TRM Piling Systems

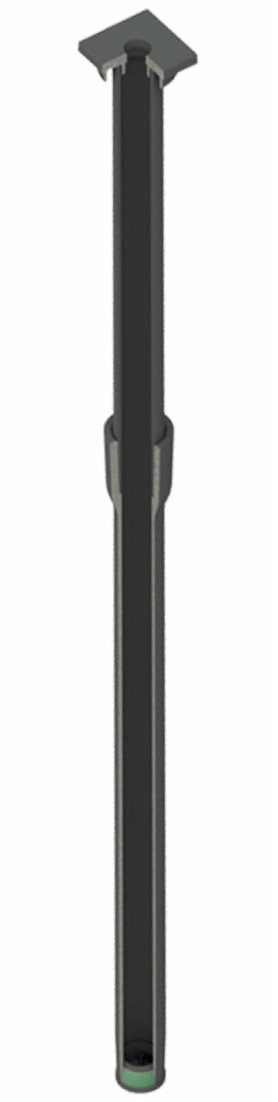
Fast. Simple. Safe.

www.trm.at

TRM Piling Systems

A complete solution

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



Pile pipes with lengths of 5.0 meters

Pile pipes made from ductile iron are manufactured in 5 m lengths and in varying wall thicknesses and outside diameters of 98 mm, 118 mm or 170 mm. The spigot and socket enable rapid and secure connection of the pile pipes to form a continuous pile of any length (Plug&Drive®). The excess length is cut off at the desired level and used as the first element in the next pile. Thus no wasted pile!

Plug&Drive® friction-locking plug-in sockets:
The high frequency impact energy produces a rigid, torsionally stiff connection between the pile pipes (Plug&Drive®), delivering the following benefit:

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

Certified and tested system:
The TRM pile system has the following accreditations:

+ European Technical Assessment ETA-07/0169 (CE Marking)
+ German Institute for Structural Enginneering Approval Z-34.25-230 / DIBt
+ BMK- GZ:2020-0.094.414

In accordance with these accreditations and in line with ÖNORM B2567 (Austrian standard), quality and suitability are reviewed during production and continuously thereafter (internal and external monitoring ISO 9001).

Overview of pile pipe types

Typ	Wall thickness [mm]	Mass [kg/m]	Resistance moment [cm³]	Biegemoment 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

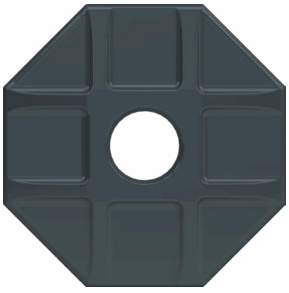
Accessories

Made by ductile iron experts.

TRM pile shoe, non-grouted: for non-grouted piles, suitable for rock and very dense soils

TRM pile shoe, non-grouted, with rock point: for non-grouted piles, suitable for rock and very dense soils with obstructions

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 pipe. Additionally a extension ring can be used in especially soft grounds



TRM Pile Head Plate:
Pile head plate to transfer the foundation structure loads to the pile, with aperture for the insertion of steel reinforcement bars

TRM coupler:
Connection for use on sites with restricted headroom

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

More information on accessories can be found in our brochure „Piles and Pile driving Accessories„

Deep foundations

Possibilities with different ground conditions

We have been producing piles made from duictile iron for deep foundations since 1986. More than 12 million meters of piles in unse today testify our wealth of experience with the TRM pile system.

We deliver economical, efficient and safe foundations, using light, standard equipment (excavator with a standard hydraulic hammer). Our Plug&Drive® connection system makes the joining together of pile pipes simple and fast.

This means that pile lengths can easily be adjusted for varying ground conditions. With design load values of up to 2,400 kN, the TRM piling system is an economical choice among many deep-foundation methods.

