JFE

J-POCKET PILE™

Leak-proof steel sheet pile for cut-off wall

JFE Steel Corporation

JFE Steel Corporation has developed the "J-Pocket Pile (JPP)", which is a leak-proof steel sheet pile with a groove type pocket at the joint portion. It is aimed to be used as vertical cut-off walls for controlled-type final waste disposal sites, whose structure and maintenance control standards have become severer by the revision of the "Instruction determining technical standards concerning final disposal sites of industrial and non-industrial wastes (June 1998)" (Joint instruction by prime Minister's Office and Ministry of Health and Welfare).

Reliable cut-off sealing work

- Use of swelling type sealing rubber practically proven as segment seal joint filler at the groove type pocket portion allows a continuous high-quality cut-off wall to be formed with excellent sealing performance and durability.
- Stable cut-off sealing work can be done by injecting a filler (such as silicone) after all working loads such as waves and soil pressure have been applied.

Monitoring and repair function

- The pockets serve as observation holes for monitoring, which enables to check the sealing condition of the cut-off wall at any time and to conduct any necessary repair work.

Stable quality

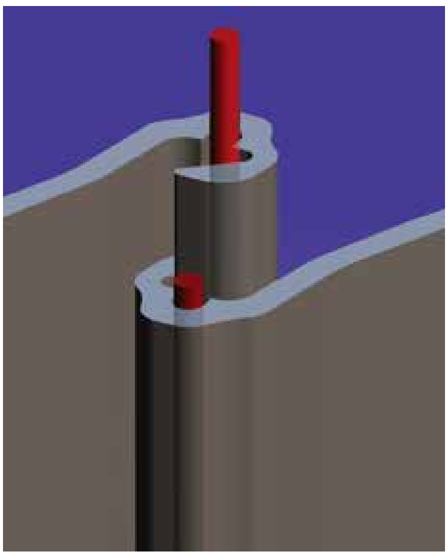
- Rolled steel manufactured by a JIS-certified plant has small quality deviation and provides high stable quality.

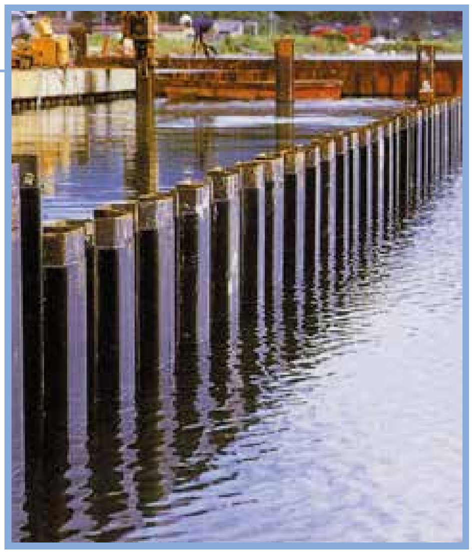
Excellent execution and economical efficiency

- J-Pocket Pile has performances equal to conventional steel sheet piles, ensuring excellent execution efficiency and economical efficiency.

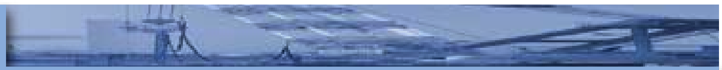
What is J-Pocket Pile (JPP)?

J-Pocket Pile (JPP) is a new steel wall specifically designed for vertical cut-off walls. It has a groove type pocket (diameter of around 10 mm), made by rolling, at the bottom portion of the joint hook of a conventional steel sheet pile. It makes it possible to install sealing material or filler injection material along the joint, and to install monitoring pipes for leak-proof observation.





STRUCTURE OF J-POCKET PILE



Sectional shape

General view

Joint hook portion

Standard

JPP's standard conforms to JIS A 5523 (weldable hot-rolled steel sheet piles) and JIS A 5528 (hot-rolled steel sheet piles).

