Successful Steel Sheet Pile Driving

Improving Pile Driving Efficiency and Performance

By Jeffrey H. Greenwald, P.E., CAE
Executive Director, North American Steel Sheet Piling Association

Introduction

Steel sheet piling (SSP) is a hot-rolled structural shape with interlocks on the flange tips that allow individual sections to be connected to form a continuous, earth-tight, and water-resistant steel wall. Because it is readily available and transportable, SSP can be a quickly installed and is an economical solution for a durable, long-lasting wall system. Applications are far reaching and include, for permanent construction, retaining walls, bulkheads, bridge abutments, graving docks, cut-off walls, mooring dolphins and pier protection cells. Common uses also include temporary structures, such as cofferdams for building excavations, trenches, piers for bridges, and lock and dams on the inland river system.

One advantage of SSP is their adaptability to various soil conditions. Typically, SSPs are installed by being lifted into position, aligned, then driven into the soil using one of a variety of driving methods. Ideally, this process is simple and straightforward. However, various site and construction conditions can occur which can cause the installation to deviate from the ideal. This article discusses various methods to improve SSP driveability and to make driving corrections when the installation does not proceed as planned.

Driving Assistance

Various methods are available to help drive piles in difficult soil conditions. The most common methods are water jetting, blasting and drilling.

Jetting

Under certain conditions, driving, vibrating and pressing of pilings can be optimized by using water jets. The objective of jetting is to use water pressure to loosen the soil and remove loose material from the toe of the piling. Jetting also helps prevent overloading the installation machine, helps prevent damage to the pilings, and reduces ground vibrations.

A pressurized water jet (connected to a supply pump on the ground surface) is located at the piling toe. The water jet reduces toe resistance of the piling and, depending on soil conditions, the rising water reduces surface and interlock friction. Jetting effectiveness is influenced by the soil density, the available water pressure and the number of jetting pipes. Care must be exercised to ensure that the ground treatment does not endanger adjacent structures. Test driving to define the particular parameters of a site is recommended.

Both low- and high-pressure jetting methods are available. Low-pressure jetting is primarily used in dense, non-cohesive soils. When used in combination with a vibratory pile driver, low pressure jetting can enable pilings to penetrate very dense soils. Vibratory hammers with variable eccentricity have proven to be particularly successful with low-pressure jetting. Two to four water tubes are fixed to a pair of sheet piles. The toes of the tubes are placed at the same level as the pile toe, and jetting starts simultaneously with the driving to prevent intrusion of soil into the tube. In general, the soil characteristics are only slightly modified by low-pressure jetting, although special care must be taken when piles are subject to vertical loads.

High-pressure jetting may be used for driving in extremely dense soil layers. If there is a risk of settlement, high-pressure jetting is preferred to low pressure due to the reduced amount of water being used. Test driving in chalk, boulder clay and hard clay has demonstrated that soil mechanical characteristics are not modified by this method. The ground conditions determine the recommended nozzle diameter, as well as the number and arrangement of tubes. Intensive monitoring is required during the work to adapt the system to the local conditions.

Blasting

Blasting uses explosives to break up the soil or rock to allow pile driving to occur. This process is applicable to most types of soil that would previously have been classified as difficult or impossible for driving SSP, H-section, box and tubular pilings.

“Normal blasting” refers to the use of explosives lowered into drilled holes and covered with soil before detonation. The blast creates a V-shaped trench along the proposed line of the wall. The size of the fragments in the trench depends on the type and amount of explosives used. Note that after blasting, the driving conditions in the loosened area are still very difficult; therefore, pile toe reinforcement is recommended.
The shock-blasting process is a highly specialized blasting technique using very low-powered explosives. The principle of shock blasting is to reduce solid rock to a fine granular material without either displacing it or blasting a cavity into the rock, thus making the driving process much easier than for normal blasting. With shock blasting, the volume of rock affected is very small, typically just slightly larger than the steel pilings. The rock immediately adjacent to this zone remains intact. To obtain maximum benefit from shock blasting, the sheet pilings should be driven into this granulated zone as soon as possible after blasting. Driving the sheet pilings into this zone compacts the soil, thus ensuring adequate support for the embedded pilings.

