



ArcelorMittal

Innovative Steel Sheet Pile Solutions for Ports

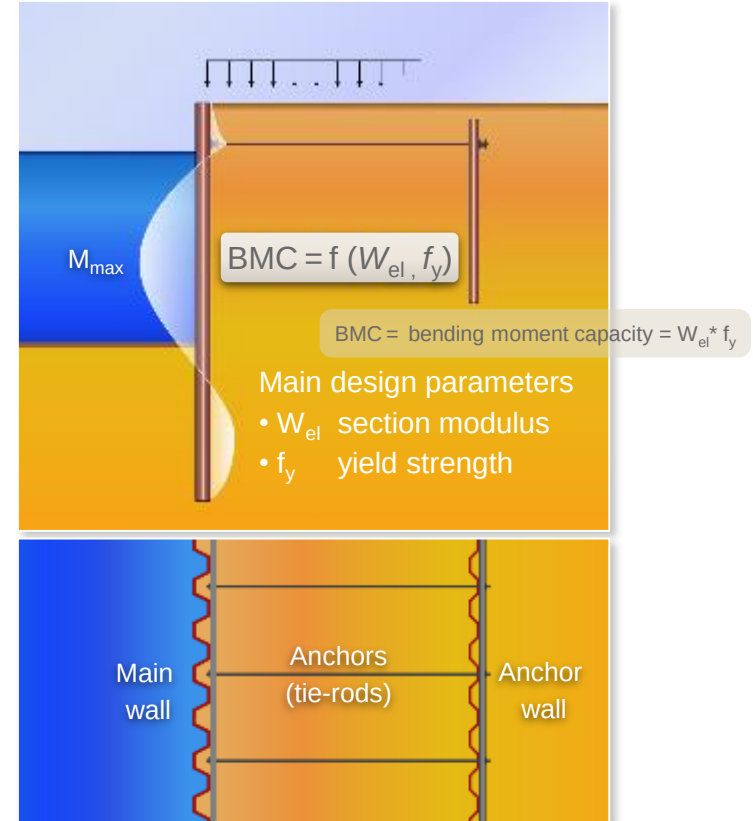
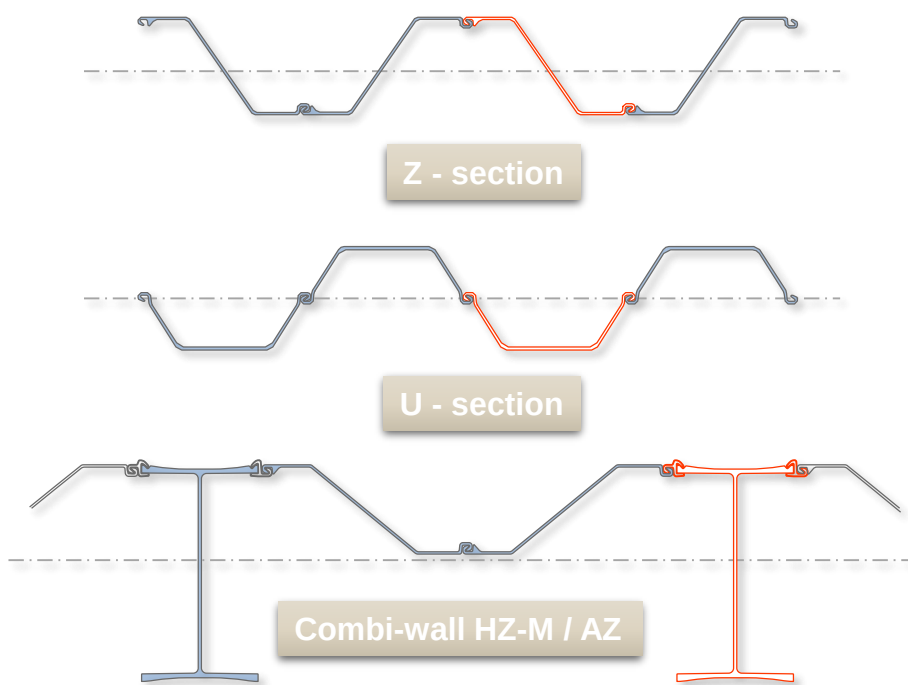
Darius MACIJAUSKAS, PhD

