O-Pile Wall for Deep Excavation & Tunnelling

January 28, 2015
Mer Lion Metals in Construction Industry

- STEEL SOLUTION PROVIDER
- PROJECT BASED WITH TAILORED SOLUTIONS
- ASIAN FOCUS
- DEEP EXCAVATION WORK
- WATERFRONT RELATED SOLUTIONS
Projects in Singapore and Asia

- Deep Excavation Work: Down Town Line C916
- Owner: Land Transport Authority
- Customer: McConnel Dowell South East Asia
Projects in Singapore and Asia

- Deep Excavation Work: Thomson Line T206 Pipes (Debonding Casings)
- Owner: Land Transport Authority
- Customer: Shanghai Tunnel Engineering Co. Ltd.
Projects in Singapore and Asia

- Deep Excavation Work: Shimizu NIPE C4
- Owner: PUB
- Customer: Shimizu

Figure 3 — Cross joint detail
Sealing groove
Curved bolt
Caulking groove

Figure 4 — Curved bolts used for cross joints
Projects in Singapore and Asia

- Other projects in Asia
Deep Excavation and Tunneling

- Multiple Levels of Tunnelling
- Minimal / No disruption
- Built Up Area
- Avoiding Utilities Tunnels
- Safety
Deep Excavation and Tunneling

- MTR in Hong Kong
Deep Excavation and Tunneling

- Pipe Roof / Box
Deep Excavation and Tunneling

- Pipe Roof / Box
Deep Excavation and Tunneling

Advantages
- Prevention of Soil Settlement
- Critical Applications
- No disruption of work above
- Diversion not possible
- Safety
Deep Excavation and Tunneling

Projects
- MTR TST Station under Nathan Road (2015)
- ER296 Sentosa Gateway Tunnel (2014)
- Alpine / McDow C917 Project under Bukit Timah Road (2014)
- LTA C8288 Bouna Vista Road (2010)
Deep Excavation and Tunneling

North Bouna Vista Road Singapore

- 230kV cables to be support by TAM
- 230kV Joint Bay to be support and jack-up
- 300mm dia. watermain to be repping
- Singtel/Starhub cables to be repping
- 150mm dia. Watermain to be repping
- 22kV cables to be support by TAM grouting
- 230kV cables to be support by TAM grouting
Deep Excavation and Tunneling

North Bouna Vista Road Singapore
Deep Excavation and Tunneling

North Bouna Vista Road Singapore
Deep Excavation and Tunneling

North Bouna Vista Road Singapore

Fig 4.2 Details of Pipe Clutch

Fig 4.3 View of interlocking pipe roof with steel entrance frame
Deep Excavation and Tunneling

North Bouna Vista Road Singapore

Fig 4.4 partially completed pipe roof

Fig 4.5 Complete pipe roof with interlocking pipes
Deep Excavation and Tunneling

Common Interlocks Used with Pipes

- **L-T Interlock**
- **P-T Interlock**
- **P-P Interlock**
- **Larssen Interlock**
Deep Excavation and Tunneling

Common Interlocks Used with Pipes

Photograph A: View of Single and Double box under construction

Figure 3. Arrangement of Single and Double Box
Deep Excavation and Tunneling

Problems Faced with Interlocks on Pipes

- Declutching (Strength of Interlock)
- Watertightness
- Difficulty in Straightness
- Difficulty in Welding
- Difficulty in Splicing
Deep Excavation and Tunneling

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Deep Excavation and Tunneling

Is there a better solution?
O-Pile Wall Connector Elements

O-Piles

- Patented
- 3x stronger than competitors
- Hot Extruded
- Eliminates all the problems with LT, PT, PP
O-Pile Wall Connector Elements

Advantages
- Hot Extruded
- Strength in Interlocks
- Ease of Welding
- Watertightness
- 20 degrees of Rotation

