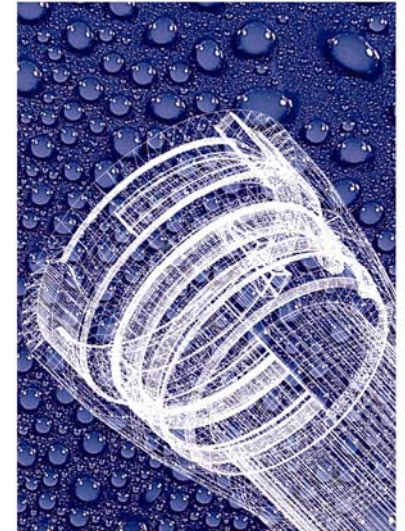


DRIVEN DUCTILE IRON PILES

Quick ▪ Simple ▪ Effective



600,000 meters driven each year

Very high installation rates – Excellent corrosion resistance

- Unique ductile iron pile system on the foundation market, the TRM system utilises spun-cast pile sections of spheroidal graphite ductile iron. This new pile material offers exceptional strength and ductility for driving processes.
- Pile sections are both connected together and installed into the earth by hammering. The exclusive conical spigot and socket joint enables incomparable speed of connection together with a high degree of stiffness.
- Simultaneous drive and grout technique or concreting of the pile bore allow the TRM system to accommodate all site conditions: dry driven pile, grouted pile, composite pile, end-bearing pile as well as skin friction pile.



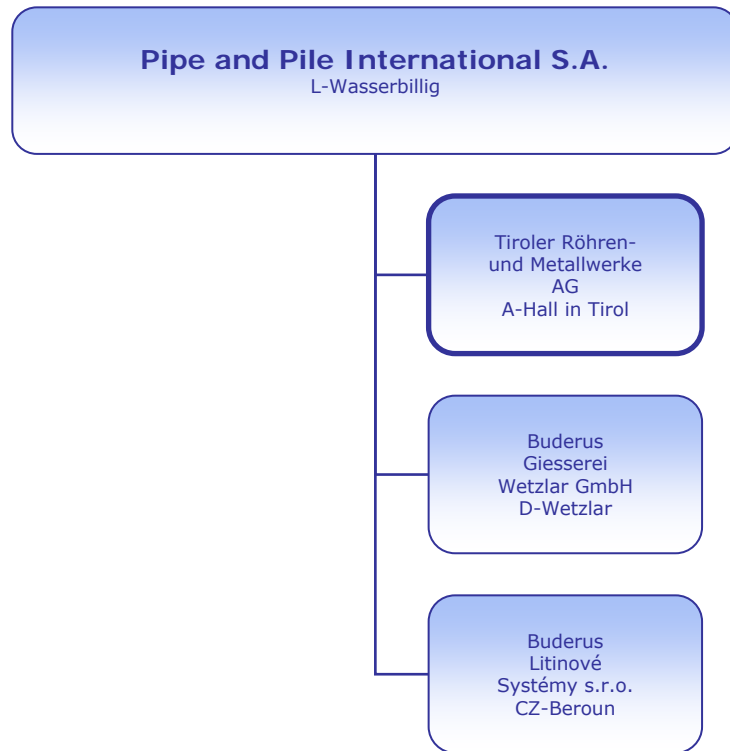
CONTENT

1. Pipe and Pile International S.A.
2. Spheroidal graphite ductile cast iron
3. TRM driven ductile iron pile
4. References and application fields
5. Contribution to environment
6. Advantages of the TRM pile system

1. Pipe and Pile International S.A.



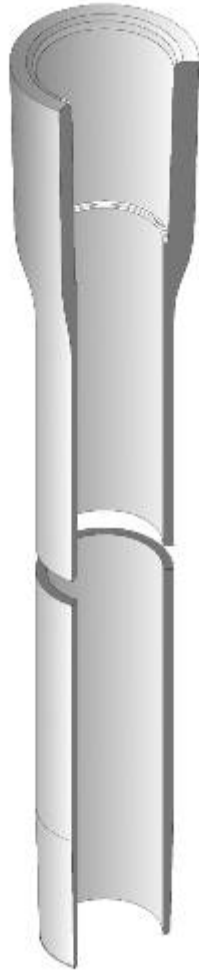
1. Pipe and Pile International S.A.



Pipe and Pile technologies

- European leading manufacturer of ductile iron pipe and prefabricated ductile iron pile systems.
- Secular tradition combined with state-of-the-art production centers in Germany/Austria satisfy high quality requirements.

1. Pipe and Pile International S.A.



Tiroler Röhren- und Metallwerke

- 70 million euros turnover in 2007, 210 employees in Austria.
- Performance: high pressure ductile cast iron pipe systems, pile system.
- Main sectors: irrigation, drinking water, firefighting, sewerage, artificial snow, hydroelectric power plant, building and bridge drainage, inverted siphon, pile foundations.
- Annual production: 35,000 tons.

