DELMAG

Techniques of operation

Driving sheet piles

Preparations

Driving sheet piles successfully depends on several factors. Paying close attention and tuning up on these factors is highly important.

Choosing the right profile

Two factors are decisive:

- The choosen profile must be of sufficient strength for the purpose it is installed.
- The choosen profile must withstand the driving stresses and be able to penetrate the soil formation on the particular jobsite (if in doubt, drive a test pile).

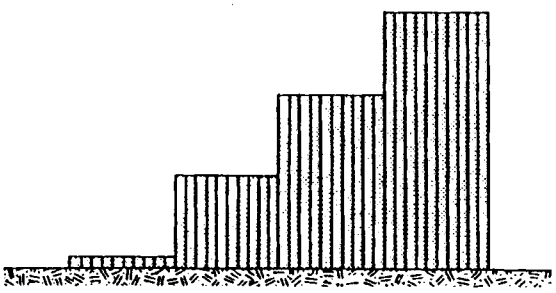
Determine how many sheets are to be driven in one operation

- single sheets (avoid, if possible)
- double sheets
- triple sheets
- quadruple sheets

Determine the driving procedure

Driving sheet piles in steps

This procedure leads to the best results. Applicable everywhere, especially where difficult soil formations are presented, where specifications require a high quality sheet wall and where long sheet piles have to be driven.



Driving sheet piles in one operation

Only applicable with short sheet piles driven in light soil formations.

Choosing the pile hammer and the carrier unit

Pile hammer

Driving sheet piles, it has to be considered that besides the friction in the interlocks, a plug is formed at the pile toe during driving, which can decrease driving speed considerably. Thus, the ratio of impact weight to pile weight should be about 1:1 to 2:1.

Carrier unit

According to the site conditions, one can choose between a pile driving rig on wheels, crawlers or on walking devices, crawler crane with hanging leader, swivel leader, swinging leader or rope suspended leader, and swivel leader mounted to a hydraulic excavator.

Using a swivel leader assures economical driving even in tight corners. The driving of corner piles and junctions is possible without additional equipment.

Choosing a pile driving crew

An experienced foreman and a good crew is the best insurance for an accurately driven sheet pile wall. They are responsible:

- For the economical use of the equipment and its maintenance.
- For the safe stand of the pile driving rig.
- For the entire pile driving operation, checking the driving progress and trouble shooting.
- For the proper alignment of hammer, pile cap and pile.
- For building and installation of guides and templates.

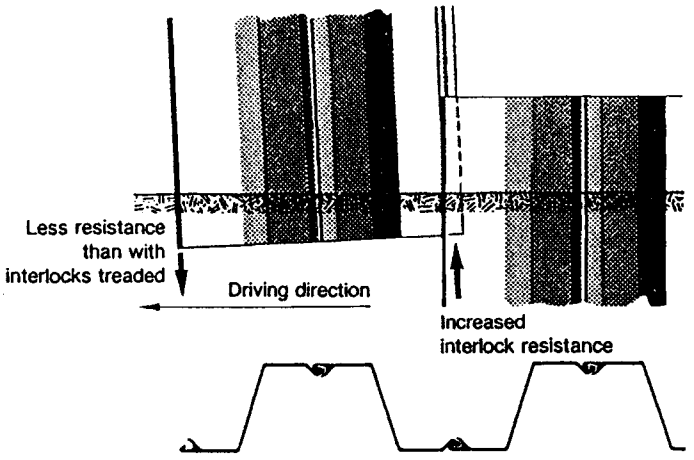
Working procedures

The most common difficulties are:

1. **Creeping ahead**
2. **Creeping back**
3. **Leaning**
4. **Damaging the pile heads**
5. **Moving of the adjoining sheet piles**
6. **Driving through rock layers and setting the pile toe into rack.**

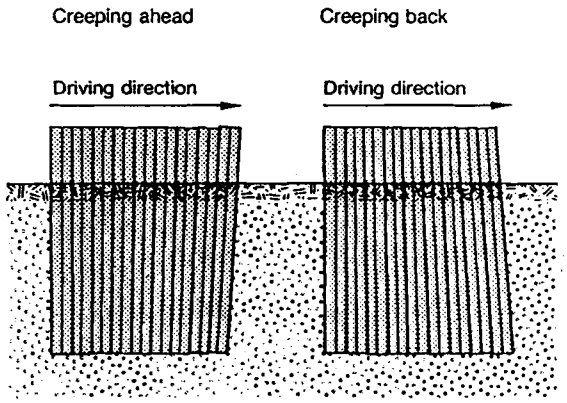
Driving with the assistance of jetting
(see enclosure ZRDE 02003/0)

Reason: Is a sheet pile driven with a finger and thumb leading, soil enters the interlook and becomes highly compacted. The following driven sheet has to force the soil highly compacted, thus increasing interlock friction considerably. The leading edge penetrates faster – the pile creeps ahead.



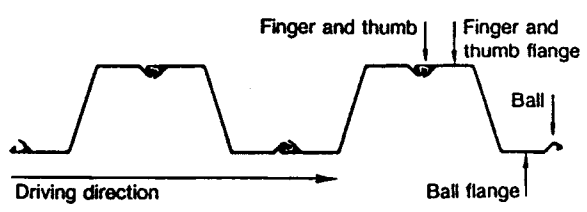
1. Creeping ahead of the driving direction

Creeping is caused by various reasons, and can be prevented in different ways.
Important is to check continuously the piles during driving. As soon as creeping occurs, corrective measures must be taken immediately when driving the next sheet pile, to keep the wall in alignment.



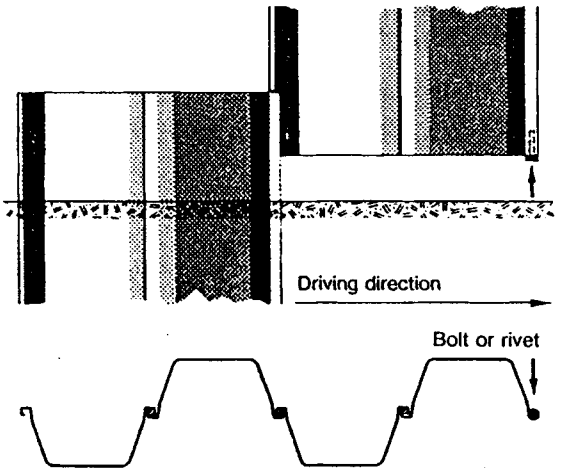
1.1 Preventing measures

1.1.1. Always drive Z-profiles the way, that the ball ist leading.

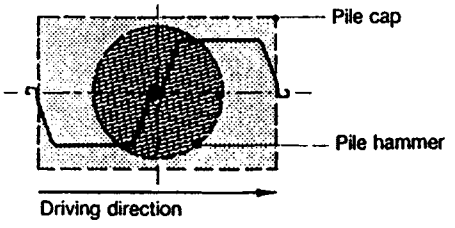


1.1.2. Driving of Larssen sheet piles

With this profile, always a thumb is in driving direction. Close the leading thumb (interlock) with a bolt, rivet or piece of round steel in order to prevent entering soil into the interlock, especially in cohesive and gravel soil conditions.
In sandy soils, close the interlock by strips of styropor 2×2 cm.

