Ductile Iron Systems
trm.at

PILING SYSTEMS

TRM piling systems – a complete solution

Construction of a ductile driven pile

The ductile driven pile of the TRM pile system is usually made up of one or more pile tubes (depending on the length required), a pile shoe (ungrouted/grouted) and a self-centering pile head plate.

Pile tube with a length of 5.0 meters

Pile tubes made from ductile cast iron are manufactured in 5 m lengths and in different wall thicknesses with an outer diameter of 98 mm, 118 mm or 170 mm. The conical spigot end and the exactly-fitting plug-in socket enable rapid and secure connection of the pile tubes to form a continuous pile of any length (Plug & Drive®). The excess length is cut off at the desired height and used as the first element in the next pile (no trimming losses).

Plug&Drive force-locking plug-in sockets

The driving process with high impact energy produces a rigid, torsionally stiff connection between the pile tubes (Plug&Drive®), delivering the following benefits:

- Fast connection of the individual elements through simple plug-in system
- No special tools and no welding required
- Flexible adjustment to the building ground

Certified and tested system

The TRM pile system has the following accreditations:

- European Technical Assessment ETA-07/0169 (CE Marking)
- General Building Inspectorate Approval Z-34.25-230 / DIBt

In accordance with these accreditations and in line with ÖNORM B2567, quality and suitability are reviewed during production and continuously thereafter (internal and external monitoring).

Overview of pile tube types

Type	Wall thickness mm	Mass kg/m	Resistance moment cm^3	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 piling systems – a complete solution

Accessories

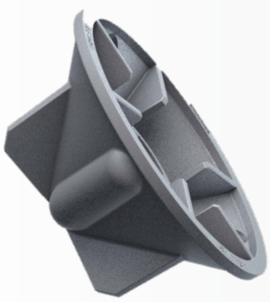
Made from ductile cast iron

TRM pile shoe, ungrouted, flat

for ungrouted piles, suitable for rock and very dense soils

TRM pile shoes, grouted, conical and flat

An enlarged pile shoe for grouted piles, allowing the creation of a "grouted mortar body" encasing the pile tube



TRM coupling sleeve

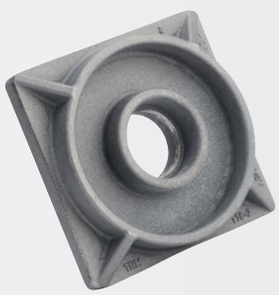
Connection for use at construction sites with restricted working headroom space

TRM pile shoe, ungrouted, with tip

for ungrouted piles, suitable for rock and very dense soils with obstructions

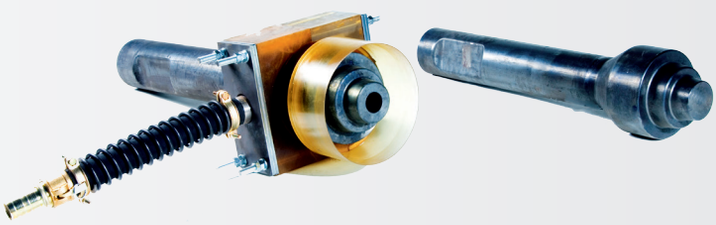
TRM pile head plate

Self-centering pile head plate to transfer the foundation structure load to the pile, with aperture for the insertion of a steel reinforcement (tension pile)



TRM pile impact component grouted/ungrouted

Available for a wide variety of hydraulic hammers



More information on accessories can be found in our brochure "Produktübersicht Pfähle und Pfahlzubehör ".

Pile foundation

Overview

We have been producing piles made from ductile cast iron for the laying of deep foundations since 1986. More than 10 million meters of piles in use today testify to our wealth of experience with the TRM pile system.

We deliver economical, efficient and safe foundations, using light, standard equipment (excavator with hydraulic rapid blow hammer). Our Plug & Drive® connecting system makes the coupling of pile tubes simple and fast. This means that pile lengths can easily be adjusted for variable building ground conditions.

