Foundation Solutions
Steel Sheet Piles

Underground car parks

Contents

Tourcoing
France

Tourcoing is situated 10 km north of Lille, just a stone's throw from the Belgian border. Famous for its 19th-century textile industry, the French city recently underwent a major redevelopment programme conducted by the urban community of the Lille metropolitan area in order to increase the attraction of the city centre. The project involves the construction of a modern-style shopping mall, a transport hub used by metro, tramway and bus, as well as the development of residential and public areas.

Among the residential areas to be developed was the 40-unit apartment block at the corner of Rue de Chanzy and Rue Lehoucq. One underground level and four upper levels were to be built in densely populated surroundings. Due to the nearby tramway and existing structures including a 19th-century monastery, the jobsite was subject to a number of constraints. Deflection of the sheet pile wall was limited to 20 mm. A fifty-year lifetime had to be guaranteed for the steel elements. A nine-metre-high barrier was erected for protection from nearby high-voltage power lines.

Steel sheet pile retaining walls require only a minimum of space and were thus the ideal retaining-wall solution for Tourcoing's latest underground carpark. The original design included sheet piles as temporary retaining elements, with a permanent concrete wall. The design was later amended to use sheet piles as permanent elements. Apart from contributing to the watertightness of the excavation, the sheet pile wall also carries horizontal loads from earth pressure including imposed loads from road traffic and the tramway.

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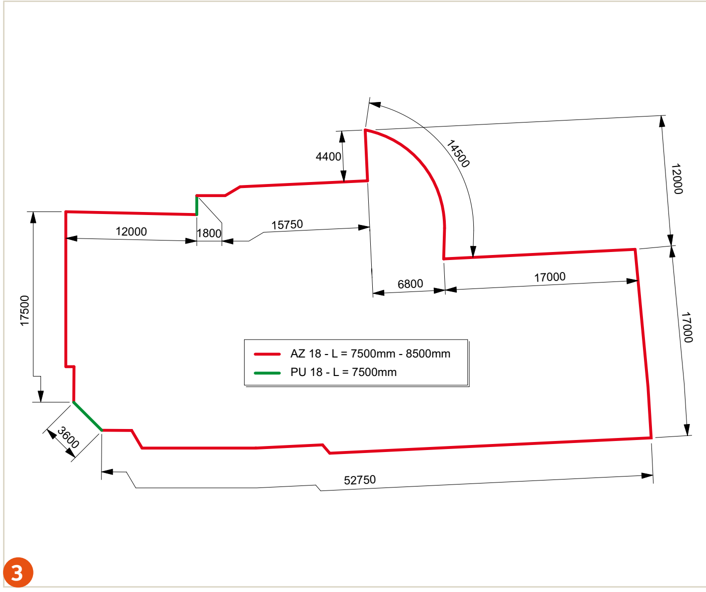

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The vertical loads of the residential superstructure were set on a deep foundation of bored concrete piles.

Several boreholes were drilled to a depth of 16 m. Soil analysis revealed the following soil layers (from the top down):

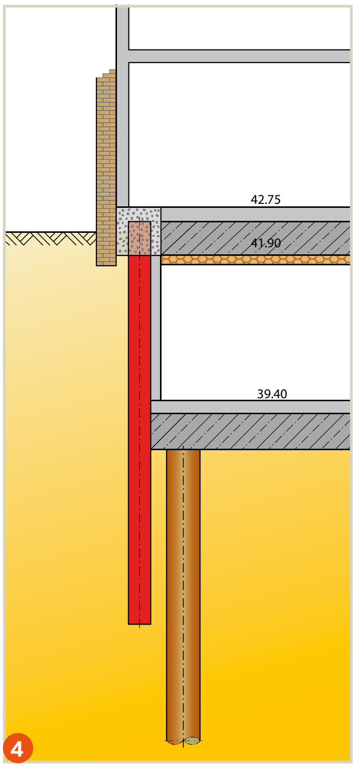
- one metre of made ground
- up to seven metres of silty to clayey river sand (internal friction angle: 20 - 28°, cohesion up to 20 kN/m^2)
- groundwater 1.5 m below ground level (El. +40.30 m)
- increasingly stiff clay substratum to bottom of borehole

The clayey soil was loosened with a 460-mm-diameter drill before the sheet piles were driven. AZ 18 profiles were mainly used for the project, as well as several PU 18 sheet piles, both types in steel grade S 240 GP. The AZ and PU sheet piles ranging from 7.5 to 8.5 m in length were driven into the stiff clay substratum with a rig-mounted ABI vibratory hammer (MRZV 925). The city had issued severe limits for vibrations in order to prevent damage to surrounding buildings. The jobsite was therefore equipped with special vibration-measuring equipment.

Once the sheet piles had been driven into the clay substratum, a reinforced concrete capping beam was poured onto the head of the piles. Large-diameter steel tubes were bolted to the capping beam to carry the horizontal reaction of the retaining walls during construction. Battered tubes attached to two double AZ piles ensured the stability of the corners of the excavation. The sheet piles remain in the ground as a permanent part of the building, and the top slab of the carpark serves as bracing. Rebars were fixed to the sheet piles before the top slab of the carpark was poured, thereby ensuring proper connection. The access ramp also features sheet pile retaining walls. The AZ 18 retaining wall has an overall length of approximately 150 m.

To ensure the watertightness of the excavation and hence of the future underground carpark, several sealing measures were implemented. The common interlocks of the AZ 18 double piles were welded together prior to delivery to Tourcoing. In addition, the leading interlocks driven below the bottom slab were filled with a bituminous sealing substance called Beltan.

Once the steel sheet piles were installed, excavation got under way inside the retaining wall. To enable work to be carried out in the dry the water table was lowered two metres by pumps inside the excavation. After completion



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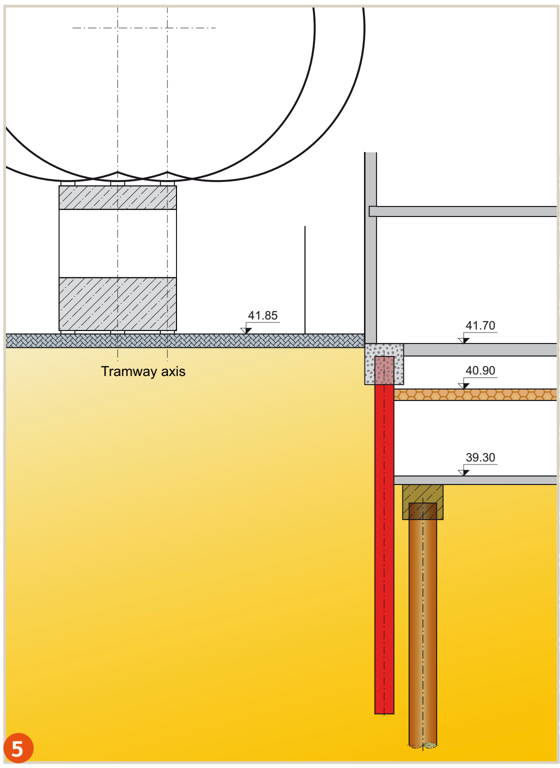

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of the excavation works, the parts of the interlocks visible from inside the excavation were seal-welded. A small horizontal drainage system completed the waterproofing system of the carpark. As the upper structure is founded on concrete dividing walls, the connection between the bottom slab and the sheet piles was not required to take significant loads.