Non-grouted end-bearing piles

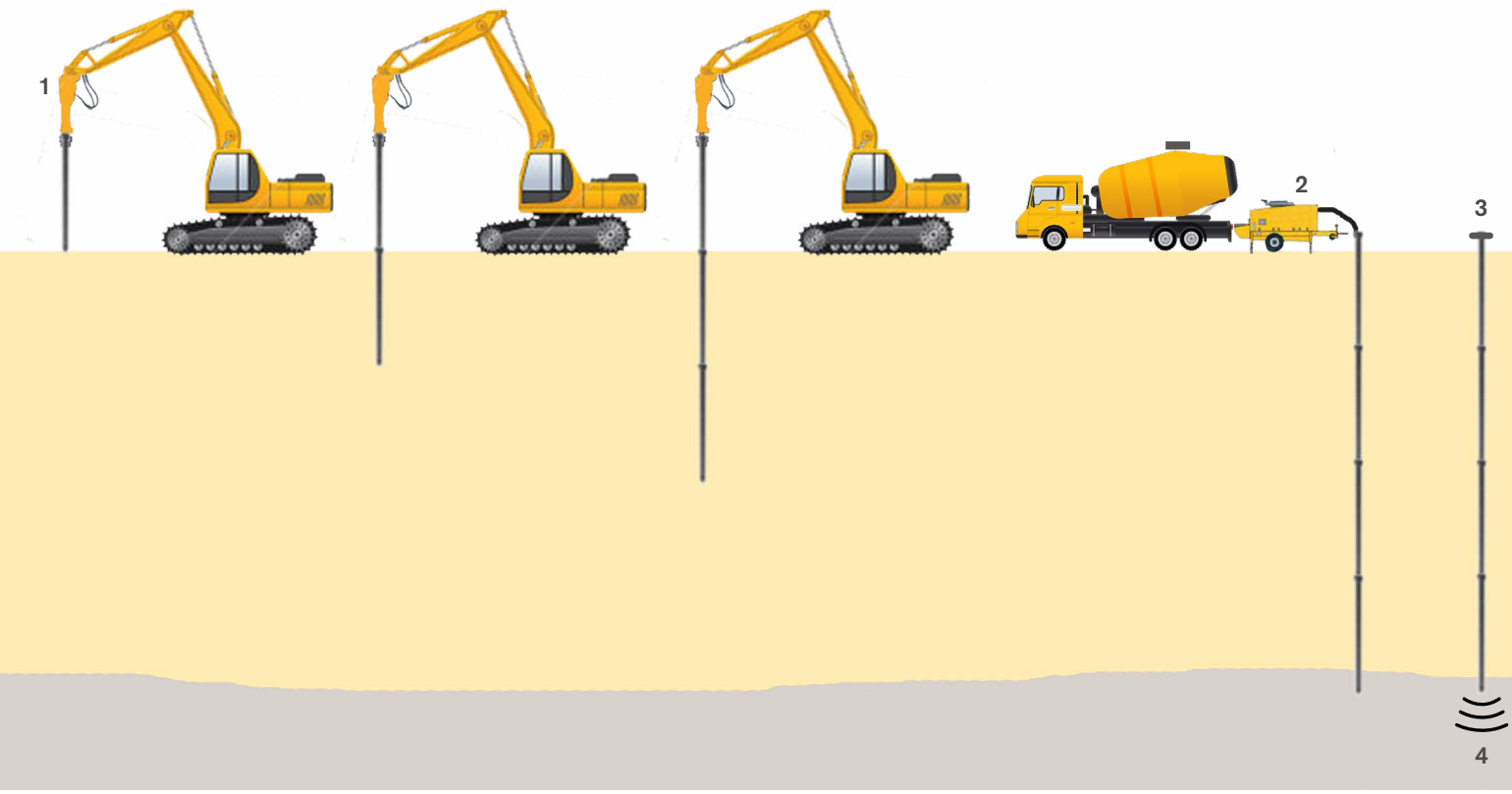
prefabricated driven pile

Non-grouted end-bearing piles are designed for projects where there is solid stratum (e.g., rock), capable of supporting the required loads through end-bearing pressure available.

+ The first pile is placed on the ground with a non-grouted pile shoe and driven into the ground using an excavator and a standard hydraulic hammer. The pile shoe fits flush with the outside diameter of the pile. The non-grouted shoes may be flat or with a rock point, depending on the ground conditions
+ The next pile piece is inserted into the Plug&Drive® socket and driven to the required set criteria is reached.
+ When excess pile pipe has been cut off (to the exact level desired) the pile is filled with cement mortar (usually C20/25 or C25/30) and a load transfer plate is placed to connect to the foundation.