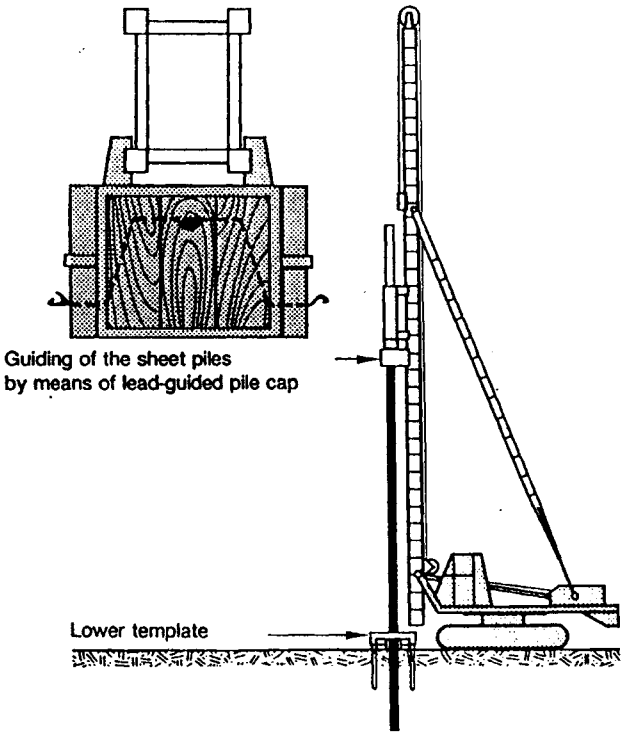


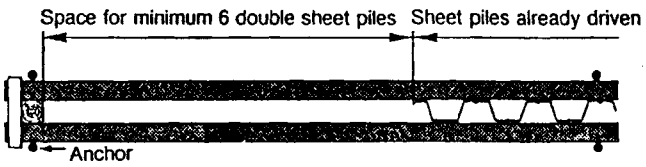
1.1.3. Make sure the pile hammer ist centered on the sheet pile, thus distributing the energy evenly to the pile.



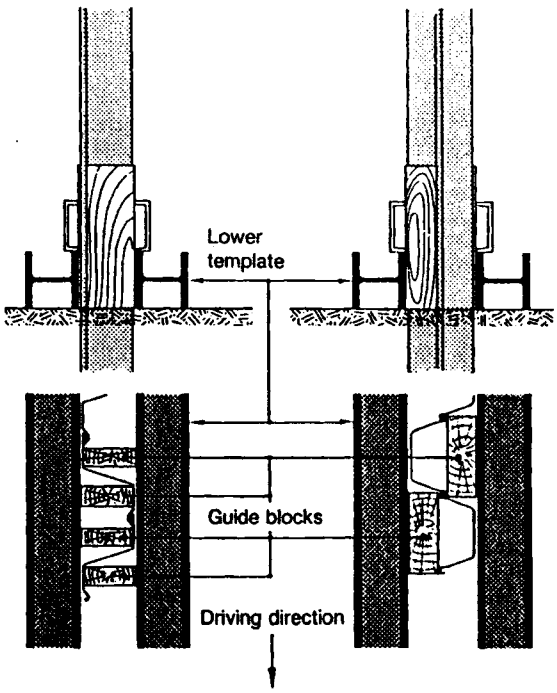
1.1.4. Guide sheet piles by means of template (walling) and a guided pile cap.

As more accurate the template, as better the guidance of the sheet pile. The template must be strongly built and anchored tightly to the ground.

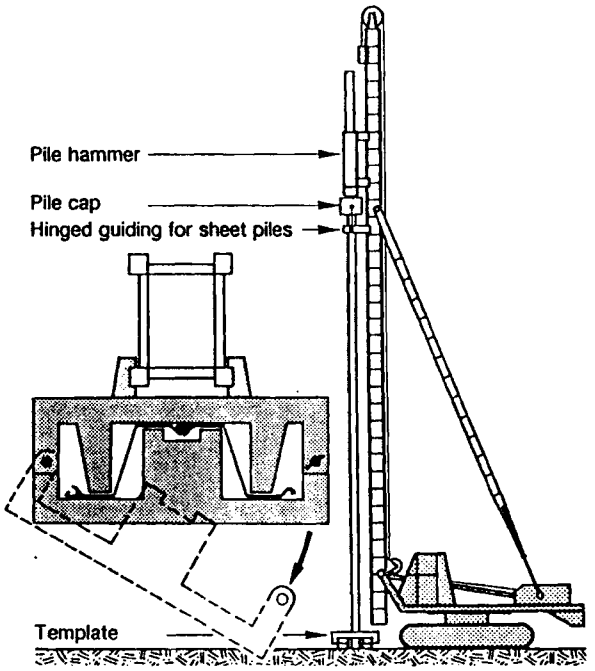




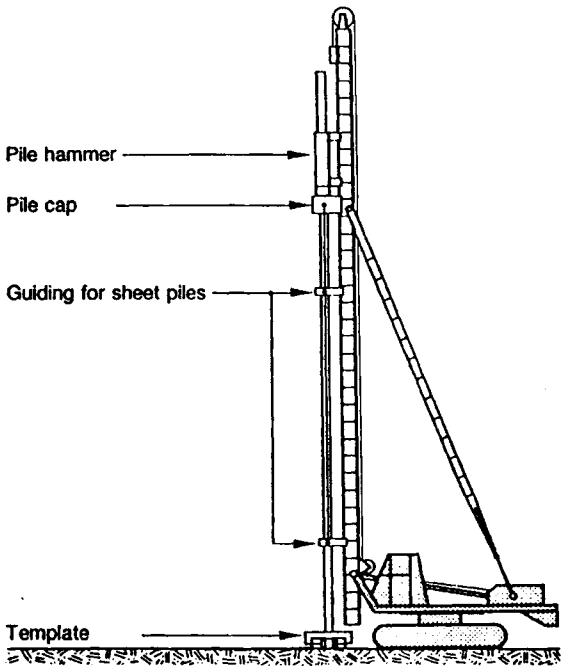
Secure sheet piles with guide blocks to the lower template during driving.



If for some reason it is not possible to use a guided pile cap, the sheets must be guided at the pile head by a pile guide to keep the pile centered under the pile hammer.

