Port Construction using Sheet Piles

Steel Sheet Piles (S. S. P.) is a row of interlocking vertical pile elements forming a continuous wall and mainly used for retaining soil and/or water. S. S. P. is used in many types of temporary works and permanent structures. The sections are designed to provide the maximum strength and durability at the lowest possible weight consistent with good driving qualities. The design of the section interlocks facilitates pitching and driving and results in a continuous wall with a serious of closely fitted joints.

A comprehensive range of sections in all forms with a wide range of sizes and weights is obtainable in various different grades of steel which enables the most economical choice to be made to suit the nature and requirements of any given contract.

For applications where corrosion is an issue, sections with minimum thickness can be delivered to maximize the effective life of the structure. The usual requirements for minimum overall thickness of 10 mm, 12 mm, 15 mm etc. can be met.

Corner and junction piles are available to suit all requirements.

S. S. P. has wide applications in the construction industry and few applications are listed below:

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Depending on shape, sheet piles can be classified in three types:

1) U Sheet Piles

2) Z Sheet Piles

3) Straight Web Sheet Piles

Manufacturing Process of S. S. P.

- Scrap is chosen as a function of the MIX (copper-content) which has to be charged.
- The quantities of lime, carbon, oxygen, etc., which have to be added are defined by computer.
- Predefined schemata regulate conducting of the EAF. For each furnace, two baskets filled with scrap are charged.
- During tapping into the ladle, additions (Si-Mn, CaO, etc.) can be made.
- At the ladle furnace, the chemical composition is adjusted by addition of ferroalloys.
- Reheating in order to achieve the casting temperature is performed.
- Desulphurisation and deoxidation are also carried out at the ladle furnace.
- The ladle filled with liquid steel is put into the ladle turret, which is located above the tundish. At the six-strand caster, three different semi-finished products can be produced.
- Sequence casting is possible by means of a tundish change.
- The foreman of the caster orders the casting temperature and the casting start time from the operator of the ladle furnace.
- The lengths of the beam blanks, which are ordered by the rolling mill, are put into the computer system (tracking).
- At the Beam Blank Handling Area the beam blanks to be put on stock are marked by the heat number.
- Hot charged beam blanks are tracked by computer.
- The material ordered by PADi is dispatched by rail to Differdange. The material [beam blanks] ordered at Differ-
dange arrives by rail and is put on stock. The identification is the heat number.

- Semi-products are cold-charged into the reheating furnace. Rolling is possible after a minimum stay of ~ 2 hours and if the temperature at the first stand allows a correct rolling.
- All relevant traceability data are introduced into the computer system.
- The whole rolling process is semi-automatic and rolling can also be done manually.
- At the hot saws the sheet piles are cut to ordered lengths.
- Dimensions are checked on samples and the results are transferred to the foreman of the rolling mill and introduced into the computer system. Samples for mechanical tests are taken in accordance with an internal instruction and are sent to the test house located in Differdange.
- The computer produces a saw report with all the relevant traceability data.

- After the hot saws, the sheet piles come to the cooling beds where different inspections are performed by specially trained operators and where the marking is done by stencil and/or label. All marking exception has to be specified at the moment of ordering.
- Defective sheet piles are segregated either scrapped or sent to a repair shop where they are repaired.
- All the sheet piles are straightened by roller straighteners.
- For orders with special requirements such as 3rd party inspection etc., the sheet piles are sent to a special hall where all the required controls, inspections, etc. are performed.
- The foreman of the repair shop decides in accordance with internal instructions if the defective sheet pile can be repaired.
- Shipping documents, invoices and certificates are established by the computer after loading.

Steel Grades of Steel Sheet Piles

Hot rolled sheet piling is supplied to EN 10248 part 1 to the steel designations detailed below:

- S 460 AP (Mill specification) is also available but please contact technical department for the confirmation.
- Steel grades with increased copper content (like ASTM A690) offering higher durability in the splash zone.

Watertightness of Sheet Piles - By Using Sealant

The ability of retaining walls to prevent or resist the passage of ground water is of great importance in many appli-
cations e.g. in basements, underground tanks, temporary cofferdams and containment barriers.

A sealed sheet pile wall provides a safe, economic solution in any situation where control of groundwater, to minimise the risk of settlement of adjacent property and keeping excavation dry, is an issue. The water tightness of sheet pile interlocks almost invariably improves with time but a sealant will provide a means by which the flow / passage of water can be controlled immediately.

