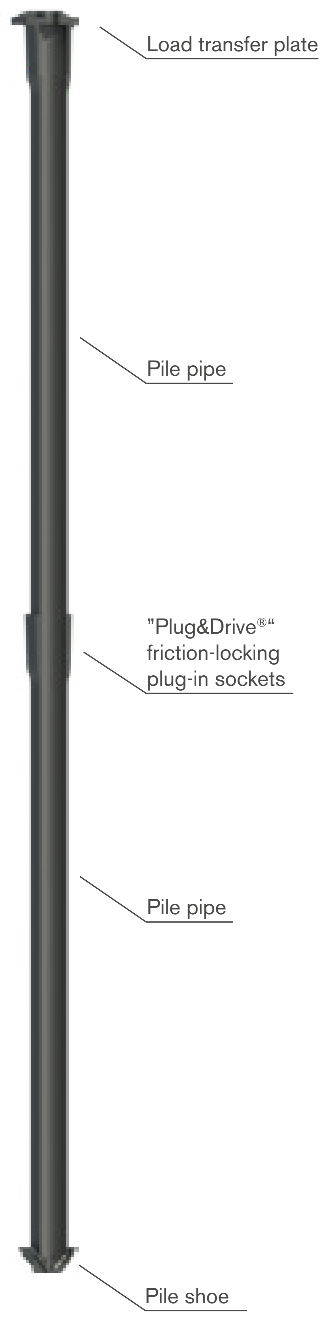
TRM Piling Systems
Fast. Simple. Safe.

www.trm.at

TRM Piling Systems

The TRM Piling System consists of one or more pile pipes (depending on the length required), a pile shoe (non-grouted/grouted) and a load transfer plate. The ductile iron material gives the pile system its high ductility and strength. This makes it possible to drive the pile pipes into the ground using powerful hydraulic hammers until the required final depth is reached.



Pile pipes with lengths of 5.0 metres

The ductile iron pile pipes are manufactured in lengths of 5 metres with outside diameters of 98 mm, 118 mm and 170 mm in various wall thicknesses between 6.0 and 13.0 mm. The spigot end and the socket enable the pile pipes to be rapidly and securely connected to form a continuous pile of any length (Plug&Drive®). The pile overhang is cut to the planned height and used as the starting element for the next pile (no waste).

”Plug&Drive®“ friction-locking plug-in sockets:
The high impact energy is used to create a rigid, torsionally stiff connection between the pile pipes (Plug&Drive®) with the following advantages:

+ Fast connection of the individual elements through simple plug-in connection
+ No special tools required
+ No welding work required
+ Flexible adjustment to the ground conditions

Certified and tested system:
The TRM Piling System has the following approvals:

+ European Technical Assessment ETA-07/0169 (CE marking)
+ German general technical approval Z-34.25-230/DIBt
+ Austrian BMK construction approval GZ:2020-0.094.414

In accordance with these approvals and in line with ÖNORM B2567 (Austrian standard), quality and suitability are reviewed continuously during production (internal and external monitoring)

Overview of pile pipe types

Type	Wall thickness [mm]	Mass [kg/m]	Resistance moment [cm³]	Bending moment M_{Rd} [kNm]
TRM 98	6.0	14.4	38	-
	7.5	17.2	45	-
TRM 118	7.5	21.0	68	21.7
	9.0	24.4	78	25.0
	10.6	28.0	88	28.2
TRM 170	7.5	33.8	149	47.7
	9.0	37.1	174	55.7
	10.6	42.5	199	63.7
	13.0	50.4	234	74.9

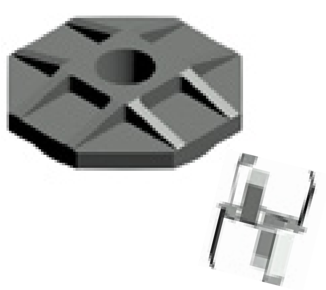
TRM Pile driving accessories

Designed & patented

TRM pile shoe, non-grouted flat: Suitable for end-bearing pressure piles on rock or very dense soils. Transverse bars provide increased stiffness of the flat pile shoe.

TRM pile shoe, non-grouted with rock point: Suitable for end-bearing pressure piles on rock and very dense soils. Especially for inclined rock strata. Pile rock point: 15 cm long / 60° inclined.

TRM pile shoe conical grouted: Suitable for grouted ductile iron piles. The enlarged pile shoe allows the creation of a ”grouted mortar body“, which encases the pile pipe and can activate skin friction.



TRM load transfer plate Octagon:
A universal head plate for all TRM 118 and TRM 170 pile types, for load transfer from the foundations to the pile. Suitable cut-out for inserting steel support members (tension pile).

Tilt protection is required when using TRM 118 piles with the TRM load transfer plates Octagon 275 and 330 as a centring aid.

TRM Couplers:
Connection for construction sites with limited working height. The coupler acts as a double sleeve that joins the cut pile pipes together again.

TRM Extension ring:
In very soft, cohesive soil, the extension ring can be used in addition to the grouted TRM pile shoe to improve the concrete flow.

MORE INFORMATION on the accessories can be found in our brochure ”Product overview piles and pile driving accessories“.

Deep foundations

The TRM Piling System as a universal deep foundation element

The ductile iron pile has been established in the field of deep foundation systems since 1986 and has been continuously developed since then.
More than 13 million metres of installed piles in 35 years testify our wealth of experience with the TRM Piling System in a wide range of soil conditions.

The use of light, standard equipment (excavator with hydraulic hammer and special TRM pile hammer adapters) enables economical, efficient and safe foundations.

TRM pile driving adapter grouted / non-grouted:
Available for a wide variety of hydraulic hammers.

Our **Plug&Drive®** connection system makes the joining together of pile pipes simple and fast.

