Introduction

Traditionally, hot-rolled steel sheet piling systems (SSP) are used as major components in the construction of port facilities, bridges, locks and dams, for remediation of contaminated soils, and for support of excavation. Optimal performance depends on proper placement procedures for the particular application and soil type involved. Placement procedures can vary with the site conditions, soil strata, and even the size and shape of the steel sheet piling itself. This article describes the impact of site and soil conditions, as well as steel sheet piling shape, on driving operations.

Site Conditions

Successful steel sheet pile driving is dependent on a good knowledge of the site conditions in order to ensure an accurate assessment of the topographical and geological conditions.

Topography describes the particular environment of the site in terms of working restrictions such as noise and vibration. Each site is subject to its own unique set of restrictions, which vary according to factors such as the proximity and nature of neighboring buildings, road category, underground services, power supplies and material storage areas.

Geological conditions refer to the vertical depth characteristics of the soil strata. To achieve the required steel sheet pile penetration, a site investigation of the soils, coupled with various field and laboratory tests, can greatly aid the installation by providing relevant information on subsoil stratification, particle size, shape distribution and uniformity coefficient, inclusions, porosity and void ratio, density, level of the groundwater table, water permeability of the soil, moisture content, shear parameters and cohesion, dynamic and static penetrometer test results, and results of standard penetration test (SPT) or pressure meter tests.

Although it would be ideal to know all of these conditions, generally only the stratification, density, shear parameters and cohesion, and dynamic and static penetrometer, standard penetration test (SPT) or pressure meter test results are available.

Different soil types result in a variety of driving characteristics. As a result, soil type greatly influences whether impact or vibratory driving will be more economical. Impact driving is best suited for soft soils such as silts and peats, loosely deposited medium and coarse sands, and gravels free of rock inclusions. For these soil types, comparatively problem-free driving may be anticipated. More difficult driving, however, can be expected in densely deposited fine, medium and coarse sands and gravels, hard clays, and soft to medium rock strata.

Vibratory driving is especially well suited to round-grain sand or gravel and soft soils, whereas angular-grain material and soils with firm consistency are much less suited. If the granular subsoil is further compacted by the vibrations, penetration resistance will increase sharply, thereby causing refusal. Driving aids, such as jetting, blasting and drilling, can be used with difficult soil layers. With both impact and vibratory driving, dry soils generally present higher penetration resistance than do moist, submerged or fully saturated soils.

Figure 1: Installing steel sheet piling depends on proper placement procedures for the particular application and soil type involved.
Effect of Steel Sheet Pile Section on Driving

For optimum economy, the steel sheet pile section chosen by the designer also needs to be capable of being driven through the various strata to the required penetration depth. The driveability of a pile section is a function of its cross-sectional properties that vary with the steel thickness, section depth and width, and the piling's designed shape, length, the steel grade and – in the case of press-in-hammer systems – the load applied, the duration of the application and the method employed for installation.

The greater the surface area of the steel sheet pile profile, the greater the driving force required to drive it to a given depth. To avoid unnecessary deformation of the pile head, the pile section chosen should be compatible with the prevailing soil conditions. In addition, the geometry of the pile section may cause plugging of the pilings in cohesive soil strata and in certain dense, granular strata.

The driving force required is also a function of the soil properties; therefore, it follows that there is a limit to the driveability of a given piling profile in a given steel grade. Higher steel grades can withstand higher stresses; thus, a higher yield strength steel piling is more resistant to head or toe deformation than is the same section in a lower steel grade. Consideration of the soil layers and appropriate parameters enables the expected driving resistance to be assessed, and it allows for the selection of a suitable section.

The selection of a suitable pile section for driving into cohesive strata is a complex process, and the section choice is usually based on previous experience, however, it is possible to assess the driving resistance using the surface area of the piling combined with the characteristics of the cohesive strata. This calculation will, of course, be altered considerably if a plug or partial plug forms across the profile of the toe. In that case, the end that bears the resistance of the plugged profile will have to be included together with a reduction in the surface area of the pile profile.

