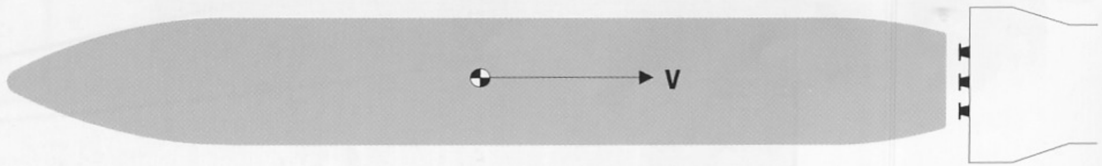
DOLPHIN BERTHING

Dolphins are common on oil and bulk berths. Vessels are usually tug assisted during their approach. Berthing speeds are fairly well controlled and typically in the range of 100-250mm/s. Berthing angles are normally in the region of 5-15°.



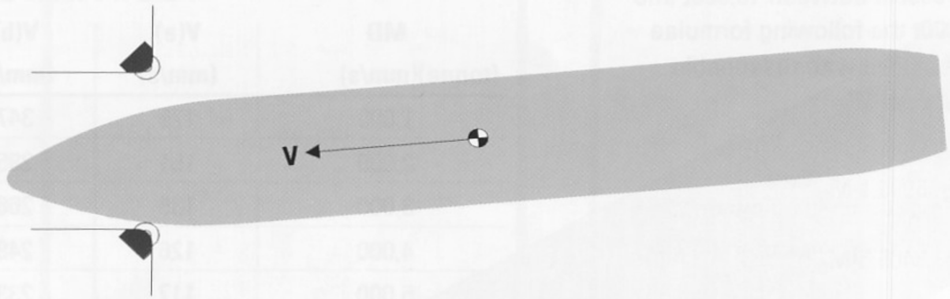
END BERTHING

End berthing is normally restricted to RoRo vessels and similar ships with stern or bow doors for unloading vehicles. End fenders are infrequently used, but when they are the berthing speeds tend to be high – typically 200-500mm/s.



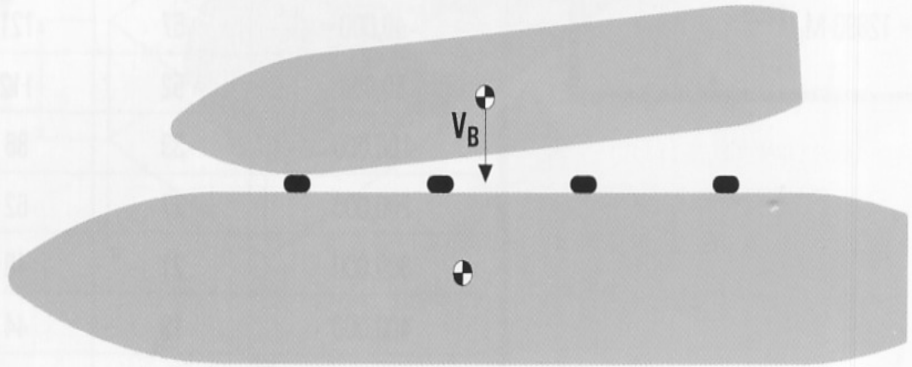
LOCK ENTRANCES

Vessels tend to approach lock entrances and similar restricted channels at fairly high forward speeds to maintain steerage – typically 0.5-2.0m/s. Transverse velocity and berthing angles tend to be fairly small. The forward motion can generate large shear on the fenders.



SHIP-TO-SHIP BERTHING

Ship-to-ship berthing commonly occurs in exposed, open waters. If both vessels are moving forward at the time of berthing, a venturi effect can cause the two ships to be pulled together very rapidly during the final stages of berthing. Typical relative transverse velocities are 150-300mm/s at angles of 5-15°.



