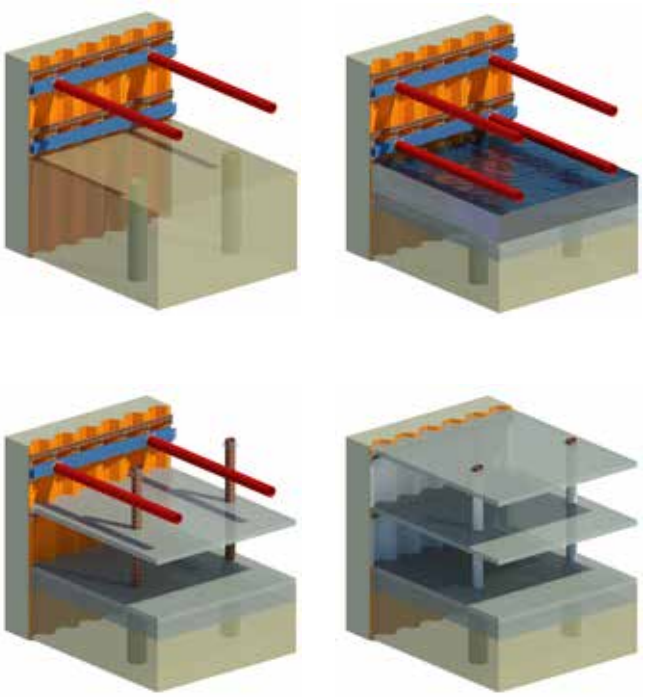
Underground car parks

Lessons learnt from Dutch practice 2018

Underground car park with permanent steel sheet pile walls at Hopmarkt shopping center, Aalst, Belgium

Property developments these days must include car parks

Construction phases:
practical case with the bottom slab poured under water

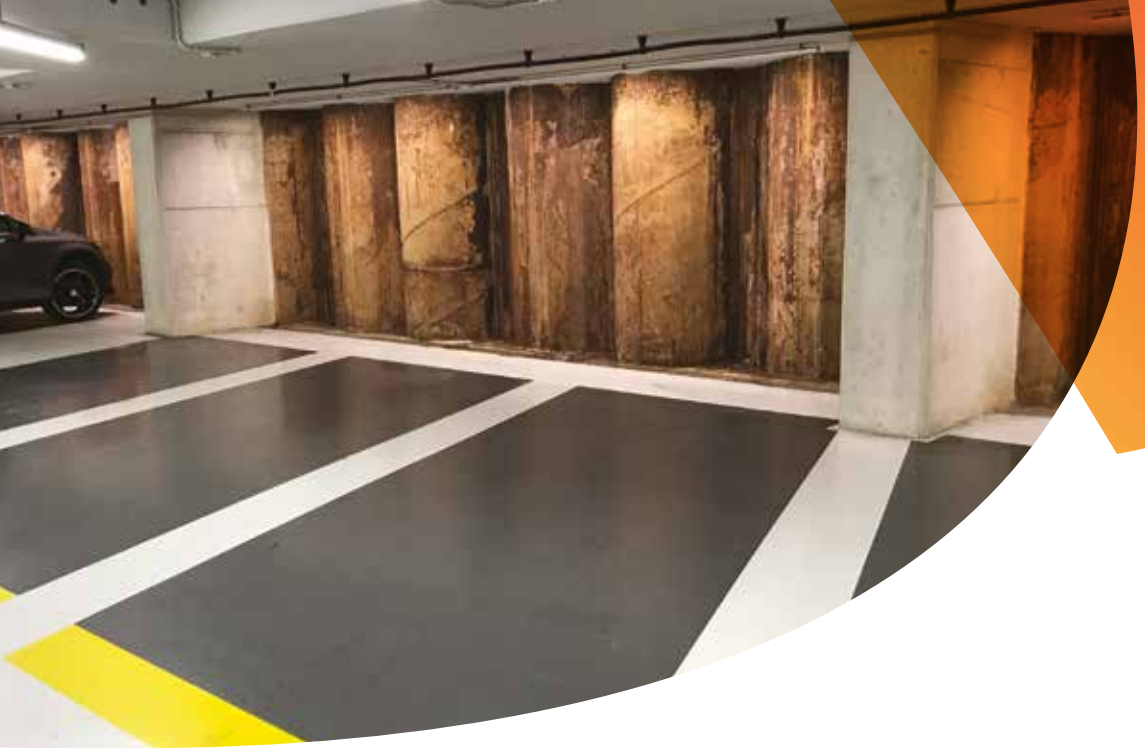


Cities have grown substantially in recent decades, resulting in higher building densities and a scarcity of space at street level. Although mindsets are changing, in many European cities mobility still relies predominantly on individual cars and the associated inherent problem: parking.