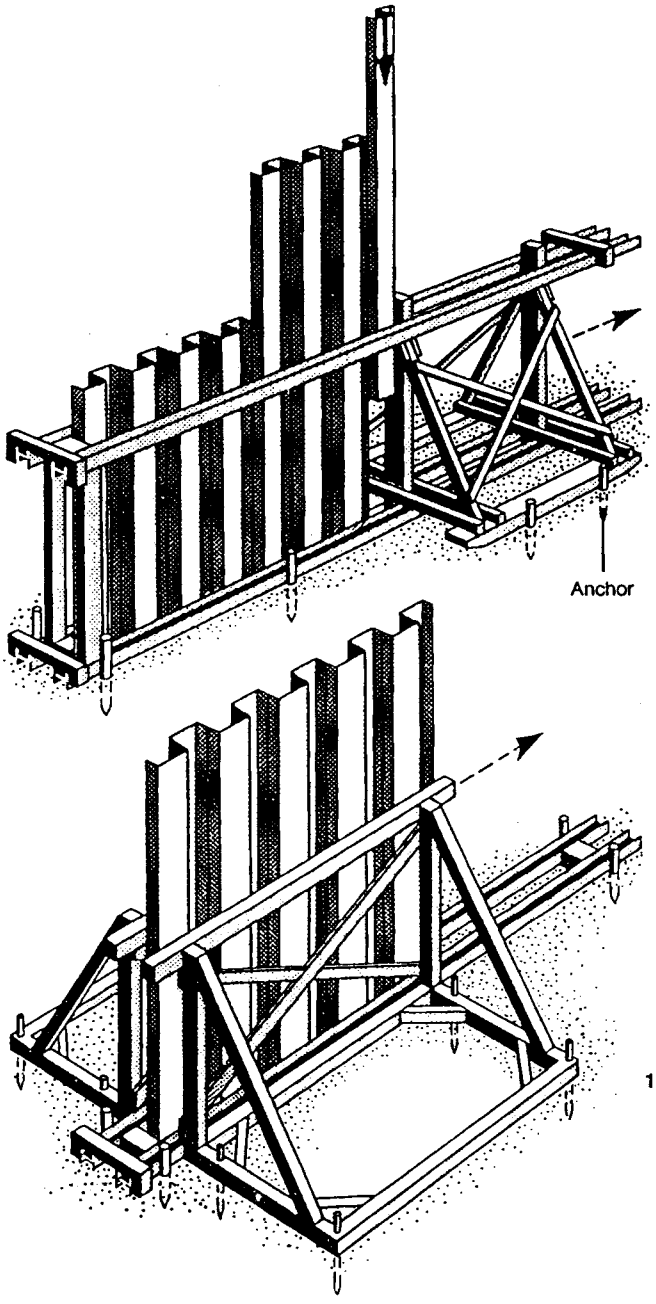


Driving very long sheet piles, it is recommended to use several pile guides. They prevent bending vibration, which leads to a considerable energy loss.



1.1.5. Driving sheet piles with swinging leaders, rope suspended leaders or free riding pile hammers, a frame type template should be used to guide the piles.

First set several sheet piles, than start driving.



The best way to get a plumb and accurate wall is:

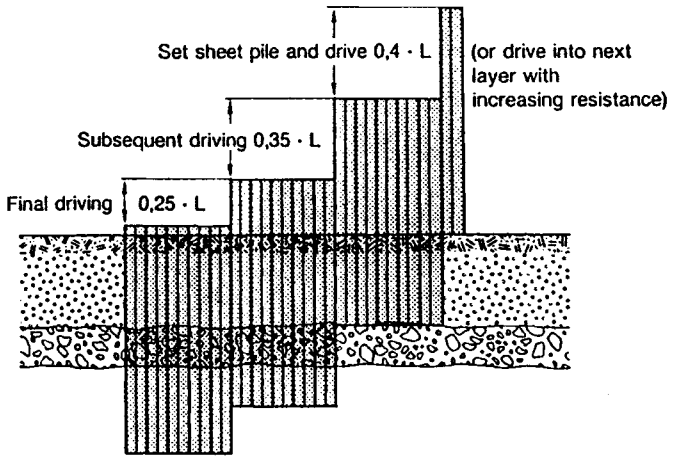
After all sheet piles are set, drive sheets until they are self-supporting. Relocate frame type template, thread the next row of sheet piles and drive to same grade as the previous ones.

Depending on the soil conditions, the sheet piles then are driven to grade in steps or in one operation. In any case the lower template remains anchored to the ground until the sheets are driven to grade.

1.1.6. In difficult soils, principally drive in steps.

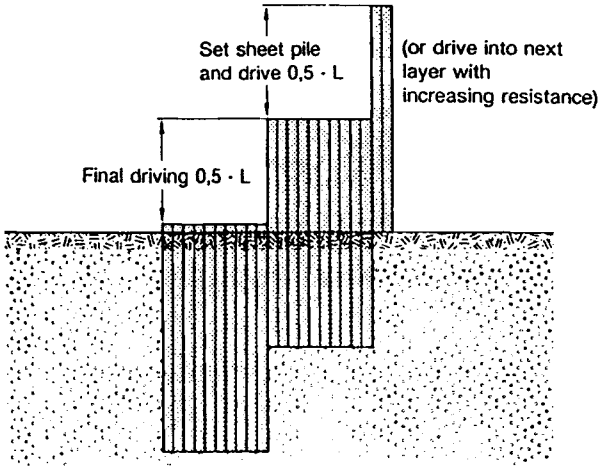
Example:

Driving in steps in heavy soil conditions; of disadvantage is, that either the sheets must be set by an additional crane or a pile driving frame with an effective leader length of L + 0,6 is required.



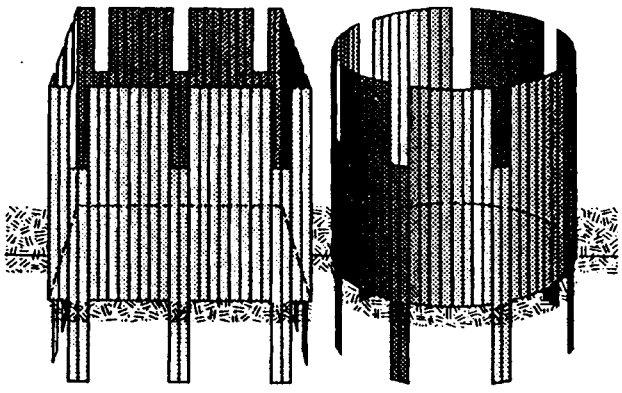
Example:

Driving in 2 steps in medium soil conditions.



1.1.7. Driving cofferdams and cellular cofferdams, set and close the entire structure, then drive each 4th or 5th pile partially.

The partially driven sheet piles anchor the cofferdam and provide a good guidance for the remaining sheets. Then drive all sheet piles to grade, proceeding in a stepwise operation.