Desplazamiento total cargado = FLD =Md =

= LW (peso de la nave)+ DW (peso de la carga)

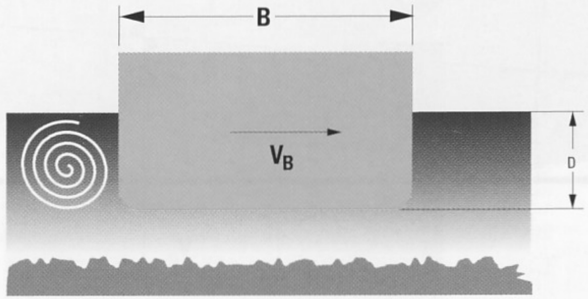
Efectos del Agua Entorno al Barco

- Cuando la nave es detenida por la defensa , el momentum del agua circundante al barco continua presionando al barco contra la estructura de atraque, lo que efectivamente puede considerarse una masa extra de agua.

VASCO COSTA METHOD ▶

$$C_M = 1 + \frac{2 \cdot D}{B}$$

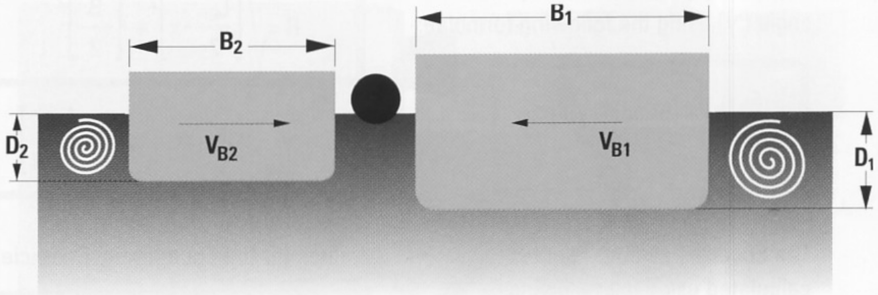
where,
D = Draft (m)
B = Beam (m)



STELSON METHOD ▶

$$C_M = 1 + \frac{\pi \cdot D^2 \cdot L_{BP} \cdot \rho_{SW}}{4 \cdot M_D}$$

where,
D = Draft (m)
L_{BP} = Length between perpendiculars (m)
ρ_{SW} = Seawater density = 1.025t/m^3
M_D = Displacement of vessel (t)
Note that C_M should be calculated for both vessels.



Coeficiente de Bloque

$$C_B = \frac{M_D}{L_{BP} \cdot B \cdot D \cdot \rho_{SW}}$$

where,

M_D = Displacement of vessel (t)