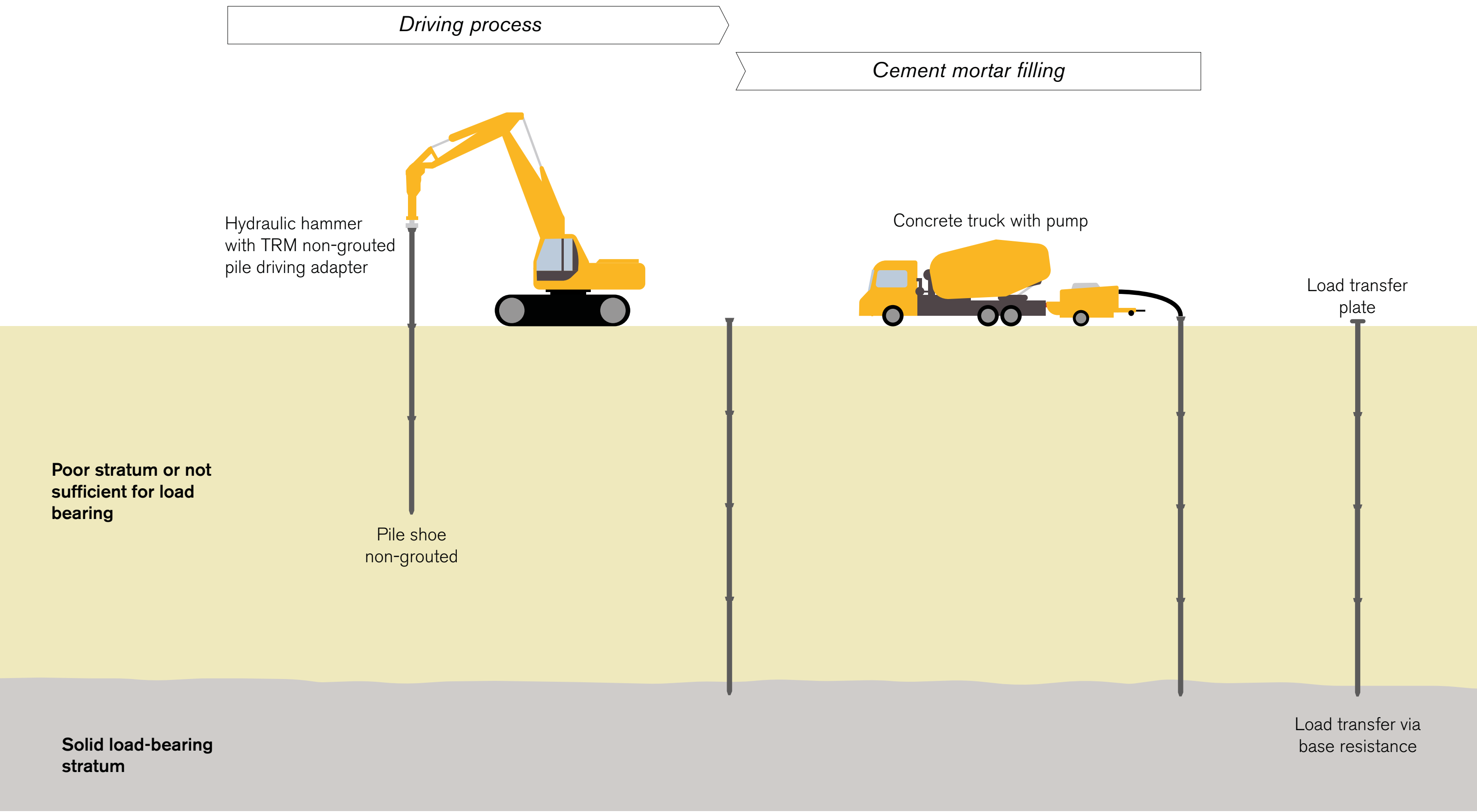
The pile lengths can therefore be easily adjusted to varying ground conditions.

We make a difference between:
+ **Compression pile without shaft-grouting**
+ **Compression pile with shaft-grouting**
+ **Tensile pile and alternating load pile**

With design values of up to 2,400 kN, the TRM Piling System is an economical choice among many deep foundation methods.

Low-vibration preparation
Measurements on construction sites in residential areas have repeatedly demonstrated the low vibration installation. The vibration values of less than 2 mm/sec measured are well below the permissible values.

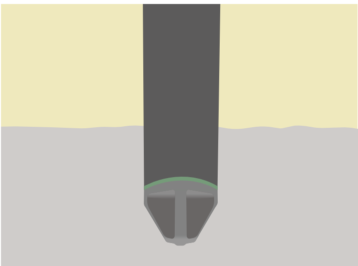
Safety on site
The soil is displaced laterally, so no debris is excavated. The manual work is limited to slinging piles and a very light labour processes.



Compression pile without shaft-grouting

Base resistance pile

The installation of compression piles without shaft-grouting requires the presence of bedrock (rock or similar subsoil) at a reasonable depth, which is suitable for bearing the required loads by base resistance only.