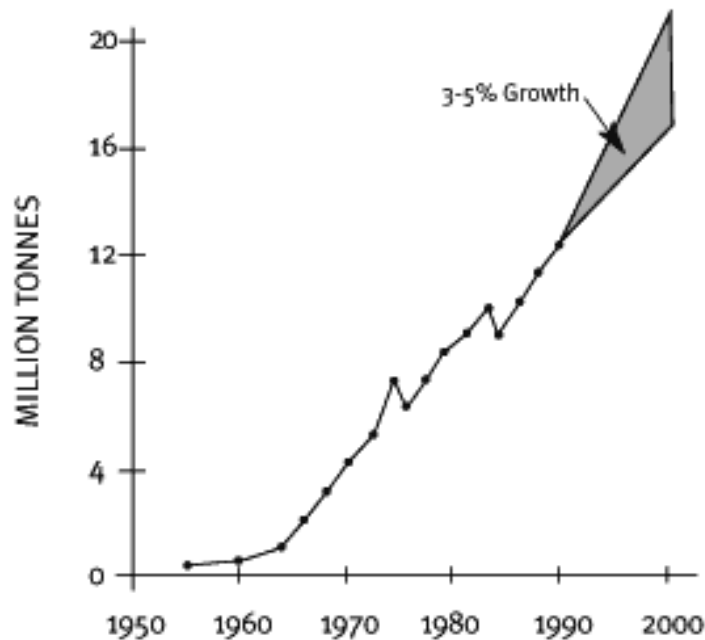
2. Spheroidal graphite ductile cast iron



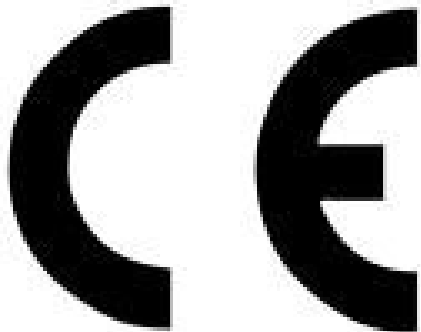
2. Spheroidal graphite ductile cast iron

Technological success

- Progression in every geographic area and every field of engineering.
- Over 50 years of continual growth, expected world production in 2006: approximately 20 million tons.
- Replacement of other materials: steel casting/forging, common irons.
- Expansion of the ductile iron family to new matrix (most recent addition: ADI Austempered Ductile Iron).



2. Spheroidal graphite ductile cast iron



Quality assurance

- Inspection documents: test report 2.2 and inspection certificate 3.1.B according to EN 10204.
- Quality management systems: certification according to ISO 9001.
- CE marking according to European technical approval ETA-07/0169.

2. Spheroidal graphite ductile cast iron



Significant advantages

- Design flexibility: centrifugal cast spigot and socket joint.
- High ductility properties guarantee more elongation.
- High impact and fatigue resistance: disappearance of the fragility.
- Vibrating damping material.
- Excellent corrosion resistance and behavior: graphite protection wall.
- Best in class strength/weight ratio.

2. Spheroidal graphite ductile cast iron

Mechanical and physical specifications EN-GJS-400-10

	EN 1563 limit value ¹⁾	EN 545 limit value ²⁾	ONR 22567 limit value ³⁾	TRM average value
Compressive strength (N/mm ²)	NM	NM	≥ 900	900
Tensile strength R _m (N/mm ²)	≥ 400	≥ 420	≥ 420	490
0.2% offset yield strength R _{p0,2} (N/mm ²)	≥ 250	≥ 270	≥ 300	330
Elongation A (%)	≥ 10	≥ 10	≥ 10	16
Matrix	NM	NM	NM	ferritic
Brinell Hardness (HB)	NM	≤ 230	≤ 250	190
Modulus of elasticity E (N/mm ²)	NM	NM	≥ 140.000 ≤ 170.000	150.000
Weigh density (kg/m ³)	NM	NM	NM	7.150

¹⁾ EN 1563 Founding, spheroidal graphite cast irons

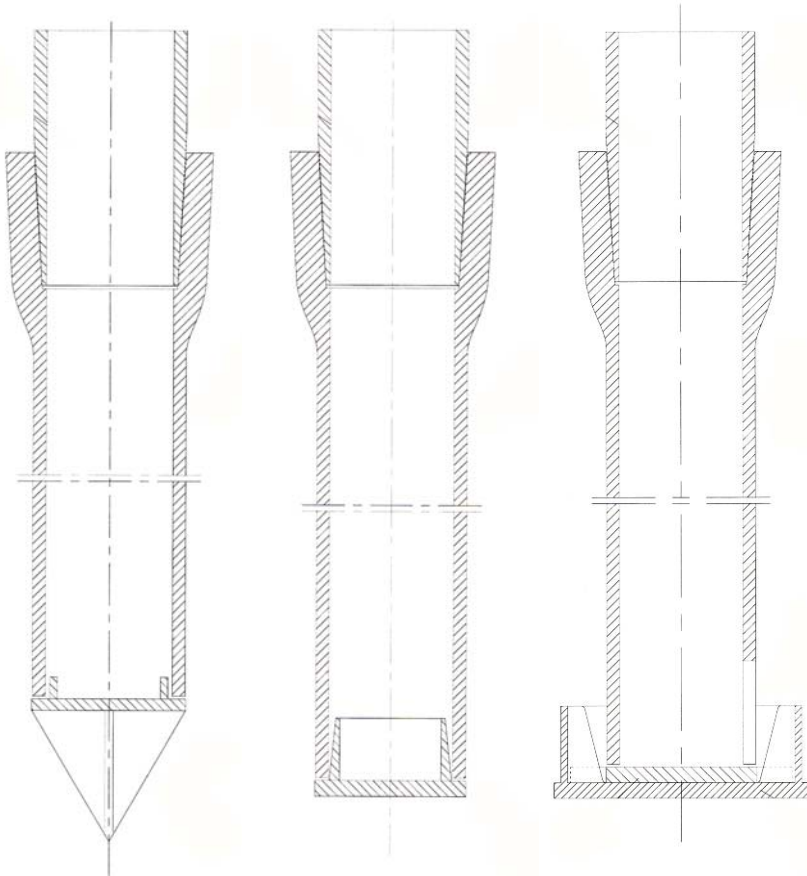
²⁾ EN 545 Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods

