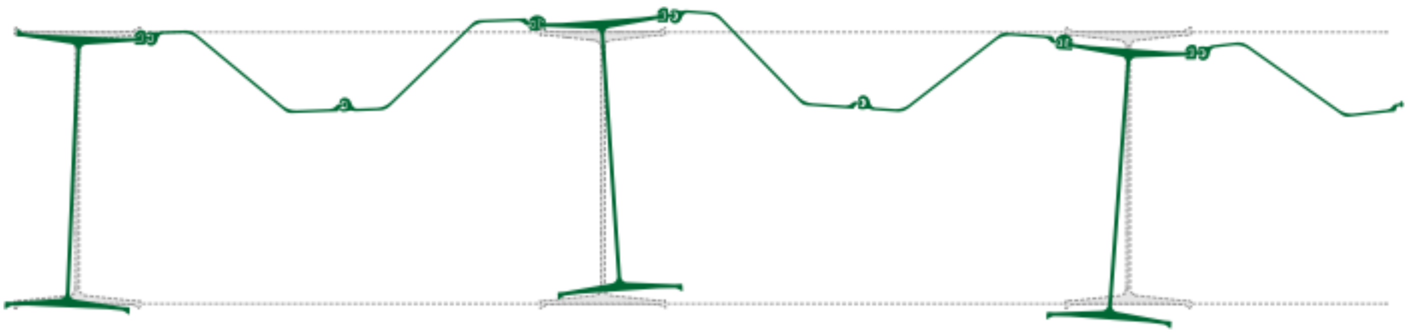
As installation of traditional contiguous sheet pile wall, such as Z-sheet piles, is fairly well known, this article will discuss how to install a combined sheet pile wall.

Construction of a combined sheet piling wall is actually very simple and straightforward.

First, drive the the beams. The king piles can be (preferably) installed before the intermediate sheet piles. Hence, the construction of the wall can progress based on the earlier delivery of the beam sections. It is recommended to use a platform or a pontoon with a horizontal frame jig for setting and driving the beams for a combined wall. Minimum two point guidance is the most effective way to have control over the beam positioning and driving.

Secondly, install the sheet piling between the already installed king piles. The sheet piling can usually be installed with vibratory hammers, thus greatly reducing the total driving effort expended in the total length of wall installed.

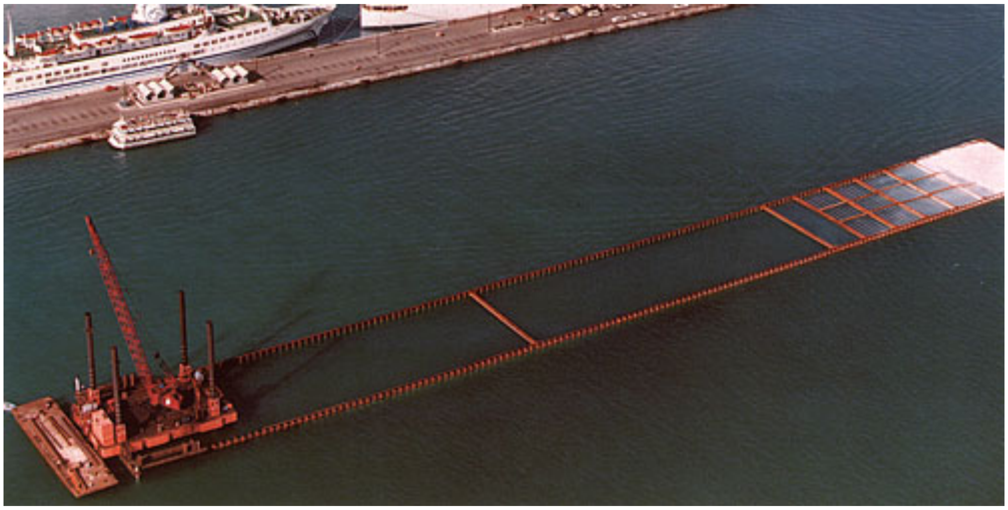
Slight deviations of the beams (from the driving line) that are inherent to the installation process will be tolerated by the flexible joints of the intermediate sheet piling and connectors, thus avoiding much of the rework involved in walls that use only heavy sheets.