Chemical composition and mechanical properties

Standard	Type code	Chemical composition (%)						Equivalent carbon content (%)	Mechanical properties			
		C	Si	Mn	P	S	Free nitrogen	Ceq	Yield point or yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%)	Charpy absorbed energy (J)
JIS A 5523 (Weldable Hot-rolled steel sheet piles)	SYW295	0.18 or less	0.55 or less	1.50 or less	0.04 or less	0.04 or less	0.0060 or less	0.44 or less	295 or more	450 or more	18 or more	43 or more
	SYW390	0.18 or less	0.55 or less	1.50 or less	0.04 or less	0.04 or less	0.0060 or less	0.45 or less	390 or more	490 or more	16 or more	43 or more
JIS A 5528 (Hot-rolled steel sheet piles)	SY295	—	—	—	0.04 or less	0.04 or less	—	—	295 or more	450 or more	18 or more	—
	SY390	—	—	—	0.04 or less	0.04 or less	—	—	390 or more	490 or more	16 or more	—

Remarks: 1.Equivalent carbon content is calculated according to the following equation: Equivalent carbon content (%)=C+Mn/6+Si/24+Ni/40+Cr/5+Mo/4+V/14 2.Charpy absorbed energy is the value obtained at a test temperature of 0°C. 3.The value of free nitrogen conforms to JIS A 5523. 4.Chemical composition is expressed in total volume of nitrogen in accordance with remark 2.

Section performance table

Model	Size			Per wall				Per meter of wall width			
	Effective width (mm)	Effective height (mm)	Thickness (mm)	Sectional area ×10^{-4} (m^2)	Geometrical moment of inertia ×10^{-8} (m^4)	Section modulus ×10^{-6} (m^3)	Unit mass (kg/m)	Sectional area ×10^{-4} (m^2/m)	Geometrical moment of inertia ×10^{-8} (m^4/m)	Section modulus ×10^{-6} (m^3/m)	Unit mass (kg/m^2)
JFESP-4WS	600	210	18.0	140.9	10,400	630	111.0	234.8	57,000	2,720	184
JFESP-5WS	600	210	22.0	160.5	11,200	660	126.0	267.5	66,600	3,170	210

FLOW OF GENERAL EXECUTION

Sealing rubber type | Filler injection type

Preparatory work (Sealing rubber type)

Preparatory work (Filler injection type)

Installation of swelling type sealing rubber into pockets, etc.

Piling work (Sealing rubber type)

Piling work (Filler injection type)

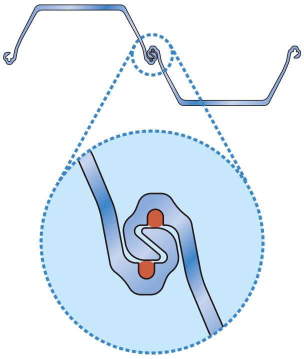
Piling by vibratory hammer

Filling hole (pocket) protection work

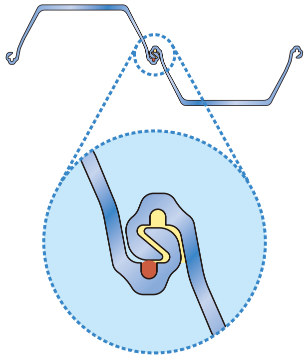
Insertion of pre-stressed concrete steel wires into pockets for protection

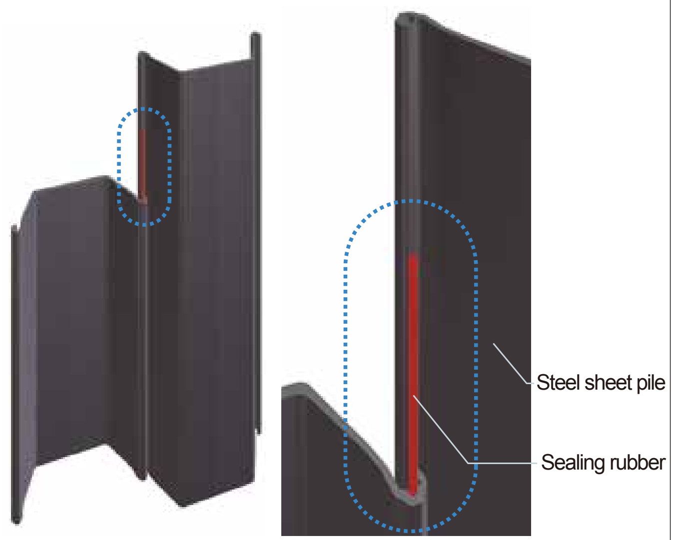
Pulling out of pre-stressed concrete steel wires

