Fender Design. Changes after PIANC WG211

PIANC APAC Conference 2024

Nerea Palacios

Associate Maritime Engineer at WSP

Overview

- Introduction
- Characteristic berthing energy
- Berthing velocity
- Berthing angle
- Design berthing energy
- Fender energy absorption capacity
- Conclusions

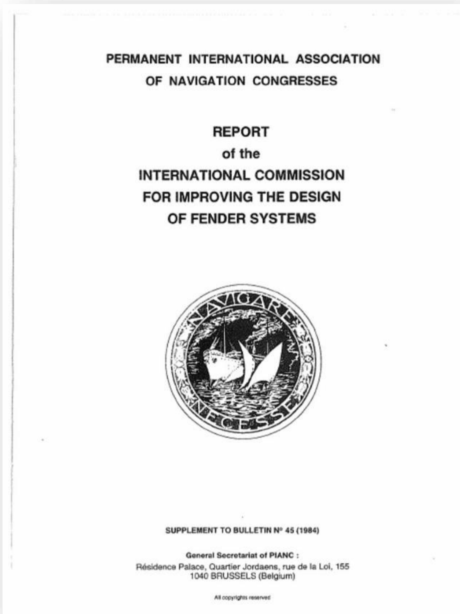
UN Goals

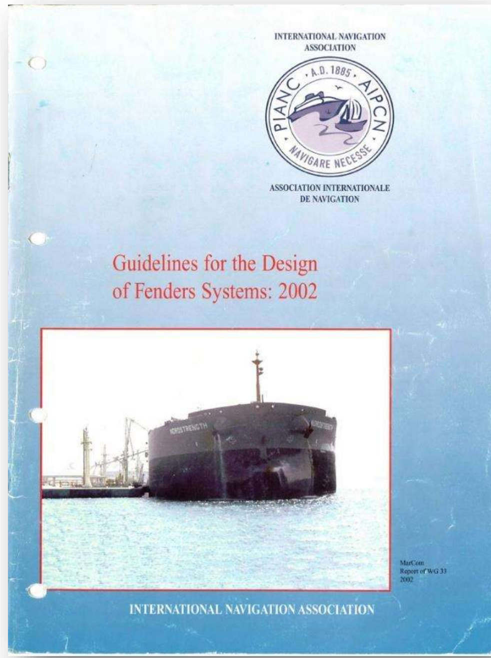
8 DECENT WORK AND ECONOMIC GROWTH

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Introduction

History of PIANC Fender Guidelines





MarCom Report of WG 145 2022

Supplement to Bulletin no. 45
1984

MarCom Report of WG 33
2002

MarCom Report of WG 211
2024

Introduction

Characteristic berthing energy

Berthing velocity

Berthing angle

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Fender energy absorption capacity

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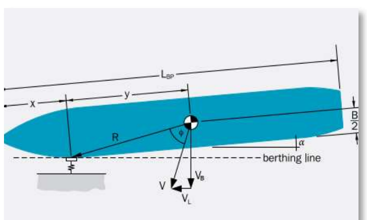
Characteristic Berthing Energy

WG 33

$$E_c = \frac{1}{2} M V_B{}^2 C_e C_m C_c C_s$$

Vessel Displacement

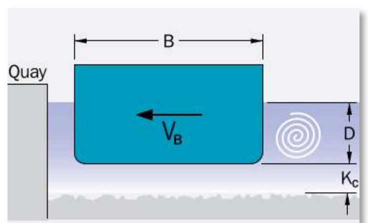
Berthing Velocity



C_e

Eccentricity factor

energy dissipated by rotation of the ship about its point of impact with the fenders