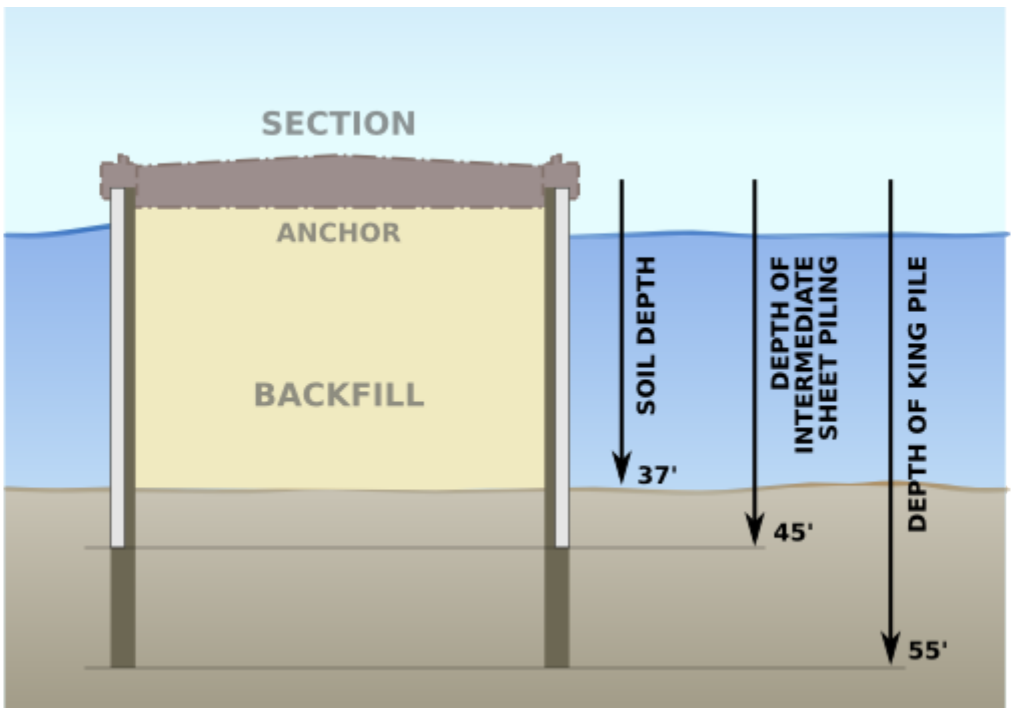


The behavior of the primary elements, whether beams or pipes, while driving into soil, is compact and stable. This advantage of the combined sheet piling over the contiguous wall in the setting/driving is another reason why combined sheet piling walls often represent the better, structurally superior retaining wall construction solution.

Combined sheet piling wall beam and pipe king piles are able to go deeper into dense soils than sheet piling sections of a contiguous wall — approximately 6.5 feet (2 meters) compared to 1.5 feet (0.5 meters). *Quite simply, the intermediate sheet piling does not need to be installed to the same depth as the beams because they do not need to contribute to the moment capacity of the system at those depths.* Hence, the sheets themselves, in a combined sheet piling wall, can be significantly shorter than the beams: in most cases, a 60% to 80% sheet-to-beam length ratio – which significantly reduces construction costs.

Here is an example of a typical combined sheet piling wall project to illustrate the above. This particular cofferdam project is in the Bahamas.





The fact that you only need to drive the beams and pipes to full depth and then simply set the intermediate sheets is an extremely important advantage of the combined sheet piling wall over heavier sheet piling from contiguous walls.

A combined sheet piling wall system has a typical sheet width of 6.33 feet (1.93 M) — two halves of each beam, two connectors, and two sheets. The usual sheet to beam ratio in a combined sheet piling wall system is around 75% sheet to 25% beam. *Hence, you are likely to only encounter hard driving 25% of the length of a combined sheet piling wall versus 100% hard driving for a contiguous sheet pile wall.*

In some cases where hard driving was experienced, it has been documented that up to 22 combined sheet piling wall systems have been driven in one 10-hour shift, amounting to well over 100 wall feet; in the same conditions, however, the same exact crew was only able to install about 1/3 of the wall feet with the heavy contiguous sheet piling that needed to be driven to full depth.