1.2. Countermeasures

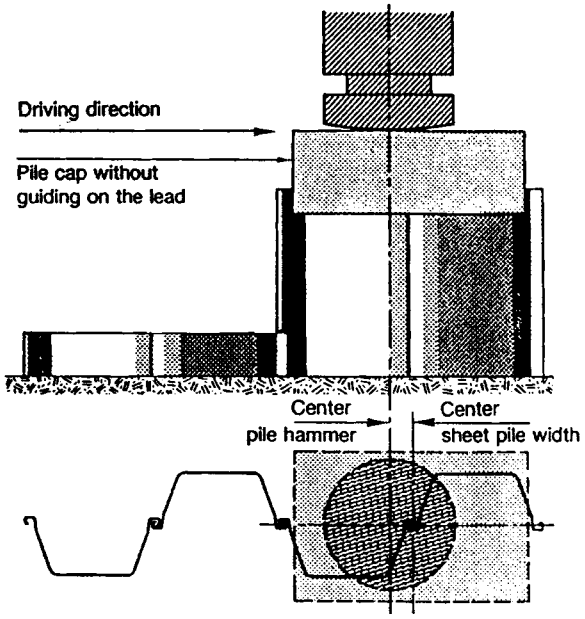
If the sheet piles get out of alignment even so all preventive measures had been taken, it can be corrected by relatively simple means.

Important!

Take corrective measures immediately once a sheet pile goes out of aligment.

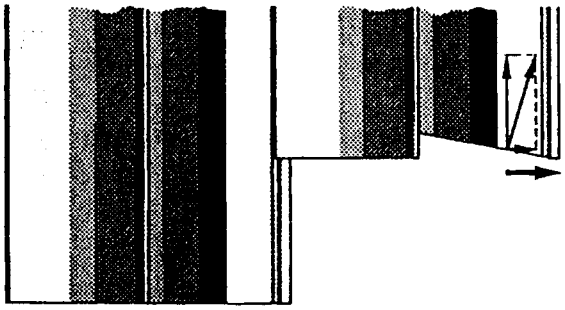
1.2.1. Shift pile hammer towards the already driven sheet pile.

Only possible when the pile cap is not guided on the lead, respectively the pile cap guides must be removed. That way the energy is induced closer to the interlock and can overcome the here prevailing resistance more easily.



1.2.2. Bevelling the sheet piles

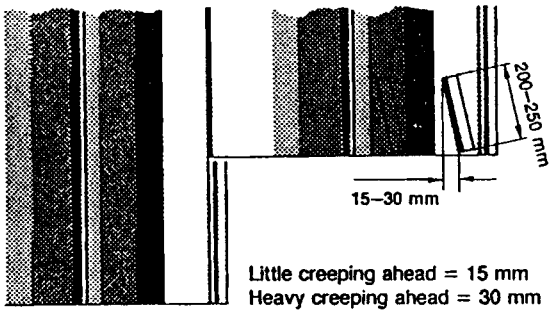
The sheet pile is pushed away from the interlock, thus allowing the pile to find back to its proper alignment.



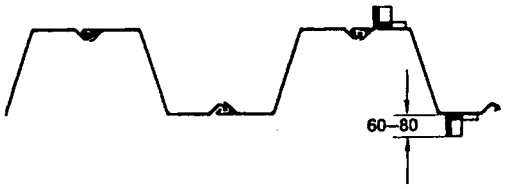
Note: Too much bevel can damage the pile.

1.2.3. Installing resistance plates.

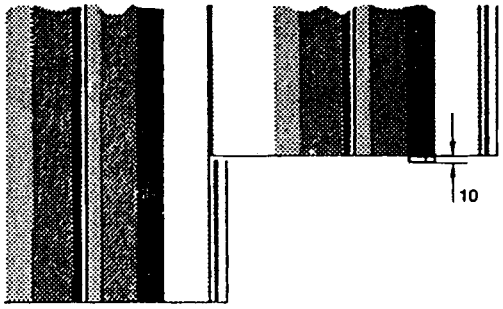
- Weld an angle iron to the pile toe

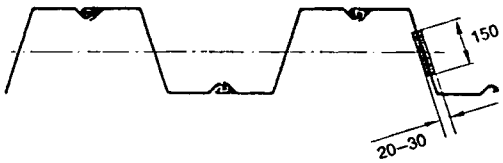


Little creeping ahead = 15 mm
Heavy creeping ahead = 30 mm

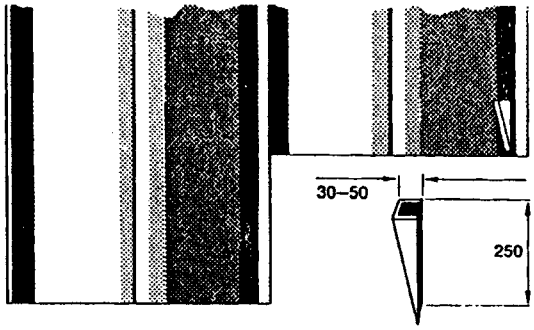


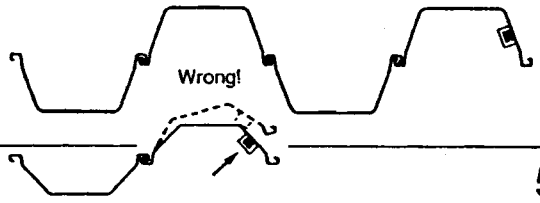
- Weld a flat bar to the web of the sheet pile or directly under the interlock.



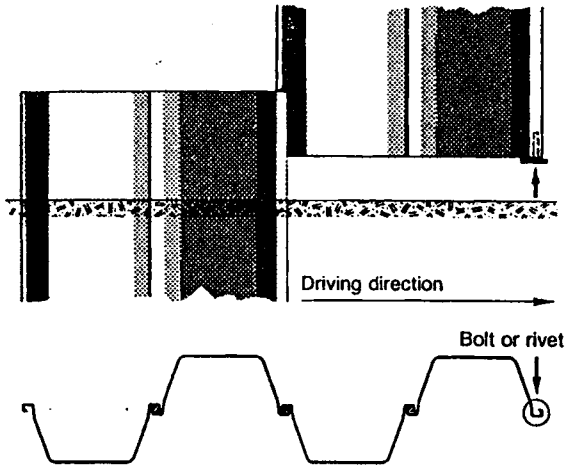


- Weld wedges, made from channel to the pile toe.
  Only applicable with a sheet pile of rather closed profile.
  More open profiles are pushed to the side.