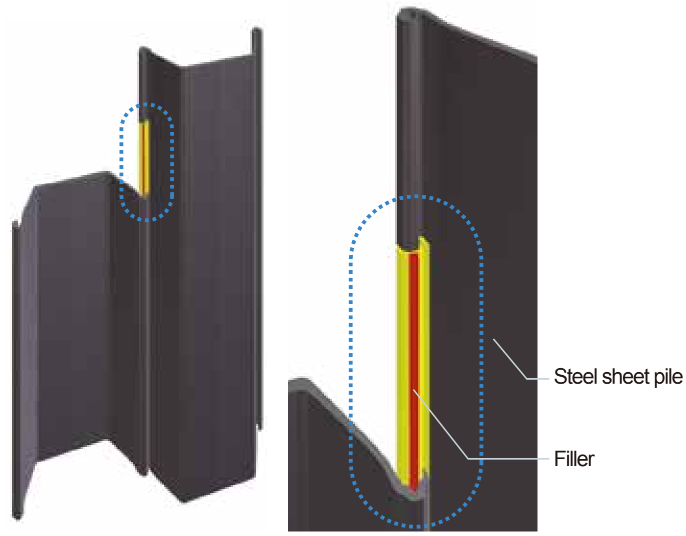
TYPES OF CUT-OFF SEALING WORK



Ground conditions for application of JPP	
Soft (N=less than 30)	Hard (N=30 or greater)
Water level at cut-off wall	
Below water level (under water)	Above water level (in air, etc.)
Low ← Cost	→ High







Sealing rubber type

Swelling type sealing rubber is applied along the pocket prior to piling. The rubber swells by absorbing water and seals the joint by its swelling pressure.

Filler injection type

The pocket of one pile is filled with sealing rubber prior to piling, and a filling injection tube is placed in the pocket of the other pile after piling. Through this tube, silicone is injected into the pocket.

Filler injection work

Insertion of filler injection tube

Setting of high-pressure pump

Injection of filler material (silicone)

Checking of filling condition by divers

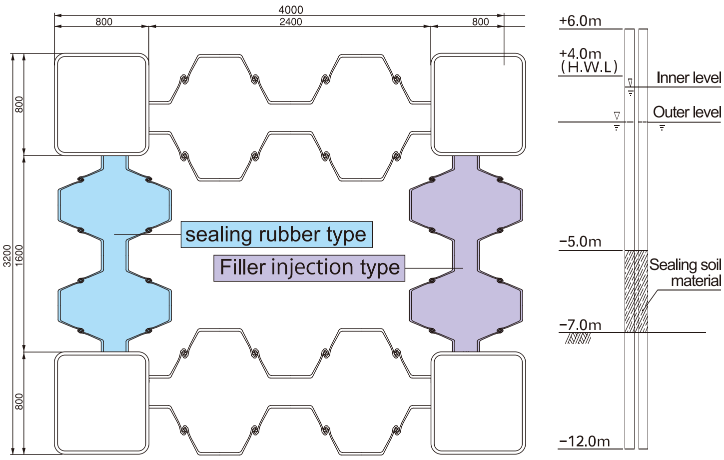
TEST RESULTS

General description of test sample (cut-off sealing structure)

In order to check the cut-off sealing performance of the J-Pocket Pile (sealing rubber type, filler injection type) in the sea, demonstrative test was carried out in cooperation with the Port and Airport Research Institute, an independent administrative institution.
Its effectiveness was proved by the test.

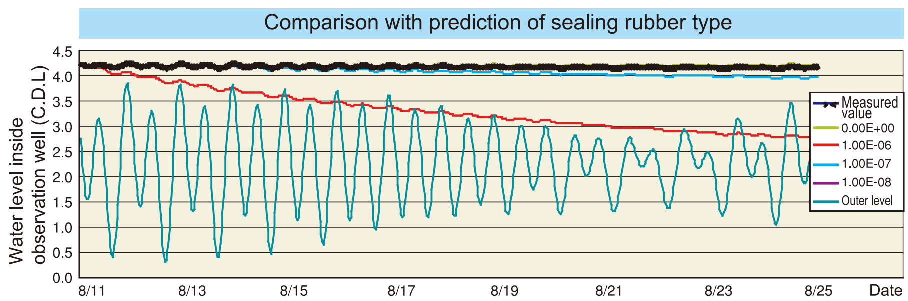
Test method

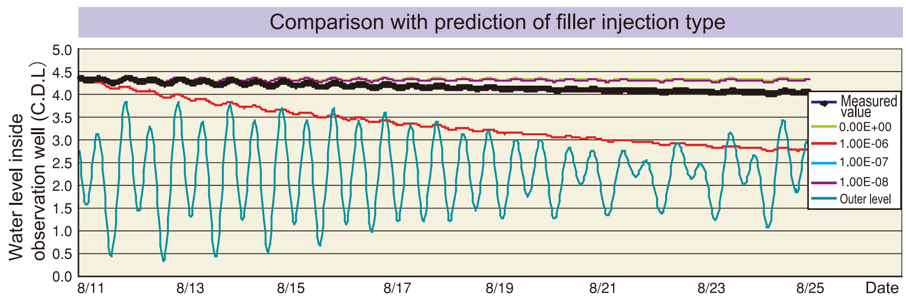
After piling the J-Pocket Piles (18 m × 10 piles) by a vibratory hammer and applying cut-off sealing works, seawater was poured into the observation wells enclosed by the piles (sealing rubber type and filler injection type as shown on the right). After the water level reached the prescribed level, lowering of water level was measured.