GENERAL SHEET PILING CONSTRUCTION PRACTICE

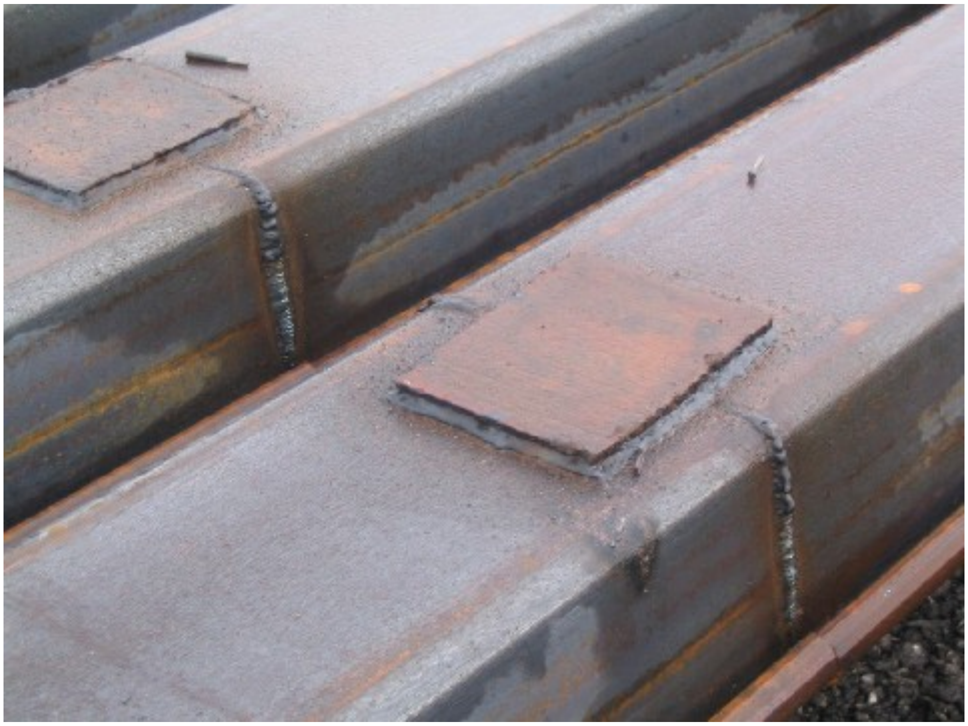
(Based on Marina Barrage Project experience)

1) Usually from 2 ends moving towards the middle to avoid pile tilting (creeping);
2) Set a stretch of pile panel, say 10m long; or within natural 2 corner piles;
3-1) On land: within the working stretch, lay guide beam ('I" beam);
3-2) On sea: install king post, "I" cross beam and guide beams ("I" beam). Also install access using "I" beam by the side of guide beam;
4) Drive the 1st layer of sheet piles to the ground level (welding seams shall be staggered during fabrication);
5) Alternate pitching the 2nd tier sheet piles and join them to the 1st tier by welding;
6) Alternate drive the 2nd tier sheet piles;
7) Repeat the procedure 4-6.

NOTE:
1) Purpose of alternate driving:
- Staggering welding point of neighboring piles;
- Avoid pile tilting (creeping).
2) Corner piles are special made for turning and joint.
3) 12 ton for a pair, 8 ton for single sheet piles.
4) There is relationship among sheet pile depth, soil condition, type of sheet pile used (III, IV, or VI) and type of hammer to be used (hydraulic or vibro, and the weight). Generally, the harder of the soil, the deeper of the penetration, the bigger and thicker size of sheet pile, the more heavy-duty hammer is required.
5) When the depth goes deeper, the resistance from the friction of the sheet pile is getting bigger and this friction prevails the soil resistance.
6) Generally, the bigger size of sheet pile can go deeper. Also, the pipe (eg. dia=600mm) can go deeper than sheet pile.
7) Sheet piles tend to be easy to be extracted later when the vibro is used instead of hydraulic hammer.