May 15, 2019 | Aktau

ArcelorMittal Commercial RPS – Sheet Piling - Luxembourg

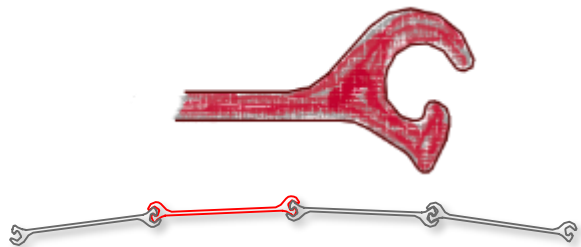
Types of steel sheet piles

Bending resistant



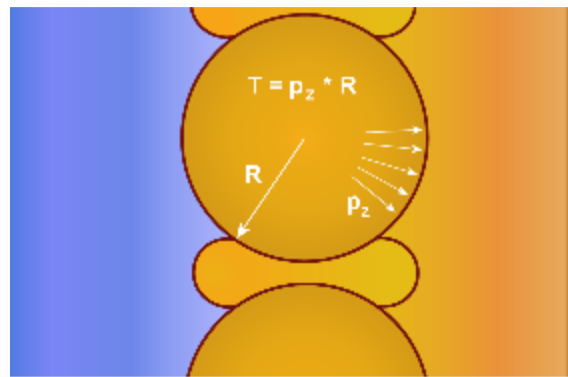
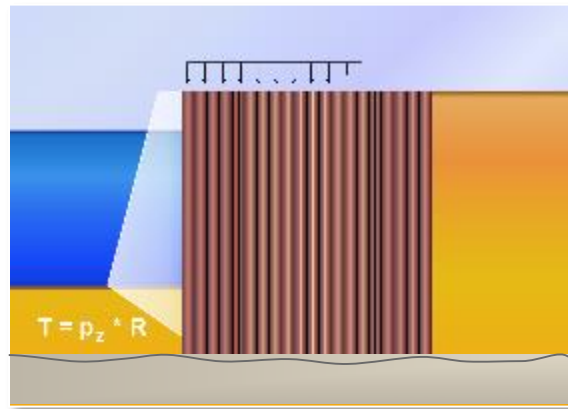
Flat steel sheet piles. AS 500[®]

Resisting by interlock tension



Straight web AS 500

- gravity structure
- deep wharfs / quays / breakwaters / cofferdams
- structures founded on bedrock
- no anchors



Marina Pez Vela | Quepos | Costa Rica (2008)

Breakwater

- circular cells, $\varnothing = 12.2 / 18.6 \text{ m}$, $L = 540 \text{ m}$
- AS 500 -1 1.0 & 12.0
- A 690, I.S. = 3 500 / 5 500 kN/m
- $l = 7.0 \sim 15.0 \text{ m}$
- 3440t



Z



AZ 18



AZ 26



AZ 48



AZ 13-700



AZ 18-700



AZ 26-700



AZ 38-700N



AZ 44-700N



AZ 50-700



AZ 13-770



AZ 20-800



AZ 25-800



AZ 30-750



AU 16



AU 20



AU 25

U



PU 12



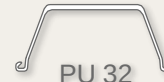
PU 18



PU 22



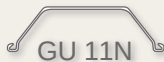
PU 28



PU 32



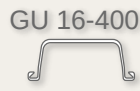
GU 7N



GU 11N



GU 14N



GU 16-400



GU 18N



GU 22N



GU 28N



GU 32N

HZ-M



HZ 880M
HZ 1080M
HZ 1180M

Flat



AS 500 - 9.5 / 11.0 / 12.0 / 12.5 / 12.7

Sheet pile range

(September 2017)