³⁾ ONR 22567 Piles of ductile iron cast - Dimensions, installation and quality assurance

3. TRM driven ductile iron pile



3. TRM driven ductile iron pile



Quick and easy connection

- 5,0 meters tubular pile sections.
- Unique conical spigot and socket joint: tapered socket and spigot end offering large driving face, internal shoulder for spigot end stop, double thickness socket wall.
- Pile driving shoes: end plug, grout shoe, rock point for driving through harder material (weathered rock).
- Other accessories: couplers, load distribution plates, pipeline saddles.

3. TRM driven ductile iron pile



3. TRM driven ductile iron pile

Operative standards and approvals

Zone	Institute	Description	Validity
Austria	ON Österreichisches Normungsinstitut	ON Standard 22567 "Piles of ductile iron cast - Dimensions, installation, and quality assurance"	Permanent
Germany	DIBt Deutsches Institut für Bautechnik	Zulassung Z34.25-200 „Rammpfähle aus duktilen Gusseisenrohren mit innerer Mörtelverfüllung (C20/25) BAUER Duktilpfahl	January 2009
Germany	DIBt Deutsches Institut für Bautechnik	Zulassung Z34.25-202 „DSI Duktilrammpfahl System TRM"	December 2008
France	SOCOTEC Société de contrôle technique et d'expertise de la construction	Avis récapitulé DTM-CT/06/1345 « DSI Pieux DYWIDAG en fonte ductile »	December 2009
Europe	AFNOR Association française de normalisation	NF EN 545 "Ductile iron pipes, fittings, accessories and their joints, for water pipelines - Requirements and test methods"	Permanent
Europe	EOTA European Organisation for Technical Approvals	European Technical Approval "TRM Pile pipes made of ductile iron"	September 2012

3. TRM driven ductile iron pile

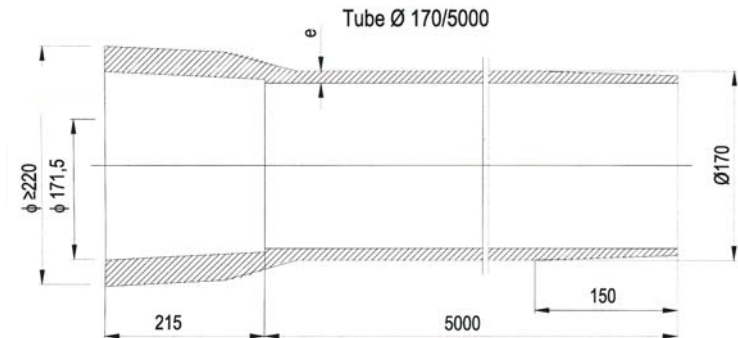
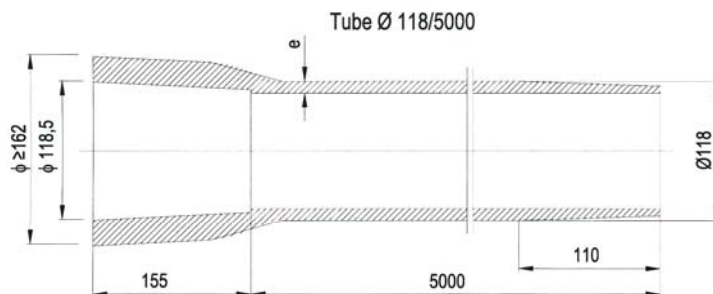
Investigations and expert opinions

Institute	Description	Publication
MA 39 – Vienna municipal accredited test and research institute	Investigations into load capacity and long-term behavior (simulation model for corrosion effects)	1999
MA 39 – Vienna municipal accredited test and research institute	Investigation into spigot and socket joint via bending and tensile tests	1999
Institute for structural calculation and material science – University of Innsbruck	Load bearing behavior of spigot and socket joint after geometrical optimization	2001
LGA – Industrial research center of Bavaria, Geotechnical Institute	Expert opinion into fatigue strength of pile foundation for rail and road structures via cyclic loading tests	1995
MA 39 – Vienna municipal accredited test and research institute GuD Geotechnik und Dynamik Consult GmbH	Measure of vibrations for projects in Vienna City Wällischgasse 3 and in Hamburg station museum in Berlin	1988-1993
Institute for structural calculation and material science – University of Innsbruck	Load capacity tests for pipeline saddles	1995
Institute for structural calculation and material science – University of Innsbruck	Calculation of pile founded canalisation systems with finite element method	2006