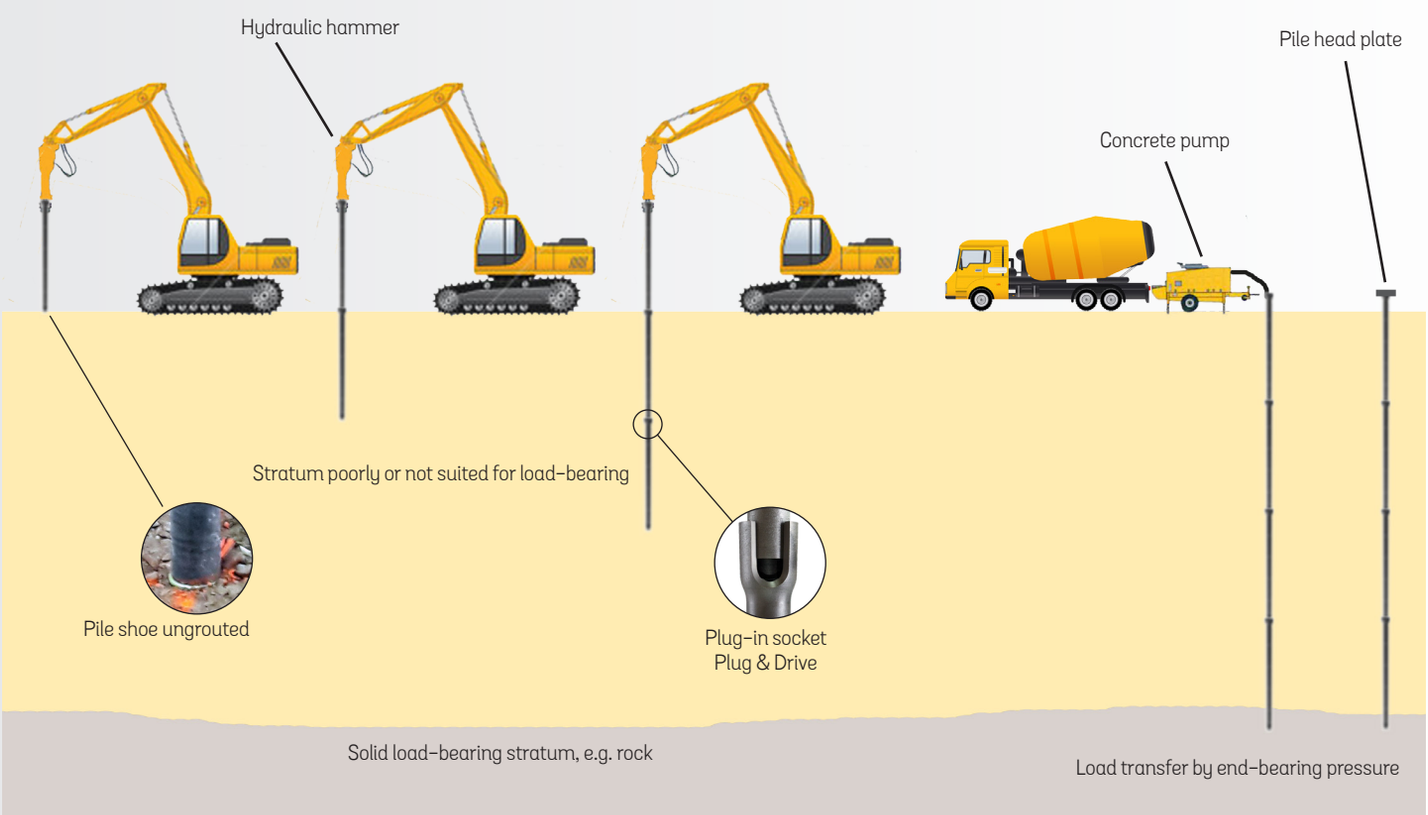
With applied load values of up to 2,400 kN, the TRM pile system is an economical choice among many deep-foundation methods.

Ungrouted point-bearing piles (prefabricated driven pile)

Ungrouted point-bearing piles are designed for sites where a solid stratum (e.g., rock), capable of supporting the required loads through end-bearing pressure, is found close to the surface.

- The first pile tube is placed on the ground with a special pile shoe ("pile shoe, ungrouted") and driven into the ground using an excavator and a powerful rapid blow hammer.
  The pile shoe fits flush with the diameter of the cast pile. The "ungrouted pile shoes" used may be flat or with tip, depending on the subsoil.
- The next pile tube (and all others) are inserted into the Plug & Drive® socket and driven to the required final depth of the pile.
- When excess pile tube has been cut off (to exact height desired) the pile is filled with cement-mortar (usually C20/25 or C25/30) and a pile head plate attached to connect to the foundation.