C_m

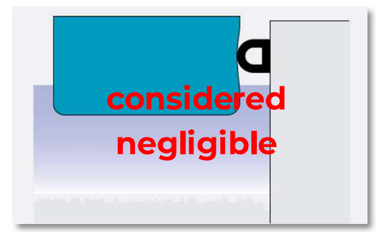
Added mass factor

mass increased by water carried along with the ship as it moves sideways

C_c

Configuration factor

energy dissipated by water between hull and quay acting as a cushion



C_s

Softness factor

energy absorbed by elastic deformation of the vessel hull

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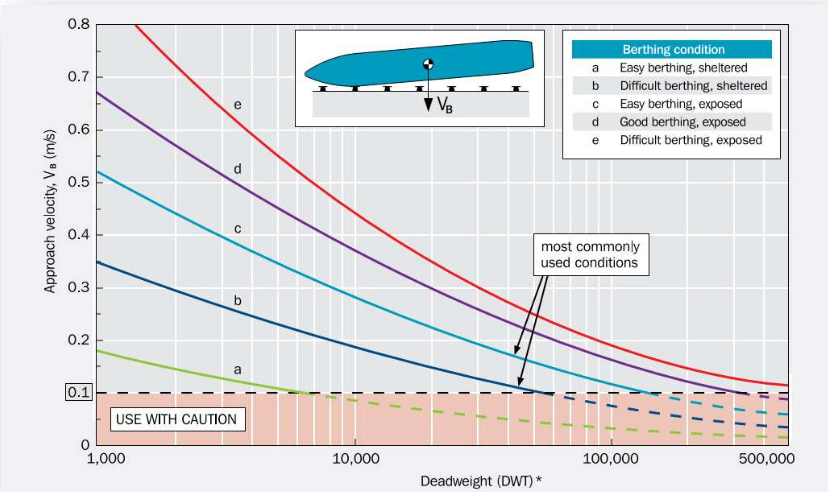
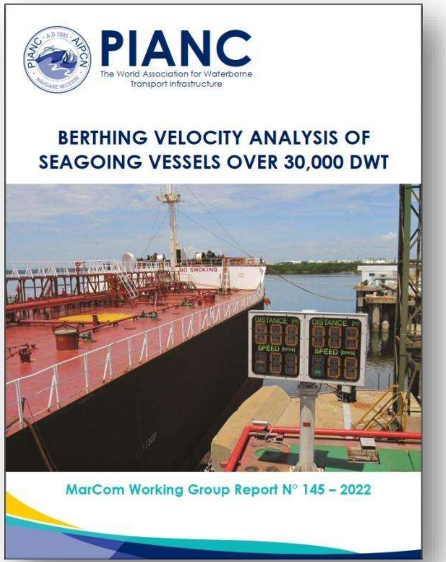
WG 33

Brolsma et al. 1977



- All velocities are based on tug assistance
- Berthing velocity is a function of:
  - Vessel size ✖
  - Berthing conditions

WG 145 (2022)



- **No evidence** of correlation between berthing velocity and vessel size
- Berthing velocity strongly depends on berthing procedures

Berthing Velocity

WG 211

- WG 211 highly encourages the use of **site specific data**
- If local data is not available, WG 211 provides table with berthing velocities as a function of:
  - Navigation conditions
  - Vessel type
- These velocities are conservative
- Using site specific information typically results in slightly smaller fenders than WG 33
- Unfavourable navigation conditions could result in larger fenders than WG 33

Navigation Condition:	Favourable	Moderate	Unfavourable
Type of Vessel[a]	$V_{B,c}$ (m/s)		
Coaster	0.180[f]	0.300[e]	0.400[e]
Feeder, Handysize	0.150[b]	0.225[c]	0.300[d]
Handymax, Panamax	0.120[b]	0.200[e,g]	0.275[d]
Vehicle Carriers	0.120[e]	0.200[e]	0.275[e]
Post Panamax, Capesize (small), Aframax	0.100[b,e]	0.175[c]	0.275[d]
New Panamax, Capesize (large), Suezmax, ULCV, VLBC, VLCC, ULCC	0.100[b,e]	0.150[c,f]	0.250[d]
Cruise & Passenger Vessels	0.100[e]	0.150[e,f]	0.250[e]

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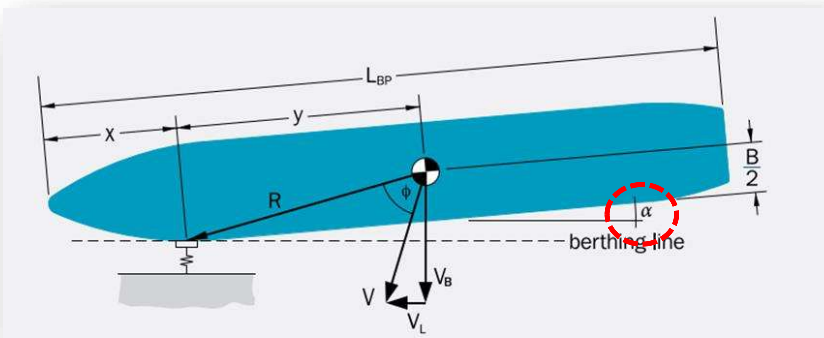
Berthing Angle