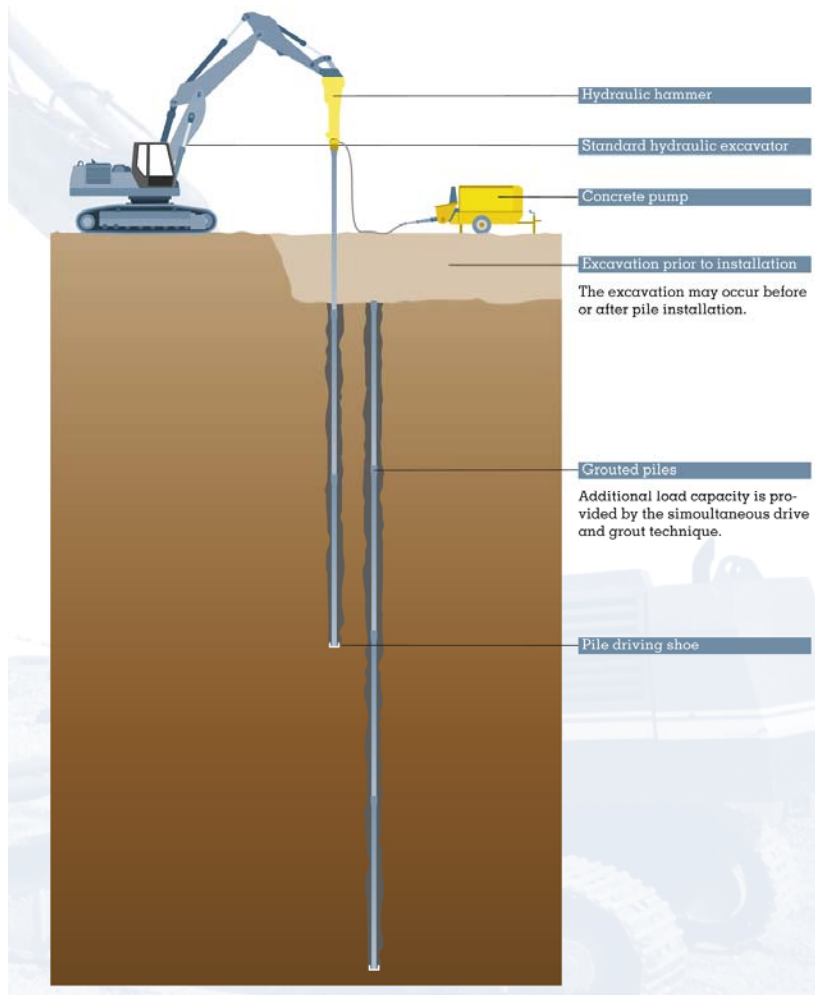
3. TRM driven ductile iron pile

Geometrical specifications

Outside diameter [mm]	Wall thickness [mm]	Length per section [mm]	Weight per section [kg]	Socket diameter [mm]	Cross sectional area [mm ²]
Ø 118	7,5	5.000	105	162	2.604
Ø 118	9,0	5.000	123	162	3.082
Ø 118	10,6	5.000	142	162	3.577
Ø 170	9,0	5.000	186	220	4.552
Ø 170	10,6	5.000	213	220	5.308



3. TRM driven ductile iron pile



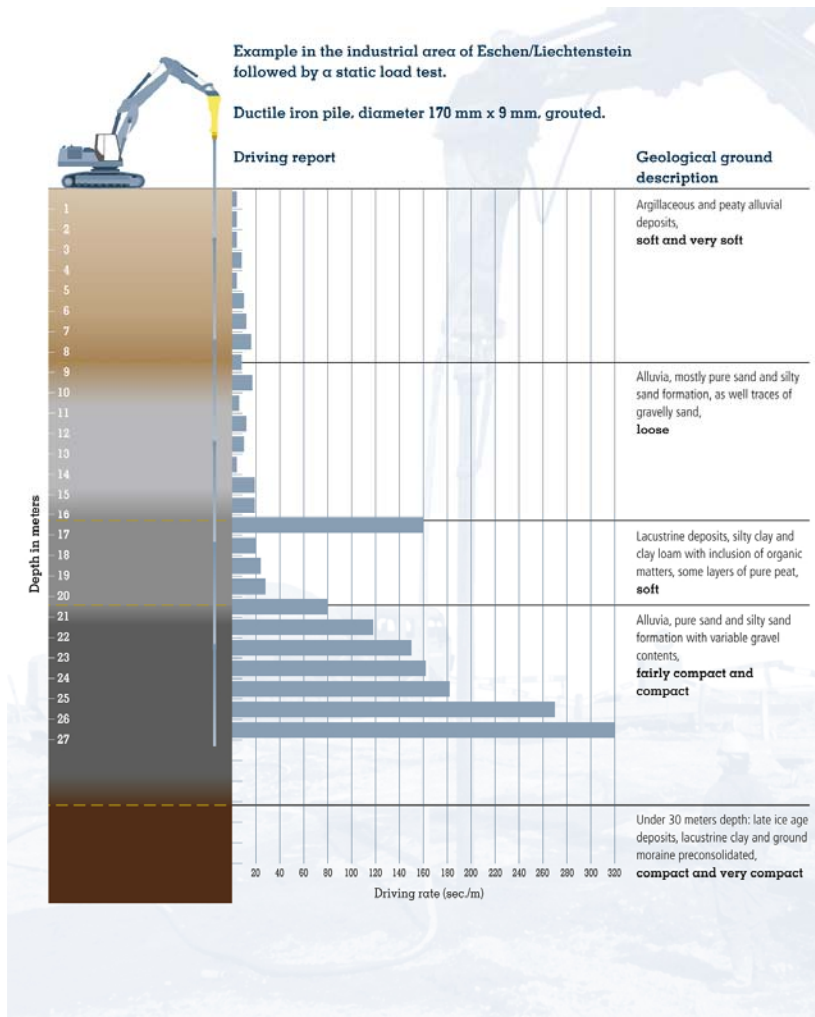
Minor investment

- 20-30 tons hydraulic excavator.
- Medium/heavy hydraulic hammer: operating weight 1.700 to 2.200 kg.
- Dry driving shank or grout injection shank with grout box.
- 40 bar by 20 m³/h concrete pump (is only required for grouted piles).
- Electric or petrol engined disc cutter.