<table>
<thead>
<tr>
<th>O-Pile: L-T</th>
<th>L-T</th>
<th>O-Pile: P-T</th>
<th>P-T</th>
<th>O-Pile P-P Small</th>
<th>P-P - Small</th>
<th>O-Pile P-P Large</th>
<th>P-P - Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>100mm*</td>
<td>100mm</td>
<td>180mm*</td>
<td>180mm</td>
<td>248mm*</td>
<td>248mm</td>
<td>248mm*</td>
</tr>
<tr>
<td>Thickness</td>
<td>9mm**</td>
<td>9mm</td>
<td>9mm**</td>
<td>9mm</td>
<td>9mm**</td>
<td>9mm</td>
<td>11mm**</td>
</tr>
<tr>
<td>Weight</td>
<td>19.7kg/m</td>
<td>32.6 kg/m</td>
<td>23.12 kg/m</td>
<td>45.6 kg/m</td>
<td>2792 kg/m</td>
<td>69.4 kg/m</td>
<td>33.54 kg/m</td>
</tr>
<tr>
<td>Interlock Strength***</td>
<td>194 kN</td>
<td>57 kN</td>
<td>194 kN</td>
<td>23 kN</td>
<td>194 kN</td>
<td>13 kN</td>
<td>194 kN</td>
</tr>
</tbody>
</table>
O-Pile Wall Connector Elements

Advantages
- Hot Extruded
- **Strength in Interlocks**
- Ease of Welding
- Watertightness
- 20 degrees of Rotation
1. Task Description

Two different interlock assemblies should be welded to piles and afterwards twisted about each other. The moment necessary to separate the interlocks should be determined.

<table>
<thead>
<tr>
<th>Pile Outer Diameter</th>
<th>Interlock</th>
<th>CAD model</th>
</tr>
</thead>
<tbody>
<tr>
<td>635 mm</td>
<td>„P-P“</td>
<td><img src="image1" alt="P-P CAD model" /></td>
</tr>
<tr>
<td>635 mm</td>
<td>„P-T“</td>
<td><img src="image2" alt="P-T CAD model" /></td>
</tr>
<tr>
<td>482 mm</td>
<td>„L-T“</td>
<td><img src="image3" alt="L-T CAD model" /></td>
</tr>
</tbody>
</table>

FIG.1.1. CAD models of the three different interlock designs.
3. Results

3.8 Comparison of Results der Zugsimulationen

To facilitate comparison, the results of Zugsimulation for the drei assemblies are displayed graphically in the load-displacement diagram below (FIG. 3.8.1).

FIG. 3.8.1 Tensile Force versus displacement in x-direction bei drei versch.Schlosskombinationen.
1. Task Description

Three different interlock combinations should be loaded by a cylinder at specified positions (FIG. 1.1). These four interlock/load assemblies were to be simulated until the jaws would open or the material would fail. The resulting stresses and deformations of the assemblies should be compared.

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Interlock</th>
<th>CAD model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly 1</td>
<td>WOF / WOM-XXL</td>
<td>![Assembly 1 Diagram]</td>
</tr>
<tr>
<td>Assembly 2</td>
<td>WOM / WOF-XL</td>
<td>![Assembly 2 Diagram]</td>
</tr>
<tr>
<td>Assembly 3</td>
<td>WOM / WOF-XL</td>
<td>![Assembly 3 Diagram]</td>
</tr>
<tr>
<td>Assembly 4</td>
<td>WOM-XXL / WOF-XXL</td>
<td>![Assembly 4 Diagram]</td>
</tr>
</tbody>
</table>

FIG.1.1. CAD models of the different interlock designs.
3. Results

3.5 Comparison of Results

To facilitate comparison, the results of the finite element simulations for the various interlock assemblies are displayed graphically in the load-displacement diagram below (FIG. 3.7).