All construction projects are unique with ground conditions and installation method varying from site to site; therefore the sealant system adopted must be designed accordingly.

The integrity of sealant system in use will depend upon it’s suitability with respect to the method of pile installation adopted and the ground conditions. Sealants are available to make driving easier and systems are also available to protect the sealant when driving the piles into gravels and difficult ground.

**Durability of Sheet Piles – Against Corrosion**

Sheet piling is widely used in permanent earth retaining and structural foundation works, and in the majority of circumstances it can be used in an unprotected condition. The degree of corrosion and whether protection is required depends upon the working environment – which can be variable, within a single installation.

In general, marine environment are the most corrosive and variable. In the few meters of vertical zoning which most structures encompass, piles are exposed to underground, seawater immersion inter tidal, splash and marine atmospheric environments. For most environments characteristic corrosion may occur, requiring detailed site examinations and data analysis.

This topic outlines the corrosion performance and effective life of sheet piling in various environments and reviews the protective measures that can be taken to increase piling life in aggressive environments. These corrosive environments can be classified as:

- Underground corrosion of steel piles
- Atmospheric corrosion
- Corrosion in fresh waters
- Corrosion in marine environments
- Localised corrosion
- Other environments

Unprotected steel in the atmosphere, water or soil is subjected to corrosion that may lead to damage. Local weakening and rusting is normally considered to be maintenance problem that can be resolved locally. Depending upon life time requirements and accessibility of the structure, they are often protected from uniform corrosion by one or more of the following methods:

- Coatings
- Using stronger section (sacrificial thickness) or higher steel grades
- Using Marine Grade Steel ASTM A690
- Avoiding important bending moments in the high corrosion zones
- Extension of concrete capping beam below the low water level
- Cathodic protection by impressed current or by sacrificial anodes.

**Case Study - Sheet Piles for 1,100 M. Long Deep Draught Berth & Shore Protection Work @ Essar Terminals - Hazira, India**

‘Hazira is a renowned Industrial hub located on western coast of India and one of the upcoming ports of India. The town is located on the bank of the Tapti River, eight kilometers from the Arabian Sea. It is a center for health tourism due to its natural springs, and also home to major industrial and shipping facilities like Essar Group, L & T, Reliance Group, ONGC etc. The Essar Group is a well-known top diversified group from India and has interests in Steel, Power, Shipping Ports & Logistics, Oil & Gas and Construction.’

To support its growth plans, Essar is developing a 1,100 M. long deep draught bulk berth at Hazira mainly for their captive usage. Essar will use this port for importing raw material as well as for exporting finished goods.

**Why Essar needed this technology**

Essar Group, being one of the leader industrial group from India, have a fully inte-grated world-class facility at Hazira, housing the world’s fourth largest single-location steel plant. It has a steel-making capacity of 10 MTPA. The facility also houses a 6.8 MTPA sponge iron plant, a 1.5 MTPA plate mill (the largest in India), a 0.6 MTPA pipe mill with internal and external coating facilities of up to 2 million square meters annually; and a 1.4 MTPA cold rolling complex comprising two galvanizing lines, a batch annealing furnace and a skin pass mill. To operate such big operation, they need contin-
ues supply of raw material & dispatch of finished steel. To achieve cost effective inwards & outwards freight and to take current location advantage, they de-cided to go for sea transport, which is most economical & cost effective mode of transport. This infrastructure is provided by Essar Ports, who develops, owns and operate ports and terminals, and is India’s second-largest private sector port and terminal company by capacity and throughput.

The Hazira facility (30 MMTPA) is an all-weather deep draft bulk terminal for import of iron ore, pellets, coal, limestone and export of finished steel products. To take care of such rapid growth, they need a construction technology which is fast, reliable, techno commercially suitable & time saving. So after lots of technical evaluation & study, they have decided to go for the sheet piling technology. This system proven to be better for the site / soil conditions and very flexible.

If they would have gone for the concrete solution, they would have required around 4 to 5 years for completing this quay wall. By using sheet piling technology, they have completed 1100.0 M. quay wall in just 13 months. This gave them immense saving of construction time & they could start their operations early & start earning their revenue much earlier which means lower break even period. In short, they have achieved time saving which directly converted in to immediate income generation.

The Construction Activity

This project was executed by Essar Projects, which is a class-leading Engineer-ing, Procurement and Construction (EPC) contractor. Essar Projects is a leading construction company specialized in marine construction & capable of constructing berths for vessels of 40,000 to 180,000 DWT capacity.