SHEET PILE FABRICATION AND TESTING

(Based on Marina Barrage Project experience)



Close view of the sheet pile spicing

Welding of splicing

MPI test (Magnetic Particle Inspection) for the welding joint

---

DRIVING-IN METHOD

(Based on Marina Barrage Project experience)

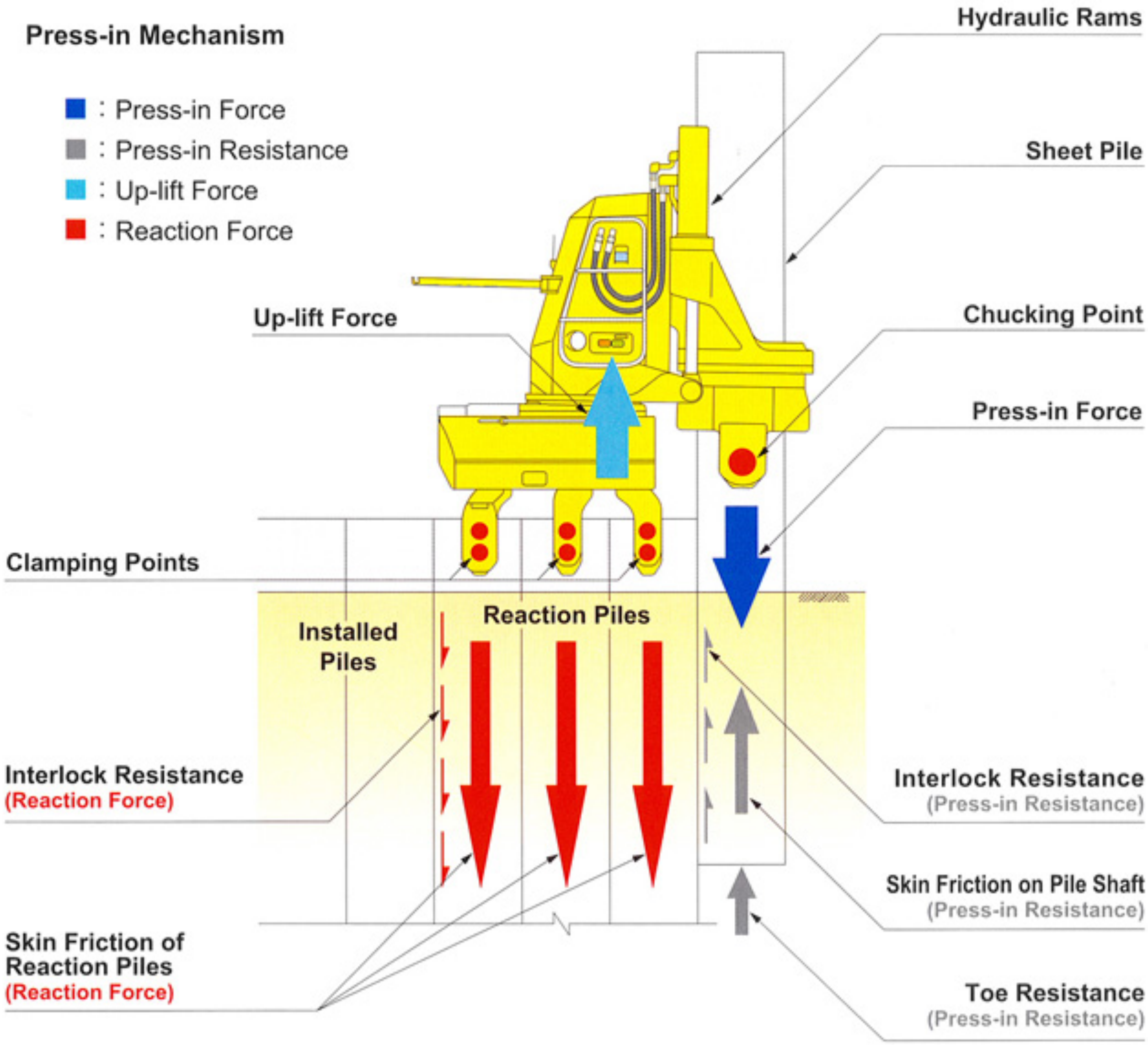
Impact Hammer Driving: A 7-ton hydraulic hammer