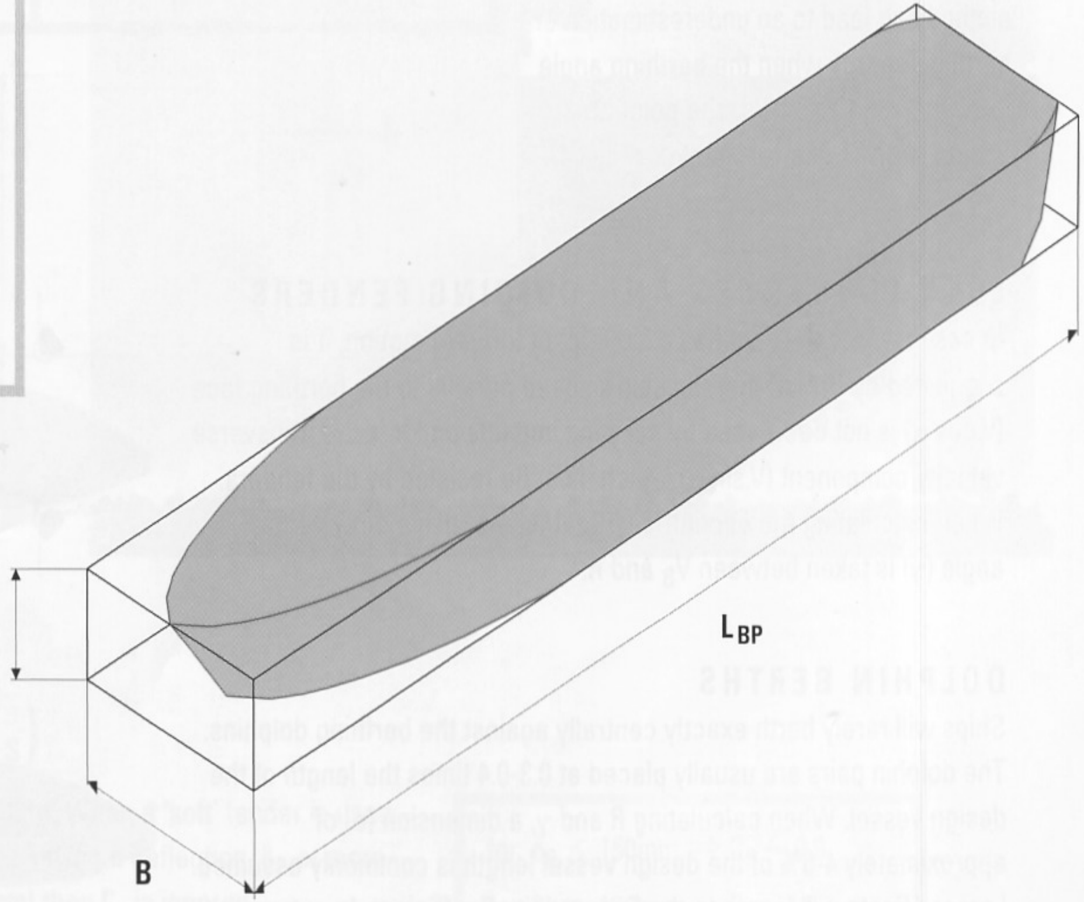
L_{BP} = Length between perpendiculars (m)

B = Beam (m)