As the pumps were placed inside the excavation, they had to cope merely with minor water flow through the unwelded leading interlocks before seal-welding of these interlocks was finalised. Alternative construction methods often require heavy groundwater pumping during the entire construction period. This may engender severe settlement, thus jeopardising nearby infrastructures.

140 metric tons of steel sheet piles with a capping beam were installed within six weeks, despite the complex shape of the excavation. Started in April 2006, construction of the residential building in Tourcoing was completed by mid 2007. The AZ 18s were coated in different colours and are an aesthetic bonus for the carpark.

Owner: Immobilière Nord-Artois
Designer: Architect Alain Bossan
Contractor: Rabot Dutilleul Construction
Steel sheet piles: AZ 18, PU 18
Connectors: C9, Omega 18, Delta 13
Steel grade: S 240 GP
Sheet pile length: 7.5–8.5 m
Total quantity of sheet piles: 140 tons

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1 The underground carpark beneath the residential building was built with a watertight sheet pile retaining wall

2|3 The AZ 18 sheet pile wall surrounding the excavation during the construction stage was subsequently left in place to serve as the outer wall of the underground carpark

4|5 The underground carpark was built in a cramped inner-city area right next to existing buildings and transport infrastructures

6|7 A concrete capping beam was then poured onto the head of the sheet piles

8 Horizontal reactions were carried by steel struts

9|10 Coated AZ 18 sheet piles as outer wall of the carpark and access ramp

Haarlem
Netherlands


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Haarlem is situated 20 km west of the Dutch capital Amsterdam. The decision to redevelop a two-hectare inner-city area as a reaction to a shortage of parking space, amongst other reasons, was made in 1998. Property development company Bouwfonds MAB Ontwikkeling and the city of Haarlem inaugurated the "Raaksproject" in 2004. It includes the development of 220 apartments and a commercial area of 20,000 m².

The existing infrastructure, a public carpark and several school buildings were demolished. The first phase of the Raaksproject, including a two-level, 200-parking-space carpark (P2), was launched in September 2006. Built mainly with AZ 26 sheet pile retaining walls, the carpark will be temporarily accessible to the public.


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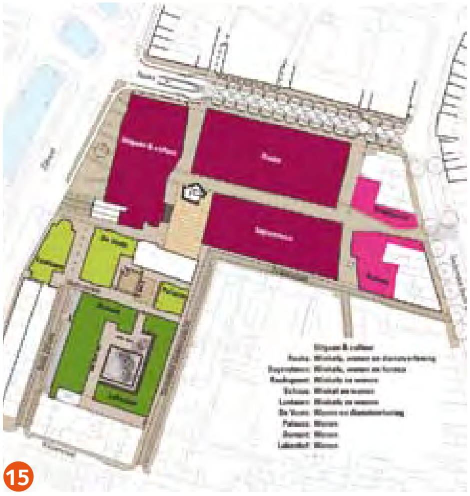
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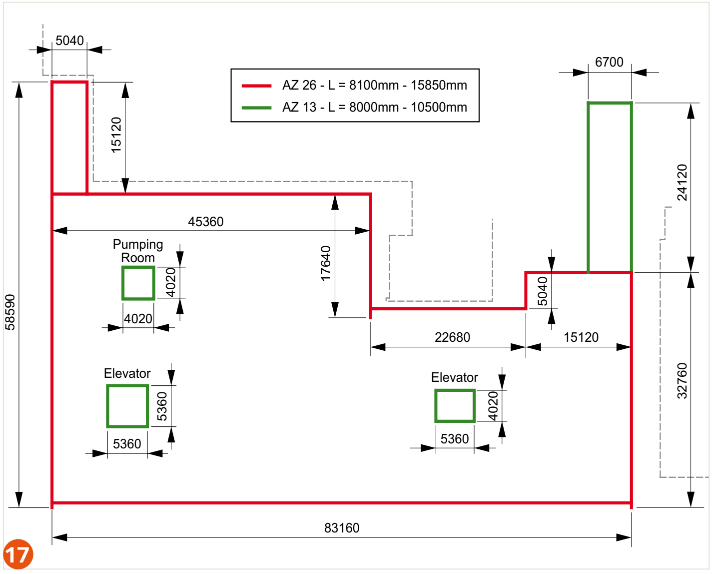

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Construction of the large, three-storey public carpark P1 with capacity for 1000 vehicles, right next to the smaller carpark, started in January 2007. Construction was divided into 2 parts: P1A and P1B. A retaining wall mainly consisting of AZ 36-700 sheet piles surrounded the excavation. Completion is scheduled for 2009, as part of the second phase of the Raaksproject. Once the large public carpark is opened, its smaller counterpart will be accessible solely to the owners of the newly built apartments.

The sheet pile walls of both carparks remain permanently in the ground.

Soil analyses were carried out with a technique commonly used in the Netherlands: the Cone Penetrometer Test (CPT). Providing real-time data, the method consists of a steel cone that is pushed into the ground hydraulically. Sensors at the tip of the cone collect data for classifying soil types.

The surface elevation ranged from +0.5 to +1.0 m and the water table was encountered just below the surface at El. -0.10 m. The cone resistance of the upper soil layer was very low (< 2 MN/m^2). At a depth of 6 metres, the resistance rose to 15–20 MN/m^2.

1,670 tons of AZ 36-700 and 250 tons of AZ 36 sheet piles were delivered by lorry to the jobsite in Haarlem. The first pile for the retaining wall of the 1,000-vehicle-capacity carpark was installed in September 2006. Once the AZ piles were in the ground, soil was excavated to a depth of -1.60 m.


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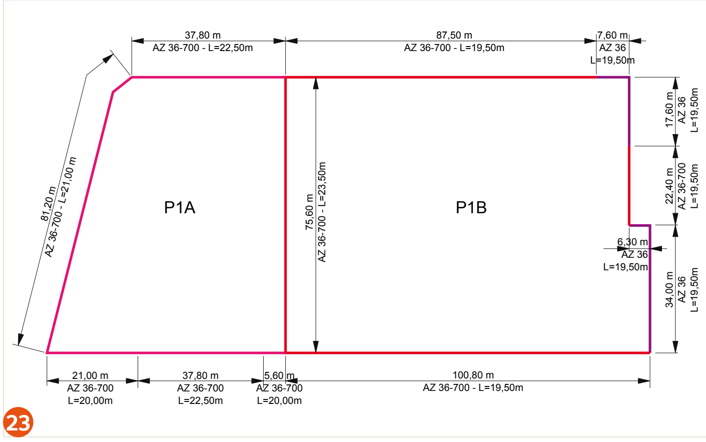

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The groundwater level was lowered to -5.3 m before the upper inclined active tie rod was placed at El. -1.10 m. Every third AZ 36-700 double pile was secured with a tie rod, corresponding to a c/c spacing of 4.2 m (c/c = 3.78 m for AZ 36 piles). Excavation then proceeded and the second tie rod level was installed at El. -4.15 m. The water level was raised to El. 0.0 m again before excavating to the final depth of -12.50 m and placing a 250-mm gravel layer and a 1,500-mm sub-base of underwater concrete. Grout injection piles hold the slab in place after dewatering.

The following types of AZ double piles in steel grade S 355 GP were installed:
P1A: 670 tons AZ 36-700,
L = 20–22.5 m
P1B: 250 tons AZ 36, L = 19.5 m and
1.000 tons AZ 36-700,
L = 19.5–23.5 m

The sheet piles were delivered as welded double piles. No other temporary sealing method was used so as not to hinder later welding works. Once driving was completed and the construction excavation dewatered, the middle interlocks were seal-welded to achieve a completely watertight retaining wall. Fire analysis showed that no special protection was necessary.