Vibro-driving: A 12-ton vibro hammer

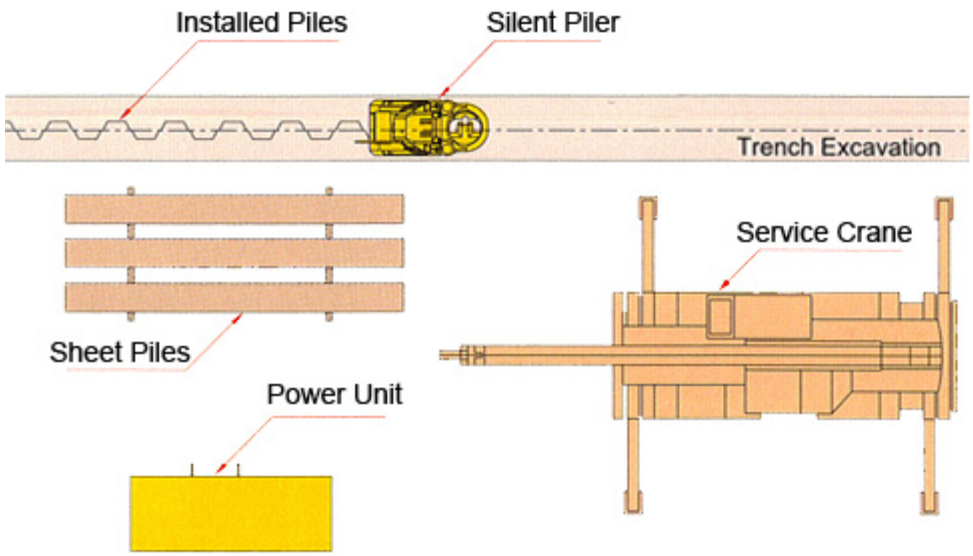
Vibro-driving: Power pack for vibro hammer

PRESS-IN METHOD (SILENT PILER)

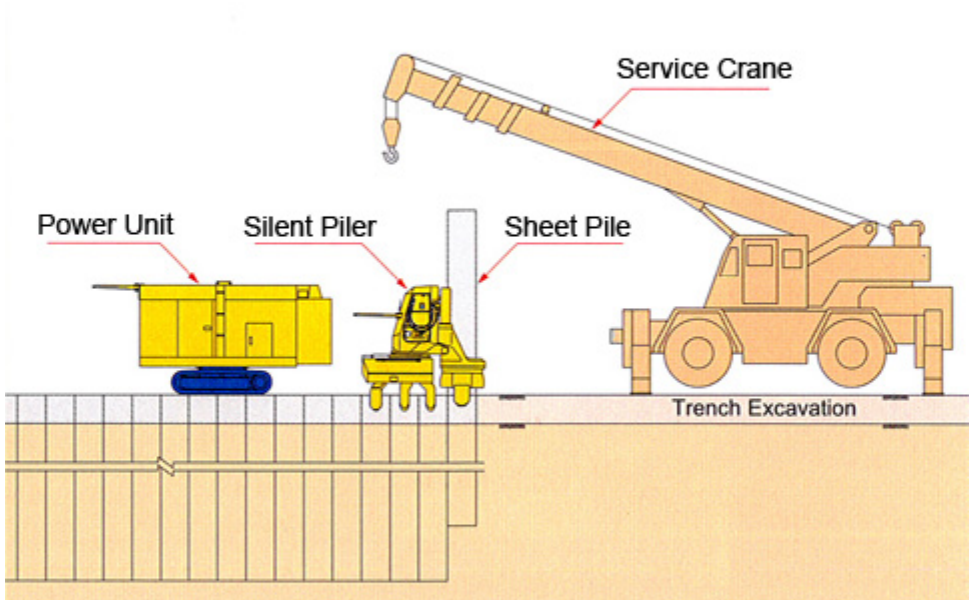
(Extracted from the Oriental-Arcelor and Giken catalogues (2006))



Press-in principle



Machine layout plan for typical silent piling



Machine layout elevation for typical silent piling

Silent piler for sheet piles

Driving Aids in Hard Soil:

- Pre-augering;
- Water jet;
- Pre-drilling

Pre-augering

Left: Water jet; Right: Pre-drilling

DRIVING GUIDE AND CORNER PILES

(Based on Marina Barrage Project experience)