Non-grouted pile shoe

Installation

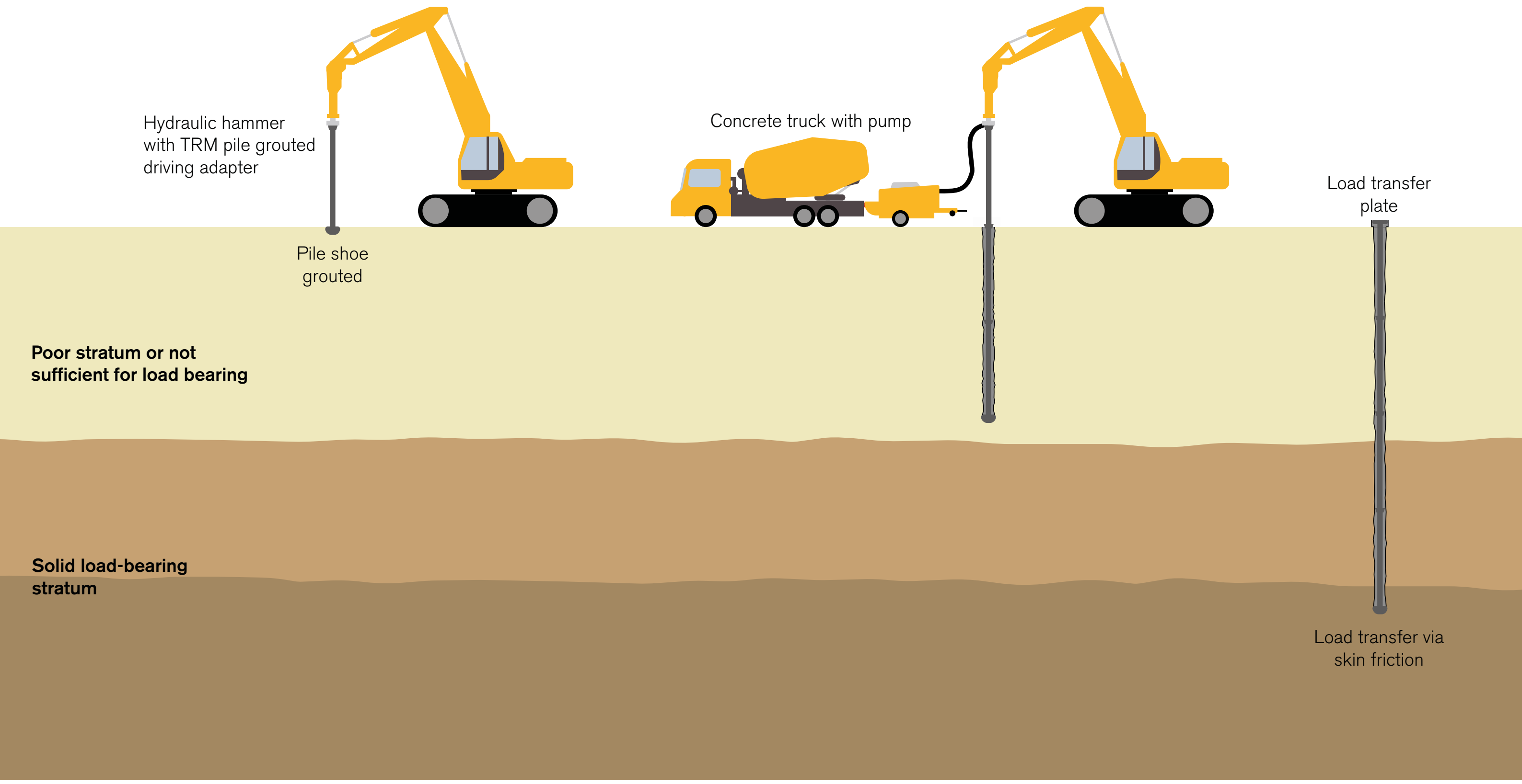
Driving process

+ The first pile pipe is placed on the ground with a special pile shoe and driven into the ground using an excavator and a powerful hydraulic hammer with a TRM non-grouted pile driving adapter. The pile shoe fits flush with the diameter of the pile. Depending on the ground conditions, a TRM pile shoe non-grouted can be used with a rock point or a flat design.
+ The next pile pipe (and all others) are inserted into the socket (Plug&Drive®) and driven in to the required final depth of the pile.

Cement mortar filling

+ When the excess pile pipe has been cut off (to the exact level), the pile is filled with cement mortar (usually C20/25 or C25/30) to further increase the internal load-bearing capacity of the system. A TRM octagon load transfer plate is then placed on top for connection to the foundation.

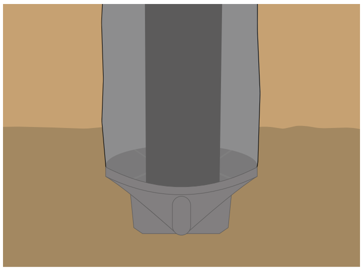
The diameter of the pile shoe corresponds to the outside diameter of the pile pipe in the version without shaft- grouting.



Compression pile with shaft-grouting

Shaft-grouted ductile driven pile

Shaft-grouted ductile driven piles are suitable for cohesive and non-cohesive soils in which the skin friction of the grouted body can be sufficiently activated to absorb the bearing loads. Part of the load is also absorbed by the base resistance.



Pile shoe grouted

Installation

+ The first pile pipe is placed on the ground with a special pile shoe, which has a larger diameter than the pile pipe, and driven into the ground using an excavator and a powerful hydraulic hammer with TRM grouted driving adapter. The TRM pile shoe grouted is available in a conical.
+ At the same time as driving, cement mortar (usually C20/25 or C25/30 with a maximum grain size of 4 mm) is pumped through the pile by means of a concrete pump, which exits at the pile shoe and returns to the upper edge of the ground in the annular space. Special openings in the pile shoe allow the cement mortar to escape.
+ The next pile pipe (and all others) are inserted into the socket (Plug&Drive®) and driven in to the required final depth of the pile.
+ This creates a continuous concrete body that generates high pile skin friction values by interlocking with the soil.
+ After cutting off the pile pipe overhang (exactly at the same level), a TRM Octagon load transfer plate is placed on top for connection to the foundation.

Tension pile and alternating load pile

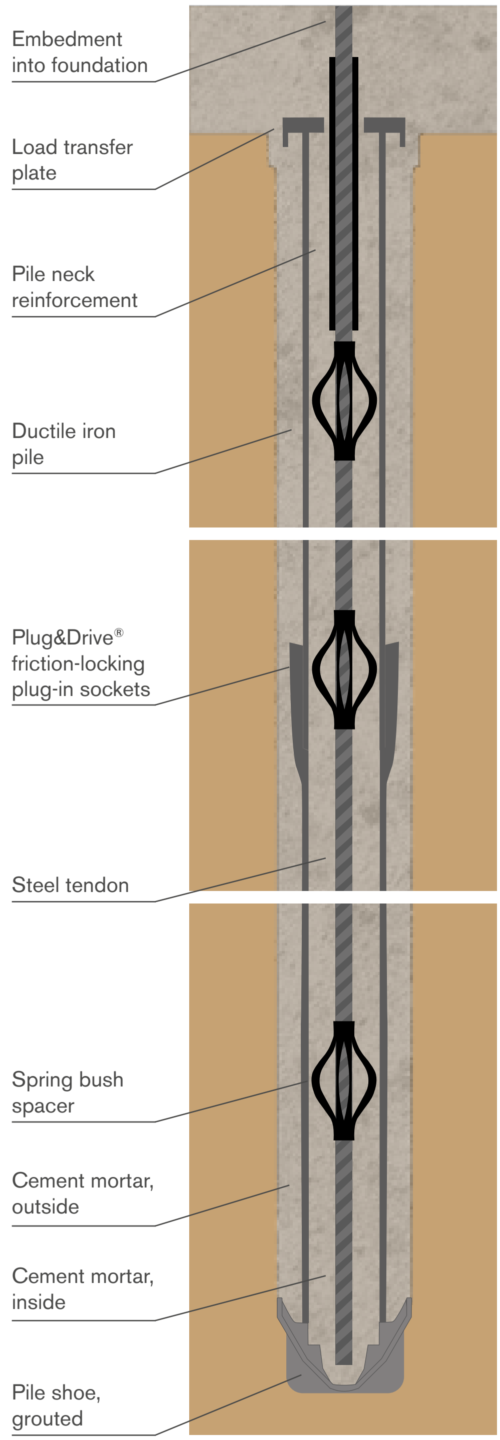
Shaft-grouted ductile driven pile

If tensile forces are to be transmitted in addition to compressive forces, the production of shaft-grouted ductile iron piles is recommended. The tensile and alternating load pile is a composite component consisting of the steel tendon, the cement mortar on the inside, the ductile iron pipe and the cement mortar on the outside. The load transfer is largely realised by activating the soil-dependent pile skin friction.