3. TRM driven ductile iron pile



3. TRM driven ductile iron pile



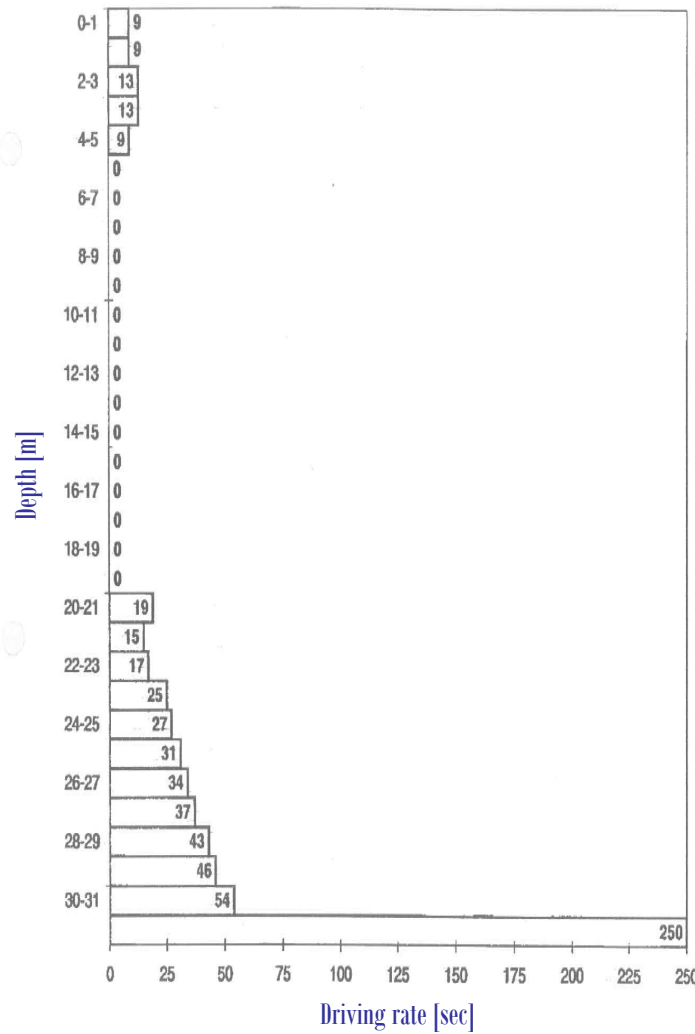
High installation rates

- The lead pile section is fitted with a shoe, and then pitched and driven.
- Additional pile sections are then added as required, to enable the pile to be driven to it's full depth.
- Pile sections are connected together with a high degree of stiffness by hammering, and form the pile core.
- The excess length of the last section is simply cut off to level with the disc cutter.

3. TRM driven ductile iron pile

Easy adaptation

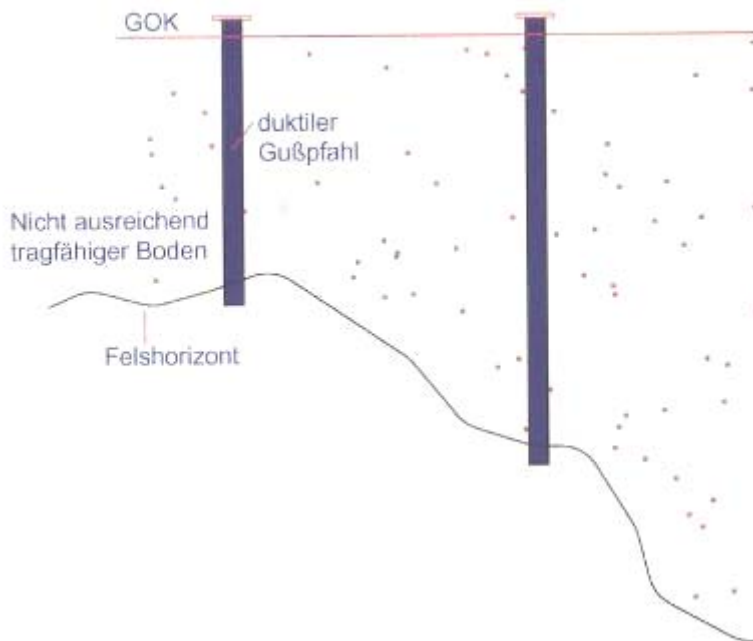
- According to site conditions, ductile iron piles can be driven to penetration, length or bearing load.
- The pile length designed and verified prior to installation, is achieved.
- Piles are driven to a set (established penetration rate, e.g. 30 mm/min).
- Pile loads are given empirically by recording and correlating driving rates versus skin friction values for each displaced soil layer.