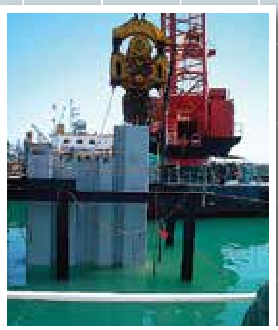
Test results and evaluation

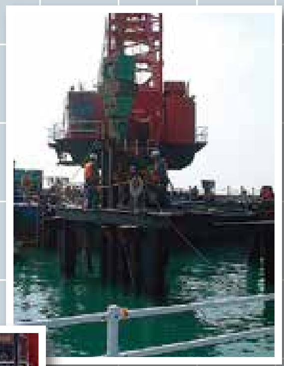
The graph on the right shows the outer water level (blue line) and the measured level inside the observation wells (black line). Predicted levels from the parameter of permeability coefficient of the wall are shown on the graph for comparison.
For the prediction, permeability coefficient was calculated assuming that the wall thickness was uniform (50 cm in this case).
From this graph, both the sealing rubber type and the filler injection type proved to have a permeability coefficient less than or equal to 1 × 10^{-7} cm/s or less.





PHOTOS OF EXECUTION SITE

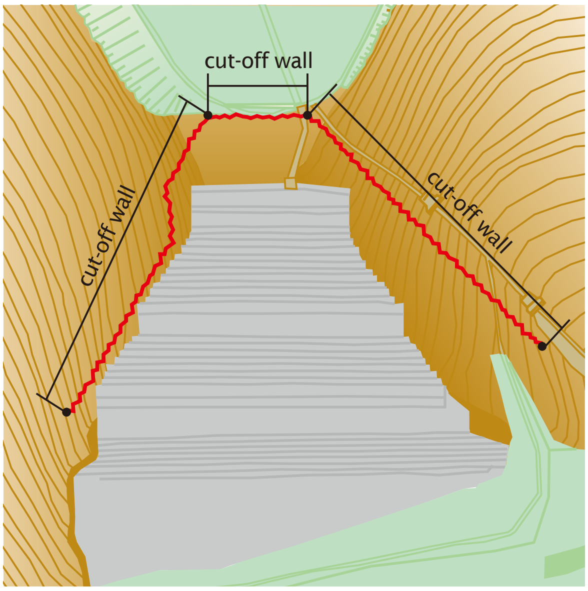




EXAMPLE OF APPLICATION ON AN ON-LAND DISPOSAL SITE

Overview

J-Pocket Pile was adopted for cut-off work of waste containment works at a non-industrial final disposal site (Yoshinogawa-city, Tokushima Prefecture).
J-Pocket Piles (9 to 24 m) were installed in a fan shape by a vibratory hammer to contain waste dumped in a valley at the site.



Photos of execution


● Installation of sealing rubber along pockets


● Piling by vibratory hammer


● Pulling out of pre-stressed concrete steel wires


● Setting of high-pressure pump


● Injection of filler material (silicone)


● Check of filling condition

CUT-OFF PERFORMANCE AT ON-SITE WELDS

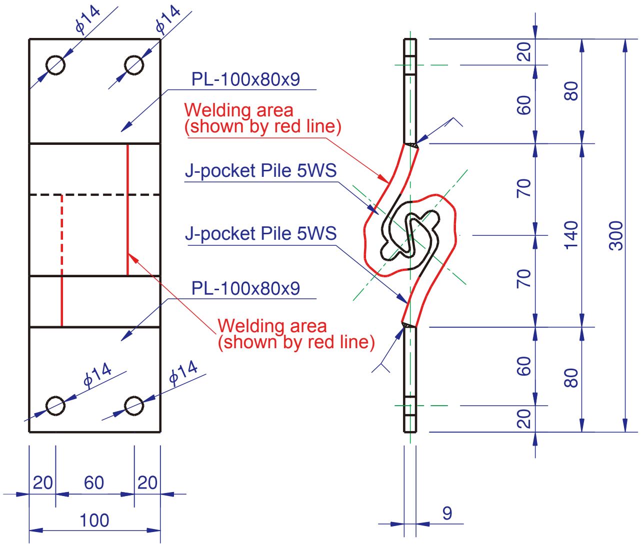
For steel sheet piles which need to be jointed by on-site welding due to transportation condition, laboratory test was conducted to check the cut-off sealing performance of the welds.