Installation

according to general technical approval Z-34.25-230/DIBt

+ First, a shaft-grouted ductile iron pile is produced.
+ To introduce tensile forces into the pile, a steel tendon is placed in the liquid cement mortar and embedded in the foundation body with the statically required anchoring length or with approved anchoring elements. This ensures the necessary frictional connection between the pile and the foundation above to transfer the tensile forces.
+ The steel tendon must be centred within the ductile iron pipes using spring bush spacers or equal.
+ At the pile neck, which is the area between the pile and the foundation body, the steel tendon is protected by a plastic ribbed tube.
+ It is important to carefully fill the annular space between the steel tendon and the plastic ribbed pipe with flowable cement mortar.
+ The TRM Octagon load transfer plate has an opening suitable for the plastic ribbed pipe to pass through.




STOP

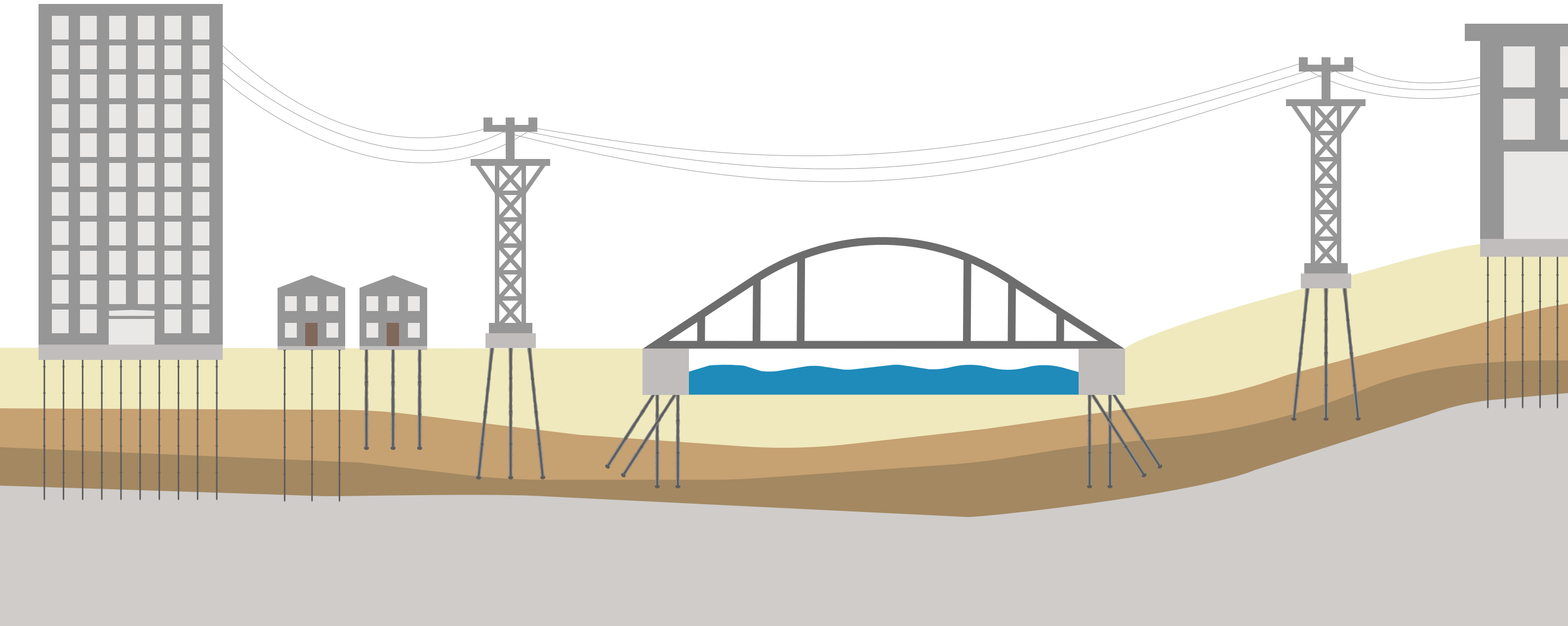
Areas of application Advantages of Piling systems

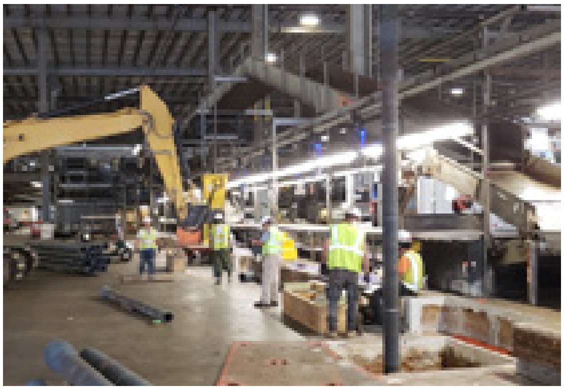
Structural engineering

TRM ductile driven piles can be used as foundations for everything from detached houses to large residential complexes and office buildings. Thanks to the lightweight, mobile equipment and the short execution time, the TRM Piling System offers a significant advantage, especially in urban areas or for small construction projects.

Industrial construction

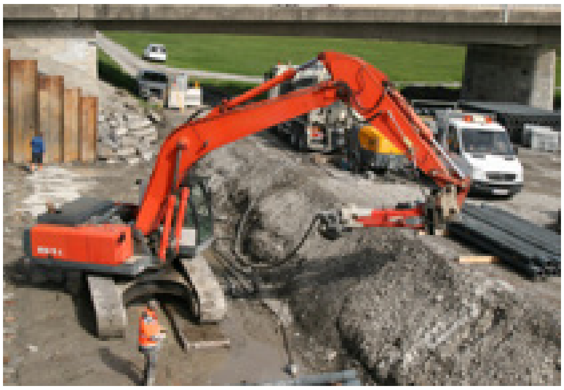
Lightweight constructions such as prefabricated units or lage warehouses are very sensitive to settlement and especially to settlement differences. Here, the TRM ductile driven pile offers a secure load transfer through the piles embedded in small foundations. Wind and structural loads are safely transferred into the ground.