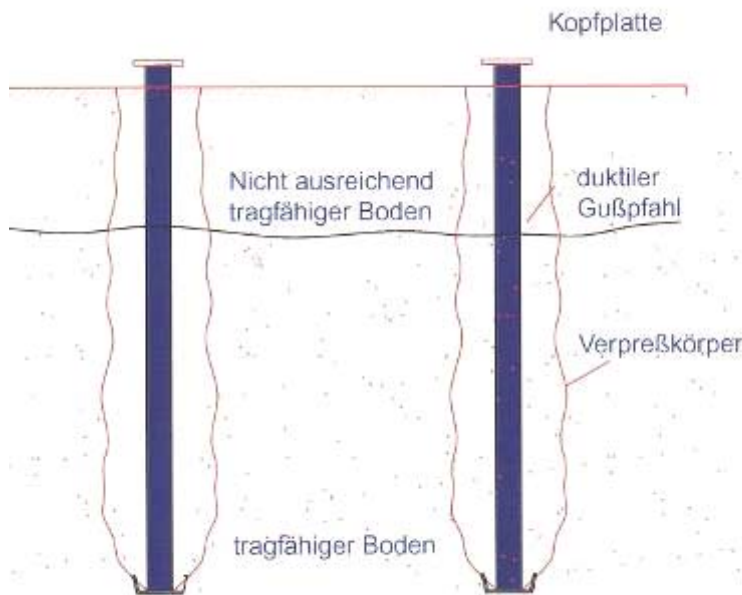
3. TRM driven ductile iron pile

End-bearing pile

- Load bearing substratum underlies very soft soil developing no friction.
- Piles are supported by bedrock or extra dense layer of soil at the tip.
- Pile lengths adapt well to variable load bearing substratum conditions.
- Extra end-bearing and skin friction area of the first pile in dense soils.
- Concreting the pile bore increases ultimate load.



3. TRM driven ductile iron pile



Skin friction pile

- Cohesive or granular soils providing frictional resistance.
- Piles are driven to the depth where friction develops the required load.
- Optimum length for each pile which accommodates all ground variations.
- Combination friction/end bearing if substratum of dense soil at the tip.
- Grouting the annulus and concreting the pile bore increase ultimate load.

3. TRM driven ductile iron pile

Mechanical specifications

Outside diameter [mm]	Wall thickness [mm]	Bending modulus [N/mm ²]	Moment of inertia [N/mm ²]	Ultimate load [kN]	Yield load [kN]
Ø 118	7,5	68	399	1.093	781
Ø 118	9,0	78	461	1.294	925
Ø 118	10,6	88	521	1.502	1.073
Ø 170	9,0	174	1.480	1.912	1.366
Ø 170	10,6	199	1.693	2.229	1.592

Tensile strength $R_m = 420 \text{ N/mm}^2$

0.2% offset yield strength $R_{p0,2} = 300 \text{ N/mm}^2$

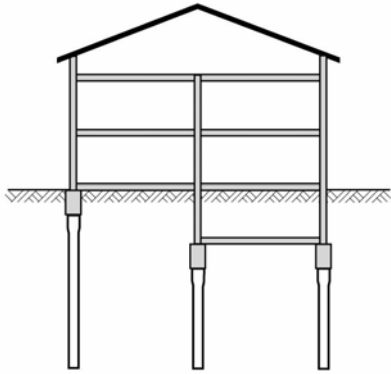
Moment of inertia $= \pi (D^4 - d^4) / 64$