Ungrouted point-bearing piles



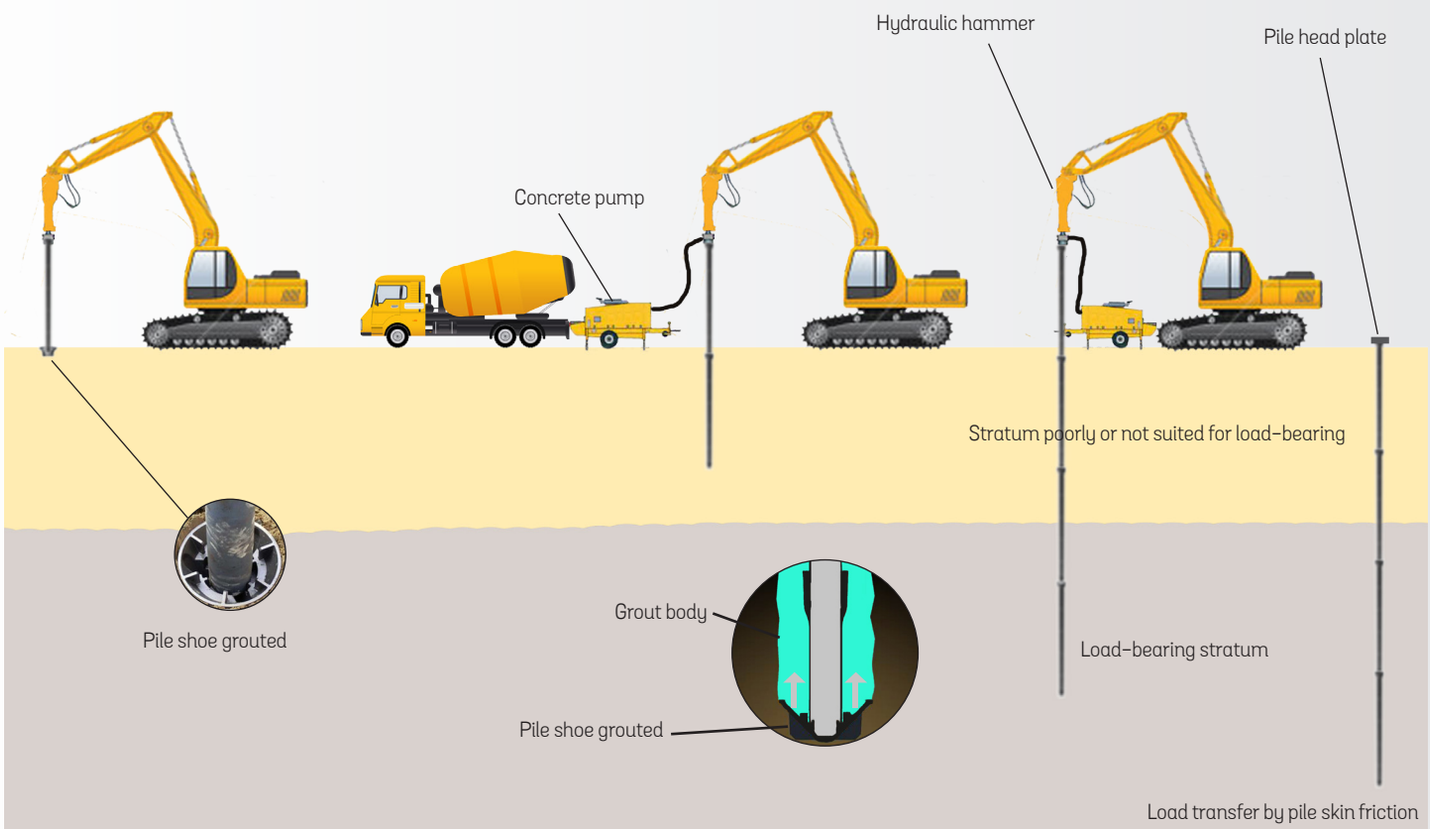
Pile foundation

Grouted piles (grouted mortar pile)

Grouted piles are suitable for cohesive and non-cohesive soils in which the skin friction of the grouted mortar element can be sufficiently activated to absorb the load. Part of the load is also transferred by end-bearing pressure.