Drilling

Easier impact driving, vibrating and pressing can be achieved by pre-drilling. Drilling can be used to make even hard rock layers suitable for driving. The drilling reduces the resistance of the soil strata by allowing soil distribution during subsequent pile driving. If soil loosening by an auger is not sufficient to allow driving, a power auger can be used to create a trench. Depending on the project conditions, this trench can either be filled with suitable material or left full of loosened soil.

Driving Corrections

The proper SSP position and orientation are indicated on the driving plan. Corrections may be necessary during driving when deviations from this theoretical layout occur due to soil conditions, drawing down or setting and driving procedures. Corrections are necessary when the installed piles exceed the driving tolerances listed in the accompanying sidebar.

Correction of Lean

Careful set up and driving procedures will help prevent leaning of the SSP. Before driving, the hammer should be positioned over the center of gravity of the piles and should be held vertically and firmly on the piles by efficient grips. Should a lean develop, corrective action depends on whether the wall has developed a transverse (out-of-plane) lean, or a longitudinal (in-plane) lean.

Efficient use of guide waling can be used to eliminate transverse leaning of sheet pilings. If pilings develop a transverse lean that needs to be corrected, the pilings should be extracted and re-driven using more efficient methods. Longitudinal leaning in the direction of driving can be caused by either friction between the previously driven sheet pile and the sheet pile being driven, or by incorrect use of the hammer. Longitudinal leaning should be counteracted as soon as it becomes apparent. One method to correct the lean is to place the hammer off-center of the pair of sheet piles, toward the last driven pilings. Another correction method is to loop a wire rope around the end of the wall and attempt to pull the sheet piles into alignment. As a last resort, taper pilings must be employed to correct the error. These methods are illustrated in Figure 1.

Drawing Down Corrections

When SSPs are driven into soft ground – particularly when they are allowed to lean – the sheet pile being driven
may draw down the adjacent piling below its intended final level. To prevent “drawing down,” several sheet piles can be bolted together with a waling, or the interlocks can be tack welded. As a further precaution against drawing down, a bolt can be inserted into the leading interlock of the sheet piles prior to driving. This both prevents the soil from entering the interlock and reduces friction for driving the next sheet pile. Alternatively, a clamping device for the SSP interlocks may be used, thereby avoiding two or more sheet piles from being drawn (or extracted) at the same time. If one clamp is insufficient, a supplementary clamp can be used on the next lock.

If drawing down does occur, a short piling length can be welded onto the affected pile to bring the top to the correct elevation.

Summary

Quality installation helps ensure optimum performance of the steel sheet piling installation. Driving aids, such as water jetting, blasting and drilling can allow successful SSP placement in even the most difficult site conditions. Methods to correct lean, such as pulling or the use of taper piles, and the prevention or correction of drawing down help ensure the SSP is installed according to plan.

About NASSPA

Founded in 2003, The North American Steel Sheet Piling Association (NASSPA) is dedicated to providing information and guidance for the efficient design, construction and maintenance of hot-rolled steel sheet piling systems. NASSPA’s members represent the producers of hot-rolled steel sheet piling that supply the North American market. The association is involved in a broad range of education, technical, research, market, and communications activity.

Recommended Driving Tolerances

General tolerances for a straight and plumb sheet pile wall should meet the following:

a) Deviation from the wall line at the top of the pile ................................................. ± 2 in./50 mm, measured normal to the wall line

b) Finished level deviation from nominal level of top of piling ................................................. ± 0.8 in./20 mm toe of piling ................................................. ± 4.7 in./120 mm
c) Deviation from vertical ...... ± 1% of driving depth