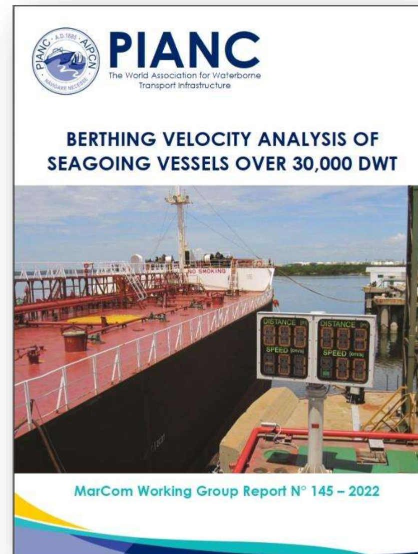
WG 33



Berthing angle is a function of vessel size:

- 6° for vessels larger than 50,000 DWT
- 10-15° for smaller vessels without tug assistance

WG 145 (2022)



- **No evidence** of correlation between berthing angle and vessel size

Berthing Angle

WG 211

- WG 211 highly encourages the use of **site specific data**
- If local data is not available, WG 211 provides table with berthing angles as a function of:
  - Method of approach
  - Use of tugs
  - Thruster capacity
- Berthing angles are typically lower than WG 33
- Effect on berthing energy is limited for single fender contact but more significant for multiple contact
- Separate angle provided to calculate fender spacing

Alongside berthing	Tugs	Thrusters[a]	α_c[b]	α_i[c]	Explanation
Parallel, (Section 5.1.1)	Yes	Yes	2	3	Vessels positioned off the berth and approach parallel. Vessels have sufficient thruster capacity. **If under keel clearance is very low and therefore it negatively influences manoeuvrability (local input needed),consider this as a 'no thrusters scenario'.**
		No	3	5	Vessels positioned off the berth and approach parallel. Vessels do not have thrusters **or very low under keel clearance negatively influences manoeuvrability.**
	No	Yes	2	3	Vessels positioned off the berth and approach parallel. Vessels have sufficient thruster/pod capacity on bow and stern (like cruise vessels).
		No	X	X	This manoeuvre can only be done using a current or strong wind. To be discussed with pilots and vessel masters.
Angular (Section 5.1.1)	Yes	Yes	3	5	Vessels have a large angle during the approach. Local current or wind is used to berth the vessel. However, at the moment of fender contact the berthing angle is low. Vessels have sufficient thruster capacity.
		No	4	7	Vessels have a large angle during the approach. Local current or wind is used to berth the vessel. However, at the moment of fender contact the berthing angle is low. Vessels do not have thrusters **or under keel clearance is very low and therefore negatively influences manoeuvrability.**
	No	Yes	8	15	Smaller coastal vessels perform an angular approach, landing using spring lines and pushing the bow or stern in with engine and rudder. Vessels have some thruster capacity.
		No	10	20	Smaller coastal vessels preform an angular approach, landing using spring lines and pushing the bow or stern in with engine and rudder. Vessels have little or no thruster capacity.

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Design Berthing Energy

WG 33

$$E_d = \gamma_E E_c$$

Abnormal Berthing Factor

VESSEL TYPE	SIZE	F_s
Tanker, bulk, cargo	Largest Smallest	1.25 1.75
Container	Largest Smallest	1.5 2.0
General cargo	–	1.75
RoRo, ferries	–	≥ 2.0
Tugs, workboats, etc	–	2.0

- Abnormal factor accounts for uncertainties in the berthing energy calculation
- Abnormal factor is a function of:
  - Vessel type
  - Vessel size

- WG 33 does not consider the frequency of berthing
- Hazardous cargoes are not considered
- No mention of multiple fender contact
- Factor is based on deterministic approach