FIG. 3.7 Load [kN] versus displacement y [mm] for the different interlock assemblies.
O-Pile Wall Connector Elements

Advantages
- Hot Extruded
- Strength in Interlocks
- **Ease of Welding**
- Watertightness
- 20 degrees of Rotation

![Diagram of O-Pile Wall Connector Elements](image)
O-Pile Wall Connector Elements

Advantages

- Hot Extruded
- Strength in Interlocks
- Ease of Welding
- Watertightness
- 20 degrees of Rotation
O-Pile Wall Connector Elements

Advantages

- Hot Extruded
- Strength in Interlocks
- Ease of Welding
- Watertightness
- **20 degrees of Rotation**

![Diagram of O-Pile Wall Connector Elements with 20 degrees of rotation and dimensions 3.5" (88mm) and 7.1" (180mm).]
Interlocked O-Pile Wall Components

- Individual O-Pile System to Replace L-T / P-T / PP Interlocks

L-T Replacement

**O-Pile: L-T**

**USE:**
- For pipe to pipe systems; has same dimensions as an L-T

- Combined Connector Width = 100mm
- Connector Thickness = 9mm
- Interlock Strength = 194 kN
Interlocked O-Pile Wall Components

- Individual O-Pile System to Replace L-T / P-T / PP Interlocks

P-T Replacement

**O-Pile: P-T**

**USE:**
- For pipe to pipe systems; has same dimensions as P-T

- Combined Connector Width = 180mm
- Connector Thickness = 9mm
- Interlock Strength = 194 kN
Interlocked O-Pile Wall Components

- Individual O-Pile System to Replace L-T / P-T / PP Interlocks

**P-P Replacement**

**O-Pile: P-P Small**

**USE:**
- For pipe to pipe systems; has same dimensions as P-P small

**Dimensions**
- Combined Connector Width = 247mm
- Connector Thickness = 9mm
- Interlock Strength = 194 kN
Interlocked O-Pile Wall Components

- WOM/WOF-S connection profiles
- For Down-the-Hole Application
Down-the-Hole (DTH) Drilling Update in the Construction Industry

- Development of new Down The Hole (DTH) techniques
- New air control bits
- Using DTH in urban areas and in sensitive ground is now possible
- No danger of overdrilling or air escaping
New Business Opportunity with O-Pile: DTH

- DTH drilling through boulders and right into bedrock
O-Pile Wall Connector Elements

- Oversized ring bit reams the space wide enough for male element to follow.

- The female element that reaches further out than the area cut by ring bits is always either in pre-drilled material or in a cavity created by a previously drilled ring bit.
O-Pile Wall Application Ideas

With interlocked casings, we can make walls to be used as:

- Interlocked pipe roofs
- Dock construction and quay walls
- Flood control and support walls
- Vertically sealed enclosure walls
- Pollution or water controll walls
- Site excavations
- Etc.

O-Pile walls can bring considerable savings in construction time, with the added possibility of completely eliminating the need for temporary retaining walls.
- Interlocked O-Pile roofs offer a new, economical way to build under streets *without* cutting off vital traffic.
O-Pile Wall Application Examples

MTR C3084-13C
- Improvement works to TST Station Exits and K11 Mall Entrance
O-Pile Wall Application Examples

MTR C3084-13C
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O-Pile Wall Application Examples

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O-Pile Wall Application Examples

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O-Pile Wall Application Examples

MTR C3084-13C
- Interlocks
- Pipes
O-Pile Wall Application Examples

MTR C3084-13C
- Interlocks
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O-Pile Wall Application Examples

MTR C3084-13C

- Interlocks
- Pipes
O-Pile Wall Application Examples

MTR C3084-13C

- Interlocks
- Pipes
Two basic applications exist,

- One where you can break through with every casing thus being able to use same drill bit several times
- Another application where pipe roof with end up in ground area that will not be excavated or will be excavated later. Sacrificed ring bit systems
Installation of O-Pile Walls with DTH

Horizontal Drilling Example
Installation of O-Pile Walls with DTH

Casing Joints

Best case scenario: The most feasible and economic solution is for all casings to be drilled single pass, given that welding time is not productive.

