

DYWIDAG Driven Ductile Iron Pipe



Installed by

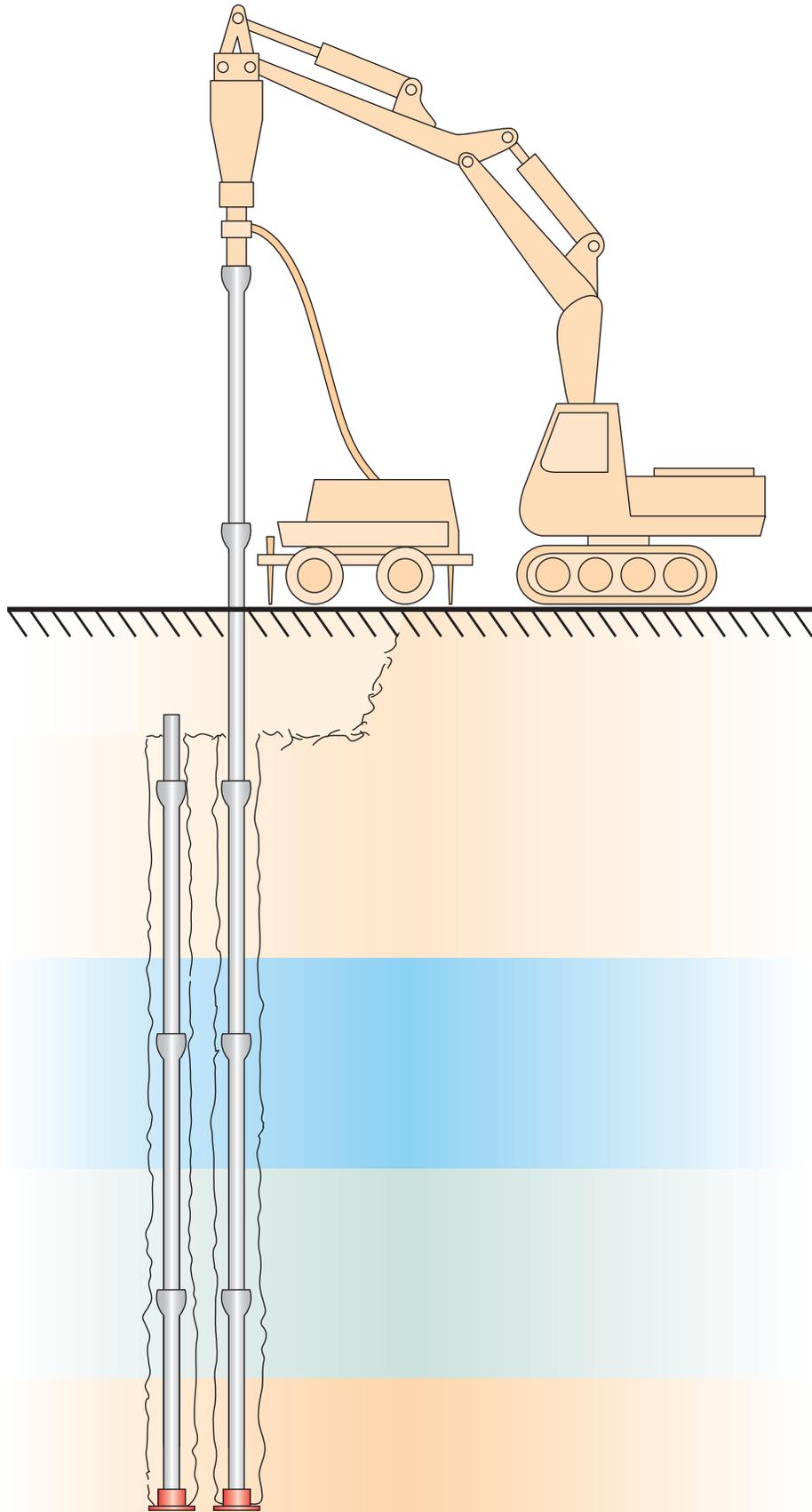
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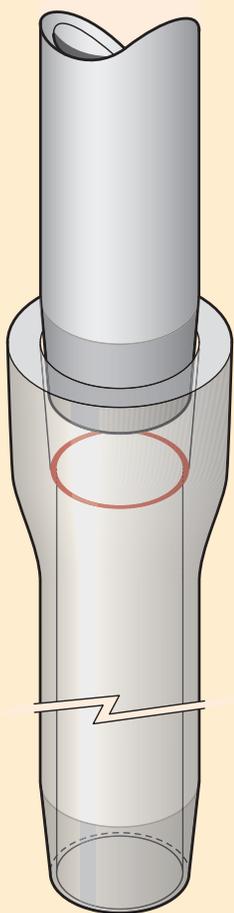
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DYWIDAG Driven Ductile Iron Piles