Design Berthing Energy

WG 211

reference factor for 100 berthings/yr

correction factor for berthings without pilot assistance

$$\gamma_E = \gamma_{E,ref}\,\gamma_n\,\gamma_p\,\gamma_c$$

correction factor for alternative annual berthing frequencies

correction factor for correlations between design variables

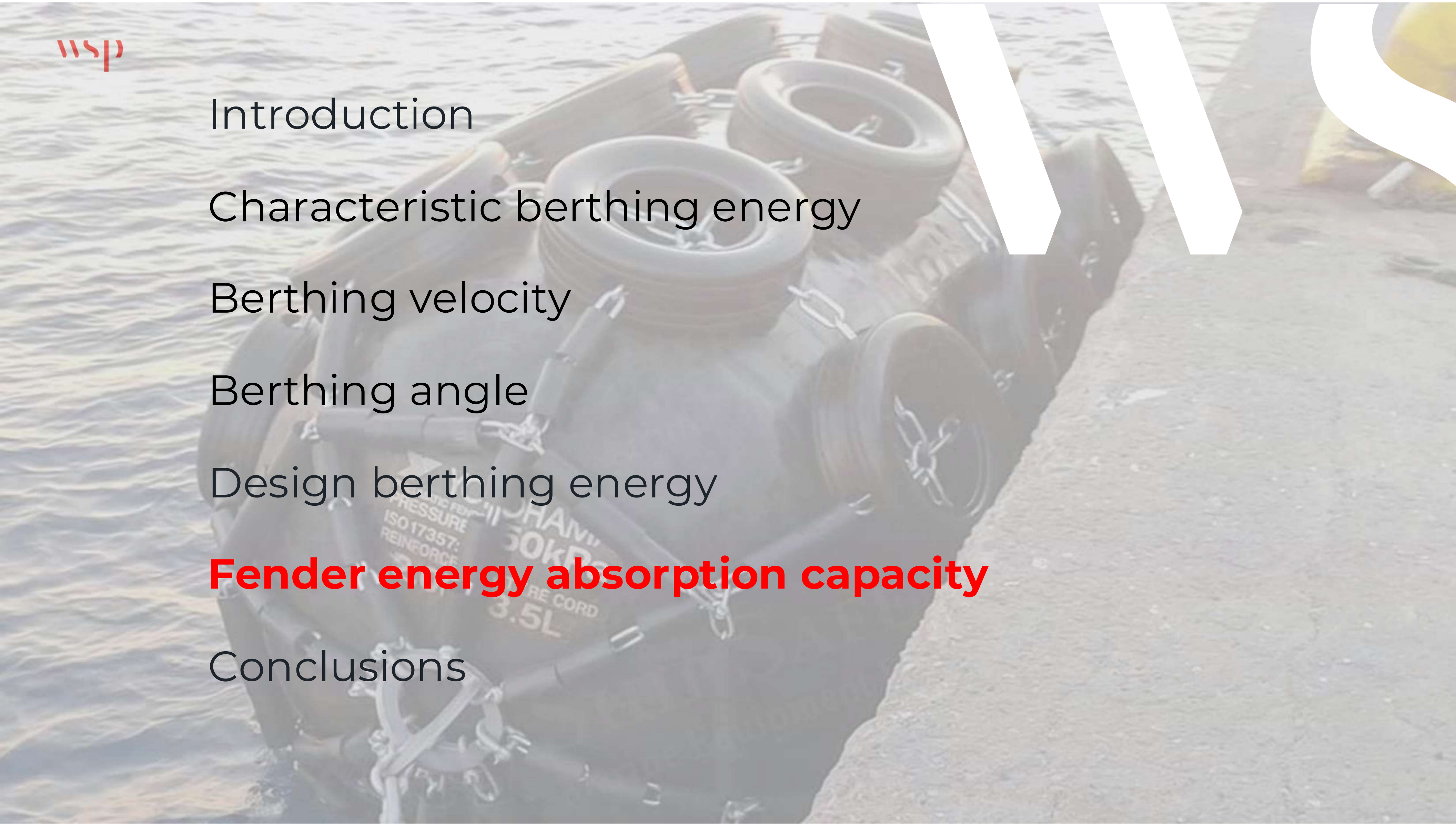
- WG 211 moves from a deterministic to a probabilistic approach
- Partial energy factor is a function of:
  - Consequence class (consequence of fender failure)
  - Navigation conditions
  - Variations in vessel size CoV_M
  - Single or multiple fender contact
  - Annual berthing frequency
  - Pilot assistance
  - Site-specific information
- Factors provided for **new structures** only