This cellular cofferdam being a self-supporting gravity structure it does not re-quired any anchors or anchor wall system with tie rods. This can be constructed on bed rock directly & can be also used for break water construction. Sheet piles are prefabricated construction so we have supplied this material in cut to length so the execution work can be started without wasting any time. They have used two tem-plates for this type of construction & used for an alternate cell construction. This be-ing a straight web section, have less sec-tional modulus. Hence special care need to be taken while driving these piles. Firstly, you need to assemble these piles around the template & complete the cell. Then you can start driving these sheet piles up to 1.0 / 2.0 M. in clockwise direction. Once you complete driving all piles then start these sheet piles for another 1.0 / 2.0 M. in anticlockwise direction. You need to complete these sequence till you reach the desired depth. You need drive these piles in small lengths of 1.0 / 2.0 M. in order to avoid declutching. After completion of balance civil works, this quay wall is ready for the operations.

There are mainly two types of cells built with straight web sheet piles:

- Circular cells
- Diaphragm cells

Essar have chosen Diaphragm cells type for their 1100 M. deep berth construction.

Usual construction sequence for Diaphragm cell structure is as follows

- Pitch the cell, using a template
- Drive the sheet piles in the first cell using 1st template
- Drive the sheet piles in the adjacent cell using 2nd template
- Then shift the 1st template to third cell & 2nd template to 4th cell & so on.
- Filling of the cells
- Transfer loads like fenders, bollard, crane load, surcharge etc.
- Complete superstructure works once the cofferdam is fully stabilized.

Pictures below will provide you overview on installation procedure.

AS 500 straight web steel sheet piles - An Introduction

Cellular cofferdams can be designed as self-supporting gravity walls not required any sup-elementary wailing or anchoring. They can be founded directly on bedrock, without any em-bedment. They are economical solutions for works in deep waters, high retaining works and long structures.
Advantages of Using Sheet Piles over concrete diaphragm

The conventional option with a Concrete diaphragm wall was a time consuming job, with slow speed of work and a long duration for project completion.

Using Steel Sheet Piles instead of concrete, can provide following advantages

- By the use of a Higher Steel Grade, they can ensure a better driveability & lesser tonnage.
- Prefabricated & Cut to length provides faster speed of installation.
- Quicker and time bound deliveries, ensures speedier work and shorten the project duration / time.

This total material will be supplied in 3 lots, which are so precisely designed that Essar’s work will progress in full swing.

Delivering 18.5 M & 20.0 M. long sheet piles is big challenge. Generally for all Break Bulk Cargo in India, Mumbai is a main port. But this time ArcelorMittal decided to accept the challenge to deliver these long sheet piles to Hazira Port. Arranging transport for oversize consignment is a challenging task in India. Even transport cost is a major issue. As ArcelorMittal are offering direct delivery to Hazira, it will help them to save on transport costs and time.

By choosing higher steel grade, Essar will have following advantages:

- Better drivability
- Lesser tonnage
- Lesser effective project cost

Deliveries scheduled and calculated to maximal support the customer’s work progress

Delivery at unconventional port safes the customer on transport costs and time

In a nutshell, for construction of 1100 M. long berth, the scope of supply includes AS 500 Straight Web Section

- Pieces : 8153 nos.
- Thickness : 12.5 mm
- Length : 18.5 M.
- Steel Grade : S 430 GP
- Interlock Tension : 5500 kN/M.

and Y – Junction Piles [120°]

- Pieces : 162 nos.
- Thickness : 12.5 mm
- Length : 20.0 M.
- Steel Grade : S 430 GP

Conclusion

By using steel sheet piles over for concrete diaphragm wall, Essar have saved considerable time in berth construction. Due to this time savings, Essar could start port operations much earlier and ultimately started generating revenue much faster. Considering these facts, sheet pile construction is highly advisable for port construction.

Author’s Bio

Kiran Pujari was born in Mumbai in 1973. His Bachelor degree in civil engineering he received from the Shivaji University, Kolhapur & Masters degree in Marketing Management from Mumbai University. He started his professional career in 1995 as a Management Trainee for a MNC company, before joining ArcelorMittal in Jan 2010 as a Technical Sales Manager for Foundation Solutions. Kiran is now In charge of Technical Services division & responsible for Marketing of Foundation Solutions in India, Bangladesh, Nepal and Sri Lanka.