Standard beam and lagging temporary shoring

A driven solution

Sheet pile: A driving innovation in building foundations

By Dean Abbondanza

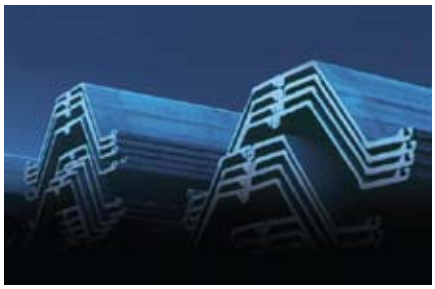
All below-grade foundations require excavation. Unless the site footprint is large enough to do a slope cut, an excavation needs to be supported. Put simply — dig a hole, support the sides and build from the bottom up! The objective is to provide a safe and dry pit to construct the foundations. Traditional "open-pit" construction methods have remained virtually unchanged for the past 50 years.

Conventional support of excavation

Soldier beam and lagging (SOE) is the most common temporary support of excavation, although soil nailing is rapidly gaining acceptance. In deeper excavations and where water is present, slurry walls, soil mixing columns, secant piles and sheet piles are better suited. With less prime real estate available and the drive for mixed-use developments, deeper excavations are becoming more common in today's construction market.

Construction economics

Foundation costs are made up of multiple time and material components, which include temporary shoring, bracing, excavation, dewatering, waterproofing and backfilling; all which need to take place prior to any permanent wall construction. Soil conditions, water table, foundation design and support of excavation (SOE) methods all have a direct impact on these costs. As you can see, the conventional foundation process involves numerous phases that lengthen the critical path of the project. The benefits of subterranean structures are overshadowed by these variables and make owners cringe at the cost of below-grade parking and basement foundations.



Innovative steel solutions

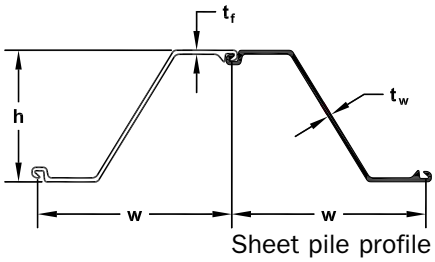
Try to imagine a versatile building material with the strength to serve as the support of excavation and permanent wall element in one. The concept is radical compared to conventional methodology, but not without merit. The material and schedule savings that would be realized could impact the project critical path like nothing ever before. The results could revolutionize foundation construction; and they are doing just that!

Consider underground parking and basement structures; in principle, they are no different than a cofferdam. The base, intermediate, and top level slabs mirror the cross bracing members that would resist lateral earth and water pressures in a traditional cofferdam. These fundamental similarities are what drove

European piling manufacturers to explore new market opportunities for sheet piles in permanent building foundations.

Permanent sheet pile application

For more than 30 years, European and Asian building consultants have embraced the concept of designing below-grade structures with steel sheet piles. So why haven't domestic designers done the same? It has to do with "product perception." European sheet pile producers have been proactive with consultants to reshape the misperceptions that sheet piles are only for temporary shoring and marine structures. By recognizing this product as the versatile structural element it is, their minds opened to this pile innovation, which revealed significant savings that were being buried with conventional foundation methods.



Sheet pile profile

Design considerations:

Loading

Sheet piles began more than a century ago as tension members with no bending capacity. Flat in shape, their strength lied only in the interlock tension. Over time, they evolved into bending elements for retaining applications, but many are still unaware of their vertical load capacity. Structurally, sheet piles are a system of beams that continuously interlock to form a wall with significant axial cross-sectional area. The sheets are providing the bending resistance for the lateral earth and water pressures, but a reserve for axial loading remains to be tapped.

Based on the perimeter building loads and the soils, the structural and geotech may have the option to design the sheet piles for axial loading.

Perimeter grade beam

The tops of the piles are cast into a grade beam to distribute the vertical loads evenly across the wall. The axial load transfer may not only reduce perimeter columns, but will remove the perimeter footings that would be needed to support a conventional structural wall. Sheet pile walls derive strength through soil mechanics, independent of footings. This is just another example of how this efficient structural element does the job of many conventional materials.

Installation

Analysis drives the structural property requirements of a retaining wall material, but there are additional design issues that help determine the sheet pile section. "Drivability" is equally important. Most times, the bending moment and deflection can be achieved by one section, but a heavier section is specified to assure precise installation of the piles without damage.

This is a permanent wall that demands a proactive plan for a proper install. A thorough understanding of the soils is critical for any SOE.

Conventional vibratory and impact hammers will do just fine in a wide range of cohesive and non-cohesive conditions. Piledriving has had some

issues regarding noise and vibrations in urban environments. New technologies in variable frequency hammers, site monitoring programs and hydraulic press equipment are addressing those negatives. Furthermore, pre-drilling, auger and water jetting attachments are enabling piledrivers to penetrate very dense soils that would not be considered in the past.

For a market with urban development sites surrounded by neighboring structures, the piledriving industry is responding to owners and consultants with pro-environmental options and reduced liability.

Durability

Service life code requirements for foundation structures are also to be considered. Fortunately, this application is a non-aggressive environment. The presence of free oxygen on the backside of the wall is virtually non-existent. Therefore, corrosion or mill loss of the steel is minimal. The exposed side of the wall is temperature controlled, ventilated and protected from the elements. With wall thickness ranging from 0.375" to 0.750", the sheet pile section provides a design life minimum of 150 years. This is far beyond what conventional foundations can claim. Durability software is used to validate the design or increase service life to 300 years and beyond.