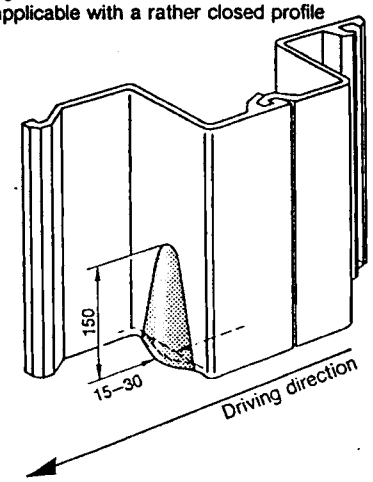




- With Larssen sheet piles the leading interlock can be closed by a bolt or rivet of suitable size to enlarge the driving resistance at this point.

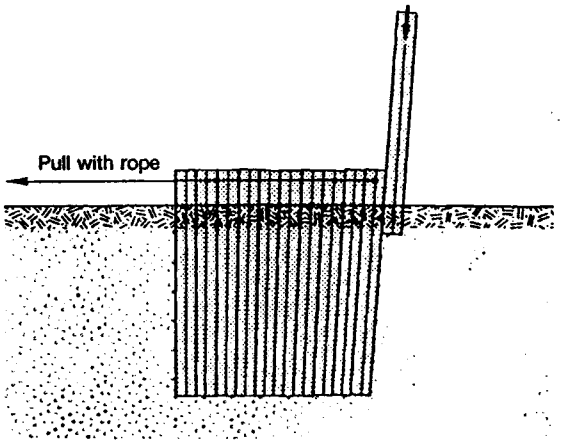


- Bulging the web
only applicable with a rather closed profile



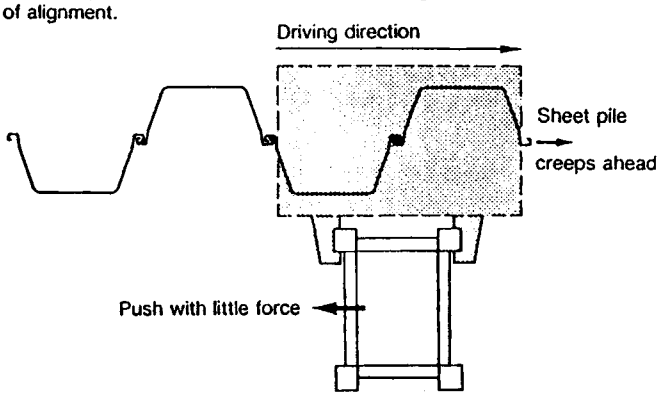
1.2.4. Take up all interlock play by pulling the last driven sheet against the direction of driving by means of one ore more "come-alongs".

Only applicable with short sheet piles and rather soft soil conditions.



1.2.5. If the pile hammer is guided on a pile driving rig, fixed leader or swivel leader carefully press the leader against the sheet pile without exerting too much force.

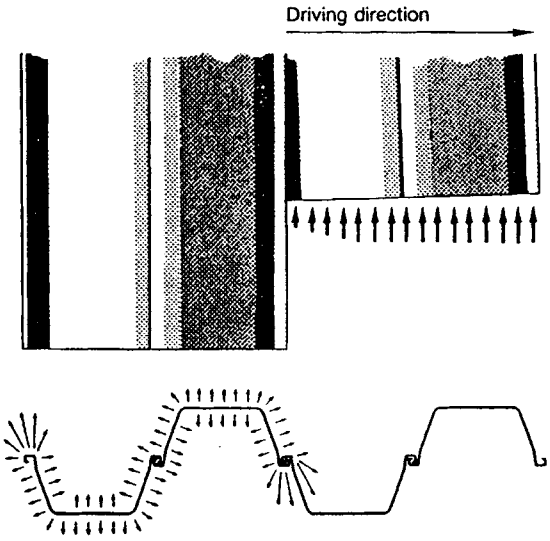
Note: Only applicable when the first sheet pile goes out of alignment.



2. Creeping back of the driving direction

In hard soil conditions the ground is loosened up due to the driving of the previous sheet pile; thus reducing the resistance near the interlock, but increasing it on the leading edge.

Therefore the sheet penetrates less on the leading edge. The sheet pile creeps back.

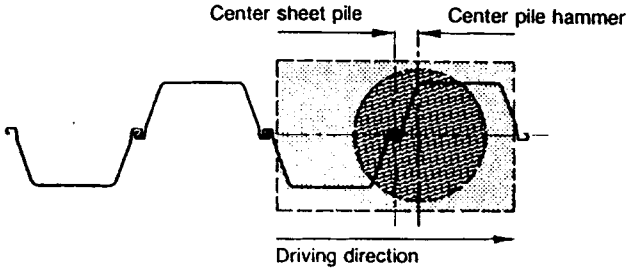


2.1. Countermeasures

Same as described under "creeping ahead" but done homologously

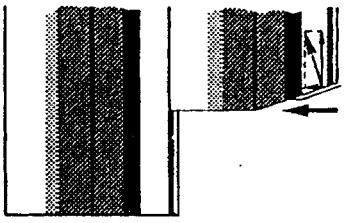
2.1.1. Shift pile hammer towards the leading edge.

The pile cap cannot be guided on the leader.