Driving Methods

While it is recognized that a measure of flexibility is desirable to meet site conditions, every precaution must be taken to maintain the necessary standards of safety while at the same time setting the required alignment and verticality of the installed pilings. The first steel sheet pile should be installed with great care to ensure that it is vertical in both planes of the wall. Before being released and driven, it is essential that subsequent piles be sufficiently interlocked with the preceding pile. This can be achieved by a preliminary dug-out trench in the wall line, which automatically reduces the driving length. There are several common driving methods.

The set-and-drive method, where each sheet pile is driven to full depth before setting the next one, is the simplest way of driving; however, it can be utilized only in loose soils and with short pilings. The free-leading interlock is constantly in danger of deviation. For dense sands and stiff cohesive soils – or in the case of possible obstructions – panel driving is recommended instead.

Figure 2: Set-and-drive Method – Each steel sheet pile is driven to full depth before setting the next sheet pile.

The panel-driving technique helps ensure that good verticality and alignment is achieved and also minimizes the risk of installation difficulties or driving out of interlock. This technique also enables complete control to be maintained over the nominal wall length. Because a whole panel of pilings is set at once, there is no need to drive all pilings fully to maintain piling operations. If obstructions are encountered, individual pilings can be left high without fear of disrupting the progress of setting the wall.

Staggered driving combined with panel installation is recommended in difficult soil conditions. The piles are installed between guide frames and then driven in short steps, as follows: pilings 1, 3 and 5 first; then pilings 2 and 4. If the soil is very dense sand, gravel or rock, pilings 1, 3 and 5 can be reinforced at the toe. In this case, these pilings are always driven first, followed by pilings 2 and 4 driven in the second stage.

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Figure 3: Panel Driving Method – Complete panels of steel sheet piling are set at the same time, enabling complete control to be maintained over the entire wall length.

Driving Templates

It is important that steel sheet piles be maintained in the correct horizontal and vertical alignment during installation. This is achieved by the use of adequate steel templates, which will also prevent lateral drift. Very long sheet piles may need intermediate guides to prevent flexing and other associated driving problems.
Irrespective of the driving method, a template is always required at a low level to ensure correct alignment of the steel sheet piling wall. It should consist of two sturdy beams and be mounted as low as possible, preferably on the ground. Lateral movement of this template must be prevented. The template length should cover at least six pile pairs and cover the existing wall (previously driven piles) by approximately 5 feet. Spacers must maintain the proper spacing of the beams.

**Extracting Steel Sheet Piles**

When piling is intended to serve only as a temporary protection for permanent construction work, it can be extracted for re-use by means of suitable extractors, either of the impact, vibratory or jacking type. Accurate driving of the sheet piles in the soil makes extraction easier.

For an evaluation of the required pulling force, the previous establishment of a driving record for each pile is very useful. This identifies the piles with the lowest resistance, thus defining the starting point for the extraction work. If driving records of the piles are not available, then the first pile to be extracted should be selected with care. Piles located near the center of a wall should be tried until one pile begins to move. If difficulty is experienced, then a few driving blows with an impact hammer may be used to loosen a pile. It may also be necessary to reinforce the head of the piles to aid the successful extraction of the initial pile.

Vibratory and extracting hammers of various sizes are available. They loosen the sheet pile from its initial position so that it moves via the pulling force of the crane. The limit values of the extracting hammers and crane loads given by the manufacturer should be used. The connection between pile and vibratory hammer is made by hydraulic clamps, shackles and bolts. Sometimes drilling or jetting is necessary to facilitate the extraction operation.

**Summary**

Successfully driving steel sheet piles requires knowledge of the project site and soil conditions, as well as the compatibility of the steel sheet piling being used. The size, shape and steel grade of the steel piling can influence the driving efficiency and maximum driving force. Various driving systems and methods are available to suit all conditions.

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**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. For more information, visit www.nasspa.com.