- The first pile tube is placed on the ground using a special pile shoe ("pile shoe grouted") with an all-round excess length and driven into the ground using an excavator and a powerful rapid blow hammer.
- At the same time, permanent cement-mortar (usually C20/25 or C25/30) is pumped through the pile interior to the pile base by means of a concrete pump. The cement mortar escapes through special openings in the pile shoe, filling the annular gap which is formed where the pile shoe protrudes.
- The next pile tube (and all others) are inserted into the socket (Plug & Drive®) and driven to the required final depth of the pile.
- When excess pile tube has been cut off (to exact height desired), a pile head plate is attached to connect to the foundation.

Grouted piles



Low-vibration preparation

Measurements on sensitive building sites repeatedly demonstrated the low-vibration insertion. The measured vibration values of ≤ 2 mm/sec were always only a fraction of the permissible values.

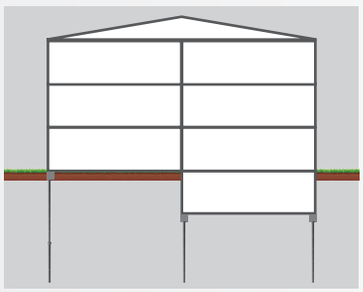
Safety on the construction site

The soil is displaced laterally, so no debris is excavated. The manual activities are limited to minor physical work and safe interventions.

Areas of application

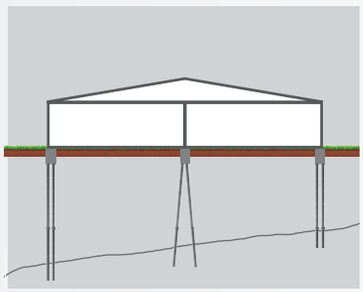
Structural engineering

Foundation of buildings: Advantages through mobile equipment and short execution time in inner-city districts. The execution of wall-thickness pile structures leads to important savings in foundation concrete.



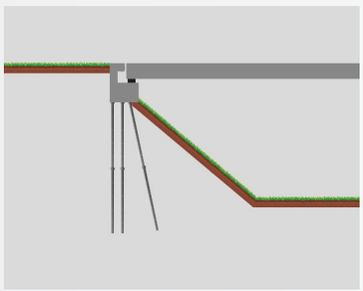
Industrial construction

Foundation of prefabricated halls: Safe load transfer through piles integrated in small bucket foundations. Excellent suitability for lightweight structures with sensitivity to subsidence and in particular subsidence differences. Wind and supporting structure loads are safely transferred to the building ground.



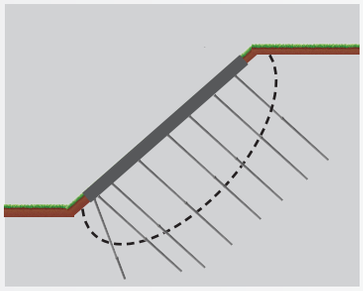
Bridge construction

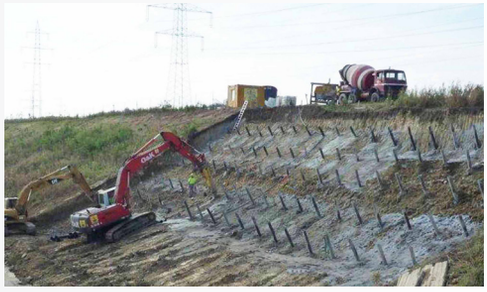
Foundation of bridge abutments: simple and fast building site movement. Torques are transferred through pile bents, and horizontal forces are transferred through inclined piles.



Slope reinforcement

Reinforcement of slopes with a high risk of slides: as a supporting or urgent measure, piles can be inserted vertically up to almost horizontally to achieve stability.

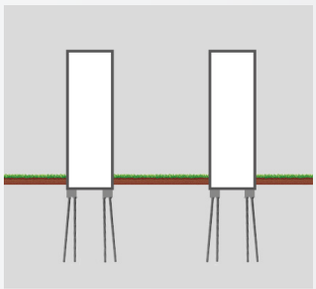




Areas of application

Narrow structures

Foundation of silos, rotating tower cranes, wind turbine, pylons and transmission poles: compression and tensile load. High buildings exposed to cyclical wind loads are founded on pile bents with additional tensile reinforcement.

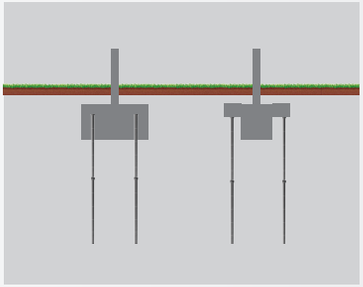


Buoyancy protection

Foundation of sedimentation tanks, subways and construction pits in the groundwater fluctuation range. The concrete floor is secured against floating by means of tension piles.