The DYWIDAG Driven Ductile Iron Pile is a driven pile system, utilizing high strength ductile cast iron. Pile sections are connected together by a unique spigot and socket joint, which offers speed of connection together with a high degree of stiffness. The piles are installed in a quick succession using an excavator with a hydraulic hammer, to both pitch and drive each pile section.

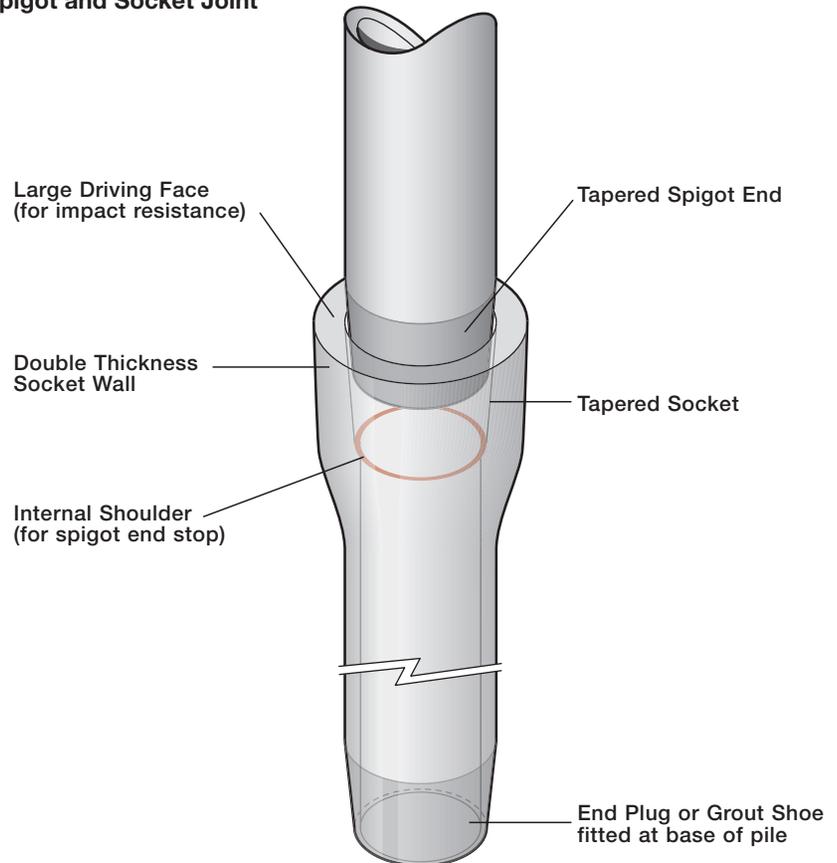
Manufactured as Ductile Cast Iron, also known as Spheroidal Graphite Cast Iron, the system is immensely strong and offers superior durability over conventional tubular steel piles. Additional compressive strength is provided by the concreting or grouting of the bore, to form a composite pile.

Installed as an End-Bearing Pile (dry driven to a set, followed by concreting of the bore) or a Skin Friction Pile (simultaneous drive and grout, with an oversize shoe), the Ductile Iron Pile can accommodate a range of different ground conditions.

Advantages

- Spigot and socket joint for quick and easy connection of pile sections
- Very fast and almost vibration free pile production
- High production rates of up to 1,300 ft per day
- Control of load capacity through correlation with driving rate
- Can be used as a permanent pile
- Easy adaption of the pile length to different soil conditions
- No off-cuts or wastage
- Quick assembly of pile heads
- Light and versatile installation equipment allows pile productions under limited space conditions and in difficult terrain

Spigot and Socket Joint



Driving a ductile pile

The low mass of the individual pile sections means that piles can be driven with a light and versatile hydraulic excavator using a rapid-stroke hydraulic hammer. This permits pile foundations to be constructed where site conditions are difficult or space is limited.