Plug&Drive® socket

Non-grouted pile shoe



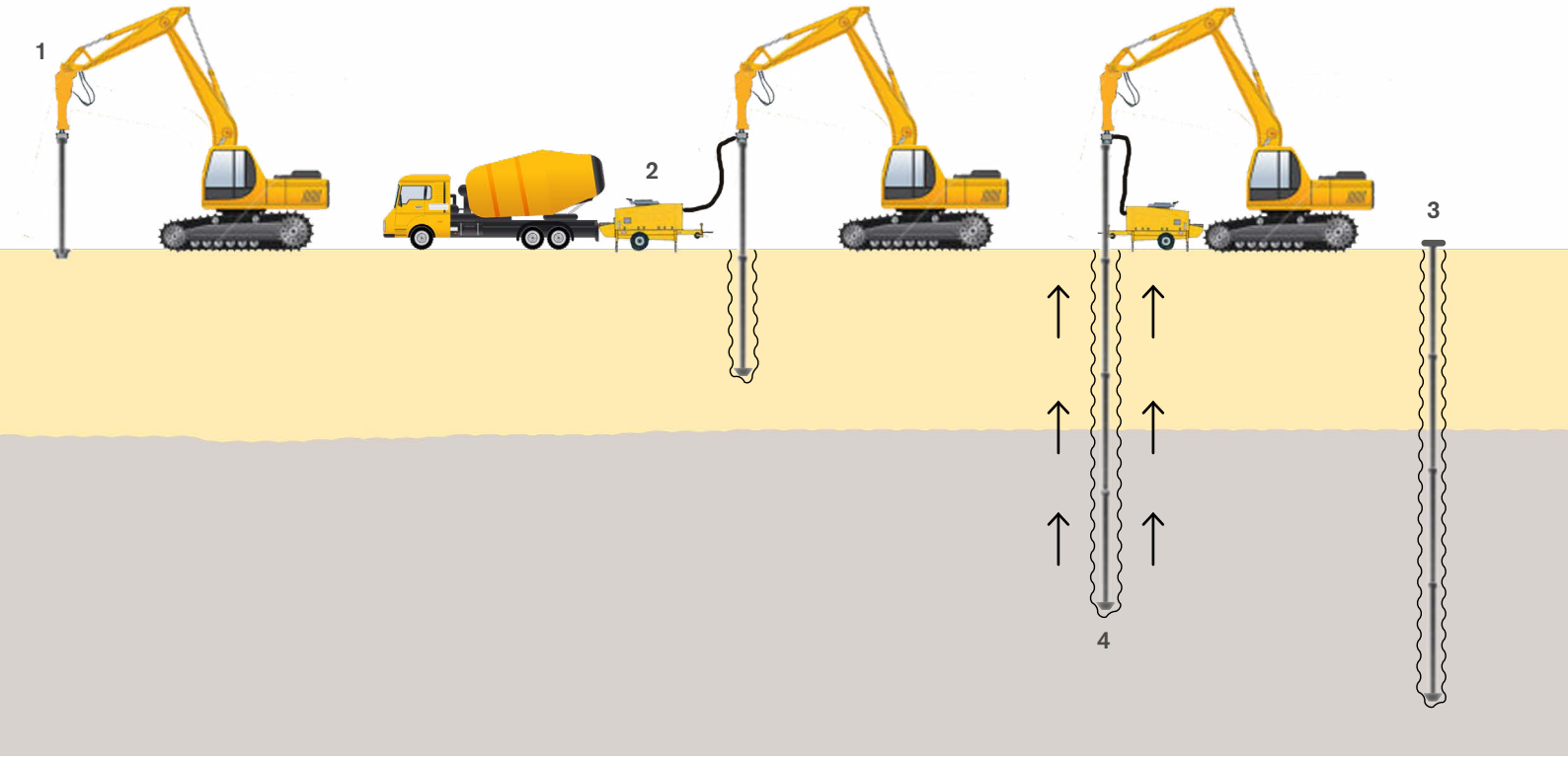
1 Hydraulic hammer **2** Concrete pump **3** Pile head plate **4** Load transfer by end-bearing pressure
Poor stratum or not sufficient for load bearing Solid load-bearing stratum, e.g. rock

Low-vibration preparation

Measurements on sensitive sites repeatedly demonstrated the low-vibration installation. The vibration values of less than 2 mm/sec were only a fraction of 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 very light labour processes.