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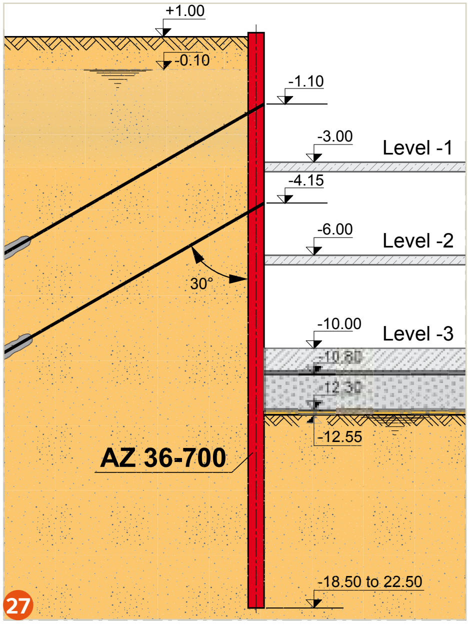

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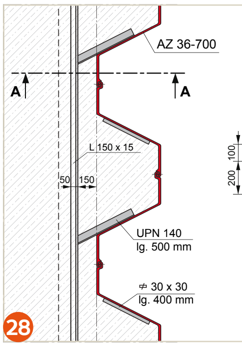

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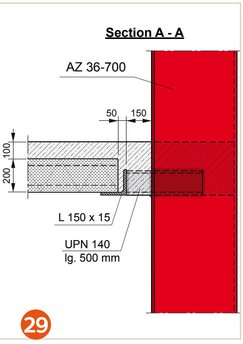

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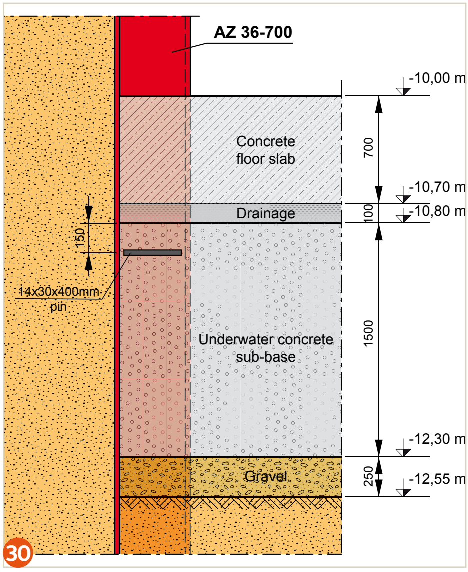

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Two different methods were used to drive the piles: the AZ 36 piles were pressed as quadruple piles with ABI's HPZ hydro-press (pressing power: 4×800 kN). The other piles were installed with a PVE 2335 VM high-frequency vibratory hammer with variable moment (eccentric moment: 0-35 kg/m, centrifugal force: 2000 kN) suspended from a crawler crane. A steel template was used to position the piles correctly; verticality was checked with a spirit level.

The sub-base also acts as a strut and by taking the thrust on the sheet pile retaining wall enabled water to be pumped from the excavation once the underwater concrete had reached a sufficient stiffness. A horizontal drainage system and a 700-mm concrete slab were installed in the dry, making the connection watertight. Studs welded to the AZ piles transmit shear forces between sheet piles and the entire base slab.

The upper three underground floors were built next, and the tie rods were cut. UPN sections with an average length of 500 mm were welded to the webs of the AZ piles to enable an L-shaped section to be fixed a standard distance of 150 mm from the sheet pile flanges. A 200-mm precast reinforced concrete top slab was lowered onto the 150*15 L section. Formwork was placed in the pans of the sheet piles and another 100 mm of concrete was then poured onto the precast slab to obtain a strong continuous 300-mm-thick slab. A separate foundation system was built, making it unnecessary for the peripheral connection to transmit the high loads of the carpark and the buildings built on top. The upper slab of level -1 coincides with the head of the sheet piles at El. +1.0 m.

A declutching detector was used to guarantee interlocking of the AZ double piles. Welded to the bottom of the interlock before driving, the detector is equipped with a sensor pin that is sheared off by the following pile. This information is transmitted to a monitoring unit on the surface, notifying the contractor if declutching is an issue on site.

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Owner: Bouwfonds MAB Ontwikkeling
Designer: Bolles + Wilson, Bouwfonds MAB Ontwikkeling
Contractor: Dura Vermeer Bouw Haarlemmeermeer BV
Steel sheet piles: AZ 36-700, AZ 36
Sheet pile length: 19.5–23.5 m
Steel grade: S 355 GP
Total quantity of sheet piles: 1,920 tons

11|12|13 The "Raaksproject" includes the construction of 220 apartments and a commercial area
14|15 The project is a redevelopment plan for a 2-hectare inner-city area
16 A steel template guided the AZ sheet piles and ensured correct positioning
17|18|19 Carpark P2: 2 levels, capacity of 200 cars, AZ 13 & AZ 26 sheet piles
20 Carpark P1 was built in two phases separated by a temporary AZ 36-700 sheet pile wall
21 Carpark P1: 3 levels, capacity of 1000 cars, AZ 36-700 sheet piles
22|23|24 1,920 tons of sheet piles were used to support the excavation (11.5 m deep in places)
25|26 The AZ piles were installed with a PVE vibratory hammer with variable moment
27 2 levels of tie rods secured the AZ 36-700 retaining wall during the basement construction phase
28|29 Sheet-pile-to-carpark-deck connection detail
30 Studs welded to the AZ 36-700 piles ensured proper connection to the base slab
31 The contractor reduced noise and vibration emissions effectively by pre-drilling the soil before driving the sheet piles

New Islington
Manchester, UK


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New Islington Millennium Village, a short distance east of Manchester's city centre, is anything but conventional as the name of the planned residential scheme "Chips" might suggest. The designer of the project, British architect Will Alsop, is famous for designing buildings of unusual forms distinguished by their vibrant use of bright colours. Surrounded by water on three sides, his latest brainchild promises to be one of Manchester's most striking buildings, with dramatic shapes and cladding. Nine storeys high, it zigzags along the edge of the Ashton Canal as a group of three-storey elements ("Chips") stacked on top of each other. Developed by Urban Splash, "Chips"— totalling 142 apartments—is the first project available for private sale at New Islington.

Launched in December 2005, the homes, work spaces and underground carpark are on target for completion by the end of 2008. Steel sheet piles had established themselves as the ideal solution for extending New Islington's canals and were now the natural choice for the retaining wall of Chips' single-level basement. Quick to install, sheet piles are the most economical retaining elements for inner-city construction sites faced with space restrictions or high groundwater levels.