W_{el} up to 46 500 cm³/m

Steel grades. Hot rolled ssp

EN 10248	
	f_y [MPa]
S 240 GP	240
S 270 GP	270
S 320 GP	320
S 355 GP	355
S 390 GP	390
S 430 GP	430

Mill specification*	
	f_y [MPa]
S 460 AP	460

ASTM		
	f_y [ksi]	f_y [MPa]
A 328	39	270
A 572 Gr. 50	50	345
A 572 Gr. 55	55	380
A 572 Gr. 60	60	415

ASTM		
	f_y [ksi]	f_y [MPa]
A 572 Gr. 65	65	450

(*) ArcelorMittal internal mill specification

- Addition of copper 0.35 %, 0.50 %
- ASTM **A 690**: high strength low alloy steel for use in **marine environments** (Gr. 50 and higher available)

Installation of steel sheet piles

Equipment

- diesel hammer
- impact hammer (hydraulic, free fall)
- vibratory hammer
- hydraulic press

Accessories

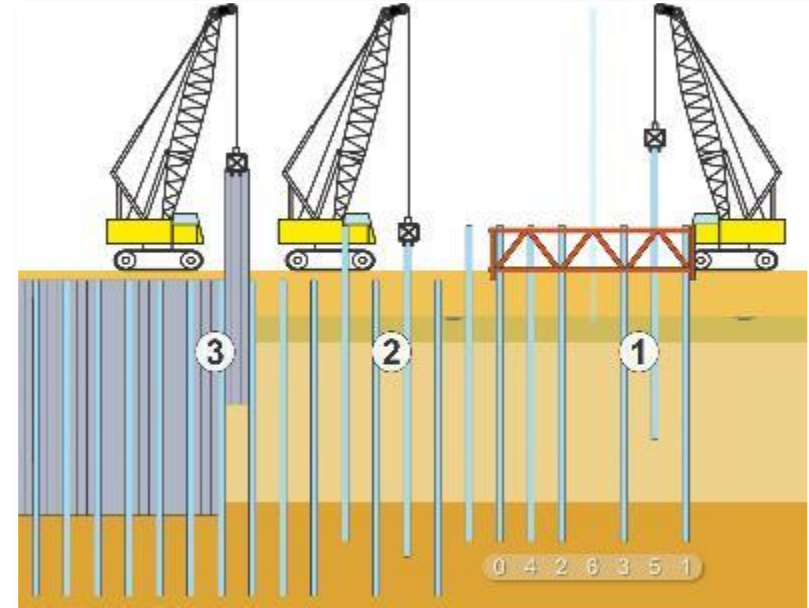
- leader, template, driving cap
- driving assistance:
 - water-jetting
 - pre-drilling
 - blasting