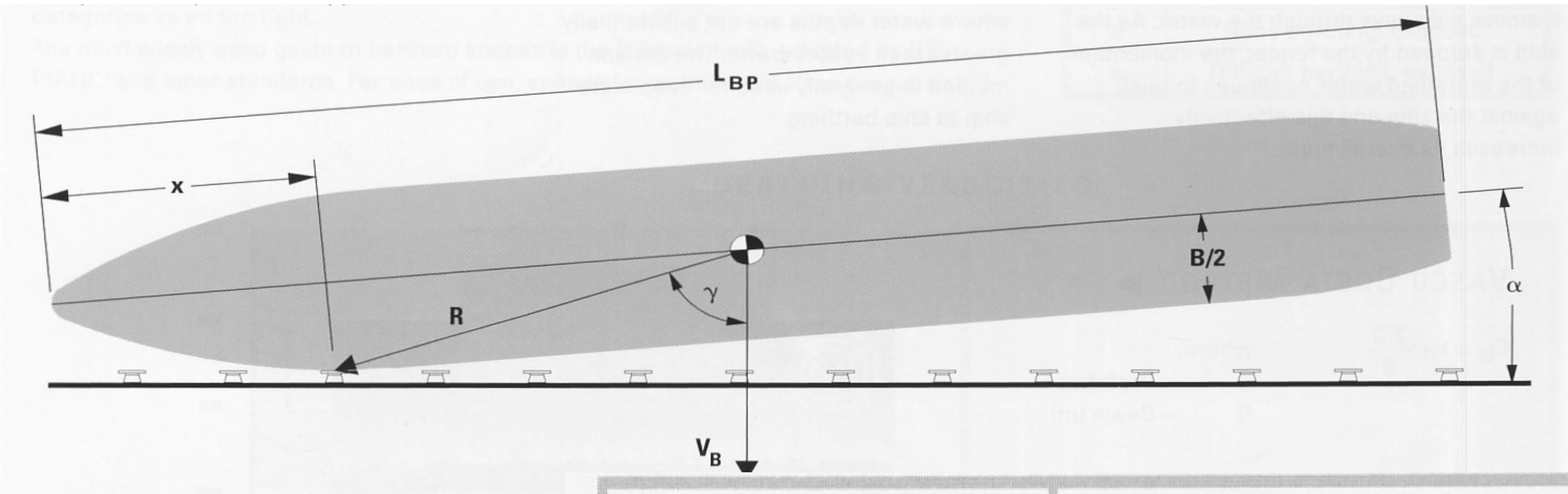
ρ_{SW} = Seawater density = 1.025t/m^3

Typical Block Coefficients (C_B)	
Tankers & Bulk Carriers	0.72-0.85
Container Ships	0.65-0.75
RoRo Vessels	0.65-0.75
Passenger Ships	0.65-0.75
General Cargo Ships	0.60-0.65

Note that if length, beam and draft are known, the table can be used to estimate displacement.



Coeficiente de Excentricidad



$$C_E = \frac{K^2 + (R^2 \cdot \cos^2(\gamma))}{K^2 + R^2}$$

$$K = [(0.19 \cdot C_B) + 0.11] \cdot L_{BP}$$

$$R = \sqrt{\left[\frac{L_{BP}}{2} - x\right]^2 + \left[\frac{B}{2}\right]^2}$$

$$\gamma = 90° - \alpha - a\sin\left[\frac{B}{2 \cdot R}\right]$$

where,

C_B = Block coefficient

L_{BP} = Length between perpendiculars (m)

x = Distance from bow to point of impact

B = Beam (m)

α = Berthing angle

- …formula simplificada para el coeficiente de excentricidad

$$C_E \approx \frac{K^2}{K^2 + R^2}$$

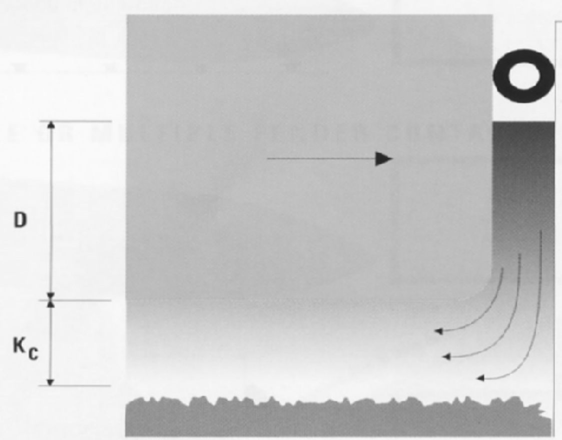
K=Radio de giro

R=Distancia del centro de masa del barco al punto de impacto

$\gamma =$ ángulo del vector velocidad

Quarter-point berthing	$x = \frac{L_{BP}}{4}$	$C_E \approx 0.4\sim0.6$
Third-point berthing	$x = \frac{L_{BP}}{3}$	$C_E \approx 0.6\sim0.8$
Mid-ships berthing	$x = \frac{L_{BP}}{2}$	$C_E \approx 1.0$