The first phase of the project – the construction of a new canal arm off Ashton Canal – was carried out in 2003. 415 tons of AZ 25 sheet piles in steel grade S 270 GP, ranging from 6 to 11 m in length, were installed as a cantilever retaining wall supporting the banks of the new canal. As well as several special piles with welded-on Omega 18 and C 9 corner sections, eight bent piles (bending angle: 11°) were used to build the corners and bends of the canal. A reinforced concrete capping beam was poured at the head of the sheet piles. The soil behind the new canal arm was removed three years later, leaving the AZ 25 wall as


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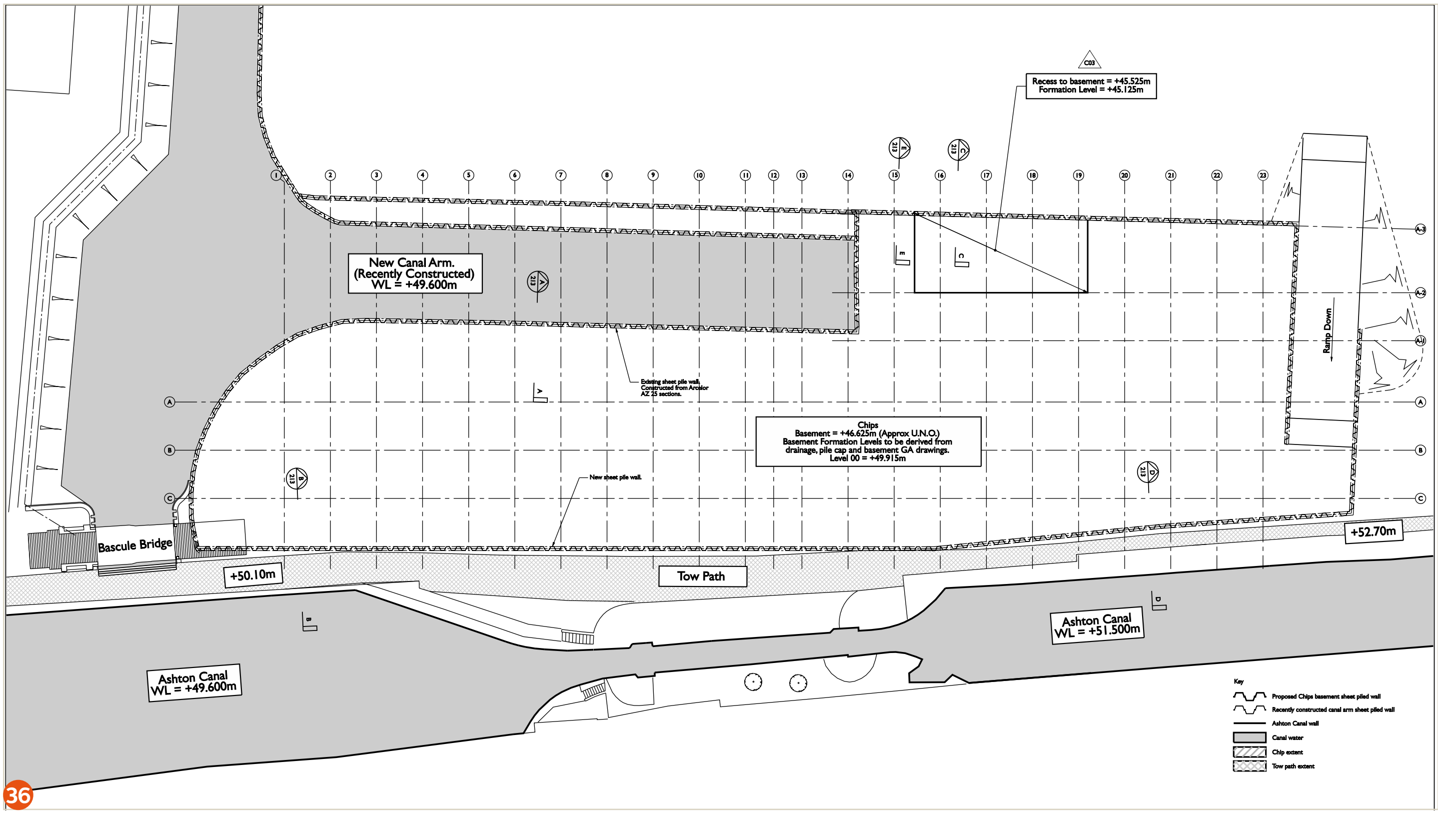

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the sole separation between the water of the new canal and the excavation for the basement of the Chips building.

The second phase was launched by investigating the geology of the former Ancoats Hospital site. This was done by Coffey Geotechnics (formerly Edge Consultants). Several 30-m-deep boreholes were drilled to predict the drivability of the sheet piles. The bore logs showed three metres of made ground overlying stiff sandy, gravelly clay with SPT values averaging 20 blows to a depth of 13 m. Further down, SPT values increase to 40 blows where a mixture of dense sand and fine gravel prevails. The water table is relatively high due to New Islington's countless canals.

Complete watertightness of the basement was achieved by seal-welding the interlocks of the sheet piles. AU 25 and AZ 25 piles are all that separates the basement from different media — soil and canal water — and thus


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minimise loss of space. The basement of the Chips building shares one wall with the adjacent development.

The sheet piles for phase 2 were carried by lorry from the rolling mill in Luxembourg to Manchester in March 2006. Piling contractor Stent Foundations Limited used an ABI rig fitted with a vibratory hammer to install the 312 AU 25 single piles up to 13 m long. A 5-m-deep pit was then excavated to place the reinforced concrete bottom slab with a watertight connection to the sheet pile wall. The upper 250 mm of the AU piles was cast into a capping beam running along the entire retaining wall. Just as with the AZ sheet piles, the interlocks of the AU piles were seal-welded to obtain a watertight wall on each side of the basement. A 300-mm-thick top slab completed the underground structure.

The Chips building basement was designed by Martin Stockley Associates, a Manchester-based consultant. The fire engineering verification proved that no fire protection was required for the majority of the sheet piles as they were installed next to canals. However for the upper part of the wall common to the neighbouring building it was necessary to provide concrete stiffening in the sheet pile pans at the position of the columns above since there was no soil to provide a suitable heat sink.

The piles were grit blasted to give a clean even surface, then left to rust. They were not coated, so as to maintain an industrial appearance for the steel – an acknowledgement of the city's past. Due to the different elements behind the sheet piles (i.e. soil, water or air), the appearance of the piles' surface varies.


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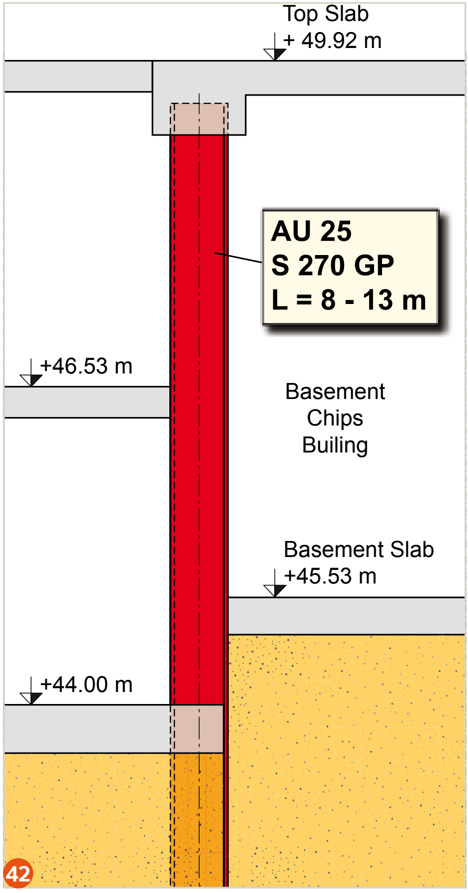