With DYWIDAG Driven Ductile Iron Piles high bearing capacities can be obtained with a rapid-stroke hammer operated at very low impact energies.

This results in smoother operations and almost vibration-free pile-driving in the

immediate vicinity of existing structures.

Pile placement is possible to within 13 in. of existing structures, and the use of excavators means that inclined piles can be placed at almost any rake.

Pile installation

The lead pile section is fitted with a pile shoe, and then pitched and driven. Additional pile sections are then added as required, to enable the pile to be driven to its full depth. The spigot and socket joint enables a very quick

connection of the individual pile sections.

The pile is driven to the required depth as calculated from penetration resistance, and any excess length is simply cut off with an abrasive saw. The off-cut is then fitted with a new pile shoe and used as the first section of the next pile, resulting in no wastage. When pile driving is finished, the piles are filled with concrete to increase their bearing capacity and, depending on the loads required, the pile head is fitted with a pile cap or reinforcing cage.

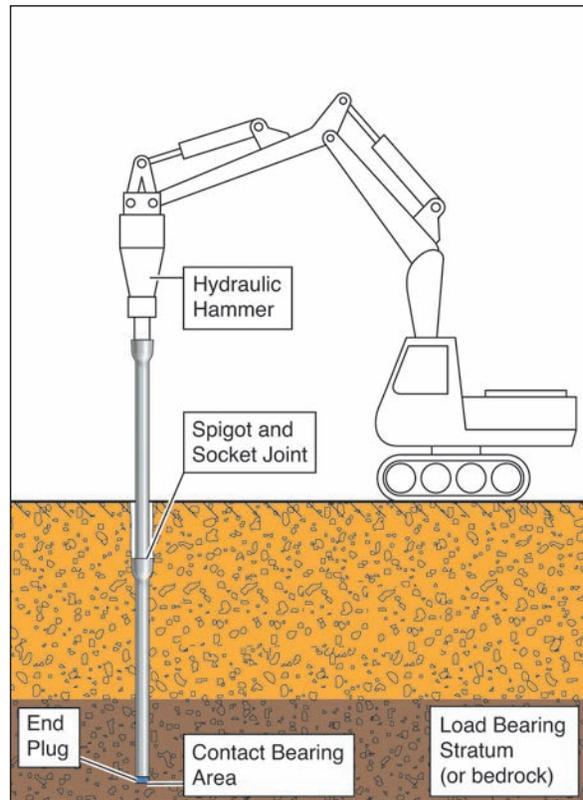
Driven Piles with Subsequent Placement of Concrete (typically end-bearing piles)

Installation of the Driven Ductile Iron Pile is one of the quickest and simplest piling methods available. The pile is driven to a “set” in dense gravel or on to bedrock. Concrete is then placed into the bore of the pile to give additional strength.

An end plug or rock point is fitted to the lead section, which is then driven to its full length, with additional sections added as required.

The set is defined as the reduced rate of pile penetration, in relation to a sustained driving energy (of the hammer), over a given time. Achievement of the set, demonstrates the pile’s ability to sustain its design load on a long term basis.

The value for the set (i.e. penetration rate in relation to sustained driving energy) is determined from empirical data, correlated with static load test results, in a range of different ground conditions over many years.



► Set Data

Pile type [mm] / [in]	Hammer Size Krupp / Atlas Copco	Hammer Power [Joules] / [ft-lbs]	Penetration Rate [mm/min] / [in/min]
118 / 4.65	HM 1000 / MB 1700	3577 / 2638	30/1 / 1.2/1
170 / 6.69	HM 1500 / MB 2200	4950 / 3651	30/1 / 1.2/1

Notes:

1. Set should be proven by three re-drives on first five piles, thereafter once or twice, in conjunction with monitoring of adjacent driven pile lengths.
2. The more powerful hammers can be used with the smaller piles, but the rate of penetration for the set remains unchanged.