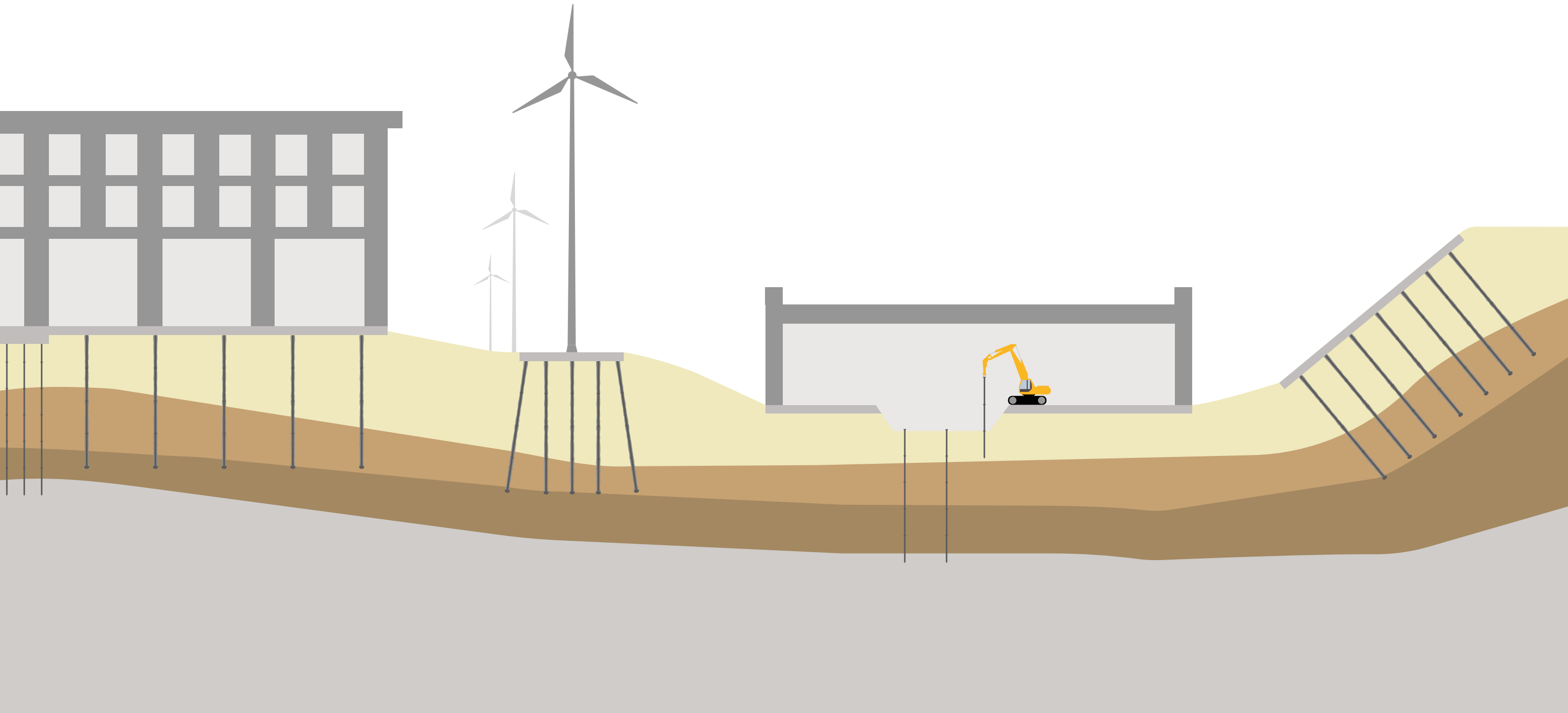
Underpinning foundation

Within buildings, old foundations are reinforced or new foundations are constructed to support additional loads. The challenge of the limited working height is solved by using the TRM couplers.



Bridge construction

The compressive and tensile forces generated by bridge abutments and piers can be absorbed by our alternating load pile. Moments are absorbed by pile supports and horizontal forces by inclined piles. The TRM Piling System offers a real advantage thanks to its fast and simple installation on site.



Areas of application Advantages of Piling systems

Tall structures

Silos, rotating tower cranes, wind turbines, electricity pylons and transmission towers are subjected to compressive and tensile loads. Tall structures with cyclical wind loads are founded on piles with additional tensile reinforcement. The TRM tension and alternating load pile is the ideal solution for safely absorbing cyclical wind loads.

Slope stabilisation

As an accompanying or urgent measure, the TRM ductile iron pile can be installed vertically to almost horizontally to achieve stability on slopes at risk of slipping.

Uplift protection

The concrete slab of sewage basins, road underpasses and excavation pits in the fluctuation range of the groundwater level are secured against floating by means of tension piles.

Special applications

CSP – Concentrated Solar Power

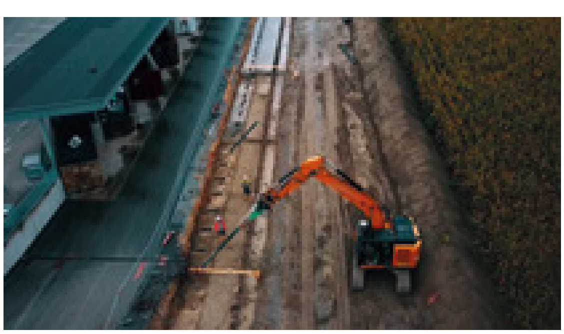
Solar thermal power plants are usually lightweight structures that are exposed to high wind loads. The TRM ductile driven pile allows for tight installation tolerances of the foundation supports and provides the construction with the necessary protection.

Noise protection

Noise protection walls are long structures. The load is transferred via individual foundations (pile supports), which are connected by a retaining wall.

Geothermal energy

Pile foundations can be used to generate geothermal energy by installing geothermal heat exchangers. The heat from the ground is used to generate cooling and heating energy.



Flood protection barriers

Flood protection barriers are becoming increasingly important due to the accumulation of storms. Inclined piles act against the horizontal forces.

Ductile cast iron GJS 450-10

We have more than 75 years of experience in the manufacture of products made of ductile iron. TRM piles are manufactured to the highest quality standards. Quality checks are subject to ongoing quality checks during production in accordance with the relevant applicable standards. Inspections include mechanical parameters, dimensions and chemical composition.

+ Quality tested to EN standards, ISO 9001 certification
+ Quality tested to ETA-07/0169 (CE marking)
+ Quality tested to ÖNORM B2567 (Austrian standard)


Recycled material


Melting plant


Constant research and development

Corrosion resistance
Due to the high carbon and silicon content as well as the annealing skin caused by production, ductile iron has a higher corrosion resistance than steel.

Recycled product
To produce the raw iron, we are using only recycling materials such as sheet metal packages, sorted steel scrap and circular material. The TRM ductile iron pile is a classic recycled product and therefore particularly resource-efficient.

High impact resistance
Thanks to the addition of magnesium to the liquid iron and the thermal treatment of the piles in the annealing furnace, the ductile iron has a high ductility and strength. This means that the piles can also be driven in with powerful hydraulic hammers without the risk of overstressing.