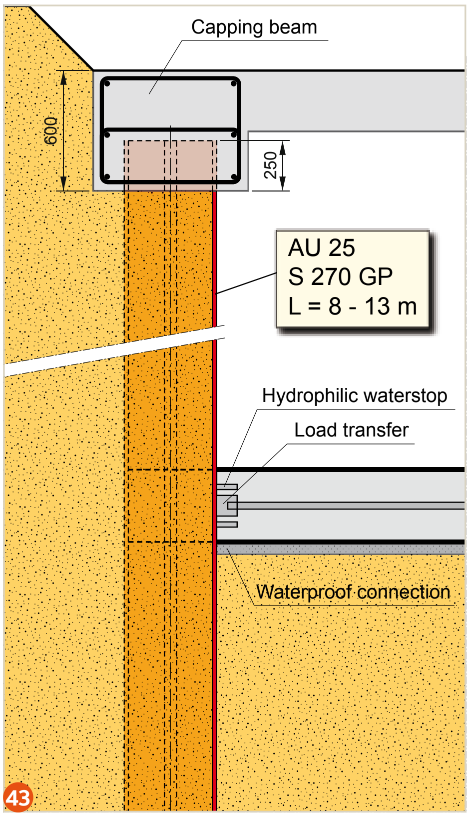

Owner: Urban Splash Ltd

Designer:
Martin Stockley Associates (MSA)

Contractor:
Urban Splash Construction Ltd,
Stent Foundations Ltd
(subcontractor piling)

Steel sheet piles:
AZ 25 (Phase 1), AU 25 (Phase 2)

Sheet pile length:
6–11 m (Phase 1), 8–13 m (Phase 2)

Steel grade: S 270 GP

Total quantity of sheet piles:
415 tons (Phase 1), 320 tons (Phase 2)

All shown images of the Chips building received from Urban Splash Ltd are credited to the photographer Mr.Joel Chester.

32|33 Designed by British architect Will Alsop, the striking Chips building is one of the main features of Manchester's New Islington Millennium Village development

34|35 New canal arms were built in New Islington in 2003 using AZ 25 steel sheet piles as retaining elements

36|37 The soil behind these AZ 25 piles was removed in 2006 to leave the sheet piles as the sole separation between the excavation and the new canal arm

38|39 AU 25 sheet piles were installed during the second construction phase as permanent outer wall of the Chips building's single-level basement

40|41 The soil and water retaining sheet pile walls enabled construction in the dry

42 The adjacent building has a common sheet pile wall with the Chips building

43 A watertight bottom-slab-to-sheet-pile connection and seal-welded interlocks ensure that no water will penetrate into the basement

44 The Splash project is due to be completed by 2008

45 The sheet piles were grit blasted, then left uncoated so as to maintain the steel's industrial appearance

Kolkata
India


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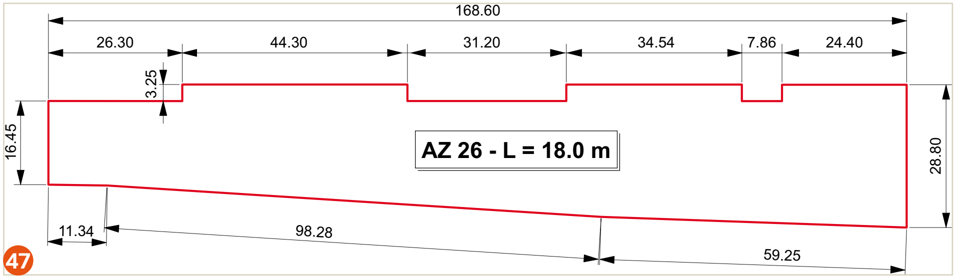

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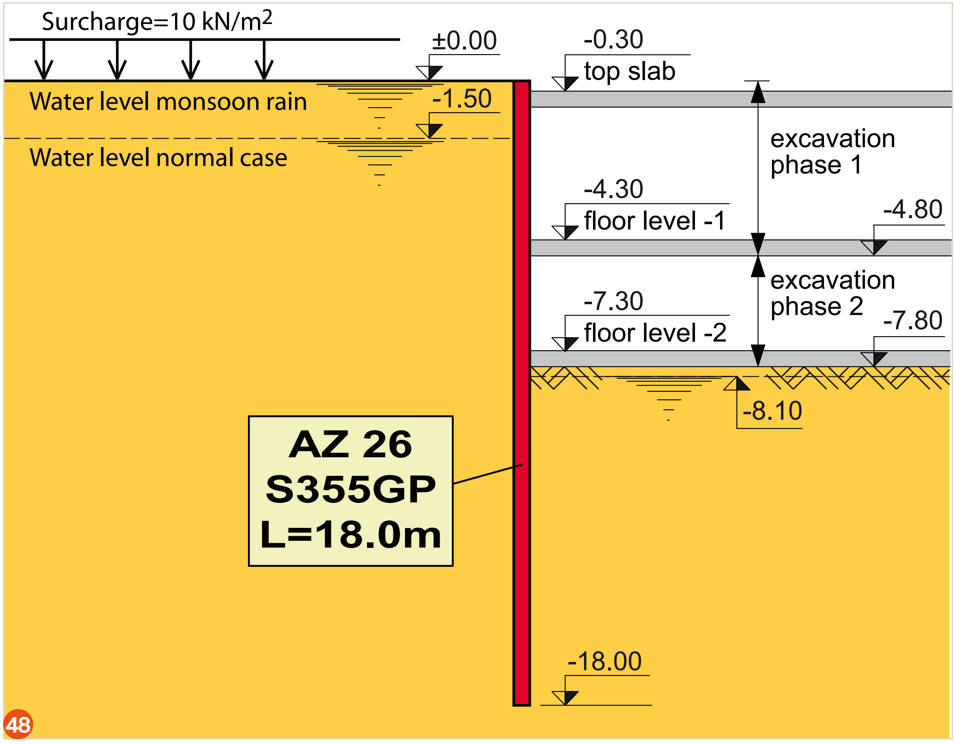

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Kolkata, formerly known as Calcutta, is India's fourth-largest city, a famous historic landmark, and the capital of West Bengal state. A period of economic stagnation followed the country's independence decades ago but has been replaced by a boom engendering rapid growth in all domains, including road traffic. The population of the eastern Indian mega-city currently exceeds 15 million.

Part of the city's expansion included a new underground shopping mall with integral carpark, to be built in the middle of dense urban development. It consists of a shopping mall at level -1 and the country's first carpark equipped with an automated parking system at level -2. It is located right next to the red-brick New Market heritage structure on Lindsey Street, famous for its fabulous clock tower. The two 4,000-m² underground levels were built with the top-down method. The basement was surrounded with a sheet pile wall, these prefabricated interlocking elements being the fastest and most economical construction alternative for the underground structure. The shopping mall was officially inaugurated after a construction time of four years. The carpark has since then attracted a lot of attention due to its efficient storage system featuring fully computerised pallets moving up to 280 cars to their designated parking slots.

The construction of the shopping mall and carpark was launched with a soil investigation carried out by the local companies Geotest and Drillers & Engineers. Special attention had to be paid to the groundwater levels that regularly rise from their habitual elevation

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of 1.5 m below ground level to El. 0.0 m or higher during the monsoon season.

ArcelorMittal's technical department submitted a preliminary sheet pile wall design to the owner. The sheet piles act purely as a retaining wall. The vertical loads of the concrete upper deck are carried by a separate foundation system. As the structure was built with the top-down method, the concrete decks at El. -0.3 m and El. -4.3 m and the bottom slab at El. -7.3 m act as struts transmitting the horizontal reactions of the retaining wall. The prime advantage of the top-down system, namely quick covering up of the construction area, was important as the square above the construction was soon to be reopened to the public.

The preliminary design was carried out in accordance with EC 3 theories: comparison of existing and maximum allowable steel stress as the main criteria for choosing the sheet pile sections. Partial safety factors were not considered however, and the result of the design was judged against a minimal global safety factor of 1.50. The influence of water pressure due to seepage under the sheet pile wall was taken into account by setting up water pressure diagrams determined with hydraulic gradients. The steel stress verification was done for the following four construction phases as well as for the final stage considering a loss of steel thickness due to corrosion after a lifetime of 50 years.