Since residents clearly prefer public parking, underground car parks (UCP) seem to be the perfect solution in urban areas.

Property developments these days must include car parks. The most common option is beneath either the building or adjacent areas, e.g. courtyards, driveways, public gardens, or parks.

In addition, as city centres become more pedestrian friendly, and in some cases car traffic is prohibited in certain zones, a need arises for additional parking facilities around the outskirts of city centres. These parking facilities must be well connected to local road infrastructures and public transport to minimize travel times.



Developers and operators look for the most cost-effective solution

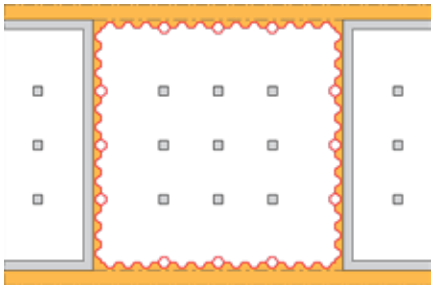
Developers and operators obviously look for the most cost-effective solution that will not compromise safety, security, comfort, or environmental integrity. In most cases, a steel sheet pile wall is the solution that meets the stringent criteria involved.

Typically, underground facilities increase land values and save space for more socially valuable activities. However, the design and operation of UCPs needs to address issues such as air quality (ventilation) and fire resistance that are less critical for similar structures above ground.

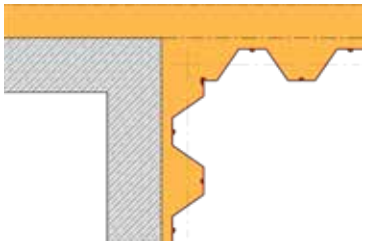
In the last 50 years, although many UCPs throughout the world have been built with steel sheet piles as permanent walls, too many architects and design engineers are still reluctant to consider this proven solution. ArcelorMittal therefore contracted Dutch engineering consultancy **Royal Haskoning DHV to draw up a guide book[1] on underground car parks, focusing on Dutch practice** regarding design, installation and permanent application of steel sheet piles.

The guide book includes two typical examples and some recent projects. It considers facilities in an urban environment and in typical subsoil conditions that are representative of the western and eastern parts of the country. Its design work complies with European standards. Although it also refers to a Dutch standard and uses Dutch software, results should be quite similar in other countries.

Space saving when using steel sheet piles as permanent retaining structures



Steel sheet piles can be used as the permanent retaining structure to optimize the ground surface



An inner concrete wall is not required (gain in available space)

With temporary steel sheet pile retaining walls, the reinforced concrete structure built inside the excavation pit reduces the available surface

[1] *Steel Sheet Piles for Underground Parking Facilities. Guide Book.* Royal Haskoning DHV NL. Ref. 2018 BF7258TPRP1812111356. December 2018 (report prepared for ArcelorMittal).

In the Netherlands, steel sheet pile walls are cost-effective for UCPs of up to 4 levels

But the guide focuses on the most common case, i.e. 2 to 3 levels.

The engineers analysed the risks that can affect design, construction and maintenance. The main potential issues that were identified are fire design and, in some sensitive areas, settlement of adjacent foundations due to deflection of the wall. These issues can be solved without any difficulty.

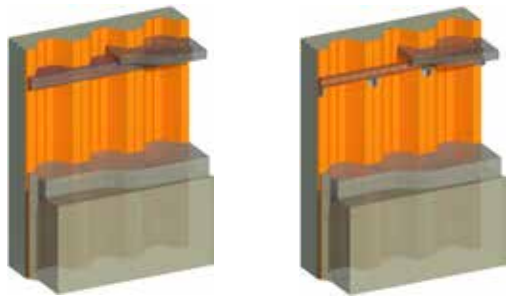
Most underground car parks in the Netherlands descend below the groundwater table, so the outer walls and the connection between them and the bottom slab must be watertight. ArcelorMittal provides several sealing systems for achieving highly impermeable steel sheet pile walls and has worked out some detailing for the connections.