General description of test

The cut-off sealing performance was tested for differnt cases (see the table on the right). Visible external area of joints were padded by manual welding. For area that could not be welded, applying of silicone caulking was evaluated. Each test sample was set on the pressure vessel as shown in the photo, and the leakage from the joint was measured.

Case	Joint shape	Cut-off sealing material	Caulking method
CASE-1	Weld joint	Sealing rubber + Sealing rubber	Application of silicone
CASE-2		Sealingrubber + silicone resin	
CASE-3		Silicone resin + silicone resin	
CASE-4		Sealing rubber + silicone resin	Not caulked
CASE-5		Silicone resin + silicone resin	

Size of test sample



● Test sample and pressure vessel

Record of accumulated leakage

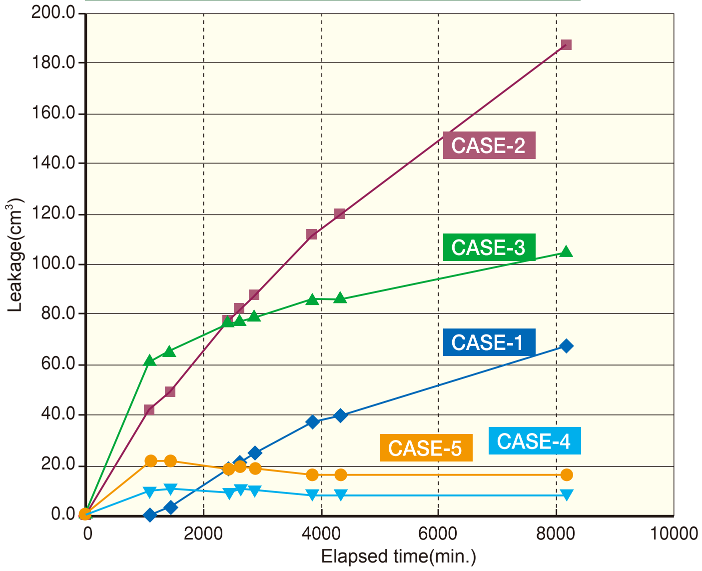


Photo of welding execution

Test results

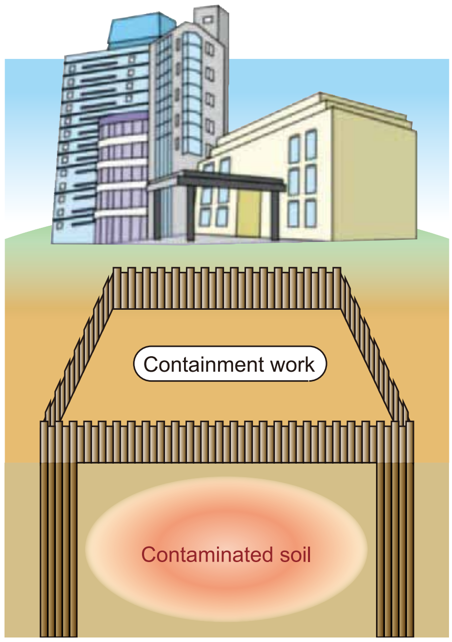
For each of case-1 to 5, the test showed that the cut-off sealing performance of on-site welds satisfied the standard.

	CASE-1	CASE-2	CASE-3	CASE-4	CASE-5
Leakage speed (cm³/s)	1.37E-04	3.83E-04	2.14E-04	1.69E-05	3.26E-05
Converted permeability coefficient (cm/s)	3.81E-08	1.06E-07	5.93E-08	4.70E-09	9.06E-09