Elastic bending modulus $W = I / v = I / 0,5D$

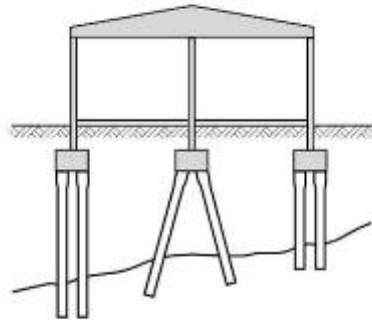
4. References and application fields



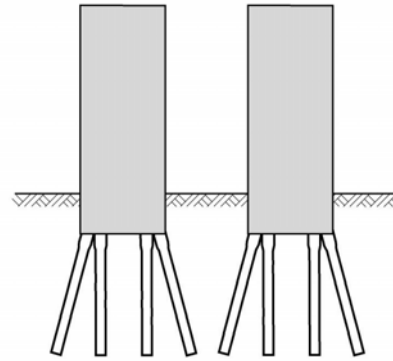
4. References and application fields



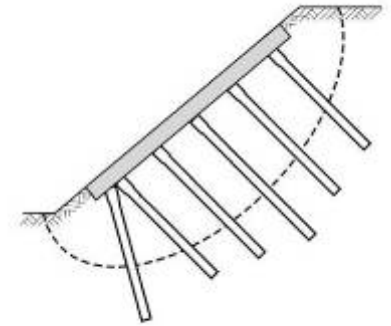
Structural
engineering



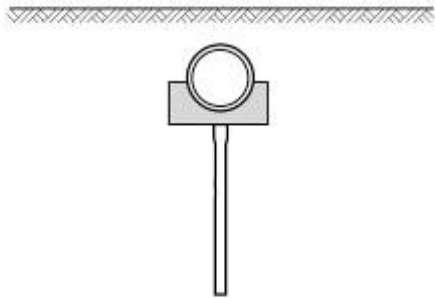
Industrial
construction



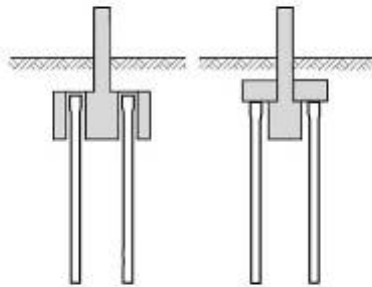
Pylons, wind turbines,
silo foundations



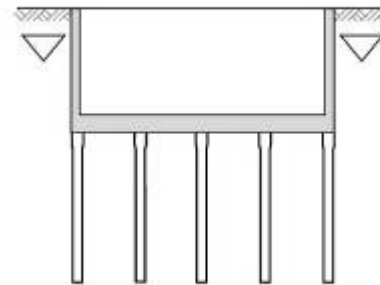
Stabilisation
of slope



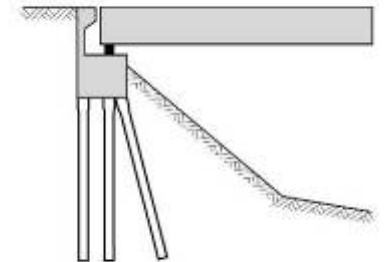
Pipeline
support



Deep
underpinning



Raft uplift
prevention



Bridge and pier
construction

4. References and application fields



Industrial plant, Monaghan, Ireland.



4. References and application fields



Mountain access way, Hintertux, Austria.



4. References and application fields



Sound wall barrier, A23 motorway, Simmering, Austria.



4. References and application fields



Energy Piles, Bad Mitterndorf, Austria.



4. References and application fields



Embankment wall, Dublin, Ireland.



4. References and application fields



Pile-supported sewerage hydraulic network, Pennewang, Austria.



4. References and application fields



Wind turbines, Wilfersdorf, Austria.



Next slide: Nursing home, Lichtenstein.



4. References and application fields



4. References and application fields



Above-ground parking structure, Zillertal, Austria.



4. References and application fields



Seaside resort, Dubai, United Arab Emirates.



4. References and application fields



Extension of industrial plant, Pöls ob Judenburg, Austria.



Next slide: Apartment building, Vienna, Austria.



4. References and application fields



4. References and application fields



Road stabilization, Sankt Valentin, Austria.



4. References and application fields



Bridge foundation in contaminated ground, Sardinia, Italia.



4. References and application fields



Pile-supported sewerage hydraulic network, Gunsirichen, Austria.



4. References and application fields



Corner building, Leermoos, Austria.



Next slide: Bridge foundation, Leutasch, Austria.



4. References and application fields



4. References and application fields



Extension and underpinning of industrial plant, Saint Lucia, Antilles.



4. References and application fields



Warehouse, Guntramsdorf, Austria.



4. References and application fields



Ski trails construction, Ehrwald, Austria.



4. References and application fields



Apartment building, Dornbirn, Austria.



4. References and application fields

Short extract of most recent projects

Country	Client	Year	Project	Quantity	Type
Italia, Cagliari	Azienda Nazionale Autonoma Delle Strade	2006	Bridge foundations	13.000 ml	Ø 118/9,0 mm
Portugal, Lisbon	Parque Oriente Bobadela	2006	Underpinning of existing halls	25.000 ml	Ø 170/9,0 mm
Slovenia, Ljubljana	Hofer-Aldi	2006	Logistic distribution center	25.000 ml	Ø 170/9,0 mm
Austria, Bad Mitterndorf	Grimming Therme GmbH	2008	Thermal center, energy piles	30.000 ml	Ø 170/9,0 mm
Austria, Simmering	Wiene Brückenbau und Grundbau MA 29	2006	Sound wall barrier A23 motorway	24.000 ml	Ø 170/9,0 mm
Germany, Aalen	Alfing Kessler Sondermaschinen GmbH	2007	Extension of industrial plant	12.000 ml	Ø 170/9,0 mm Ø 118/9,0 mm
Austria, Lower Austria	Windkraft Simonsfeld GmbH & Co KG	2005	Wind turbines, 28 stations	11.000 ml	Ø 170/10,6 mm

4. References and application fields

Our partners both at home and abroad

Dywidag-Systems International DSI
www.dywidag-systems.com, www.dywidag.co.uk

Bauer AG,
www.bauer.de

Grund- Pfahl- und Sonderbau GmbH
www.gps-bau.com

Cimar SL
www.cimar-sl.es

Stump Spezialtiefbau GmbH
www.stump.de

ITW Ingenieurunternehmung AG
www.itw.li

Meisterbau AG
www.meisterbau.li

- SIF-Groutbor SA
www.sif-groutbor.ch

- Porr Technobau und Umwelt AG,
www.ptu.at

- Demler Spezialtiefbau GmbH
www.demler.de

- Kurt Motz e.K.
www.kurt-motz.de

- Neue Gründungstechnik Spezialtiefbau GmbH
www.ngt.at

- GK construction GmbH
www.gk-construction.com

- Hydrotecno s.r.l.,
www.hydrotecno.it

5. Contribution to environment

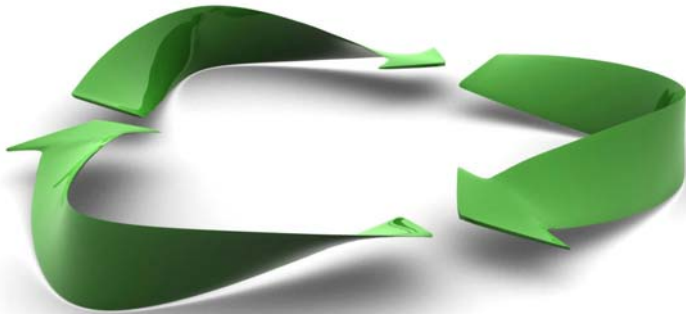


5. Contribution to environment



All-recycled product

- Recycling of 350 tons scrap per day: steel/iron scraps, rejects, discards.
- Valorization of 10% of total Austrian scrap market.