Installation method of combined walls HZ-M/AZ



Driving sequence



AZ infill sheets installed after driving king piles HZM

Durability of steel structures

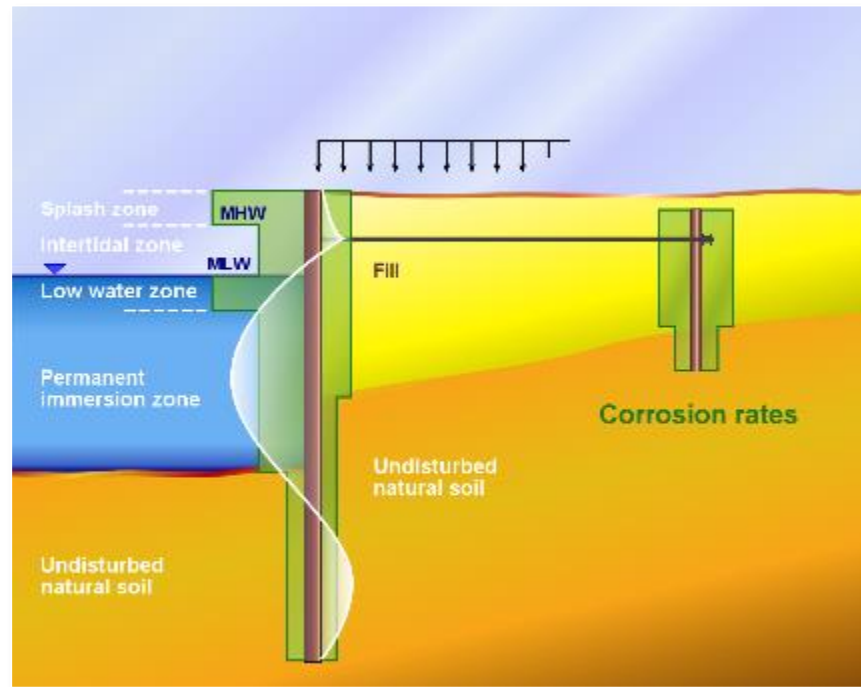
- corrosion in undisturbed natural soils is negligible (exception peat, ...)
- in common fresh water, corrosion is low
- in sea water, corrosion has to be considered (splash zone, low water)

Loss of thickness (mm). Table 4.1 & 4.2, EN 1993-5 (2007)

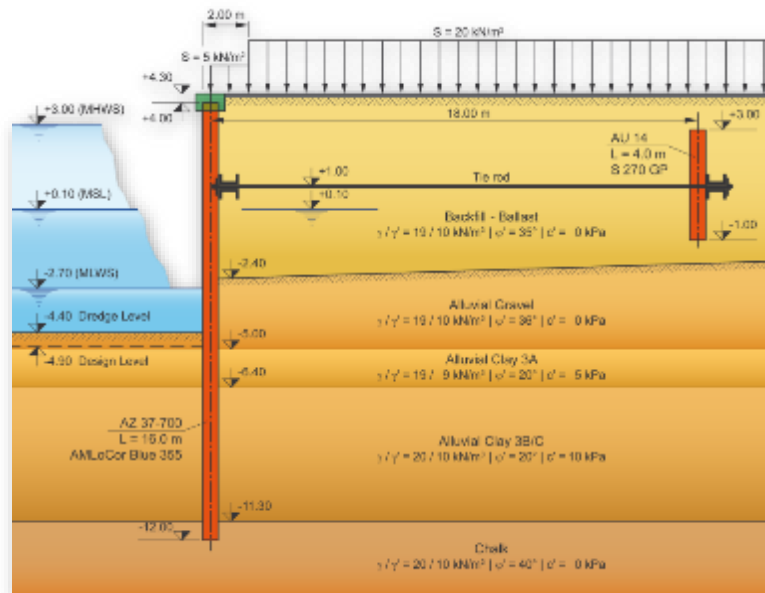
design life (years)	5	25	50	75	100
undisturbed natural soils (sand, clay, ...)	0.00	0.30	0.60	0.90	1.20
common fresh water: waterline	0.15	0.55	0.90	1.15	1.40
sea water: permanent immersion & intertidal	0.25	0.90	1.75	2.60	3.50
sea water: splash & low water zone	0.55	1.90	3.75	5.60	7.50

Durability of steel structures. Solutions

- design ssp with maximal bending moment in zone with reduced corrosion rates
- ‘**sacrificial**’ thickness of steel
- higher steel grade
⇒ increases safety factor on steel
- surface protection
(coating ⇒ aesthetics)
- cathodic protection
(zones constantly in contact with water)
- concrete capping beam down to 1.0 m below low water



AMLoCor®. The steel of the future... in marine applications



Sheet piles equipped for yearly inspection of the residual thickness over 5 – 10 years

Pilot project. Port of Shoreham, UK (2010)

AZ 37-700, 16.0 m long

AMLoCor Blue 355



Unitterminal | Port of Køge | DK (2015 - 2016)