Nodular ductile iron	
Tensile strength	≥ 450 N/mm²
Yield strength 0.2 %	≥ 320 N/mm²
Modulus of elasticity	170,000 N/mm²
Compressive strength	700 N/mm²
Breaking elongation	≥ 10%
Density	7,050 kg/m³

Load-bearing capacity of ductile iron piles

Verification of internal load-bearing capacity

The design of the internal load-bearing capacity of piles must be carried out in accordance with EUROCODE 3 and EUROCODE 4 and the national annexes. **The following national specifications must also be taken into account:**

+ European Technical Assessment ETA-07/0169 (CE marking)
+ Germany: General technical approval Z-34.25-230 (DIBt)
+ Austria: Austrian construction approval GZ: 2020-0.094.414 (BMK)

Cross-section load-bearing capacity

The cross-sectional load-bearing capacity depends on the pile type, pile diameter, wall thickness and cement mortar used. Design values of piles without/with shaft-grouting under compressive stress according to ETA can be found in the table below.

Stability verification (buckling)

A stability verification must be carried out for partially free-standing piles. According to EN 1997-1, this must also be performed if the piles are surrounded by soils with a characteristic shear strength in the undrained state of $cu \leq 10$ KPa (kN/m²). A higher partial safety factor must be taken into account for stability verifications. The values given in the table must be reduced accordingly.

Composite joint

The composite joint must be verified for design purposes in Germany in accordance with the "General technical approval Z-34.25-230". This design value specifies the load-bearing capacity of the composite joint between the ductile iron pipe and the shaft grouting.

Corrosion rates for the design

+ For compression piles with shaft-grouting, the cement mortar provides comprehensive corrosion protection.
+ For pressure piles without shaft-grouting, a loss of wall thickness due to corrosion must be taken into account in the design. The values can be taken from EN 1993-5 clause 4.4 in accordance with ETA-07/0169. The design values must be adjusted accordingly.

Table with design values of the internal load-bearing capacity according to ETA-07/0169:

Type	Nominal wall thickness	Internal load-bearing capacity N_{Sd}		
		Pile	Pile + concrete (C20/25)	Pile + concrete (C25/30)
	[mm]	[kN]		
TRM 98	6.0	555	632	652
	7.5	682	754	773
TRM 118	7.5	833	944	972
	9.0	986	1091	1117
	10.6	1144	1243	1267
TRM 170	7.5	1225	1477	1540
	9.0	1457	1699	1759
	10.6	1699	1930	1988
	13.0	2052	2269	2323

The above design values apply to compression piles for which no wall thickness loss due to corrosion is assumed and for shaft-grouted ductile iron piles. National specifications must also be taken into account. Higher or different concrete qualities are permissible.

Verification of the external load-bearing capacity

A comprehensive and meaningful soil investigation (dynamic probing, etc.) is the basis for the economic calculation of the piles. Verification of the external load-bearing capacity must be provided by load tests or determined on the basis of empirical values (values according to EA piles - 3rd edition or company-specific empirical values).

The TRM Piling System provides additional insights during production:

+ The measured driving resistance (driving progress in sec/m) can be used to draw conclusions about the "actual" load-bearing capacity of the soil.
+ The pile lengths can be adjusted during installation according to the soil conditions.

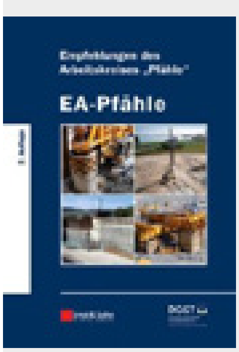
Compressive pile with shaft-grouting

As part of a joint research project with the University of Kassel between 2015 and 2020, 338 pile test loads were analysed according to scientific criteria. These results have now been graphically illustrated in the following figures as empirical values for determining pile peak pressure and pile skin friction in the ultimate limit state for grouted ductile iron piles and included in tabular form in the EA Piles - 3rd edition (point 5.4.9.6). The following must be taken into account:

+ The pile base resistance and skin friction should always be determined using the 10% quantile, based on EA piles.
+ Values exceeding these pile resistances (maximum up to 50% quantile) should only be selected after confirmation by a geotechnical expert

Compression pile without shaft-grouting

Comprehensive soil exploration with investigation of the depth of the load-bearing layer is a prerequisite. Once the load-bearing layer has been reached and pile driving has progressed 3cm/min, the permissible loads must be determined by a geotechnical engineer on the basis of his experience in similar soil or, as a rule, by means of a test load.



"EA Pfähle" - 3rd edition

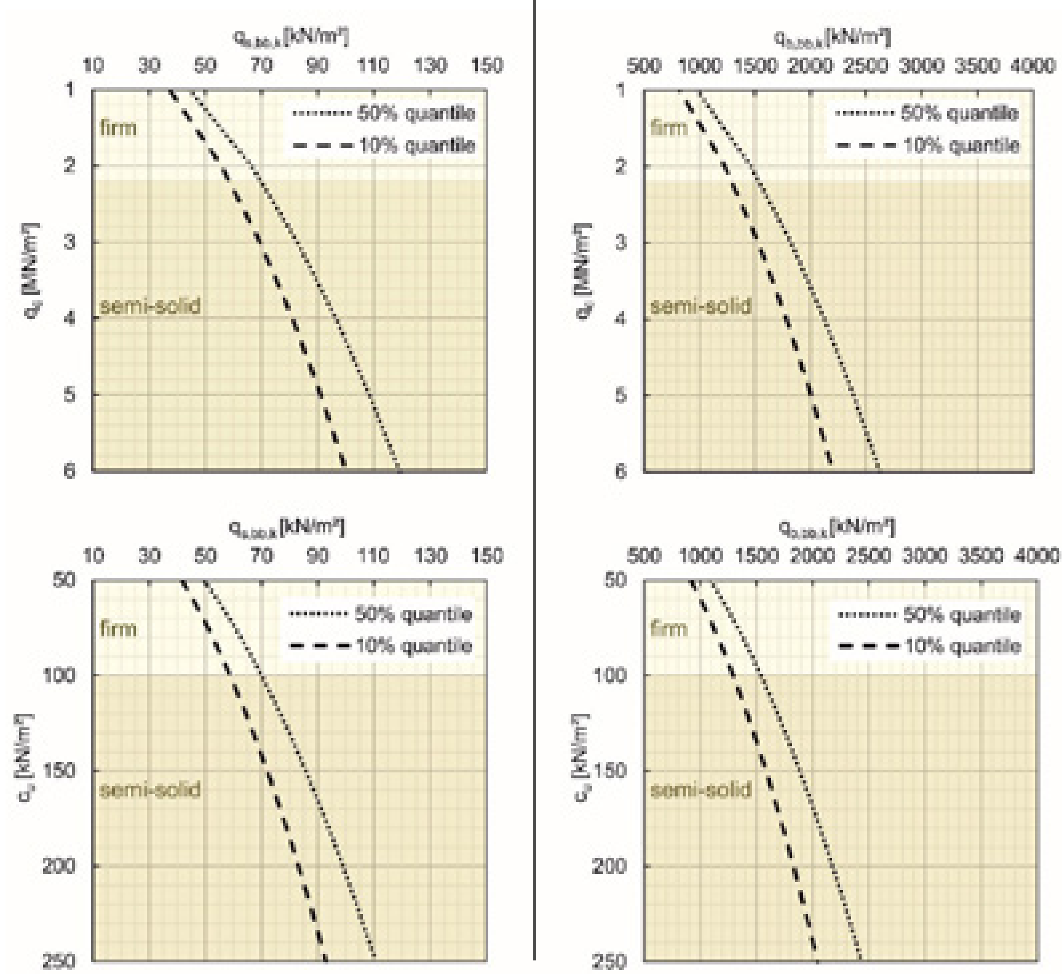
According to the current status, the 3rd edition of "EA Pfähle" should be published in 2024. Compared to the 2nd edition, a fundamental editorial revision has been carried out. In future, **section 2.2.5.3** will deal with "Shaft-grouted ductile iron piles". In addition to information on pile production, the new regulations contain notes on quality assurance during construction and **empirical values** for determining **pile base resistance** and **pile friction** in the ultimate limit state. The empirical values developed by the University of Kassel as part of the research project (see pages 18-19) have been adopted. The new regulations were incorporated into the EA piles with the 2022 annual report of the "Piles" working group of the German Society for Geotechnical Engineering (DGGT) and can be found in section 4.2.