*Converted to thickness of 50 cm

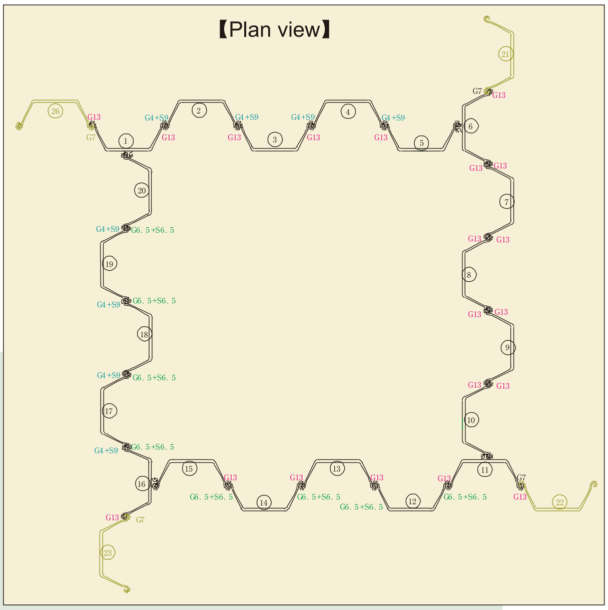
CUT-OFF WORK IN URBAN AREA

When using J-pocket Pile for soil contamination prevention work or waste disposal site construction work in an urban area, execution with low vibration and low noise is required. An execution test with a silent piler was carried out in order to observe issues such as deformation of the joint and damage to the sealing rubber.

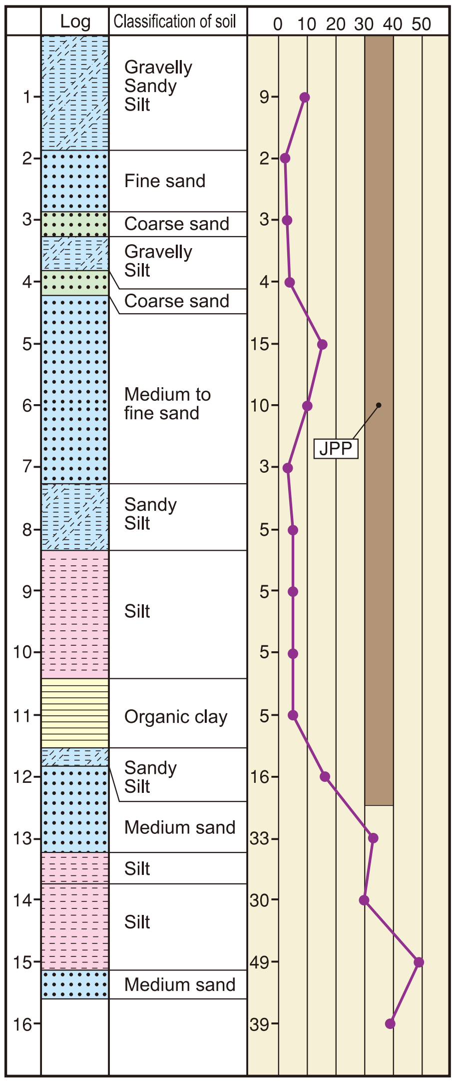


General description of test

13 m long J-pocket Piles were installed in a rectangular shape as shown on the right by a silent piler so as to check ① execution efficiency by press-in pile driving and ② extent of damage to the sealing rubber applied along the pockets.



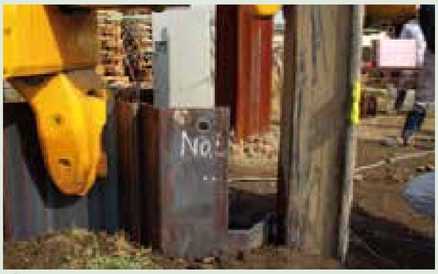
Boring log



STATE OF PILING EXECUTION

By installing piles with sealing rubber and pre-stressed concrete steel wire along the pockets, it was verified that J-pocket Pile has equal execution efficiency as conventional steel sheet piles, for both straight and corner areas.

● Execution at a corner



● Execution at a corner overlapping area

● Installation with pre-stressed concrete steel wire along pockets

Test results

Observation of damage to the sealing rubber pulled out from the piles after piling proved that press-in pile driving has no damage effect on the sealing rubber.