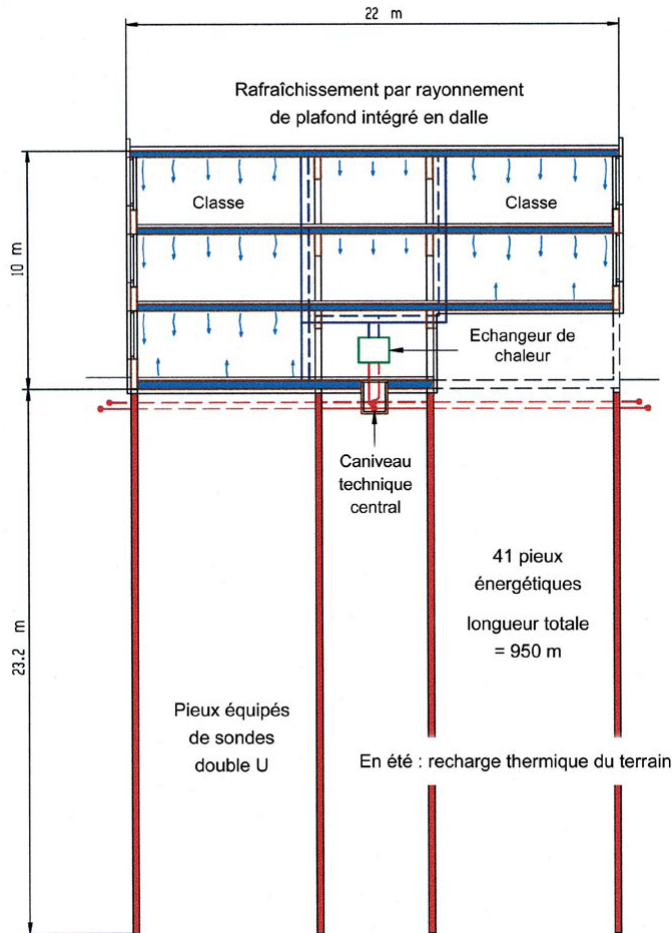
5. Contribution to environment



Ecological process

- Afterburning of residue gas from cupola furnace: energy recovery.
- Environmental-friendly freight: transport of recycled scrap by rail.
- Valorization of by-products: slag (road construction), dusts (zinc).
- Respect of the hydrologic milieu: closed circuit cooling.
- Recycled material helps preserving and saving natural resources.

5. Contribution to environment



Renewable energy

- Energy piles circulate heat transfer medium into geothermal ground storage for both heating and cooling purposes.
- Unobtrusive integration in building design, no extra building site cover.
- Minimal additional investment (paid for by the savings in running costs).
- Pile depth between 10 to 50 meters accommodate most of the cases.

5. Contribution to environment



Sustainable solution

- Long structures' service life: exposition time up to 100 years in the surrounding ground in respect with usual corrosion assessment.
- High durability in moderately, mildly and very corrosive soil conditions.

6. Advantages of the TRM pile system



6. Advantages of the TRM pile system

Driven preformed pile

- Reliability: inspection of predetermined shape/size and material performance in factory, control of load carrying capacities during the installation.
- High installation rates of up to 400 meters per day.
- Displacement pile: positive group effect, high mobilisation of skin friction ¹⁾.
- Additional ultimate load by the concreting or grouting of the bore pile.
- High hammer frequency: almost vibration-free pile installation, possible pile-driving in the immediate vicinity of existing structures - within 40 cm.
- Environmentally friendly: no spoils for removal, no disposal for potentially contaminated materials.

¹⁾ Synthesis and recommendations of the French national project on micropile FOREVER, 2004. English translation by FHWA.

6. Advantages of the TRM pile system

Tubular 5,0 m section length

- Improved site logistics: restricted stock area, easy to handle.
- Light and versatile equipment: minor investment, low costs for transport and site set-up, minimal requirements to working conditions (platform, access).
- Adjustable lengths: piles accommodate all variable site conditions.
- High installation rates: quick and easy succession of natural sequences.
- High ultimate load: tubular cross-section ¹⁾, 5 pile types.

¹⁾ Synthesis and recommendations of the French national project on micropile FOREVER, 2004. English translation by FHWA.

6. Advantages of the TRM pile system

Continuous modular assembly

- No wastage: excess length is cut off and used as first section for the next pile.
- No pile crushing: no added costs for reworking of pile heads, construction proceeds timely without delays, pile level independent of working platform.
- High installation rates: connection needs neither couplers, nor special tools.
- High ultimate load: very stiff joint, high resistance to bending.
- High driving ability: large driving face for impact resistance, double thickness socket wall, internal shoulder for spigot end stop.

6. Advantages of the TRM pile system

Spheroidal graphite ductile cast iron

- Longevity: excellent corrosion resistance, lengthening structures' service life.
- High driving ability: vibrating damping, impact resistance, high ductility.
- Energy pile: high conductivity, efficient heat transfer.
- High ultimate load: surface roughness through tubes' centrifugal casting ¹⁾.
- Density of volume: high strength/weight ratio, proportionally very low impact energies.

¹⁾ Synthesis and recommendations of the French national project on micropile FOREVER, 2004. English translation by FHWA.

THANK YOU FOR YOUR ATTENTION

jerome.coulon@trm-ag.at