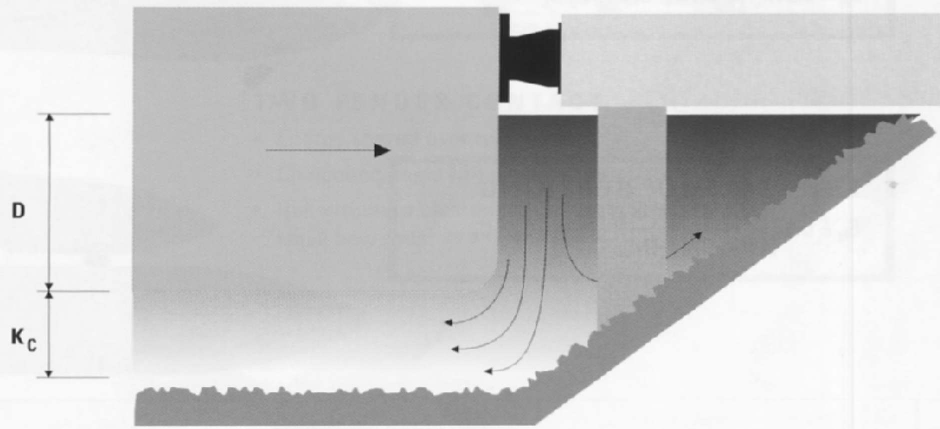
COEFICIENTE DE CONFIGUACIÓN DEL ATRAQUE



CLOSED STRUCTURES

$$\text{for } \frac{K_C}{D} \leq 0.5 \Rightarrow C_C \approx 0.8$$

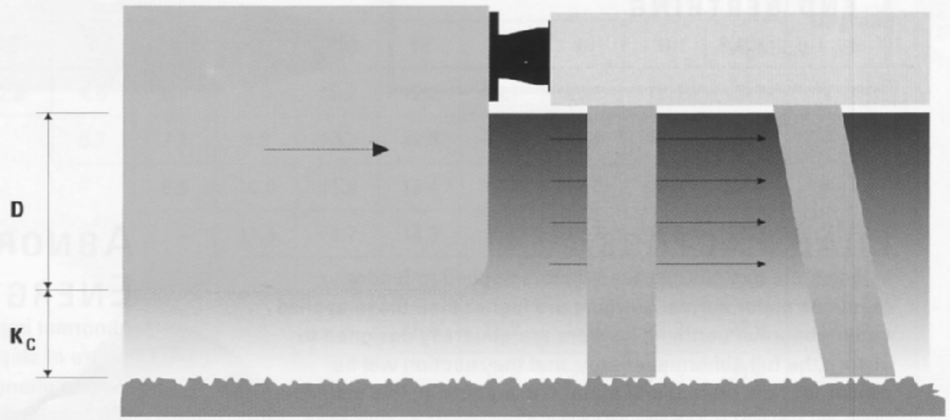
$$\text{for } \frac{K_C}{D} > 0.5 \Rightarrow C_C \approx 0.9$$



SEMI-CLOSED STRUCTURES

$$\text{for } \frac{K_C}{D} \leq 0.5 \Rightarrow C_C \approx 0.9$$

$$\text{for } \frac{K_C}{D} > 0.5 \Rightarrow C_C = 1.0$$



OPEN STRUCTURES ▶

$C_C = 1.0$

where,

K_C = Under keel clearance (m)

D = Draft (m)

Coeficiente deformación de la Defensa

$$\text{for } \delta_F \leq 150\text{mm} \Rightarrow C_S \approx 0.9$$

$$\text{for } \delta_F > 150\text{mm} \Rightarrow C_S = 1.0$$

δf es la deformación de la defensa. 150 mm es el límite ‘soft fender’. Medida de la deformación elastica del casco de la nave.