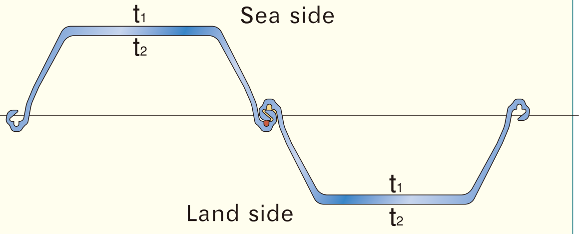
Section performance with corrosion

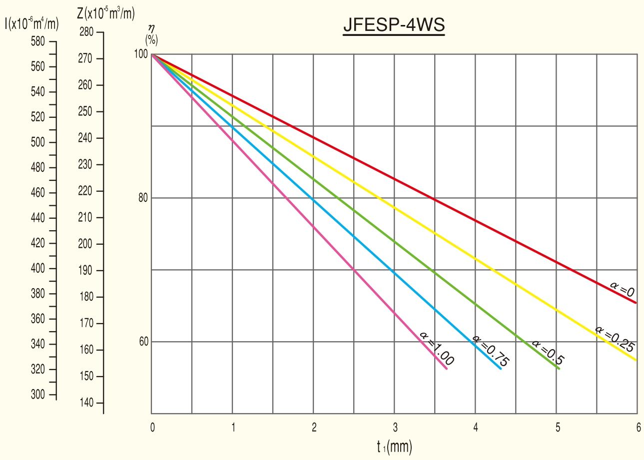
The below table shows the section performances of J-pocket Pile with corrosion of 1 mm on both sides (by 2 mm in total).

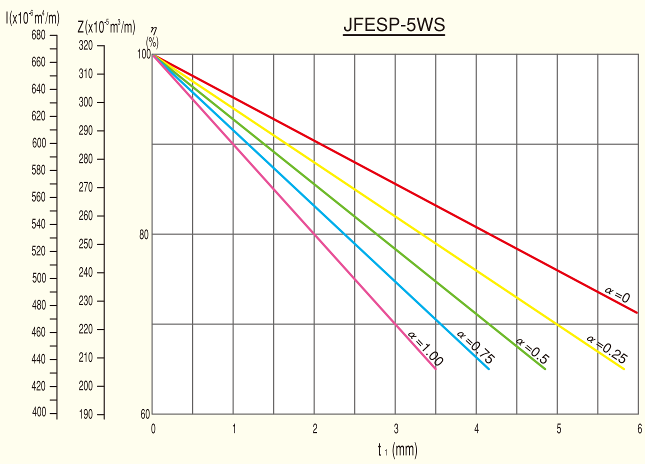
Model	Nominal performance		With corrosion of 1 mm on both sides		
	I_0 (m⁴/m)	Z_0 (m³/m)	η (%)	I (m⁴/m)	Z (m³/m)
JFESP-4WS	$57{,}000\times10^{-8}$	$2{,}720\times10^{-6}$	88	$50{,}200\times10^{-8}$	$2{,}390\times10^{-6}$
JFESP-5WS	$66{,}600\times10^{-8}$	$3{,}170\times10^{-6}$	90	$59{,}900\times10^{-8}$	$2{,}850\times10^{-6}$

The diagram below shows the section modulus of a pile with corrosion.

I_0	Geometrical moment of inertia with corrosion ($\times10^{-8}$m⁴/m)
I	Geometrical moment of inertia with corrosion ($\times10^{-8}$m⁴/m)
Z_0	Section modulus before corrosion ($\times10^{-6}$m³/m)
Z	Section modulus before corrosion ($\times10^{-6}$m³/m)
η	Rate of reduction in section modulus after corrosion (%)
t_1, t_2	Corrosion allowance of each side (mm)
α	Ratio of t_2 to t_1 $\alpha = t_2/t_1$







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JFE Steel Corporation

http://www.jfe-steel.co.jp/en/

HEAD OFFICE
Hibiya Kokusai Building, 2-3 Uchisaiwaicho 2-chome, Chiyodaku, Tokyo 100-0011, Japan Phone: (81)3-3597-3111 Fax: (81)3-3597-4860

■ ASIA PACIFIC

SEOUL
JFE Steel Korea Corporation
16th Floor, 41, Cheonggyecheon-ro, Jongno-gu, Seoul, 03188, Korea
(Youngpung Building, Seorin-dong)
Phone: (82)2-399-6337 Fax: (82)2-399-6347

BEIJING
JFE Steel Corporation Beijing
1009 Beijing Fortune Building No.5, Dongsanhuan North Road, Chaoyang District, Beijing, 100004, P.R.China
Phone: (86)10-6590-9051 Fax: (86)10-6590-9056

SHANGHAI
JFE Consulting (Shanghai) Co., Ltd.
Room 801, Building A, Far East International Plaza, 319 Xianxia Road, Shanghai 200051, P.R.China
Phone: (86)21-6235-1345 Fax: (86)21-6235-1346

GUANGZHOU
JFE Consulting (Guangzhou) Co., Ltd.
Room 3901 Citic Plaza, 233 Tian He North Road, Guangzhou, 510613, P.R.China
Phone: (86)20-3891-2467 Fax: (86)20-3891-2469