1 Hydraulic hammer **2** Concrete pump **3** Pile head plate **4** Skin friction load transfer
Poor stratum or not sufficient for load bearing Solid load-bearing stratum, e.g. rock

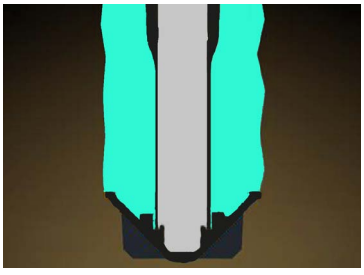
Grouted piles

Skin friction piles

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 carry the load. Part of the load is also transferred by end-bearing pressure.

+ The first pile pipe is placed into a special pile shoe and driven into the ground using an excavator with standard hydraulic hammer.
+ At the same time, 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 pipe (and all others) are inserted into the socket (Plug&Drive®) and driven to the required final depth of the pile.
+ When excess pile pipe has been cut off (to the exact level desired), a load transfer plate is attached to connect to the foundation.

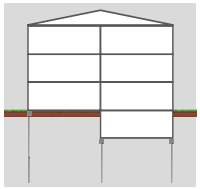
Grouted pile shoe



Pile shoe grouted,
grout body made of concrete

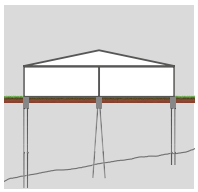
Areas of application Advantages of Piling systems

Structural engineering



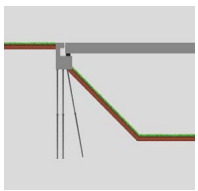
Foundation of buildings: Advantages through mobile equipment and short execution time in inner-city districts. The execution with TRM piling system leads to important savings in foundation concrete.

Industrial construction



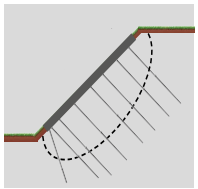
Foundation of prefabricated structures: Safe load transfer trough piles integrated into caps supporting steel or concrete columns. Excellent suitability for lightweight structures with sensitivity to subsidence and in particular differential subsidence. Wind and supporting structure loads are safely transferred to the ground.

Bridge construction



Foundation of bridge abutments: simple and fast pile installation leads to short overall construction times. Large bending moments are carried through the pile into piles and horizontal forces are taken care of using raked piles.

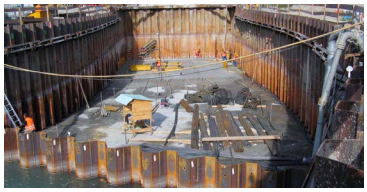
Slope stabilisation

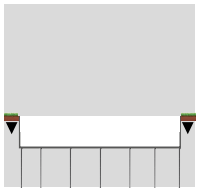


Reinforcement of slopes with a high risk of failure: as a supporting or urgent measure, piles can be inserted at almost any angle to carry out the task of stiching unstable layers together with competent ground.

Areas of application Advantages of Piling systems

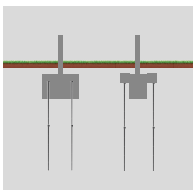
Uplift protection





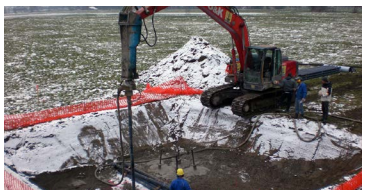
Foundation of tanks, subways and construction pits in the groundwater fluctuation range: The concrete slab is secured against uplift by means of tension piles.

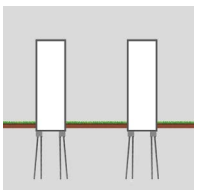
Underpinning foundations



Underpinning of existing buildings: Within warehouses and buildings, old foundations are reinforced, or new foundations laid to accommodate additional loads (meeting the challenge of restricted working head-room).

Tall structures





Foundation of silos, rotating tower cranes, wind turbi-nes, electricity pylons and transmission towers: require capacity for high compression and tensile loads. High buildings exposed to cyclical wind loads are founded on piles with additional tensile reinforcement.

Ductile cast iron

GJS 450-10

We have more than 75 years experience in the manufacture of products made of ductile iron. 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 (Austrian standard)

100% Recycled material

State of the art production equipment

Constant research and development

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.

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 the piles can safely withstand the immense forces of the hydraulic hammer during driving.

Sustainable material

Our piles are made from 100% recycled material. We rely exclusively on raw materials from the recycling industry such as laminated cores, sorted steel scrap and recycled materials, certified to be from european sources.