Retrofit foundations

Underpinning of existing buildings: Within halls and buildings, old foundations are reinforced, or new foundations laid to accommodate additional loads (meeting the challenge of restricted working headroom space).



Ductile cast iron GJS 450–10

We have more than 70 years' experience in the manufacture of products made of ductile cast iron

Highest quality standards through industrial production

TRM piles are manufactured to the highest quality standards. Production is subjected to ongoing quality checks in accordance with the applicable standards. Inspections cover the mechanical parameters, the dimensions and the chemical composition.

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

Corrosion resistance

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

Sustainable material

Our piles are made from 100% recycled material. For our pig iron, we rely exclusively on raw materials from the recycling industry such as laminated cores, sorted steel scrap and recycled materials.

High impact resistance

Our ductile iron has a high ductility and strength, thanks to the addition of magnesium to the liquid iron and the thermal treatment of the piles in the annealing furnace. This means that the piles can safely withstand the powerful hydraulic hammers used to drive them in.

Nodular cast iron	
Tensile strength	≥ 450 N/mm2
0.2% elastic limit	≥ 320 N/mm2
Modulus of elasticity	170000 N/mm2
Compressive strength	900 N/mm2
Elongation after rupture	≥ 10%
Density	7050 kg/m3


VOLVO
VOLVO
VOLVO
VOLVO

Demonstration of the interior load–bearing capacity

Demonstration of cross–section load–bearing capacity

The pile tubes are available in diameters of 98 mm, 118 mm and 170 mm with different wall thicknesses. Filling or grouting is usually carried out with cement–mortar strength categories C20/25 or C25/30.

Applied load values of internal load–bearing capacity according to European Technical Assessment ETA–07/0169

Type	Nominal wall thick–ness	Applied load value: 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	1,091	1,117
	10.6	1,144	1,243	1,267
TRM 170	7.5	1,225	1,477	1,540
	9.0	1,457	1,699	1,759
	10.6	1,699	1,930	1,988
	13.0	2,052	2,269	2,323

The above applied load values apply to ungrouted point–bearing piles with no anticipated loss of wall thickness due to corrosion, and to grouted piles. National regulations must also be observed (e.g., General Building Inspectorate Approval, Germany). Higher or other concrete qualities are permitted.

Buckling analysis

For partially free–standing piles, a buckling analysis is to be carried out. According to EN 1997–1, an additional buckling analysis is required if the piles are enclosed by soil with a characteristic shear strength of $c_u \leq 10$ KPa (KN/m²) in an undrained state. National regulations must also be observed (e.g., General Building Inspectorate Approval, Germany).
For buckling analyses, a higher partial safety coefficient should be observed. The values listed in the table above should be reduced accordingly.

Corrosion

For grouted piles, the cement–mortar surrounding the ductile cast pile provides comprehensive corrosion protection. Calculations concerning ungrouted piles should take into account a loss of wall thickness due to corrosion. The values can be taken from EN 1993–5 point 4.4 in accordance with ETA–07/0169. The applied load values should be adjusted accordingly (see ETA–07/0169). National regulations must also be observed (e.g., General Building Inspectorate Approval, Germany).

Demonstration of exterior load–bearing capacity (geotechnical load–bearing capacity)

General

A comprehensive and relevant soil exploration (dynamic probing etc.) determines the economic dimensioning of the piles. The exterior load–bearing capacity is to be demonstrated by means of test loads or proved on the basis of empirical data (meeting the criteria of the German Recommendations on Piling, or company–specific empirical criteria).

The TRM pile system allows additional insight–gathering during construction:
- Conclusions can be drawn about the "actual" load–bearing capacity of the ground by measuring penetration resistance (driving progress in sec/m) (see diagrams below).
- The pile lengths can then be adjusted during construction to the actual building ground conditions

Ungrouted piles (prefabricated driven pile)