Energia de Atraque

SIDE BERTHING

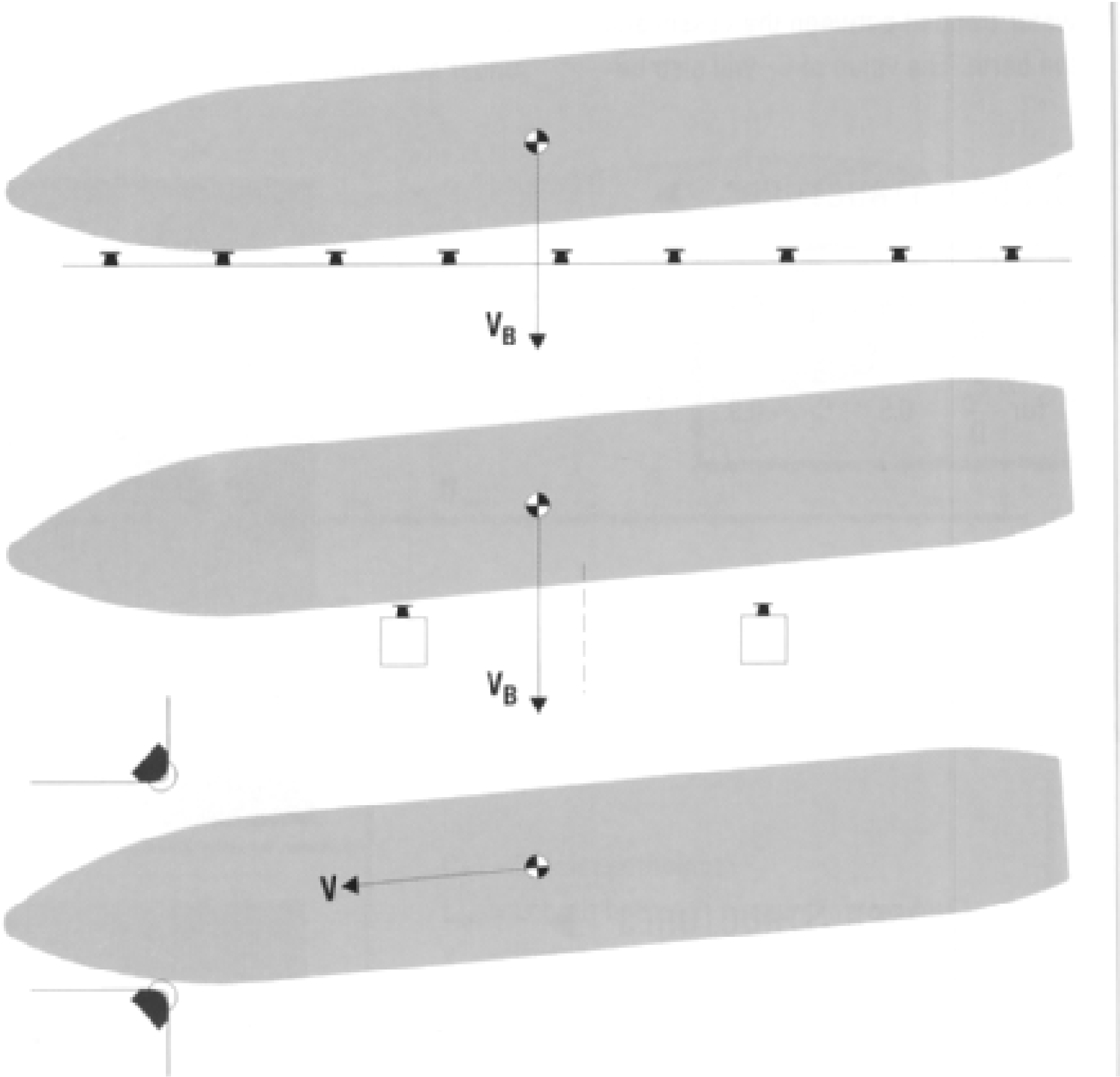
$E_N = 0.5 \cdot M_D \cdot (V_B)^2 \cdot C_M \cdot C_E \cdot C_S \cdot C_C$