- Phase 1: Excavation & dewatering to El. -4.80 m, upper strut at El. -0.30 m
- Phase 2: Excavation & dewatering to El. -7.80 m, strut at El. -4.30 m, water level at El. -1.50 m
- Phase 3: as per phase 2, water level at El. 0.0 m (monsoon season)
- Phase 4: Final stage, bottom strut at El. –7.30 m, maximal water level under hydrostatic conditions.

The highest bending moment (465 kNm/m) and deflections (63 mm) occur during phase 4. The technical department proposed an 18-m-long AZ 26 sheet pile in steel grade S 355 GP as a suitable


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profile. The steel stress verification of the AZ 26 characterised by a section modulus of 2,600 cm^3/m showed an existing stress of 179 N/mm^2. The allowable stress amounts to 355 N/mm^2, resulting in a safety factor of 2.0.

The verification after an assumed lifetime of 50 years is based on the loss of steel thickness due to corrosion given by tables in EC 3. As the inner side of the basement structure is coated, loss of thickness had to be considered only on the outer side. A loss of 1.75 mm was determined assuming the presence of aggressive natural soil. The recalculated reduced section modulus of the AZ 26 sheet pile due to corrosion was 2.300 cm^3/m. The safety factor following a half-century's exposure to aggressive natural soil thus amounts to 1.76.

The owner of the project eventually opted for AZ 26 sheet piles in 6 and 12 m lengths to allow shipment in containers. The piles were spliced on the job site. Some 1,110 tons of 18-m-long AZ 26 single piles in steel grade S 355 GP were installed. C 9, C 14 and Omega 18 connectors were used to join the piles at the corners of the wall. The AZ 26s were driven with a resonance-free vibratory hammer suspended from a crawler crane. They form a 167-m-long parallelogram with a width of 15 to 27 m and a perimeter of about 376 m. The vertical loads of the superstructure are carried by 500-mm-diameter concrete columns.

The side of the AZ piles facing the shopping mall and carpark was coated for aesthetic reasons. Kolkata's first fully automatic carpark was made watertight by seal-welding the Larssen interlocks of the AZ 26 sheet piles. A fire analysis showed that fire protection could be assured by an ordinary sprinkler system.


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Owner: Simpark Infrastructure Pvt Ltd
Contractor: Simplex Projects Ltd
Consultant:
Aronsohn Constructies, Rotterdam
Steel sheet piles: AZ 26
Sheet pile length: 18 m
Steel grade: S 355 GP
Total quantity of sheet piles:
1,110 tons


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46 The two-level underground structure will feature a shopping mall and a carpark
47 The retaining wall is approximately 376 m long overall
48 Several construction stages were considered when designing the sheet pile wall
49 Steel sheet piles are a preferred choice for construction sites in confined spaces
50 The perimeter wall of the carpark was built with 628 AZ 26 sheet piles
51|52 The top-down method reduced the period during which the construction area was unavailable for public use
53|54 The sheet piles were installed with a resonance-free vibratory hammer
55|56 A separate foundation system carries the main vertical loads
57|58 The sheet piles of the carpark and shopping-mall levels were seal-welded and coated

St. Martens Latem

Gent, Belgium

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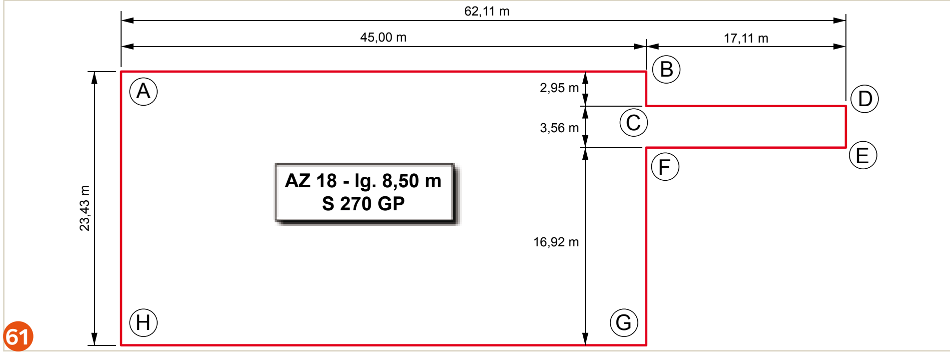
Saint-Martens-Latem is a small town of 8,000 inhabitants situated in the Belgian province of East Flanders, right next to Ghent, formerly one of the largest and richest cities in north-western Europe due to its busy port.

The street Kortrijksesteenweg is home to the Mercedes-Benz and Smart dealer in Sint-Martens-Latem. Two new showrooms, a workshop and an underground carpark feature among the new buildings of the sales and after-sales service built in 2002. The outer wall of the single-level underground carpark was designed as a sheet pile retaining wall. The sheet piles function as a watertight excavation enclosure, are an essential part of the loadbearing structure of the showroom above, and last but not least, as permanently visible elements, are a precious aesthetic contribution to the showroom.

ArcelorMittal's in-house design department carried out a preliminary static analysis and proposed 8.5-m AZ 18 steel sheet piles in steel grade S 270 GP with a section modulus of 1,800 cm^3/m as retaining wall elements. The rectangular basement, 45 m in length and 23.5 m in width, features a 15-m-long access ramp. The corners were executed with C 9 and C 14 connectors and with the help of two special piles.

The design of the sheet pile retaining wall is based on the geometry defined by ELD Partnership and on the bore logs from Bureau Geosonda who carried out several cone penetration tests (CPT) in situ. The log files report soft, cohesion-free silt (CPT = 4 MPa) to a depth of 15 m. The borehole was stopped when a