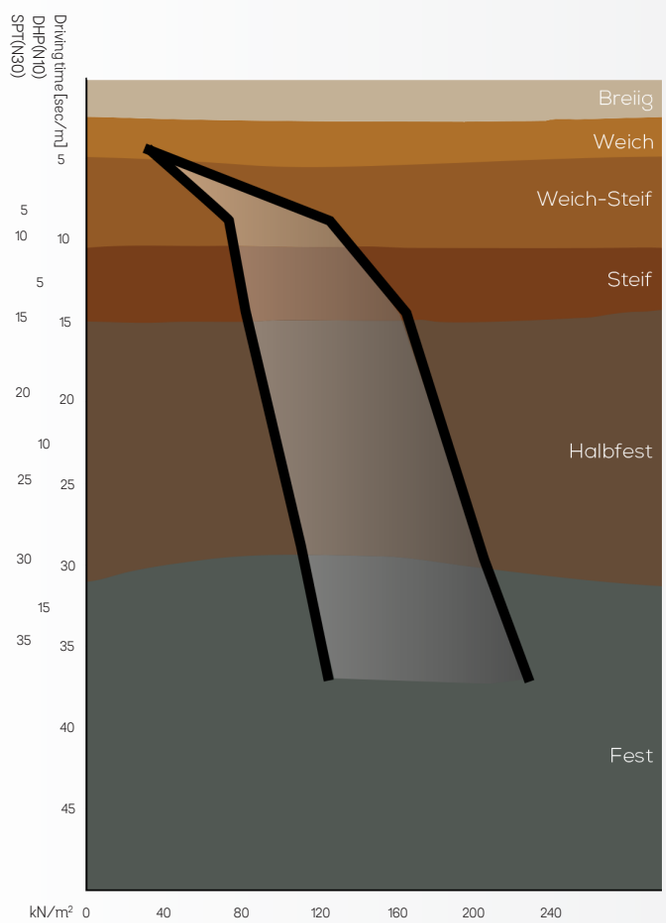
A comprehensive ground survey to determine the depth of the load–bearing stratum is a prerequisite. Once the load–bearing stratum has been reached and driving progress of ≤ 3 cm / min achieved, the allowable loads are to be set by a geotechnical engineer based on their experience on similar ground or, in general, through a trial load.

Grouted piles (grouted mortar pile)

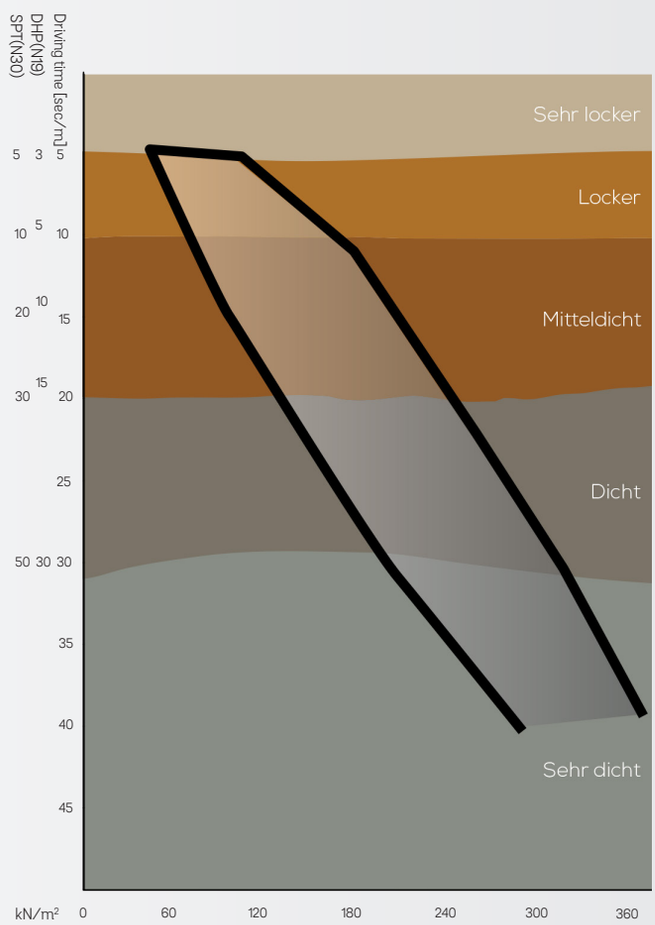
The following diagrams show the fracture values for pile skin friction (q_{sk}), drawn from experience gained by TRM over many years.