Navigation Condition	CoV_M	Reference partial energy factor for consequence classes [$\gamma_{E_{ref}}$]			
		A	B	C	D
Favourable	High	1.30	1.50	1.60	1.70
	Moderate	1.35	1.55	1.65	1.80
	Low	1.50	1.70	1.80	1.95
Moderate	High	1.35	1.60	1.70	1.85
	Moderate	1.45	1.65	1.75	1.90
	Low	1.60	1.80	1.90	2.10
Unfavourable	High	1.50	1.85	2.00	2.20
	Moderate	1.60	1.95	2.05	2.30
	Low	1.80	2.15	2.30	2.55

Table 5-8: Reference partial energy factor[$\gamma_{E_{ref}}$] for 100 berthings per year – single fender contact

Navigation Condition	CoV_M	Reference partial energy factor for consequence classes [$\gamma_{E_{ref}}$]			
		A	B	C	D
Favourable	High	1.15	1.35	1.40	1.50
	Moderate	1.20	1.40	1.55	1.55
	Low	1.35	1.50	1.60	1.70
Moderate	High	1.20	1.40	1.45	1.60
	Moderate	1.25	1.45	1.55	1.65
	Low	1.40	1.60	1.70	1.80
Unfavourable	High	1.25	1.55	1.65	1.85
	Moderate	1.35	1.60	1.75	1.95
	Low	1.50	1.80	1.95	2.15

Table 5-9: Reference partial energy factor[$\gamma_{E_{ref}}$] for 100 berthings per year – multiple fender contact



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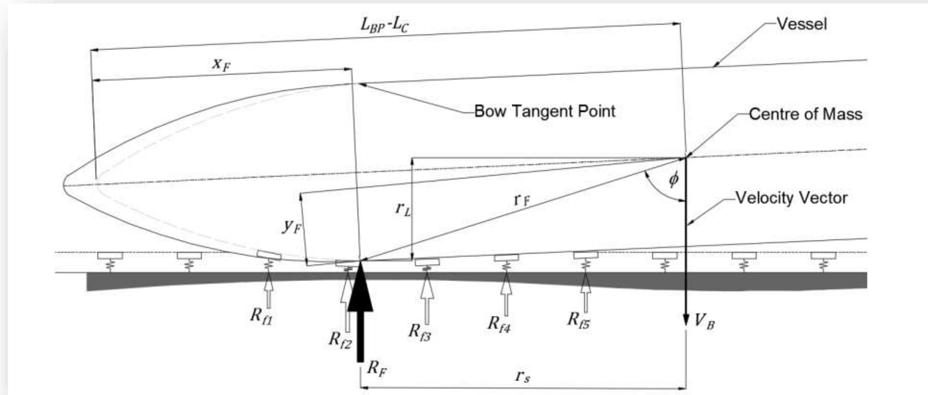
Fender energy absorption

WG 211

➢ The base energy absorption capacity of the fender –as supplied in catalogue E_{base}- is adjusted by correction C and partial resistance factors γ:

- Velocity factor $C_{v,c}$
- Temperature factor $C_{t,c}$
- Angular factor $C_{ang,c}$
- Performance tolerance γ_f
- **Multiple fender contact factors**
  - $C_{mult,c}$
  - γ_{mult}

