Basic Types of Sheet Pile Walls and Their Application in the Construction Industry—a Review

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ABSTRACT

This paper presents some of the most common applications of sheet piles namely anchored, cantilevered sheet piles, excavation or cofferdams. It also contains various shapes and types of sheet piles and their advantages. Wood, concrete, steel, and aluminium are common materials that make sheet piles. This review also explains a new type of steel sheet piles wall with improved workability and higher resistance to driving stresses which is called in the construction industry HAT-TYPE Sheet pile 900.

KEYWORDS: Sheet pile, Retaining wall, Sheet piles application, Sheet piles types, Hat-Type.

INTRODUCTION

Sheet pile walls consist of continuously interlocked pile segments embedded in soils to resist horizontal pressures. Classified as a flexible retaining system, sheet pile walls can tolerate relatively large deformations. (Stanislav, 2006)

Sheet piles are being used as retaining systems for many years. They are widely used for several purposes such as:

*large and waterfront structures  
eroison protection  
stabilizing ground slopes

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shoring walls of trenches and other excavations, and cofferdams.

Generally sheet piles that used for retaining walls are classified as Anchored sheet piles or Cantilevered sheet piles.

Sheet piles are made of different kinds of materials such as wood, concrete, steel or aluminum and these different materials cause different applications which are illustrated in following sections.

Sheet pile walls are constructed by:
1. Laying out a sequence of sheet pile sections, and ensuring that sheet piles will interlock.
2. Driving (or vibrating) the individual sheet piles to the desired depth.
3. Driving the second sheet pile with the interlocks between the first sheet pile and second "locked"
4. Repeating steps 2 & 3 until the wall perimeter is completed
5. Use connector elements when more complex shapes are used.

Sheet pile wall disadvantages are:
1. Sections can rarely be used as part of the permanent structure.
2. Installation of sheet piles is difficult in soils with boulders or cobbles. In such cases, the desired wall depths may not be reached.
3. Excavation shapes are dictated by the sheet pile section and interlocking elements.
4. Sheet pile driving may cause neighborhood disturbance.
5. Settlements in adjacent properties may take place due to installation vibrations.

APPLICATIONS OF SHEET PILE WALLS

As stated earlier, one of the effective methods to retain a soil mass is to install a vertical wall which consists of long thin element such as steel, concrete or wood that are driven in the ground. The elements are usually connected by interlocking joints. Sheet piles in comparison with massive type of walls (concrete or stone) are considered as flexible structures, in which bending moments are developed by the produced lateral loads. Therefore they should be designed so that, they are able to resist the maximum bending moments.

Some of their common applications are shown in Fig. 1.
Figure 1: Application of sheet pile wall (www.geolab)

Cantilever sheet pile walls

Cantilevered sheet piles are usually used for the height of about 6m or less than dredge line. (Fig.1-a)

In geotechnical practices, cantilever embedded retaining structures are specifically used for protecting permanent and temporary excavations, for highway constructions, and sanitation of landslides. These structures are mostly sheet walls as temporary retaining structures, and pile walls and diaphragms as permanent retaining structures. (Stanislav, 2006)
Anchored sheet piles

When the height of sheet pile is less than 6m, it is economical to use sheet pile which is anchored near its top. (Fig.1-b) Anchoring the sheet pile cause less penetration depth and also less moment to the sheet pile.

Well constructed anchor walls undergo less lateral deflection than braced walls and so provide a better control of back-slope subsid ence. Anchor installation only requires a small excavation to allow equipment access.

Anchored walls are always pre stressed which essentially removes the slacks from the system. The anchor will maintain their load through the excavation sequence unless creep occurs. The anchors also place the entire soil mass between the anchors and wall in compression, thus creating a very large gravity wall. (Hunt, 1986)

There are two causes of subsidence for anchor systems:

1) Caving of the anchor holes prior to grouting

2) Flow of cohesionless material into the excavation through wall opening made for anchor installation.

Another disadvantage includes possible downward movement of the wall due to the vertical component of the anchor forces.

Excavation

Sheet piling systems comprises developed sheet pile sections with either an overlapping joints or an interlocking one (Fig.1-c). The sections can either be cantilevered to support the excavation, depending on the imposed loads, or they can be restrained by a specially designed mechanism with anchor. During excavation ground anchors are progressively installed to restrain the sheet piling. This creates a ‘reinforced earth zone’ behind the sheet piling to form a retaining wall structure around the excavation. Hence, deep excavation can be supported in a wide range of ground conditions.

Cofferdams

A cofferdam is a temporary structure designed to keep water and soil out of the excavation in which a bridge pier or other structure is built. (Fig.1-d) When construction must take place below the water level, a cofferdam is built to give dry work enviroment. sheet piling is driven around the work site, seal concrete is placed into the bottom to prevent water from seeping in from underneath the sheet piling.

TYPES OF SHEET-PILING

Traditional sheet pile shapes are “Z” type and “U” type.
Z-Type (Z): Used for intermediate to deep wall construction, Z sections are considered one of the most efficient pile available today. Z-piles are commonly used for cantilevered and tied-back systems. Additional applications also include load bearing bridge abutments. “U” Type (U) sheet piles are used for the applications similar to Z-Type (Nemati, 2007).