The fracture values for pile skin friction (q_{sk}) in relation to pile times (sec/m) were determined
- for a TRM pile 118 with pile shoe 220 mm driven with an Atlas Copco MB1700 rapid blow hammer
- and for a TRM pile 170 with pile shoe 270 mm driven with an Atlas Copco HB2200 rapid blow hammer

Fracture value q_{SK} of pile skin friction in cohesive soil



Fracture value q_{SK} of pile skin friction in non–cohesive soil



TRM–Pile systems and sustainability

General

Care for the environment has always been central to TRM's approach. For example, the iron for our casting process has been obtained from steel scrap for many years. In recent years, we have also found a way to make use of waste heat from the production of district heating for the local district heating network.

After long and intensive preparation, we are therefore particularly pleased to have received an EPD (Environmental Product Declaration) for our TRM pile systems.

What is EPD?

The EPD (Environmental Product Declaration) summarizes environmental information so that the sustainability and impact on the environment of similar products can be compared. The awarding of EPDs and the content of an EPD are regulated by ISO 14025 and EN 15804. A notable component of the EPD is the GWP (Global Warming Potential – represented as CO_2 equivalent).

The award was based on data and parameters from central production and from construction sites. This data and the EPD itself were reviewed and approved by Bau EPD (issuer and "administrator" of the EPD) and a team of verifiers.

Why EPD?

Following inquiries from various corners of the world, we decided to take the lead among foundation systems in special deep–foundation engineering by putting the topic of CO_2–consumption (CO_2–footprint) on a sound scientific footing.

In our EPD statement, we give detailed information about (for example) the CO_2 consumption of our pile system, taking into account activities on the construction site as well as pile production in the factory (consideration of all life cycles "from cradle to grave").

Figures, data, facts

- For an "average" transport route and an "average" construction site, for example, CO_2 consumption through all life cycles lies at:
  - 26.7 kg CO_2 equiv / m pile (without cement mortar) for a TRM pole 118/7.5;
  - 45.8 kg CO_2 equiv / m pile (without cement mortar) for a TRM pile 170/9.0;
- In a study seen by TRM, comparisons of TRM piles with bored piles were carried out on 2 projects (1 x industrial construction in Germany, 1 x bridge in South Africa). Use of the TRM piles reduced the global warming potential by 30% and CO_2 emissions by 60%


PILING SYSTEMS
PILING SYSTEMS
PILING SYSTEMS

Project examples

Rebuilding of Lustenau Station, Austria

- Foundation of a new passenger underpass and two forecourts with TRM piles
- Pile production during ongoing operations in a sheet piling enclosure with a working headroom space of only 5 meters
- Pile production between existing tracks during ongoing railway operation
- Approx. 6,500 m of ductile TRM piles 118/170
- Execution period: 2016

Real Estate Project Grand Angle Fréjus, France

- Excavation pit with TRM piles
- Piles with a 10 m length and 0.5 m center distance, anchored with GEWI 25 length 15 m
- Approx. 660 m of ductile TRM piles 170
- Execution Period: 2017

Lahore – Sialkot Highway, Pakistan

- Foundations of abutments of 2 bridges with TRM piles
- Approx. 3,600 m of ductile TRM piles 170
- Execution period: 2018

TRM pile systems – all benefits at a glance

- **Cost-effective site set-up**
  Our 5 meter long piles allow for the use of lightweight, mobile and standard equipment, reduced maintenance costs through reduced wear

- **Fast and force-locking connection with Plug&Drive®**
  Simple assembly of individual pile tubes during driving without special tools or welding

- **Demonstration of exterior load-bearing capacity**
  Driving resistance provides insight into geotechnical load-bearing capacity

- **Flexible adjustment of pile lengths** to the building ground on site and to changing building ground conditions

- **Low-vibration driving**
  Center distance to existing buildings from 50 cm, pile preparation possible even in confined conditions

- **High economic efficiency, short construction time**
  Low investment costs

- **No additional costs**
  for the disposal of debris or reworking of pile heads

- **No trimming losses**
  Any excess length is cut off at the desired height and used as the first element in the next pile

- **Large Warehouse at TRM**
  deliveries possible at short notice to construction sites

- **High corrosion resistance**
  less corrosion than steel

- **Small space requirement and space-efficient**
  piling platform

- **Coupling sleeves enable use in**
  reduced working headroom space

Contact

TIROLER ROHRE GMBH

Innsbrucker Straße 51
6060 Hall in Tirol
Austria

T +43 5223 503 0
F +43 5223 43619
E pfahl@trm.at
W www.trm.at

Ductile Iron Systems
trm.at

TIROLER ROHRE

07/2018 Images: TRM