Nodular ductile iron	
Tensile strength	≥ 450 N/mm²
Yield strength 0,2 %	≥ 320 N/mm²
Modulus of elasticity	170000 N/mm²
Compressive strength	700 N/mm²
Breaking elongation	≥ 10%
Density	7050 kg/m³

Verification of load bearing capacity

Design of the characteristic values

Design of internal load-bearing capacity

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

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 cu ≤ 10kPa (kN/m2) in an undrained state. National regulations must also be observed (e.g., German Institute for Structural Enginneering Approval, DIBt, Germany). For buckling analyses, a higher partial safety coefficient should be observed. The values listed in the table below should be reduced accordingly.

Corrosion

For grouted piles, the cement mortar surrounding the ductile pile provides comprehensive corrosion protection. Calculations concerning non-grouted 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., German Institute for Structural Enginneering Approval, DIBt, Germany).

Design of external load-bearing capacity

General:
A comprehensive and relevant soil exploration (dynamic probing etc.) determines the economic dimensioning of the piles. The external 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 (EA-Pfähle), 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 next page).
+ The pile lengths can then be adjusted during construction to the actual building ground conditions.

Design load values of internal load-bearing capacity according to European Technical Assessment 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 applied load values apply to non-grouted 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., German Institute for Structural Enginneering Approval, DIBt, Germany). Higher or other concrete qualities are permitted.

Non-grouted piles
end-bearing piles

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 ≤ 3cm /min achieved, the allowable loads are to be set by a geotechnical engineer based on their experience on similar ground or, in general, through testing.

Grouted piles
skin friction pile

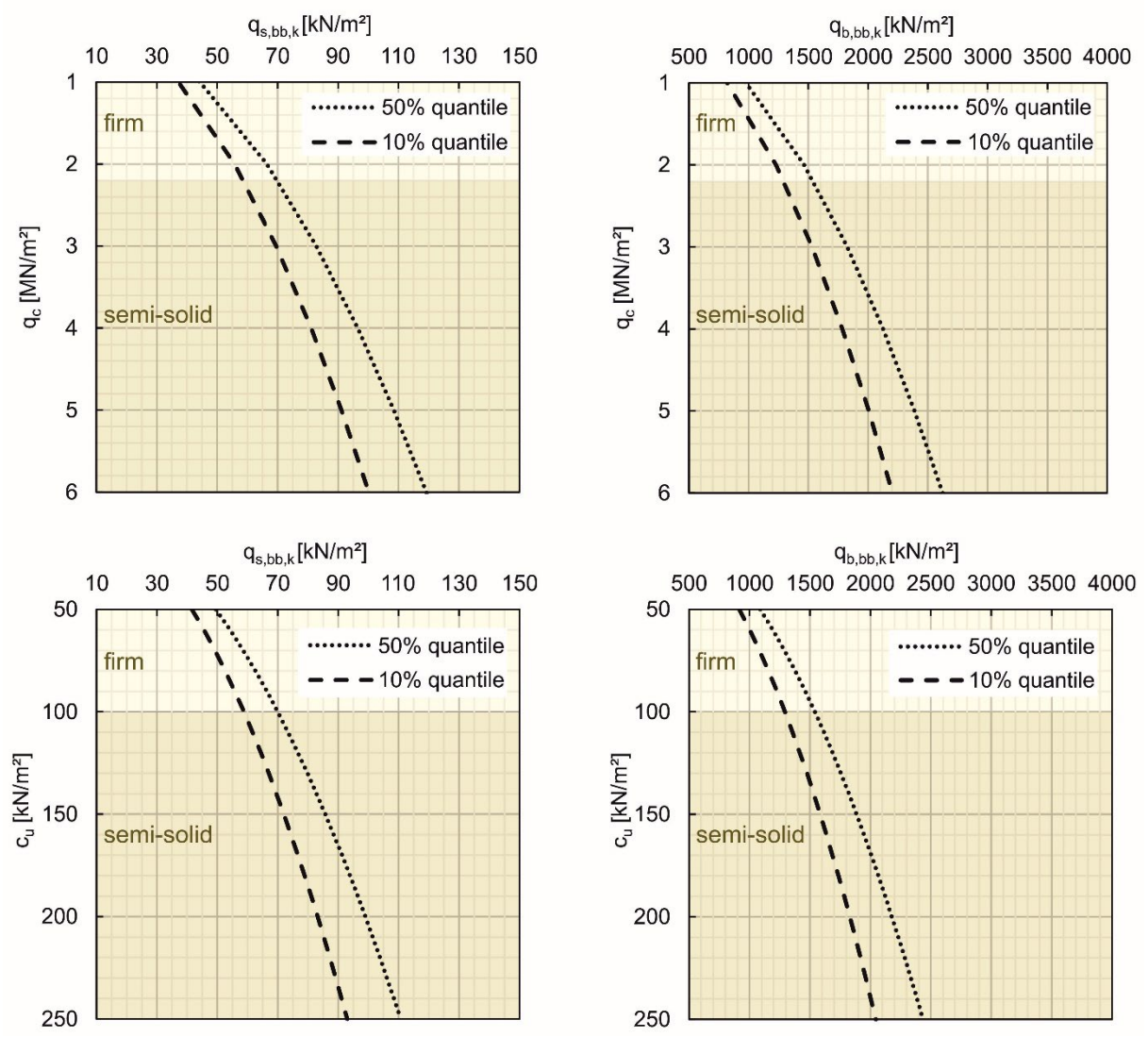
As part of a joint research project with the Department of Geotechnical Engineering at the University of Kassel, data from a total of 121 projects with a total of 338 pile test loads were combined in the period from 2015 to 2020 and the correlation between the characteristic skin friction qs,k and the characteristic peak pressure qb,k and the results of the soil investigation were investigated according to scientific criteria. In addition, numerous pile test loads with accompanying measurements and tests were carried out at 2 test locations(1x on cohesive soil, 1x on non-cohesive soil) in order to investigate the load-bearing behaviour of ductile-driven piles in detail.