Nowadays, **with the latest installation techniques** using high-frequency resonance-free vibratory hammers or hydraulic presses, **noise and vibration during driving of sheet piles can be reduced or even eliminated.**

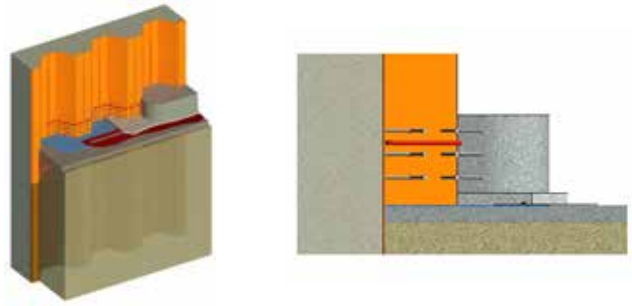
Another interesting feature is that steel sheet piles can act as a bearing element, transferring high vertical loads to the ground and thus **reducing the number of columns and foundations required inside the walls.** ArcelorMittal's R&D department has developed a quite straightforward design method for building concrete capping beams to transfer high vertical loads from the superstructure to sheet piles. It was validated by the German DIBt institute which granted an *"Allgemeine Bauartgenehmigung"* (National Technical Approval).

Finally, the investor benefits from a larger net usable area because sheet pile walls are thinner than alternative solutions.

Connection sheet pile wall to horizontal slabs



Connection sheet pile wall to bottom slabs (watertightness)



Markthal building in Rotterdam (NL) with 3 levels of underground car park. © Digikhmer

A steel sheet pile wall is up to 50% more cost-effective than a secant pile wall and can be built up to 2 times faster

From an environmental point of view, steel is the perfect solution

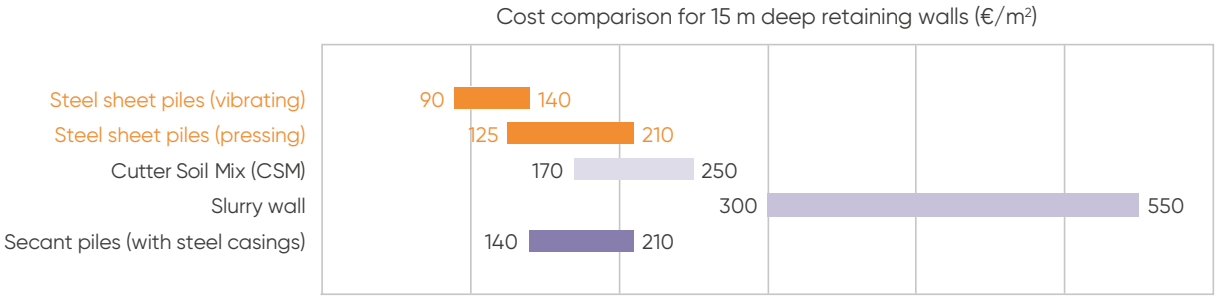
All the sheet piles can be extracted at the end of their service life, and either reused (quite rare after 50 years) or 100% recycled into new steel elements. **Re-using and/or recycling significantly reduces the full-lifecycle carbon footprint of a project.** Since sustainability criteria might be part of the tender process, a steel solution can become even more attractive.

A further advantage of steel sheet piles is the smaller number of trucks delivering material to the jobsite, as well as the reduced space required for storage and installation: less traffic congestion during a shorter construction period means less disturbance to neighbours.

The consultant compared different alternatives such as secant piles, slurry walls and cutter soil mix (CSM) walls and estimated a budget, based on their experience, for a 15-m-deep wall (2–3 level UCP) in the Netherlands. It is given below.

The consultant pointed out that further cost reductions might be achieved by using higher steel grades than the normal S 355 GP.

Cost comparison of technical alternatives



Note: the values in the graph consider costs for design and installation, excluding coatings, sealing systems, fire protection elements, etc.

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ArcelorMittal Commercial RPS S.à r.l.
Sheet Piling | 66, rue de Luxembourg | L-4221 Esch-sur-Alzette
T +352 5313 3105 | sheetpiling@arcelormittal.com
sheetpiling.arcelormittal.com