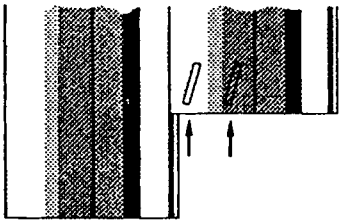
2.1.2. Bevelling the sheet pile

Note: Too much bevel can damage the pile

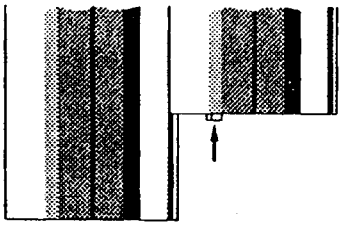


2.1.3. Installing resistance plates to the pile toe

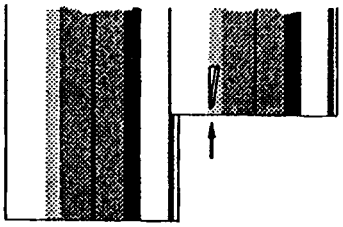
- Angle iron



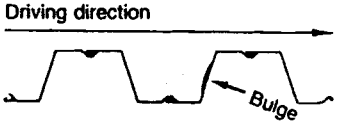
- Flat bar



- Wedges made from channel



- Bulging the web

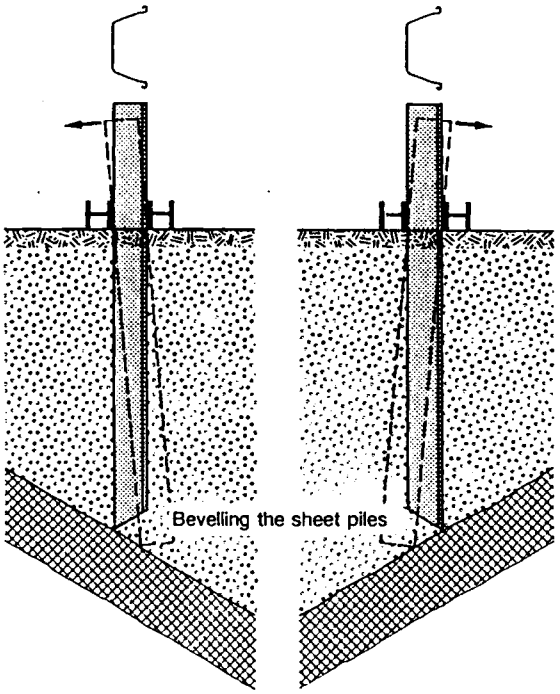


3. Leaning of the sheet piles perpendicular to the driving direction

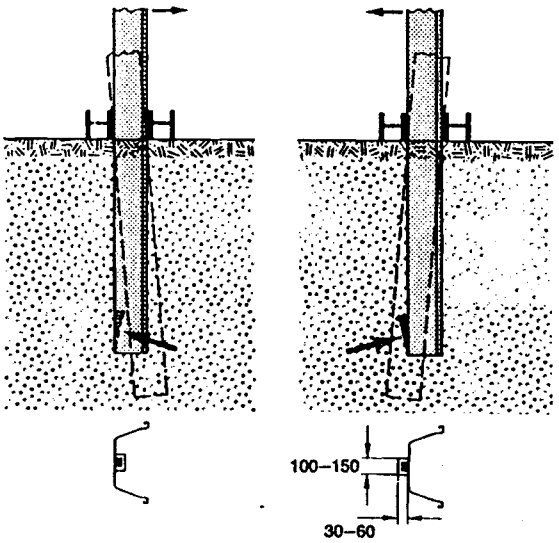
is caused by either hard slanted soil strata or other obstacles within the ground.

3.1. Countermeasures

3.1.1. Bevel sheet pile that the edge hits the strata first.



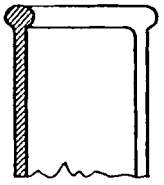
3.1.2. Weld wedges to the sheet pile



4. Damaging the piles heads

Quite often pile heads are partially or entirely damaged. Possible causes and prevention of the damages are:

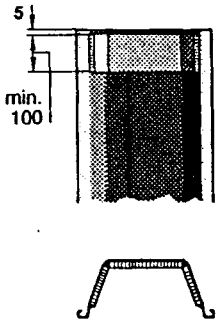
4.1. The pile head becomes rolled



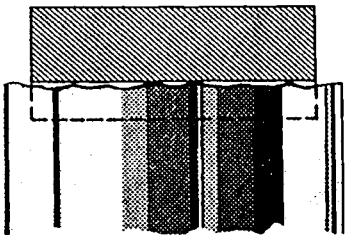
4.1.1. The impact weight is to small. The pile head becomes coldforged.

Remedy:

- Use a hammer with a heavier impact weight.
- As an exception, reinforce the pile head.



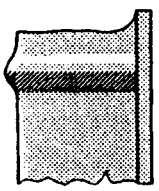
4.1.2. The pile head was not cut straight; the pile cap has only partially contact with the pile head.



Remedy:

- Cut pile heads square and straight.

4.2. The pile buckles below the pile cap



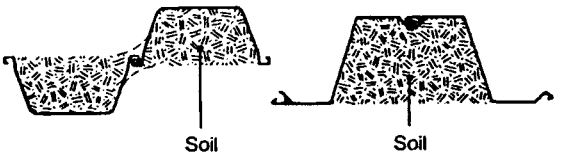
Possible causes:

4.2.1. The sheet piles are not strong enough for the encountered soil conditions.

Remedy:

- Use sheet piles of the same profile but made from special steel
- Use a heavier profile

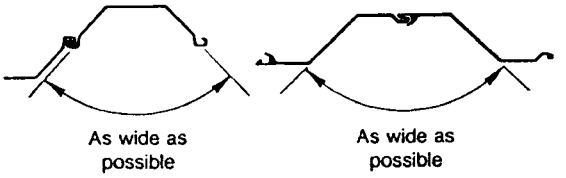
4.2.2. The soil between flange and web becomes so tightly compacted during driving, that a plug is formed.



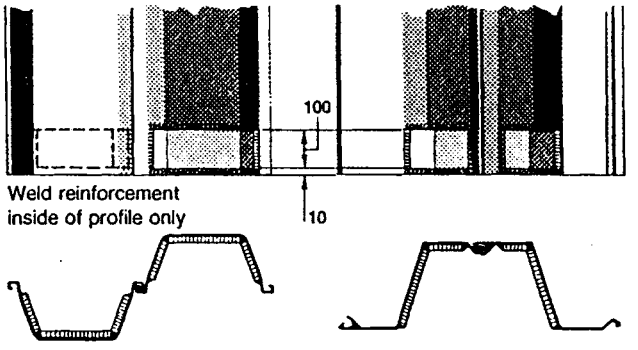
The driving gets much harder due to the increased area.

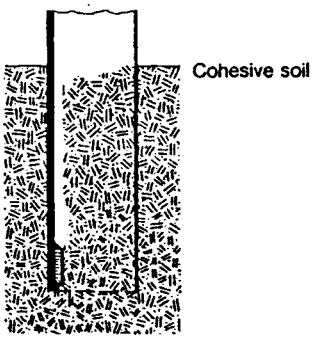
Remedy:

- Use a heavier profile
- Use a more open profile, because it does not form a plug that easily.



- In cohesive soils reinforce the pile toe to keep the soil from forming a plug.





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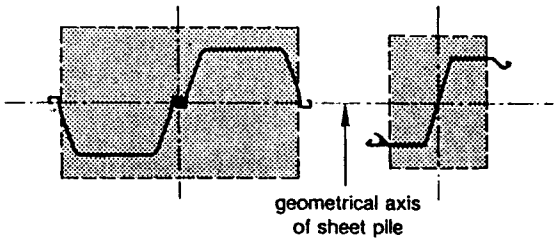
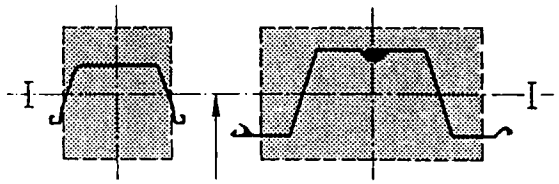
4.2.3. The pile cap does not cover the crossectional area of the sheet pile evenly.

The energy must be distributed evenly over the crossectional area covered by the pile cap.

This is the case when driving sheet piles of the Larssen profile in doubles and single sheet piles of the ⌐⌐ type profile.