62,11 m
45,00 m
17,11 m
23,43 m
2,95 m
3,56 m
16,92 m
A
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H
AZ 18 - lg. 8,50 m
S 270 GP
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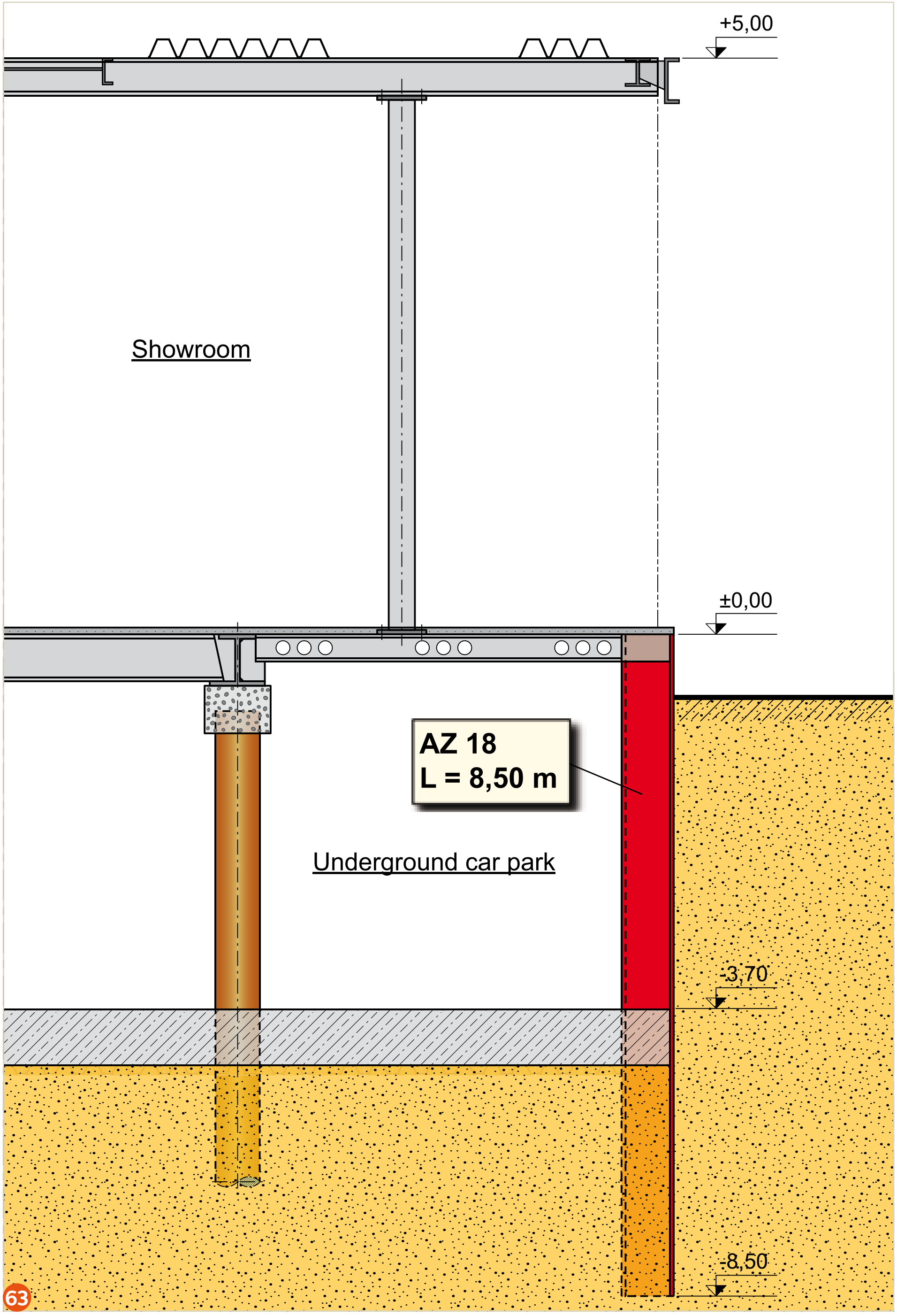
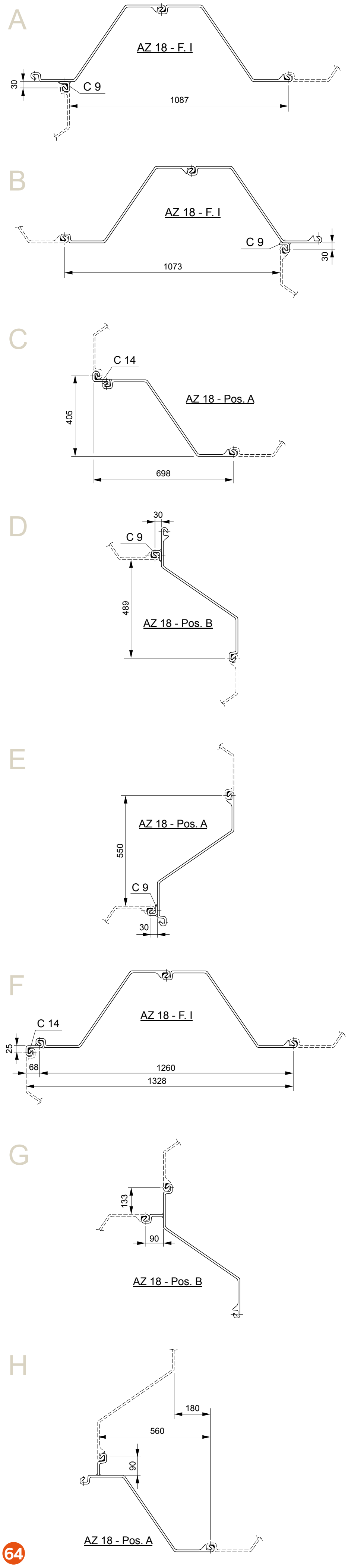

+5,00
±0,00
Showroom
AZ 18
L = 8,50 m
Underground car park
-3,70
-8,50
63


A
AZ 18 - F. I
C 9
30
1087
B
AZ 18 - F. I
C 9
1073
30
C
C 14
AZ 18 - Pos. A
405
698
D
30
C 9
489
AZ 18 - Pos. B
E
AZ 18 - Pos. A
550
C 9
30
F
C 14
AZ 18 - F. I
25
68
1260
1328
G
133
90
AZ 18 - Pos. B
H
180
560
90
AZ 18 - Pos. A
64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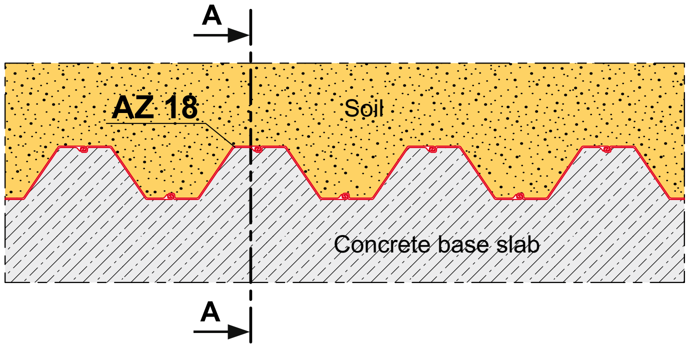
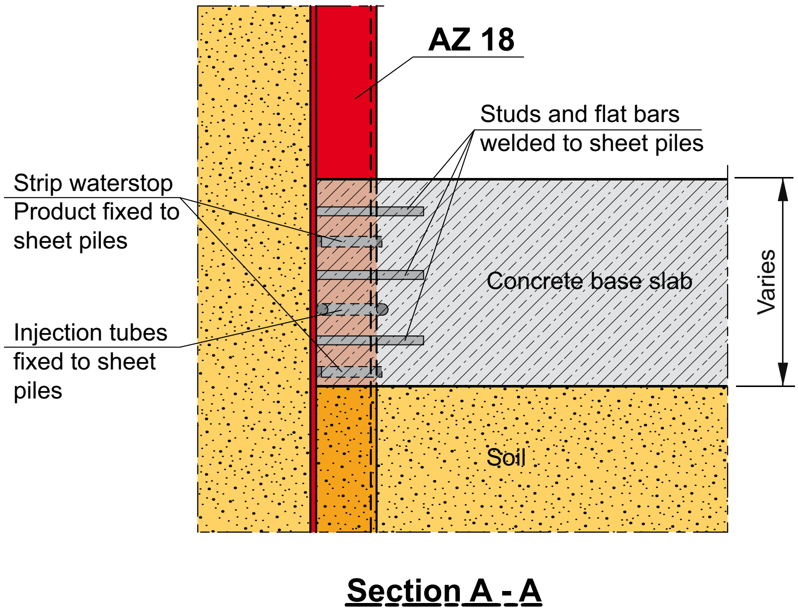


67



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dense sand layer was reached just below El. -15 m. Groundwater was encountered just below the surface (El. -0.5 m).

Due to the proximity of existing buildings, the sheet piles had to be installed with a minimum of vibration. A practically vibration-free method uses hydraulic presses. The contractor used a rig-mounted ABI hydraulic press to drive the AZ 18 sheet piles. The press is equipped with four clamps to grip four single piles at once. One of the four piles is pushed into the soil under adjustable pressure while the other three piles provide the necessary reaction.