AMLoCor ~ 3 900 t

- 1 200 m long berth for container vessels
- dredge level -9.5 m
- AZ 26-700, AZ 38-700N & AZ 42-700N
- up to 22.0 m
- driving equipment: IHC S 70 (hammer)

Unitterminal | Port of Køge Container Terminal Køge | Denmark

Project Owner Køge Kommune (Port of Køge), Køge, Denmark
Design office Sweco, Denmark (formerly Grontmij / Carl Bro Denmark)

Contractor Per Aarsleff A/S, Hvidovre, Denmark

Sheet Piles	AZ 26-700	AMLocor Blue 390	L=16.5 to 19.0 m	756 t
	AZ 38-700N	AMLocor Blue 355	L=16.5 to 22.0 m	662 t
	AZ 42-700N	AMLocor Blue 320	L=18.0 to 22.0 m	2 506 t

Total 3924 tonnes of sheet piles

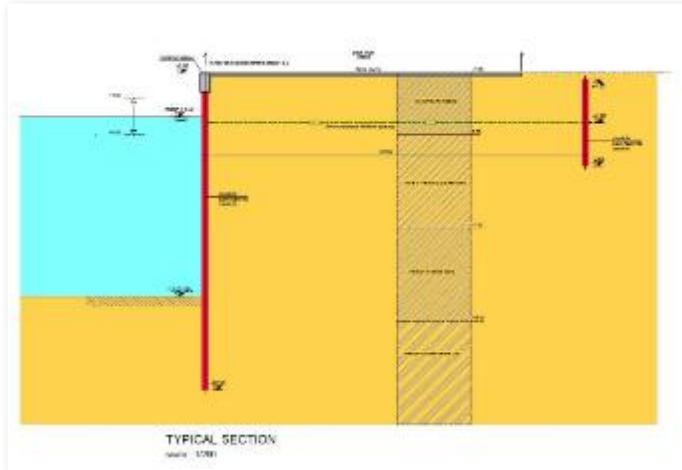
Tie-rods	Ø43.0 mm	St 670/800	L=7.0 to 18.0 m	4t
	Ø57.5 mm	St 670/800	L=10.3 to 15.2 m	662 t

Steel beams	HEB 300	S355 J0+M	L=25.0 m	830t
	UNP 350	S355 J0+M	L=12.0 to 15.0 m	250 t



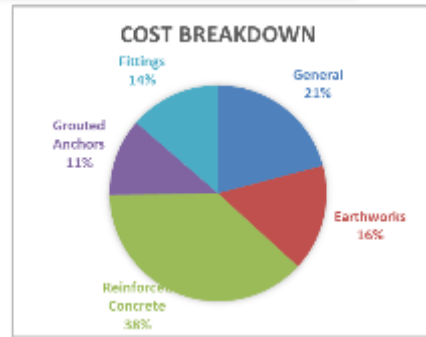
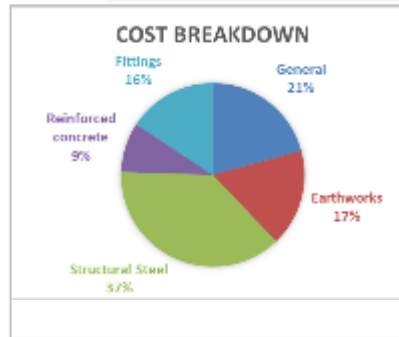
Construction cost analysis (by Tractebel in 2018).