Lay guide beams before installation of sheet piles

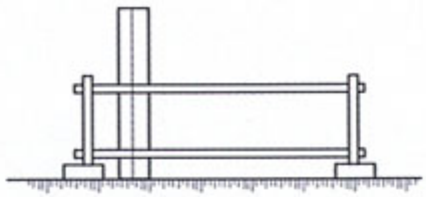
Corner pile

NORMAL DRIVING METHODS

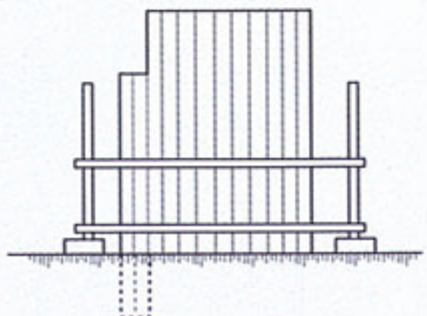
- Pitch and drive;
- Panel driving;
- Staggered driving;
- Combination

Panel Driving Method - A Recommended Driving Method
(Extracted from the Oriental-Arcelor (2006))

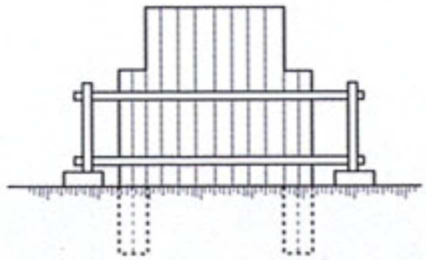
❶Pitch, align & plumb 1st Pair



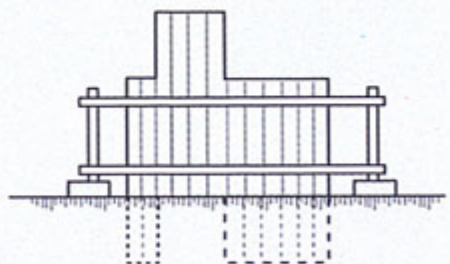
❷Drive 1st pair - carefully & accurately pitch remainder of panel



❸Ensure last pair are accurately positioned & plumbed, drive last pair.

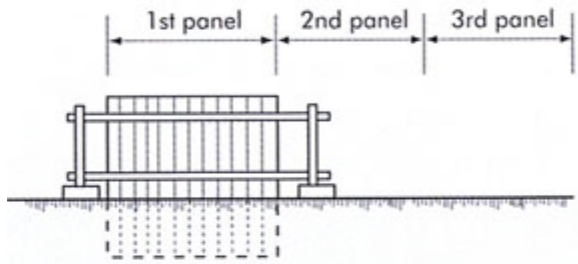


❹Drive remainder of panel - working backwards towards 1st pair

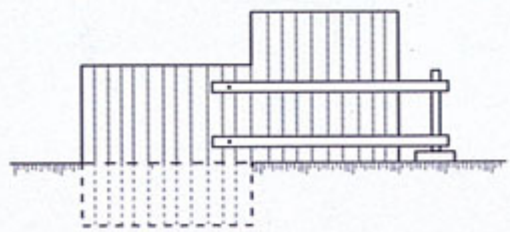


---

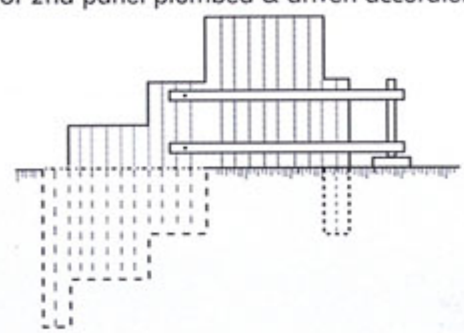
❺ 1st panel part driven



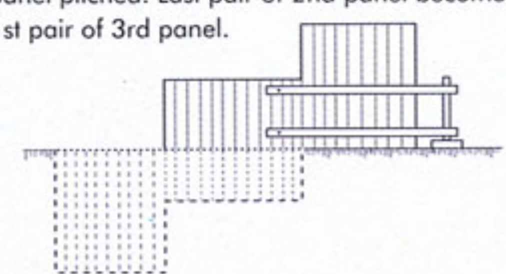
❻ 2nd panel pitched. Last pair of 1st panel become 1st pair of 2nd panel, gates supported by thro'bolting to last driven past



❼ 1st panel driven to final level in stages. Last pair of 2nd panel plumbed & driven accurately



❽ lst panel completed, 2nd panel part driven, 3rd panel pitched. Last pair of 2nd panel become 1st pair of 3rd panel.