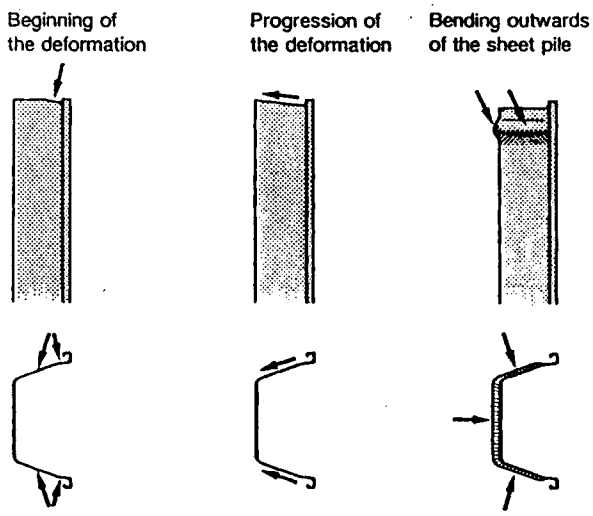


Driving a Larssen profile in single sheets and a ⌐⌐ profile in doubles the pile cap does not cover the crossectional area evently.



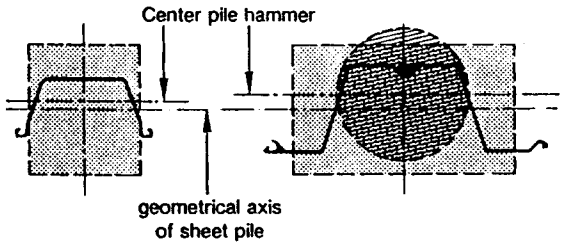
If the pile hammer ist put on the geometrical center of the sheet pile, the energy is distributed evenly to the upper and lower half of axis I-I. But the crossectional area of the sheet pile below the axis I-I is smaller than above. The stress induced below is considerably higher and can go beyond yield during hard driving – thus deforming the pile head.

Since the deformation on single sheet piles of the Larssen profile and on double sheet piles of the ⌐⌐ profile is similar, in the following it is shown for the Larssen profile only.



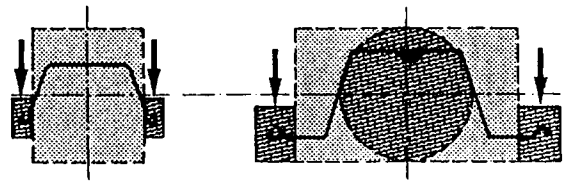
Remedy:

- Move center of pile hammer away from the geometrical center towards the back of the sheet pile.



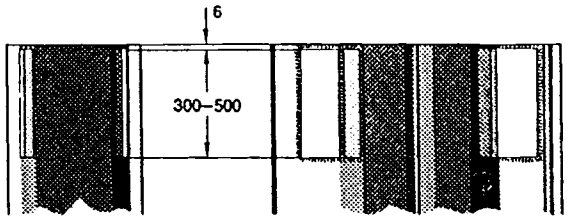
How much the pile hammer must be moved depends on the used profile and the friction in the interlocks.

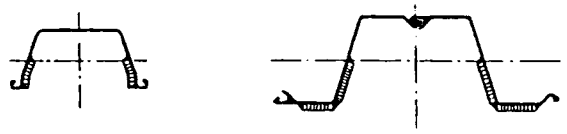
- Extend the pile cap such it will cover the interlocks. This is expensive but very effective!



The extension of the pile cap is only possible if each sheet pile single or double is set individually and driven in one operation. Only then are both interlocks free.

- Reinforce pile head to distribute stresses more evenly. The reinforcing can be put to the in- or outside.





Note: The pile cap has to be altered according to the reinforcement!

Quite obviously, sheet piles made from St Sp 37 are more easily damaged than those made from St Sp 45 or St Sp "S". Therefore it is recommended to use a better grade steel in hard driving conditions.

4.2.4. **The driving energy transmitted to the sheet pile is too high.**

Remedy:

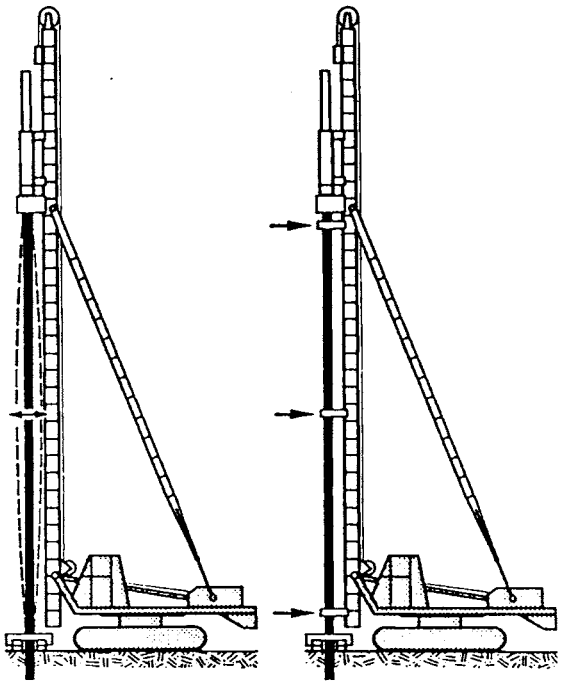
- Reduce energy or use smaller pile hammer.

4.2.5. **The sheet piles are of sufficient size for the purpose installed, but to slender for driving.**

The pile bends under the impact and moves horizontally; therefore the impact hits the pile head on one side and deforms it.

Remedy:

- Keep sheet piles from bending by installing one or more pile guides.

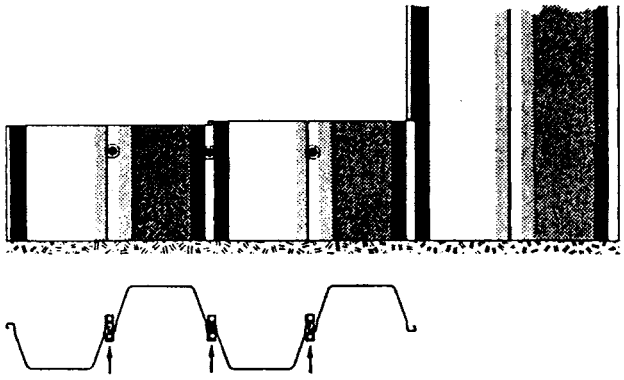


5. Moving of the adjoining sheet piles

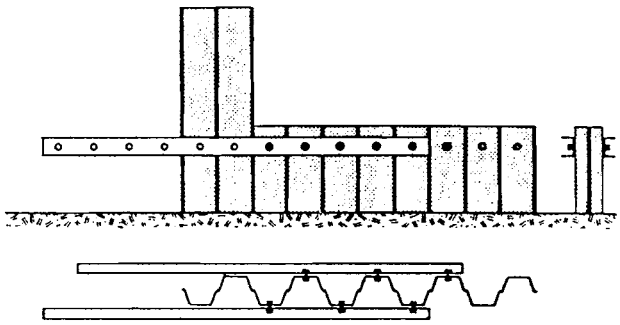
If the interlock friction is larger than the driving resistance of the adjoining sheet pile, then the adjoining sheet pile starts moving too and penetrates beyond grade.