You can find the 2022 annual report in our Secure Download area:

External load-bearing capacity of ductile iron piles

Correlations of pile base resistance $q_{b,k}$ and pile skin friction $q_{s,k}$ with probing resistances in **cohesive soil**

Pile skin friction | Pile base resistance



Experience values in tabular form according to EA-Pfähle - 3rd edition

Shear strength $c_{u,k}$ of the undrained soil [kN/m²]	Ultimate limit state value of pile skin friction $q_{s,k}$ [kN/m²]
60	45-55
150	75-85
≥ 250	95-110
Intermediate values may be linearly interpolated.	

Table 5.35 Empirical data ranges for the characteristic skin friction $q_{b,k}$ for shaft-grouted ductile driven piles in cohesive soils.

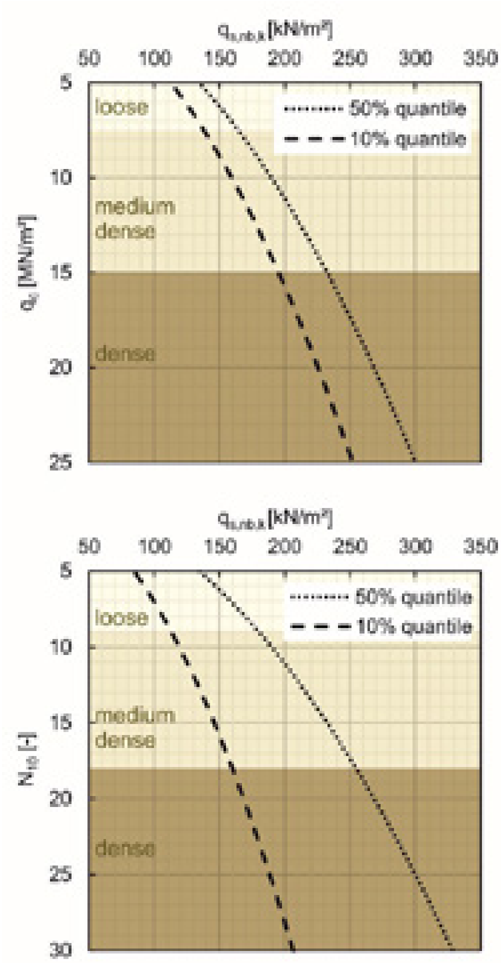
Relative pile head settlement s/D_b	Pile base resistance per unit area $q_{b,k}$ [kN/m²]		
	Shear strength $c_{u,k}$ of the undrained soil [kN/m²]		
	7.5	15	≥ 25
0,10 (Sg)	1300-1500	1600-1900	2000-2400
Intermediate values may be linearly interpolated.			

Table 5.36 Empirical data ranges for the characteristic base resistance per unit area $q_{s,k}$ for shaft-grouted ductile driven piles in cohesive soils.

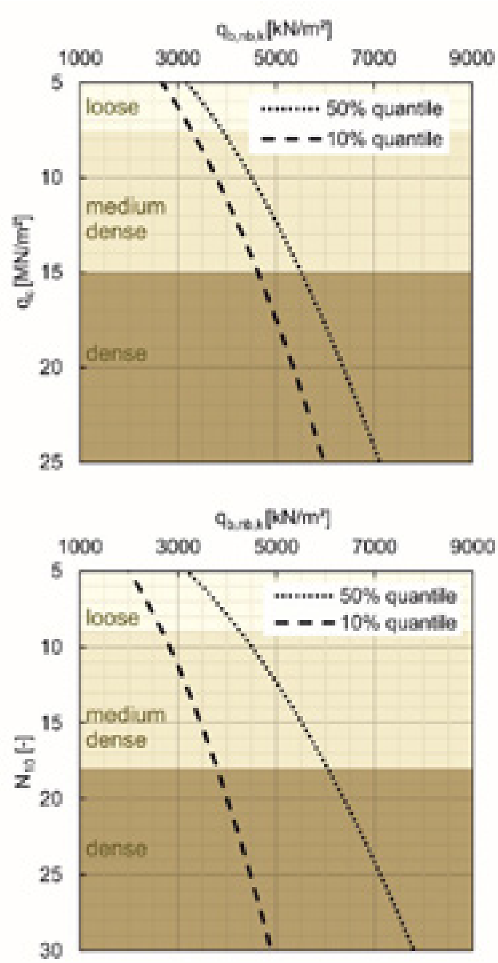
External load-bearing capacity of ductile iron piles

Correlations of pile base resistance $q_{b,k}$ and pile skin friction $q_{s,k}$ with probing resistances in non-cohesive soil

Pile skin friction



Pile base resistance



Experience values in tabular form according to EA-Pfähle - 3rd edition

Mean cone resistance [MN/m²]	Ultimate limit state value of pile skin friction $q_{s,k}$
7,5	135-165
15	195-230
≥ 25	250-300
Intermediate values may be linearly interpolated.	

Tabelle 5.34 Empirical data ranges for the characteristic skin friction $q_{b,k}$ for shaft-grouted ductile driven piles in non-cohesive soils.