DOLPHIN BERTHING

$E_N = 0.5 \cdot M_D \cdot (V_B)^2 \cdot C_M \cdot C_E \cdot C_S \cdot C_C$

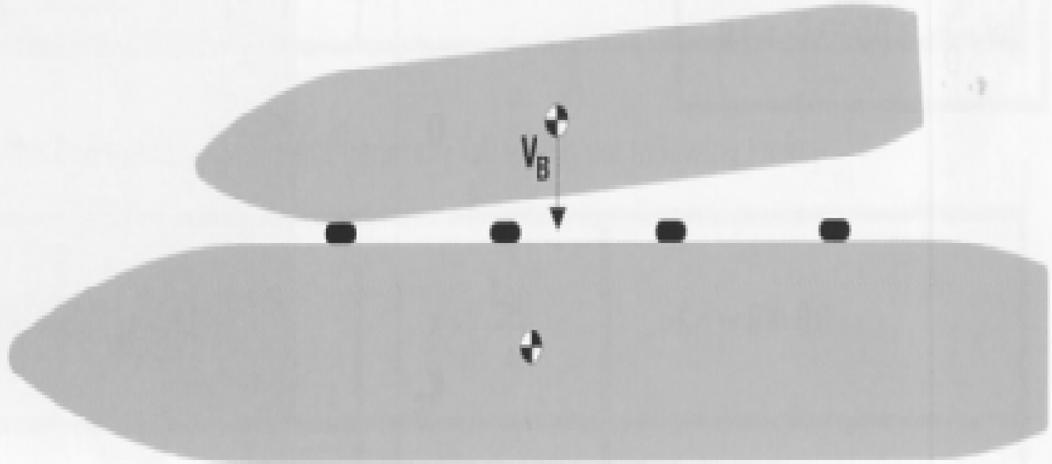
LOCK ENTRANCES

$E_N = 0.5 \cdot M_D \cdot (V \cdot \sin \alpha)^2 \cdot C_M \cdot C_E \cdot C_S \cdot C_C$



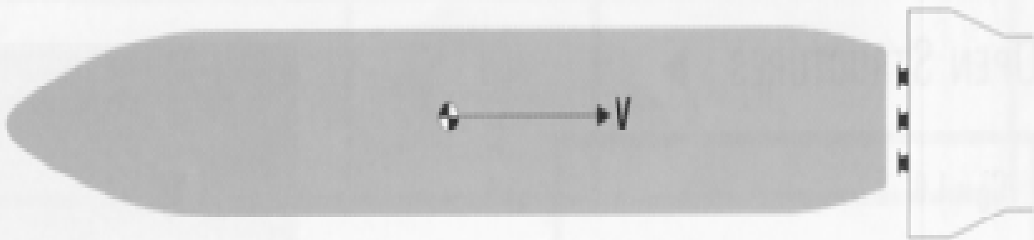
SHIP-TO-SHIP BERTHING

$$E_N = 0.5 \cdot \left[\frac{(M_{D1} \cdot C_{M1}) \cdot (M_{D2} \cdot C_{M1})}{(M_{D1} \cdot C_{M1}) + (M_{D2} \cdot C_{M1})} \right] \cdot (V_B)^2 \cdot C_E$$