Remedy:

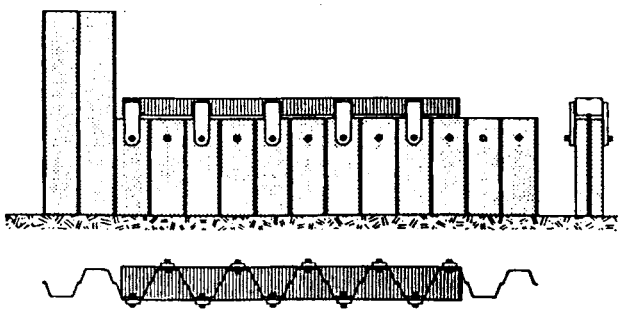
- Cut holes through the interlocks and install bolts.



- Install beams to each side of the sheet wall and fasten with bolts.

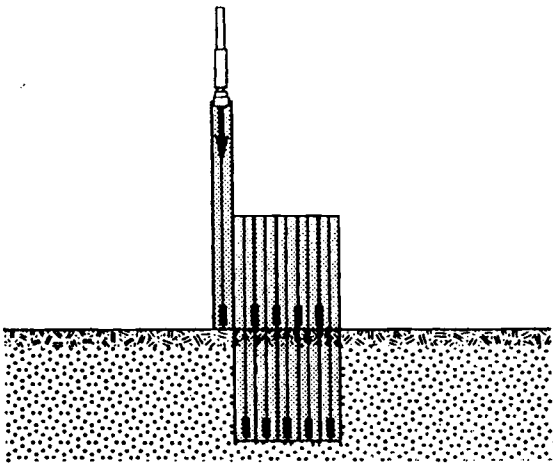


- Install beam on top of the sheet wall and connect to the sheets via straps and bolts.

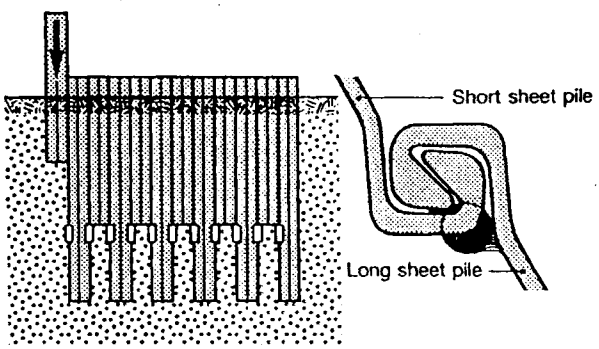


(This method is more complicated as the one described above, because the beam must be set ahead after each driven sheet pile).

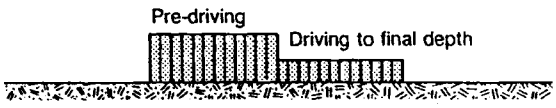
- Weld interlocks together to prevent the moving of the adjoining sheet. If driving doubles weld the driven pair together at the toe.



- When driving sheet piles of uneven length weld stop blocks to the longer sheets.



- Sometimes it is sufficient to stop driving shortly above grade and drive the entire wall to grade later on.



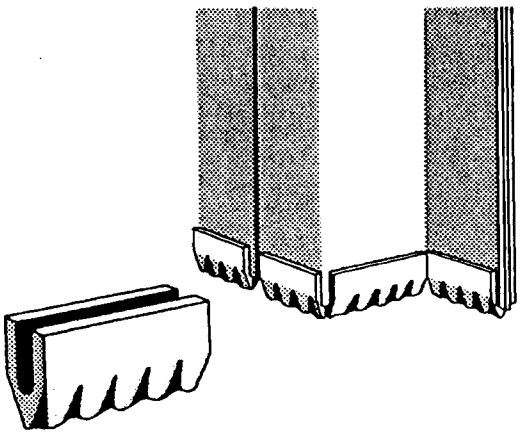
6. Driving through rock layers and setting the pile toe into rock

Are rock layers encountered during driving, the sheet piles either must be driven through the rock layer or set into the rock. To do this, one has the choice of the following reinforcements:

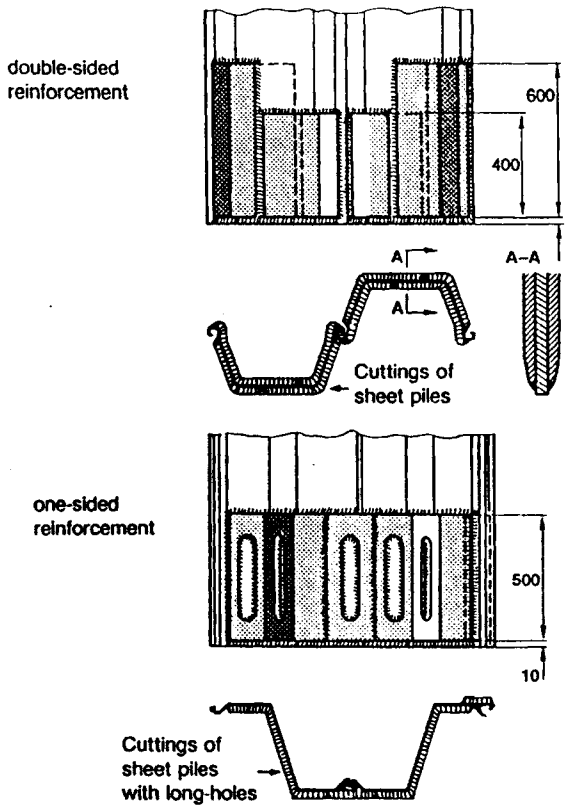
- Use sheet piles of higher steel grade
- Use sheet piles with a heavier profile
- Use a toe-reinforcing

Examples for toe-reinforcing

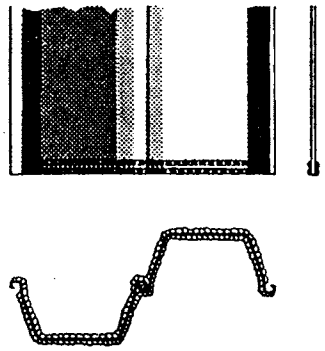
- Weld cutting points made from hardened sheet to the toe. (also called protectors)



- Weld angles or flat bars to the toe.



- In soft rock it is sufficient to reinforce the pile toe by one or two layers of hardfacing weld



Allways drive in steps

Due to the stepwise driving it is quite often possible to fracture the rock. The driving to grade is then easier and faster. Of advantage is often the "skipped driving method". First drive the sheets 1, 3, 5 etc., thereafter drive sheets 2, 4, 6 etc. stepwise to grade.