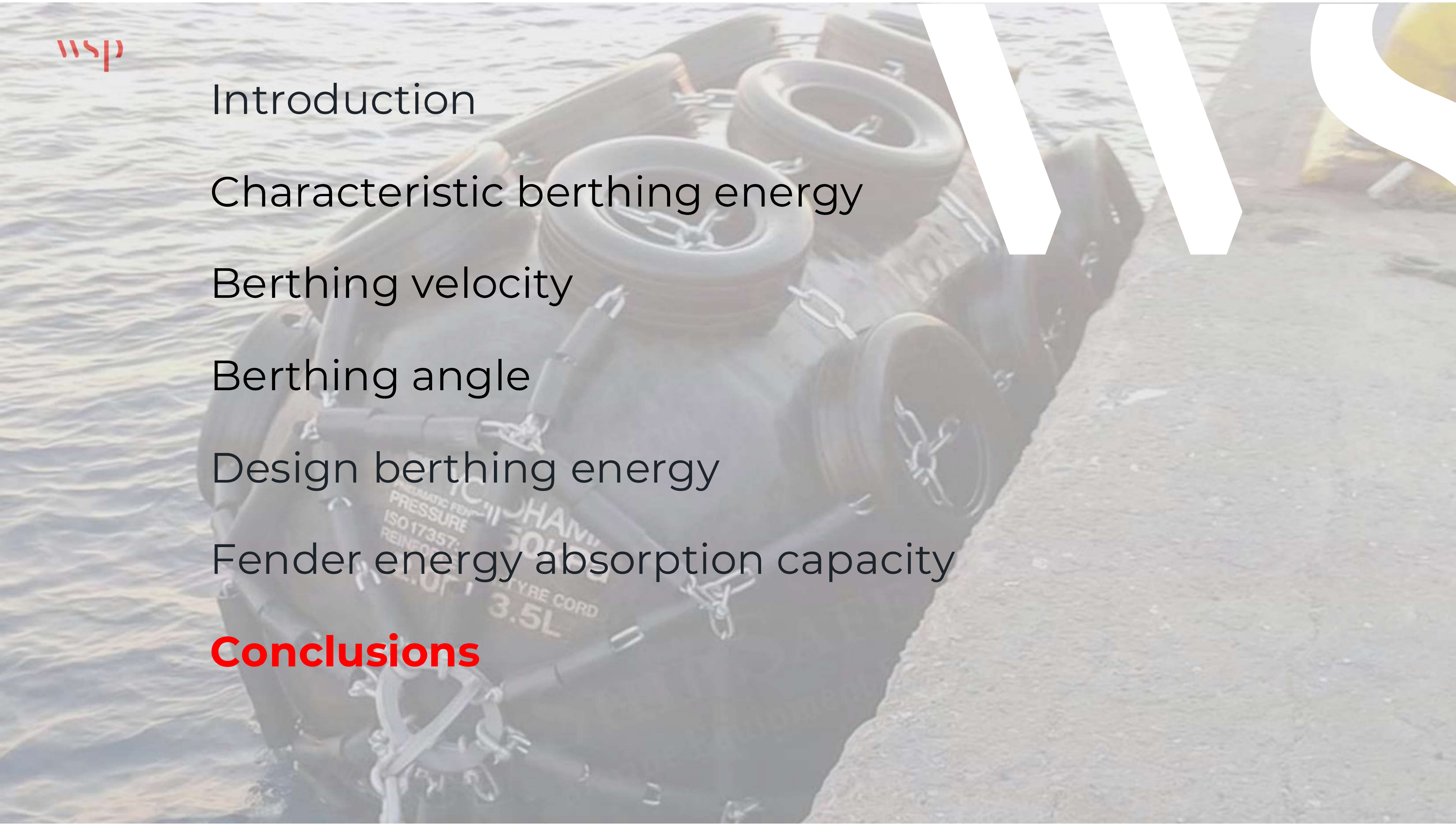


Fender contact	Berthing angle °	Partial Safety Factor γ_{mult} for each Consequence Class			
		A	B	C	D
Single	All.	1.0			
Multiple	$\alpha_c \geq 2°$	1.0			
Multiple	$\alpha_c < 2°$	1.00 [b]	1.10 [b]	1.15 [b]	1.20 [b]

$$\frac{E_{base} \times C_{v,c} \times C_{t,c} \times C_{ang,c} \times C_{mult,c}}{\gamma_f \times \gamma_{mult}} \geq \frac{1}{2} \times M \times V_B^2 \times C_e \times C_m \times \gamma_{E,ref} \times \gamma_n \times \gamma_p \times \gamma_c$$

Design fender energy absorption capacity

Design berthing energy



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Conclusions

1. WG 211 is a new guideline rather than an update
2. WG 211 describes the physical processes of berthing better than WG 33 resulting in higher velocities, lower berthing angles and specific guidance on multiple fender contact
3. WG 211 strongly recommends the use of local data
4. Using local data typically results in slightly more economical fenders than WG 33
5. If no local data is available, fenders might be overdesigned
6. Designers should always engage with potential users such as harbour masters, pilots and asset owners

Thank you

Nerea Palacios
nerea.palacioscalvo@wsp.com

wsp.com