However, if welding does need to be done (and is allowed at the site), then casings can be extended by welding.
O-Pile Wall Drilling Tools

DTH Drill Bits

- Designed for interlocked pipe pile walls,
- Feature an oversized ring bit;
- Most important is the air flow balance between the flush face and the direct flow back to the casing

18 mm back flush holes
Almost all pipe pile walls done with wing bits have had many connector element breakages and other failures. This is due to the wing bit’s tendency to deviate from hard layers and boulders and the casing’s natural turning to the right, especially if the casing is poorly flushed and full of soil, which turns the casing right and down, under the drill rig.
Installation of O-Pile Walls with DTH

Sealing

Interlocked pipe pile walls can be sealed against water leakage up to a 5 bar pressure difference, which means 50 meters in wall depth!

Wadit® sealant is applied hot to the female connector rail.
Installation of O-Pile Walls with DTH

Sealing

- Prevents water leakage up to a 5 bar pressure difference, which means 50 meters in wall depth!
- Hydrophobic
- Environmentally Friendly
O-Pile Wall Application Examples

Cut and Cover Tunnel / Launching Shafts
- Large Retaining Wall for Deep Excavation
- High Bending Moment Requirements

Contiguous Bore Piles

Interlocking Bore Piles

Secant Bore Piles
O-Pile Wall Application Examples

Cut and Cover Tunnel / Launching Shafts
- Large Retaining Wall for Deep Excavation
- High Bending Moment Requirements

Diaphragm Wall

1. Guide-wall construction
2. Panel excavation in progress
3. Installing stop ends
4. Panel concreting
O-Pile Wall Application Examples

Cut and Cover Tunnel / Launching Shafts
- Large Retaining Wall for Deep Excavation
- High Bending Moment Requirements

Secant Bore Piles
Casing size requirements vary according to the load requirements.

Applications typically vary from 168 mm to 2000 mm casings, while the lowest total material costs are in between 406 and 1000 mm.

Small sizes, from 168 mm to 273, can be drilled with a water hammer, too, utilizing outside flushing bits that minimize water requirement.
O-Pile Wall Site Photos
O-Pile Wall Site Photos

※施工事例については、米国Pilepro社の皆様のと、横山基礎工事が使用しています。
O-Pile Wall Site Photos
### The system you selected

**ArcelorMittal AZ 50**

<table>
<thead>
<tr>
<th>weight</th>
<th>panel weight</th>
<th>section modulus</th>
<th>moment of inertia</th>
<th>width</th>
<th>panel depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>252.5 kg/m²</td>
<td>146.7 kg/m</td>
<td>5.015 cm²/m</td>
<td>121,060.0 cm³/m²</td>
<td>580.0 mm</td>
<td>483.0 mm</td>
</tr>
</tbody>
</table>

**O-Pile® O 50 - 36” x .025”**

<table>
<thead>
<tr>
<th>weight</th>
<th>panel weight</th>
<th>section modulus</th>
<th>moment of inertia</th>
<th>width</th>
<th>panel depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>330.4 kg/m²</td>
<td>361.6 kg/m</td>
<td>9,641.0 cm²/m</td>
<td>413,365.3 cm³/m²</td>
<td>914 mm</td>
<td>914 mm</td>
</tr>
</tbody>
</table>

**O-Pile® O 56 - 36” x .0375”**

<table>
<thead>
<tr>
<th>weight</th>
<th>panel weight</th>
<th>section modulus</th>
<th>moment of inertia</th>
<th>width</th>
<th>panel depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>239.9 kg/m²</td>
<td>262.6 kg/m</td>
<td>6,428.9 cm²/m</td>
<td>283,927.3 cm³/m²</td>
<td>1,094.4 mm</td>
<td>914.4 mm</td>
</tr>
</tbody>
</table>
Thank You

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www.merlionmetals.com | www.o-pile.com