Key Indicators - Cost



- length quay wall: 200 m
- location: Antwerp (BE)

	Steel sheet piles	Diaphragm wall (RC)
Design activities	7%	
Preliminary activities	15%	
Construction cost	6.0 M€	6.9 M€

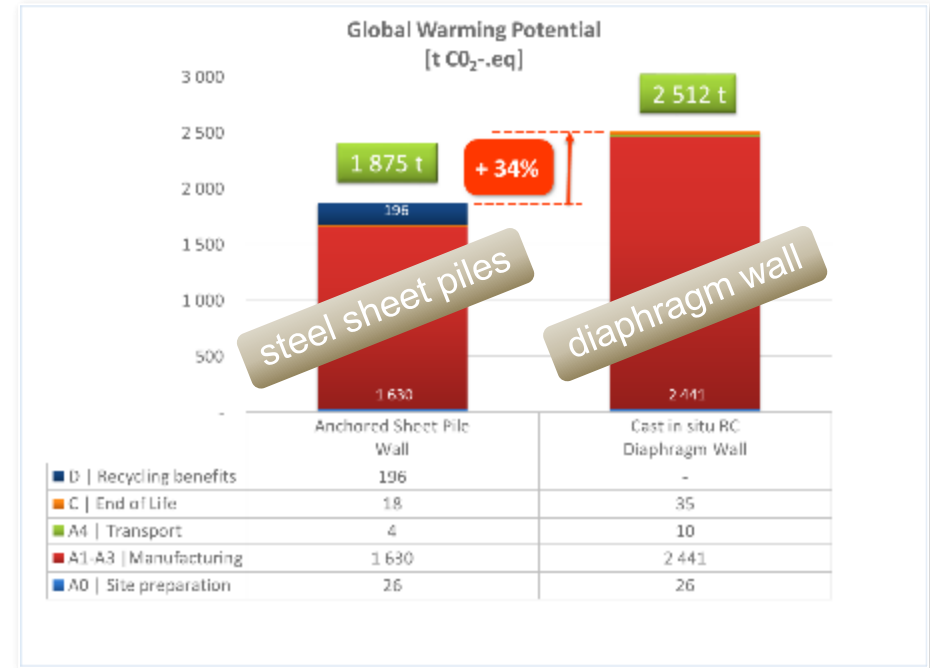


Steel sheet piles: savings **15%**

Construction cost analysis (by Tractebel in 2018).

Key Indicators - Life Cycle Cost

- length quay wall: 200 m
- location: Antwerp (BE)
- transport:
 - concrete: 10 km (425 trucks!)
 - steel sheet piles: 270 km by train
- monetization: software DuboCalc (NL)
⇒ 50 €/t of CO₂



Projects

Aktau Pier | Kazakhstan (2016)



1 800 t of steel foundation products

- HZ-M/AZ combined wall system
- ASDO tie-rods

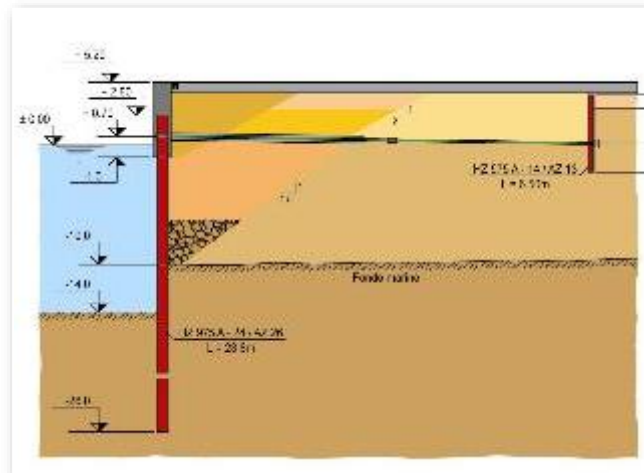
Cargo Transportation Route (CaTRo) | Kazakhstan (2015 - 2016)

5 400 t of steel foundation products

- PU 12 / PU 28-1 / PU 32+1 coated
- ASDO tie-rods



Puerto de Mejillones | Chile (2002)



Quay wall in a high seismic zone

- HZ 575A-14 / AZ 13
- HZ 975A-24 / AZ 26
- length 6.0 – 28.8 m
- about 5 000 t

Container Terminal 1 | Gdansk | PL (2006)

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Thank you for your attention ...