Fireproofing

European codes do not enforce fire ratings for structures. The fire resistance is engineered into the foundation in the structural design. The United States building code requires a construction material to be fire rated first, then the structural consultant may implement that product into the design. Because this application is new to the domestic market, there are no UL/UBC fire safety codes to refer to for sheet pile as a permanent foundation wall. Fire ratings and code interpretation vary by local jurisdiction throughout the country. Wall vicinity, adjacent property, ventilation, and vertical loading all play a role in the code interpretation.

The AZ sheet pile sections have been independently fire tested to ASTM E-119 standards. The results showed these sections achieved a four-hour rating under axial load. The fire engineering is inherent to the bare steel sections and no additional fireproofing measures are required for the application.

Waterproofing

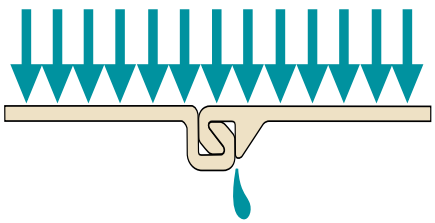
In below-grade parking or basement structures there are two aspects of water intrusion. One pathway is from the base slab/wall interface. This is referred to as waterstop. Whether you have a conventional concrete wall or sheet pile wall, the waterstop measures are no different. A membrane or barrier system is required for the bottom of slab. A hydrophilic stripping about the perimeter walls will address the floor/

Conventional hammer installation for permanent sheet pile wall

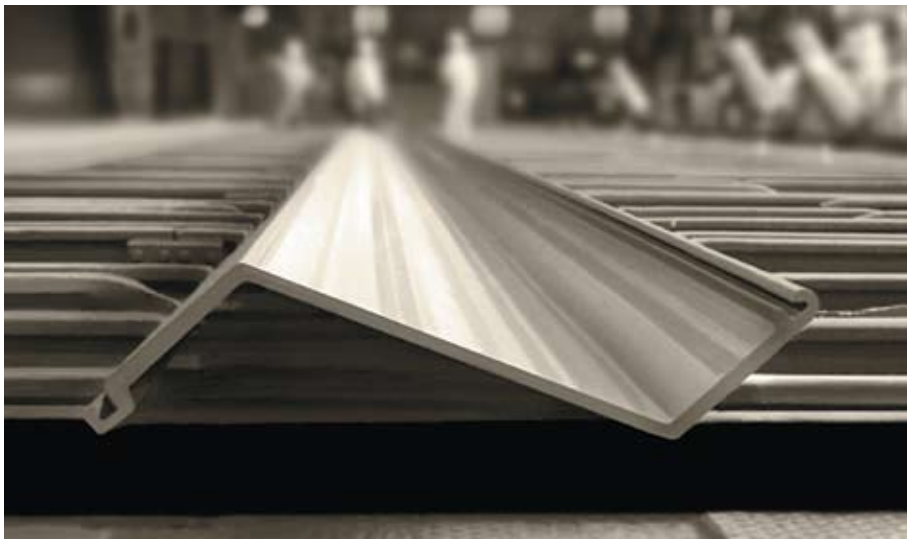
wall interface connection.

When ground water is present, the geotech and structural will increase the mass of the base slab and or incorporate tension piles to resist hydrostatic uplift forces. Unlike cast-in-place walls, sheet piles penetrate about 10 feet or more below the base slab, providing a natural cut-off. This will reduce the base slab material and construction costs compared to concrete walls.

The other aspect of waterproofing refers to the horizontal pathway directly through the wall. With concrete construction, a membrane system is applied to the backside in between the shoring system and basement wall. Steel piling is impermeable to vapor and liquid. The only pathway is through the connection, which accounts for less than one percent of the total wall area. AZ sheets are produced with a Larrsen interlock and have the lowest rate of conductivity among sections produced. Not only is the potential penetration identified, it is minimized. A non- structural seal weld is applied to every exposed interlock to assure a watertight seal for the life of the structure.



Permeability of sheet pile wall



Features and benefits

Foundation footprint

Steel sheet piles initially serve as the temporary shoring. After excavation, they are cleaned, prepped for welding, painted, and left in place as the permanent wall structure. This simple but versatile use of material eliminates the conventional offset area and permanent wall construction costs. With section

Floor / wall interface connection

profiles of 12 to 20 inches in depth, it is easy to see how sheet piles simplify the foundation system and maximize the basement area.

Method of excavation

Permanent sheet pile foundations offer something that conventional systems do not: options. In addition to open pit excavation, sheet piles walls can be used with top-down excavation methods. Unlike most conventional foundations, sheet piles are precast sections that are ready for immediate loading.

Top-down excavation is the only method of excavation that allows the superstructure to be built during the subgrade work. This removes the foundation from the critical path at the earliest point in the schedule. This method employs the slab construction during excavation, so anchors or bracing are not required. Yet again, offering more time and material benefits.

Material and schedule

Open pit excavation with permanent sheet piles is the quickest form of foundation construction. No other SOE system can get a foundation out of the ground and off the critical path faster. In comparison, this offers some material costs savings, but more importantly, dramatically reduces the foundation schedule by up to 50 percent.

Top-down excavation is the fastest method for total project completion. In addition to the material savings, the months of construction removed from the project schedule result in loan interest and liability insurance savings for the owner. Lastly, the facility is in operation generating revenues months ahead of conventional schedules for a better return on investment.

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