Drainage on the outer side of the building excavation was prohibited so as to avoid settlement of nearby structures. Vertical anchors to hold the base slab in place were installed first. The future carpark was then excavated and the concrete base slab was poured. A special connection with studs, injection tubes and waterstops ensures the complete watertightness of the structure built below the groundwater level. Construction of the carpark and show rooms proceed in the dry. The interlocks of the AZ 18 sheet piles were seal-welded to achieve 100% watertightness. A coating was applied for aesthetic reasons.

Owner: Mercedes Benz Gent NV
Designer: Bureau Jaspers
Project management and engineering: ELD Partnership
Contractor: Democo NV, Wedam Bvba
Steel sheet piles: AZ 18 and C 14 connectors
Sheet pile length: 8.5 m
Steel grade: S 270 GP
Total quantity of sheet piles: 175 tons

59 The Mercedes-Benz and Smart dealer in Sint-Martens-Latem built an underground showroom in 2002
60 The sheet piles were installed with an ABI hydraulic allowing vibration-free installation of four single piles at once
61|62 175 tons of AZ 18 sheet piles were used to build the 45 by 23.5 m underground showroom
63 The AZ piles remain visible once the showroom is completed
64 The corners of the basement wall used connectors and special piles
65|66 After excavating inside the basement walls, anchors were installed to hold the concrete base slab securely in place
67|68 A watertight connection between the sheet pile wall and the concrete base slab was designed
69 The AZ sheet piles were seal-welded and coated to complete the aesthetic showroom

Dadeland
Miami, USA


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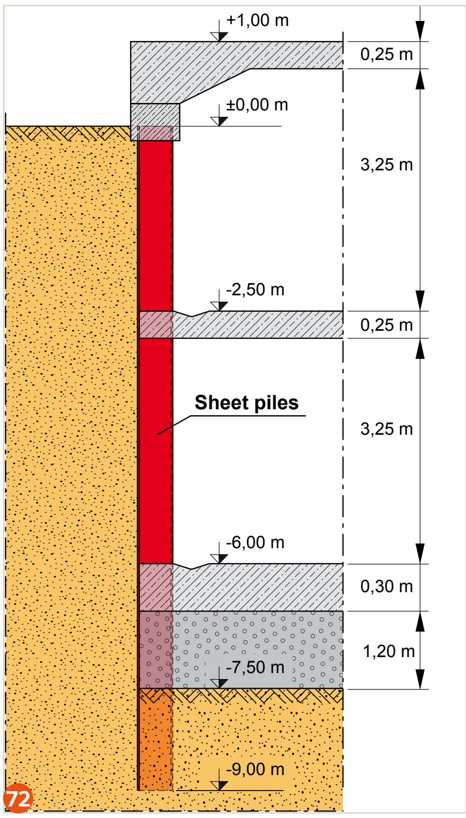

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Dadeland is located in South Miami, Florida, USA. The contract to build the $170 million "Downtown Dadeland" project, a mixed-use re-urbanisation development located on North Kendall Drive across from the upmarket Dadeland Mall, was awarded to local general contractor Miller & Solomon. The 30,000-m² landmark project in South Florida is a "village within a city" including 416 condominium residences, an 11,500-m² retail area, and a large underground parking garage for 970 cars, all forming seven low-rise buildings. The project was completed in the spring of 2005.

The project got underway in early 2004 with local contractor Ebsary Foundation appointed as subcontractor for the foundation works, including sheet pile installation. The contractor's extensive experience with foundation projects in the highly variable soil strata of South Florida proved invaluable.

Geological investigations of the downtown Dadeland site were carried out by Miami-based geotechnical consultant Kaderabek Company.

Water was encountered three metres below ground within the 4-m-thick top layer of soil, a Miami limestone characterised by SPT values ranging from 30 to 50 blows per 30 cm penetration of the measuring tool. Beneath the Miami limestone, 3 m of loose sand (SPT tests: 10–20 blows) overlie dense limestone and sandstone where the SPT tests reached 100 blows. South Florida's hard stone layers in conjunction with the high water table often rendered previous below-ground construction expensive and time-consuming.

A "bottom-up" sheet pile solution was chosen for the project in place of conventional temporary excavation support and an in-situ concrete wall because of the significant cost and schedule savings it induced. Sheet piles used as permanent retaining elements considerably simplify the construction process. The separate foundation system consisting of concrete bearing columns for the seven seven-storey buildings was built first. The sheet piles of the retaining wall for the 7,5-m-deep excavation for the two-level underground

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carpark had to be driven through the limestone to reach the design elevation.

Skyline Steel, a wholly owned subsidiary of ArcelorMittal, provided a complete foundation package including design recommendations, specification of sheet pile sections and on-site guidance for the construction team. The innovative solution involved using steel sheet piles as permanent retaining elements once excavation was completed and as temporary separation walls as the site was divided into a number of construction bays. Subdivision into several sections primarily reduced the concrete pour for the bottom slab into manageable sizes.

Some 3,000 metric tons of steel sheet piles were installed with a crane-mounted vibratory hammer using a single-level template for guidance. About half the piles remained in the ground at the end of construction as the permanent outer wall of the basement structure.

9-m-long AZ 26 sheet piles with a web / flange thickness of 12.2 / 13.0 mm were chosen to ensure penetration through the hard soil layers to the depth required by the design. An HP pile fitted with a driving shoe was driven ahead

of the line of sheet piles to fragment the limestone, enabling the sheet piles to be driven without damage.

Once pile driving was complete, formwork was placed at the heads of the sheet piles and a concrete cap poured. The capping beam incorporated temporary ground anchors that had been drilled through the sheet piles to provide temporary support until the floor slabs were cast. The interior of the first bay was then excavated to El. -7.5 m. Divers inspected and where required cleaned the sheet piles at the bottom of the excavation to ensure proper connection with the bottom slab. Underwater concrete was tremied to create a 1.2-m-thick slab that provided the seal needed for construction to begin within a dry excavation. The sheet piles, which came under pressure as the water was drawn down, were pressed against the concrete, effectively sealing off water from below trying to seep through the concrete-to-steel interface.

The middle interlocks of the AZ 26 double piles had been welded prior to installation. Once groundwater was pumped out, the remaining interlocks were seal-welded. When the sealing was completed, the piles serving as permanent walls were cleaned and an aesthetic coating was applied. The requirements for life expectancy and those resulting from fire analysis were easily met by the exposed sheet pile solution.

Owner: Gulfside Development
Contractor:
Miller & Solomon, Ebsary Foundation
Designer: CEC Consultants
Steel sheet piles: AZ 26
Sheet pile length: 9 m
Steel grade: A572 Gr 50

70 3,000 tons of steel sheet piles were used as permanent and temporary retaining elements
71 The residential complex built in Dadeland, Miami includes an underground carpark for 970 cars
72 The sheet piles for the two-level structure were driven through the tough Miami limestone
73|74 A driving template was used to guide the AZ 26 piles
75|76|77 The concrete bearing columns of the residential buildings' foundation were built before installing the sheet piles
78|79 A capping beam incorporating temporary tie rods was placed at the head of the AZ 26 piles
80|81 The underwater concrete of the bottom slab was poured with a tremie
82|83 The interlocks of the piles were cleaned and seal-welded to render the excavation watertight
84|85 Temporary sheet piles separating different parts of the excavation were held together with walings
86 The coated sheet pile walls add an aesthetic aspect to the finished carpark

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