Results of the research project are graphically evaluated in the following figures. The following should be taken into account:

- The end bearing pressure and the pile skin friction should, in principle, be determined with the 10% quantile, following EA piles.
- Values exceeding these pile resistances (maximum up to 50% quantiles) should only be selected after confirmation by an expert in geotechnical engineering.

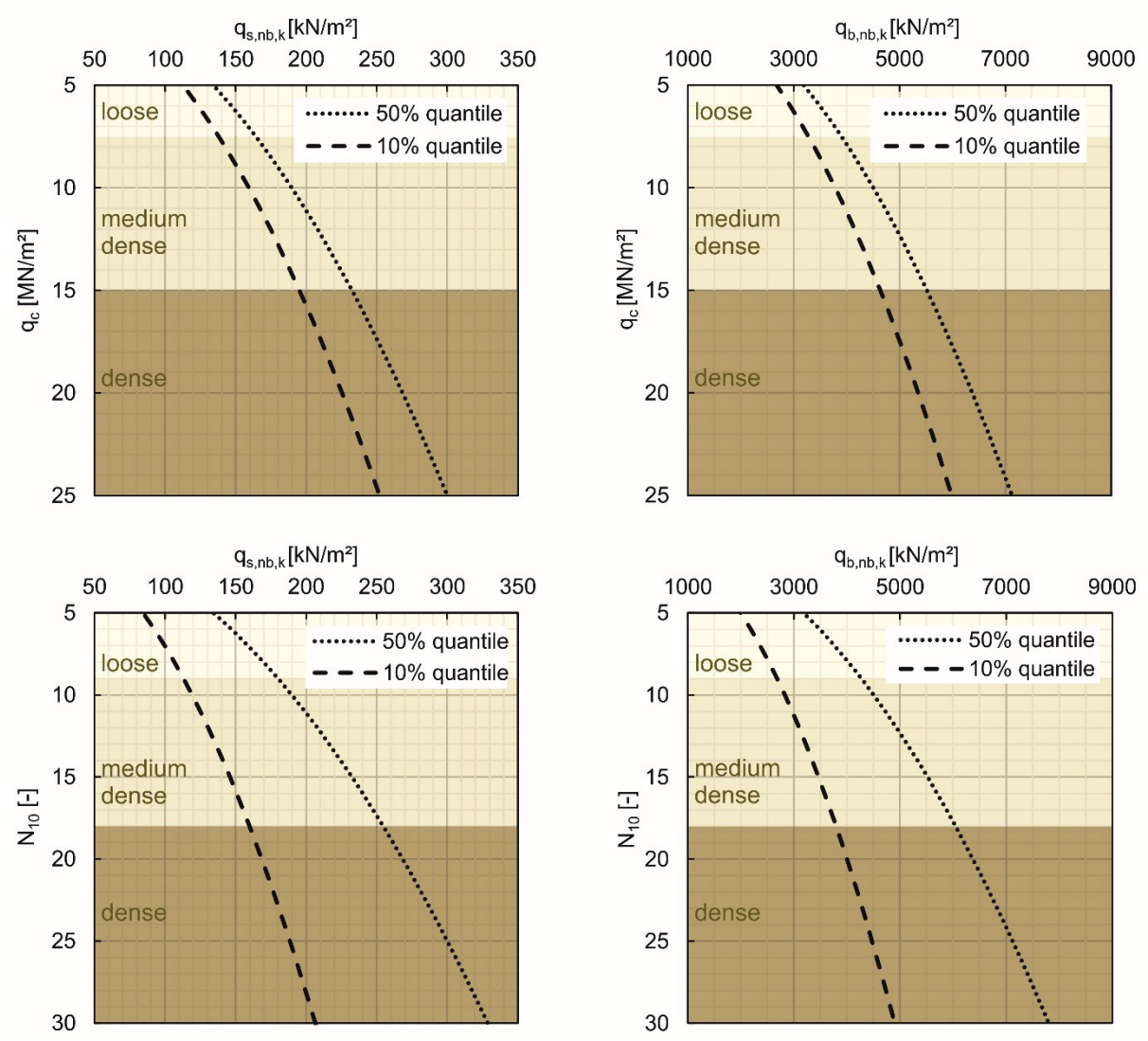
External load-bearing capacity of driven ductile piles