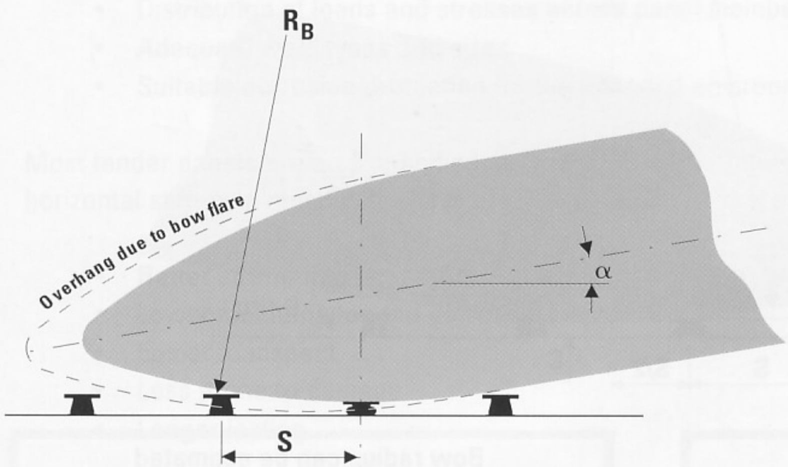
END BERTHING

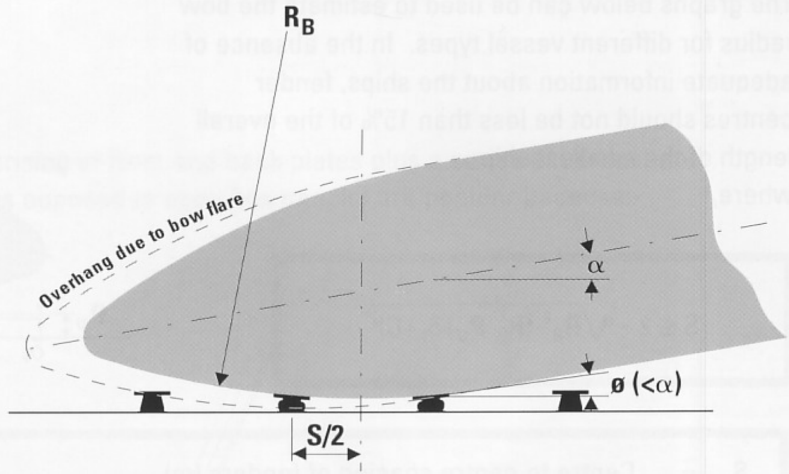
$$E_N = 0.5 \cdot M_D \cdot V^2$$



Selección de la Defensa

SINGLE OR MULTIPLE FENDER CONTACTS





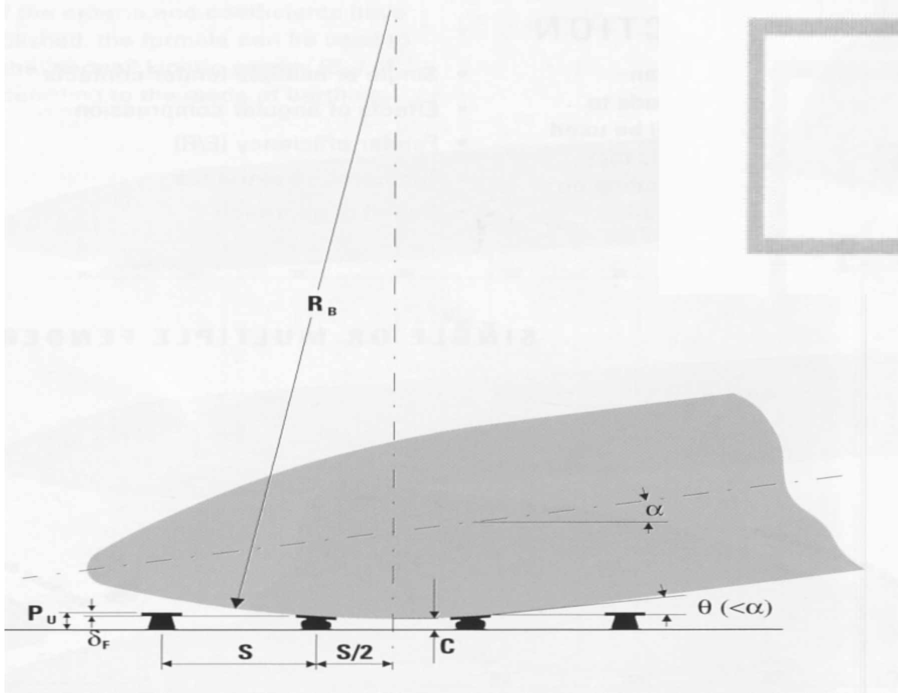
SINGLE FENDER CONTACT

- All energy absorbed by a single fender
- Full fender deflection likely
- Bow flare angle (β) is important
- 3-fender contact also possible when fenders are installed closer together

TWO FENDER CONTACT

- Energy shared over two fenders
- Compound angle (ϕ) is important
- Hull-structure clearance (C) may be less, especially for small bow radii

Espaciamientos



$$S \leq 2 \cdot \sqrt{R_B{}^2 - (R_B - P_U + \delta_F + C)^2}$$

S	=	Centre to centre spacing of fenders (m)
R_B	=	Bow radius (m)
P_U	=	Uncompressed fender projection including rubber, panel etc (m)
δ_F	=	Fender deflection (m)
C	=	Clearance distance (m)

Bow radius can be estimated with the following formula:-

$$R_B \simeq \frac{1}{2}\left[\left(\frac{B}{2}\right) + \left(\frac{L_{OA}{}^2}{8B}\right)\right]$$

Iterar…

- Seleccionar Defensa según energía
- Obtener Reacciones Máximas
- Calcular Reacciones
- Chequear presión de Contacto