DRIVABILITY

(Extracted from the Oriental-Arcelor (2006))

Proposed Driving Methods in Cohesionless Ground

SPT Value	Vibrodrive	Impact Drive	Pressing in Singles (with Jetting)
0-10	Very Easy	Runaway problem - use vibro method to grip pile	Stability problem & insufficient reaction
11- 20	Easy	Easy	Suitable
21 - 30	Suitable	Suitable	Suitable
31 - 40	Suitable	Suitable	Consider pre-auger
41 - 50	Very Difficult	Suitable - Consider high yield steel	Pre-auger
51+	Not Recommended	Suitable - Consider high yield steel	Very difficult

Proposed Driving Methods in Cohesive Strata

Su Value	Vibrodrive	Impact Drive	Pressing in Singles
0-15	Easy	Runaway problem - use vibro method to grip pile	Stability problem & insufficient reaction
16- 25	Suitable	Easy	Easy
26 - 50	Suitable - becoming less effective with depth	Suitable	Easy
51 - 75	Very Difficult	Suitable	Suitable
76 - 100	Not Recommended	Suitable	Suitable
100+	Not Recommended	Suitable	Difficult

LAND SHEET PILING

(Based on Marina Barrage Project experience)

With Hydraulic Hammer

PRODUCTION RATE	CREW	PLANT	WORKING CONDITION
150-200 m (penetration)/rig.d, or 3-4 m/rig.d (on plan)	- 1 charge hand - 1 piling rig operator; - 1 welder	- Diesel driven crawler type piling rig; - 8-6 ton hydraulic drop hammer	- Soft to media sandy clay; - 18m deep; - 2 rigs working cooperatively: 1st (light weight hammer) pitching, 2nd (heavy weight hammer) tapping to the design level - Drive in single sheet pile

With Vibro Hammer

PRODUCTION RATE	CREW	PLANT	WORKING CONDITION
150 m (penetration)/rig.d, or 3 m/rig.d (on plan)	- 1 charge hand; - 1 crane operator; - 2 vibro controllers	- Crawler crane; - Vibro hammer: 12 ton for driving a pair of sheet pile, 8 ton for a single sheet pile	- Soft to media sandy clay; - 18m deep; - May also use 2 rigs working cooperatively: 1st (light weight hammer) pitching, 2nd (heavy weight hammer) tapping to the design level - Usually driving in pair of sheet piles

Typical Photographs

Driving sheet pile using hydraulic hammer

Driving sheet pile using vibro hammer

CROSS REFERENCE

MARINE SHEET PILING

(Based on Marina Barrage Project experience)

PRODUCTION RATE	CREW	PLANT	WORKING CONDITION
240-350 m (penetration)/rig.d, or 2.3-3.3 m/rig.d (on plan)	- 1 captain; - 1 crane operator; - 2 vibro controllers; - 1 vibro power pack operator; - about 5 welders	- Crane barge; - 8 or 12 ton vibro hammer with power pack; - Material barge; - Tug boat (shared use)	- Soft to media sandy clay; - 42m deep; - Can be 2 barge working cooperatively: 1st (light weight vibro pitching, 2nd (heavy weight vibro) tapping to the design level - Driving in pair of sheet piles

NOTE:
1) Typical crane barge size: 40-45m x 13-15m;
2) Anchor length (2 nos. and crossing, at both ends): the longer, the stable. Minimum 20m (1:2), normally 40m (1:1);
3) Crane lifting capacity 150t can lift up to 12t vibro hammer.

TYPICAL PHOTOGRAPHS

A typical layout when piling for marine sheet piles

Sheet pile fabrication yard - to join 2 pieces of sheet piles (12m, 14m, 16m) by butt welding and splice plate

Interlocking 2 pieces of sheet piles to become a pair


Install a guide beam before driving sheet piles

Close view of the guide beams

Driving marine sheet pile using vibro hammer from crane barge

Sheet pile installation pattern - alternate pitching and driving (neighbouring welding splice staggered)