Correlation of pile end bearing $q_{b,k}$ and pile skin friction $q_{s,k}$ with probing resistances in **cohesive soils**



External bearing capacity of ductile driven piles

Correlation of pile end bearing pressure $q_{b,k}$ and pile skin friction $q_{s,k}$ with probing resistances in **non-cohesive soils**



TRM Piling systems and sustainability

Resource-saving and efficient

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 the TRM piling system.

What is EPD?

Environmental Product Declaration

The EPD (Environmental Product Declaration) summarises 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 pile 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 (1x industrial construction in Germany, 1x bridge in South Africa). Use of the TRM piles reduced the GWP (global warming potential) by 30% and CO_2 emissions by 60%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PFAHLSYSTEME
PFAHLSYSTEME

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

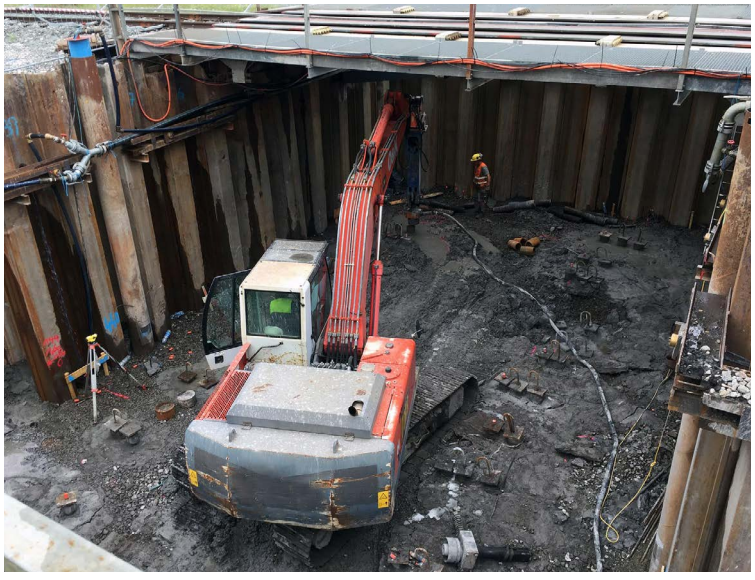
France

+ Retaining wall with TRM piles
+ Piles with a 10 m length and 0.5 m c/c distance anchored with GEWI 25 length 15m
+ Approx. 660 m of ductile TRM piles 170
+ Execution Period: 2017