Relative pile head settlement s/D_b	Pile base resistance per unit area $q_{b,k}$ [kN/m²]		
	For a mean cone resistance $_{qc}$ [MN/m²]		
	7.5	15	≥ 25
0,10 (Sg)	3300-3900	4600-5500	6000-7100
Intermediate values may be linearly interpolated.			

Tabelle 5.33 Empirical data ranges for the characteristic base resistance per unit area $q_{s,k}$ for shaft-grouted ductile driven piles in non-cohesive soils.

TRM Piling Systems and sustainability

TRM attaches great importance to the concept of sustainability. The iron that is required for the casting process is obtained only from raw materials from the recycling industry. The TRM ductile iron pile is therefore a classic recycled product.

Value creation in Austria
The TRM ductile iron pile is manufactured in our own factory in Hall in Tyrol (Austria). The majority of our raw materials are delivered by rail. We also take care to use resources as ecologically as possible during delivery.

Renewable energy
Tiroler Rohre GmbH has the largest photovoltaic system in Tyrol with an area of 9,000 m^2. It generates an output of 851 kWp. The electricity fed into the grid supplies 300 households in the region. In addition, we only purchase electricity from renewable energy sources.

Long-lasting buildings
Our TRM Piling System is designed so that buildings can be founded on it for 100 years. It is also possible to reuse this foundation.

Digitally optimised processes
One of the most modern systems is used to continuously monitor and control energy consumption and key figures. The waste heat from production is used to produce district heating for the local district heating network, which supplies 650 households. With the help of sophisticated filter technology, which is always state-of-the-art, Tiroler Rohre GmbH ensures that no pollutants are released into the atmosphere or the environment.

Innovation for sustainability
Tiroler Rohre GmbH obtained an EPD (Environmental Product Declaration) in 2017 for the TRM ductile iron pile, which was updated again in 2022. Thanks to the efforts and improvements in production, approx. 9% of GWP (Global Warming Potential) total (kg CO_2 equivalent) has been saved since the first EPD.

Environmental Product Declaration (EPD)

Environmental Product Declarations (EPDs) are playing an increasingly important role in the construction industry when it comes to assessing the environmental impact of building products and materials. EPDs help building owners to make informed decisions based on ecological criteria and contribute to sustainability in the construction sector.

An EPD is based on international standards and guidelines (ISO 14025 and EN 15804), which define the principles and requirements for carrying out environmental assessments.

When creating the EPD for the TRM ductile iron pile, a holistic approach was taken to the product. All life cycles of the product are considered. It therefore not only looks at the manufacturing process in the factory, for example, but also focusses on all life cycles of the product. It is therefore a ”cradle-to-grave“ approach.

This data and the EPD itself were checked and approved by Bau EPD (publisher and ”administrator“ of the EPD) and a team of verifiers.

Further information can be found in our Secure Download area:

Figures, data, facts

Taking into account an ”average“ transport route and an ”average“ construction site, for example, when considering all life cycles:

+ TRM pile 118/7.5 (without cement mortar): 26.4 kg CO2 equiv/m pile
+ TRM pile 170/9,0 (without cement mortar): 44.47 kg CO2 equiv/m pile

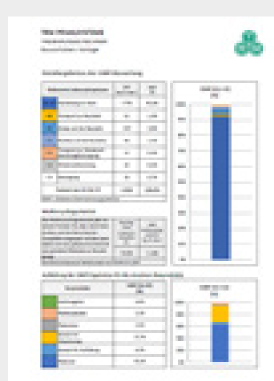
Life cycle assessment studies

In a TRM study, a comparison of TRM piles and bored piles was carried out for 2 projects (1x industrial building in Germany, 1x bridge in South Africa). The use of TRM piles reduced the global warming potential by 30% and 60% of CO_2 emissions respectively.

TRM greenhouse gas calculator

Based on the results of the EPD, an Excel-based calculation tool was developed that can be used to calculate an overall GWP* balance for any building project quickly and easily.

*(GWP = Global warming potential)



Reference projects

BRIDGE CONSTRUCTION

New construction of Rhine bridge
Austria

+ Foundation of the bridge structure and retaining walls
+ 36,260 m of TRM 170 ductile piles in wall thickness 9.0 with grouted pile shoe DN 320
+ Shaft-grouted ductile iron piles as compression and alternating load piles up to a design value of 550 kN
+ Some inclined piles up to 45°
+ Execution period: 2021 – 2023

INDUSTRIAL CONSTRUCTION

Expansion of logistics centre
Italy

+ Foundation of logistics centre with high-bay warehouse
+ 15,000 metres of TRM 170 ductile piles in wall thicknesses 9.0/10.6/13.0 with grouted pile shoe DN 270
+ High requirements in the area of the high-bay warehouse
+ Load-bearing soil layers only in deeper layers
+ Execution period: 2022

STRUCTURAL ENGINEERING

Al-Madina Al-Shamaliya
Bahrain

+ Foundation of two building complexes, each with 20 storeys and a total of 400 flats
+ 43,000 metres of TRM 118 ductile iron piles with a wall thickness of 7.5 and a grouted pile shoe DN 270
+ Foundation in the desert
+ Load-bearing capacity reached after just ten metres, as there is a tensile freshwater layer under the claystone
+ Execution period: 2021 – 2024

All benefits at a glace

+ **Cost-effective site equipment:**
  Only light, commercially available equipment (excavator with hydraulic hammer and special TRM pile driving adapter) is required for the TRM Piling System.

+ **Flexible adjustment of the pile lengths:**
  The pile lengths can be adjusted to the soil on site based on the driving criteria. Changing ground conditions are therefore no problem.

+ **Fast construction time:**
  The Plug&Drive® connection system enables the individual pile pipes to be coupled quickly. This enables a high driving capacity of 200-500 linear metres per day, depending on the pile diameter and soil. No welding required.

+ **No waste:**
  The overhang is cut off at level height and can be reused as a starting piece for the next pile.

+ **No reworking of the pile heads**

+ **Small space requirements:**
  Thanks to the lightweight equipment, pile production is also possible in confined spaces. The minimum centre distance to existing buildings is 50 cm.

+ **Limited working height:**
  By using TRM couplers, TRM ductile iron piles can be shortened as required and used in limited working headroom conditions.

+ **Low-vibration and driving:**
  Pile driving in the immediate vicinity of older building structures is possible without any problems due to the low particle acceleration.

+ **Large stock:**
  The warehouse of Tiroler Rohre GmbH in Hall in Tirol offers sufficient material for deliveries to the construction site at short notice.

+ **Design as tensile piles possible:**
  By inserting a steel tendon, a design as a tensile and alternating load pile is also possible.

+ **No additional costs for drilling material transport**

+ **Low investment costs:**
  No requirement for large expensive piling equipment.

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