MANILA
JFE Steel Corporation, Manila Office
23rd Floor 6788 Ayala Avenue, Oledan Square, Makati City, Metro Manila, Philippines
Phone: (63)2-886-7432 Fax: (63)2-886-7315

HO CHI MINH CITY
JFE Steel Vietnam Co., Ltd.
Unit 1704, 17th Floor, MPlaza, 39 Le Duan Street, Dist 1, HCMC, Vietnam
Phone: (84)28-3825-8576 Fax: (84)28-3825-8562

HANOI
JFE Steel Vietnam Co., Ltd., Hanoi Branch
Unit 1501, 15th Floor, Cornerstone Building, 16 Phan Chu Trinh Street, Hoan Kiem Dist., Hanoi, Vietnam
Phone: (84)24-3855-2266 Fax: (84)24-3533-1166

BANGKOK
JFE Steel (Thailand) Ltd.
22nd Floor, Abdulrahim Place 990, Rama IV Road, Silom, Bangrak, Bangkok 10500, Thailand
Phone: (66)2-636-1886 Fax: (66)2-636-1891

YANGON
JFE Steel (Thailand) Ltd., Yangon Office
Unit 05-01, Union Business Center, Nat Mauk Road, Bocho Quarter, Bahan Tsp, Yangon, 11201, Myanmar
Phone: (95)1-860-3352

SINGAPORE
JFE Steel Asia Pte. Ltd.
16 Raffles Quay, No.15-03, Hong Leong Building, 048581, Singapore
Phone: (65)6220-1174 Fax: (65)6224-8357

JAKARTA
PT. JFE STEEL INDONESIA
6th Floor Summitmas II, JL Jendral Sudirman Kav. 61-62, Jakarta 12190, Indonesia
Phone: (62)21-522-6405 Fax: (62)21-522-6408

NEW DELHI
JFE Steel India Private Limited
806, 8th Floor, Tower-B, Unitech Signature Towers, South City-I, NH-8, Gurgaon-122001, Haryana, India
Phone: (91)124-426-4981 Fax: (91)124-426-4982

MUMBAI
JFE Steel India Private Limited, Mumbai Office
603-604, A Wing, 215 Atrium Building, Andheri-Kurla Road, Andheri (East), Mumbai-400093, Maharashtra, India
Phone: (91)22-3076-2760 Fax: (91)22-3076-2764

CHENNAI
JFE Steel India Private Limited, Chennai Office
No.86, Ground Floor, Polyhose Towers(SPIC Annexe), Mount Road, Guindy, Chennai-600032, Tamil Nadu, India
Phone: (91)44-2230-0285 Fax: (91)44-2230-0287

BRISBANE
JFE Steel Australia Resources Pty Ltd.
Level28, 12 Creek Street, Brisbane QLD 4000 Australia
Phone: (61)7-3229-3855 Fax: (61)7-3229-4377

■ EUROPE and MIDDLE EAST

LONDON
JFE Steel Europe Limited
15th Floor, The Broadgate Tower, 20 Primrose Street, London EC2A 2EW, U.K.
Phone: (44)20-7426-0166 Fax: (44)20-7247-0168

DUBAI
JFE Steel Corporation, Dubai Office
P.O.Box 261791 LOB19-1208, Jebel Ali Free Zone Dubai, U.A.E.
Phone: (971)4-884-1833 Fax: (971)4-884-1472

■ NORTH, CENTRAL and SOUTH AMERICA

NEW YORK
JFE Steel America, Inc.
600 Third Avenue, 12th Floor, New York, NY 10016, U.S.A.
Phone: (1)212-310-9320 Fax: (1)212-308-9292

HOUSTON
JFE Steel America, Inc., Houston Office
750 Town & Country Blvd., Suite 705 Houston, Texas 77024, U.S.A.
Phone: (1)713-532-0052 Fax: (1)713-532-0062

MEXICO CITY
JFE Steel America, Inc., Mexico Office
Ruben Dario #281-1002, Col. Bosque de Chapultepec, C.P. 11580, CDMX. D.F. Mexico
Phone: (52)55-5985-0097 Fax: (52)55-5985-0099

RIO DE JANEIRO
JFE Steel do Brasil LTDA
Praia de Botafogo, 228 Setor B, Salas 508 & 509, Botafogo, CEP 22250-040, Rio de Janeiro-RJ, Brazil
Phone: (55)21-2553-1132 Fax: (55)21-2553-3430

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