Lahore – Sialkot Highway

Pakistan

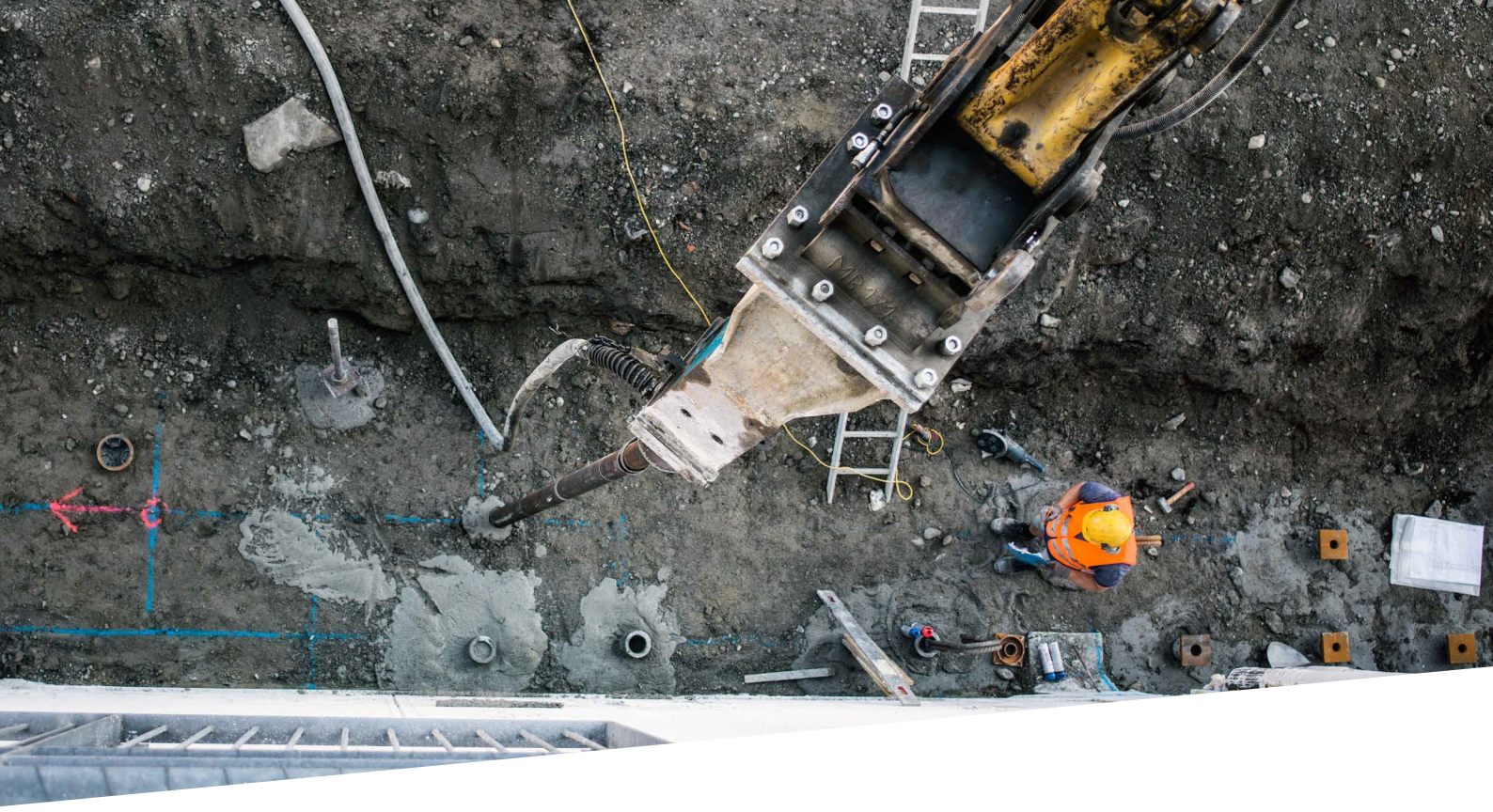
+ Foundations of abutments of 2 bridges with TRM piles
+ Approx. 3,600 m of ductile TRM piles 170
+ Execution period: 2018



Lustenau Train Station, Austria

Retaining wall in Fréjus, France

Bridge abutment foundation, Pakistan



All benefits at a glance

+ Cost-effective site set-up:
  - Our 5 meter long piles allow for the use of light-weight, mobile and standard equipment, reduced maintenance costs through reduced wear
  - Center distance to existing buildings only 50 cm

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

+ Design of external (geotechnical) 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 ground conditions

+ Low-vibration driving:
  - pile installation possible even in confined conditions

+ High economic efficiency:
  - short construction time and 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 level and used as the first element in the next pile

+ Large stock at TRM:
  - deliveries possible at short notice

+ High corrosion resistance:
  - less corrosion than steel

+ Small space requirement:
  - space-efficient piling platform

+ Couplers enable use in:
  - restricted working headroom

NOTES:

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