Flat/ straight Type (SA), (S): Used for filled cell construction.

Larson/ “U” Type (U): Used for applications similar to Z-Type.

Sheet piles are made of different materials such as wood, concrete, aluminium, steel or vinyl which are briefly explained in the following sections:

**Wooden sheet pile**

Wooden sheet piles are the oldest construction materials used for temporary light structures to prevent cave-ins. All woods degrades over times, especially when exposed to water and extrem temperatures, where fungus and bugs accelerate decomposition. Wood sheet piling is still used today, however the wood is either fully encapsulated, or treated with chemicals like chrome, aluminum or steel plating.

**Concrete sheet pile**

Precast concrete sheet piles are more aesthetics but are heavy and produce large disturbance during driving. Concrete sheet piles are primarily used as bulkheads in either fresh or saltwater, in this case they are normally tied back with dead men. Rock in close proximity to the ground surface is a concern with this type of sheet pile walls as they are normally installed by jetting.

**Aluminium sheet pile**

Aluminium sheet piles have cross-sections similar to those of steel. It is constructed using 6061 alloy, and often anodized or painted or visible applications. Aluminum is 100 percent
recyclable, durable and resistant to corrosion from air, water, extreme temperature and chemicals, but is more expensive than other types.

**Vinyl sheet pile**

Vinyl, also known as the “infrastructure plastic,” is the most widely used sheet piling for heavy loads and marine applications today. Vinyl is not only inert, durable and less expensive than wood, concrete and steel, it is 100 percent recyclable.

**Steel sheet pile**

The steel sheet pile alternative is the most popular due to its strength, ease of handling and ease of construction.

Steel sheet piles are available in various cross-section shapes. They can have problems with corrosion that can be prevented by coating. Their thickness is about 10 to 13mm; the allowable stress is 170 Mpa to 210 Mpa (25 – 30ksi).

Their advantages are summarized as follow:

- resistant to high driving stresses
- relatively lightweight
- reusable
- long service life
- easy to increase length by welding
- joints are less apt to deform; and
- can produce a watertight wall.

Also regarding to the usages and advantages of steel sheet piles, a new type with improved workability named “Hat-Type” is explained below.

**Hat-Type Sheet Pile 900**

A new generation of steel sheet pile with improved drivability, higher structural reliability, and more economical merit compared with traditional U type sheet piles, is Hat-Type sheet pile 900 which has thin and large section shape of 900mm in effective width has been developed on the basis of state of the art rolling technology and design. (Noriyosh, 2008)

As shown in Fig. 3 the Hat shaped sheet pile is available in two types of sections 10H and 25H.
Development of Hat-Type sheet pile 900: (Noriyosh, 2008)

*Efficient pile-driving work;

Since this type is more rigid than conventional wide type sheet pile, pile deformation while the pile is driven into the ground is effectively restrained, and hence even longer pile can be driven in efficiently.

*Higher structural reliability;

Since the Hat-type sheet pile joints are at the outmost part of the wall structure, the natural axis of each of the piles coincidences with that of the wall structure formed. Therefore the “joint efficiency” (i.e., the decline in sectional performance ascribable to the sheet pile shape and joint position) that needs to be considered when the U type sheet pile is used may be left out of consideration. Thus Hat-type sheet pile 900 is able to display its structural performance under various construction conditions.

It enables a reduction in the amount of steel required per unit wall area. It also enables a reduction in number of sheet piles used, make it possible to shorten the construction period and cut construction costs. In addition, the new sheet piles allows for efficient structural design in which the joint efficiency need not to be taken into consideration.

**Development of pile driving methods**

The vibratory driving or the hydraulic jacking methods are commonly used to drive steel sheet piles into the ground.

In the vibratory driving method, as the hammer vibrates while chucking the top of the sheet pile, the vibration is transmitted to the sheet pile and ground, so that the sheet pile driven into the ground. This method is the most popular because it can shorten the construction time and can be applied even to hard ground.
Sheet pile which has already been driven into ground is used as the reaction to push another sheet pile statically into the ground. This method is suitable for low-vibration, low-noise pile-driving at construction sites in urban areas and for pile-driving at confined construction sites.

Some of its applications are shown in Fig. 4.

**Figure 4**: Applications of hat-type sheet pile 900 (Noriyosh, 2008)
CONCLUSION

Sheet piles are structural tools which are designed to resist horizontal forces as they embedded in soils. They are also used as retaining systems. Sheet piles are made of different materials which plays an important role in their applications. Steel sheet pile is considered the most common type because of its advantages and providing higher structural reliability as well as workability. The Hat-Type sheet pile 900 is a structural steel product that incorporates the essence of sheet pile manufacturing technology and application technology relating to design and construction projects. Its application extends beyond conventional civil engineering works, such as river revetments and port piers. It also can be applied in different ways as measures to prevent ground subsidence. Promoting the Hat-Type sheet pile 900, contributes much to reduce construction costs and construction durations.

REFERENCES

7. http://geolab.unm.edu/chapter_204.pdf Chapter 4. Sheet pile walls: Cantilevered and Anchored
10. www.ebookbrowses.com/s/sheet_pie_wall

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