► Contact Bearing Area

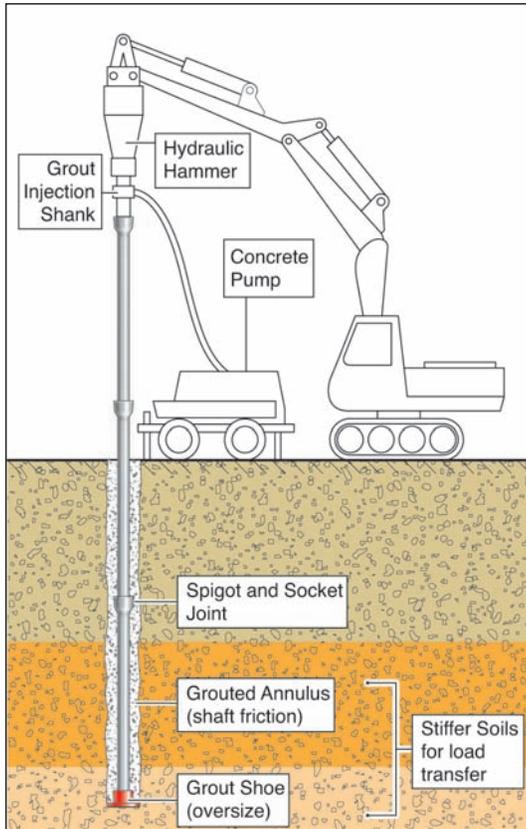
Pile type [mm] / [in]	End Plug [mm] / [in]	Contact Bearing Area of End Plug [mm ²] / [in ²]	Pile Socket [mm] / [in]	Extra Bearing Area of Socket [mm ²] / [in ²]
118 / 4.56	120 / 4.72	11311 / 17.53	160 / 6.3	8797 / 13.64
170 / 6.69	175 / 6.89	24055 / 37.29	218 / 8.58	13275 / 20.58

► Concreting of the Pile Bore

For dry driven piles, the bore of the pile is concreted after driving, at the end of the shift (to limit standing time for concrete delivery trucks). The mix is discharged via a chute into the top of the pile.

A high slump cohesive mix (piling mix), with a 3/8" aggregate and high fines content is typically used to fill the bore of the pile. Slump of 6 to 7 in. collapse, ensures full placement in the bore. Concrete strength per project specifications.

Driven Piles with Grouted Annulus (typically skin friction piles)



Grouted driven piles combine the installation benefit of a driven pile with the flexibility of a grouted system.

An oversize grout shoe is fitted to the base of the lead pile section. As the pile is driven into the ground, the oversize shoe creates an annulus between the pile shaft and the ground,

which is constantly filled with a pile-concrete, to mobilize skin friction.

Installed by the simultaneous drive and grout technique, grouted piles can be also used in ground conditions where other systems are not suitable (i.e. high ground water or contaminated sites).



► Indicative Driving Rates and Skin Friction Values

	Soil Type	SPT		Driving Rate		Skin Friction	
		[kPa] / [psi]	[N] Value	[Sec/m] / [Sec/ft]	[N/mm ²] / [psi]		
Cohesive	Stiff	75-150 / 11-22	10-14	10-15 / 3-5	0.04 / 5.8		
	Very Stiff	150-300 / 22-44	16-30	15-30 / 5-9	0.07 / 10.15		
	Hard	> 300 / > 44	> 30	> 30 / > 9	0.1 / 14.5		
Granular	Medium Dense		10-30	10-20 / 3-6	0.08 / 11.6		
	Dense		30-50	20-30 / 6-9	0.12 / 17.4		
	Very Dense		> 60	> 30 / > 9	0.15 / 21.75		

Notes:

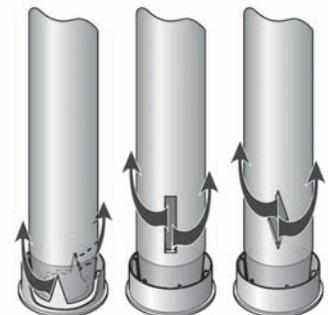
1. Driving rates based on grout shoe (200mm dia. for 118mm piles, 250mm dia. for 170mm piles).
2. In cohesive soils, driving rates require careful assessment, due to the potential for build up of positive pore water pressures during driving.
3. Skin friction value of 0.04 N/mm² (5.8 psi) is informative only, not used for pile loading.
4. Skin friction values are based on approximate stresses with a safety factor of 2 applied. Site trials should be conducted to establish actual values.

► Sanded Grout Mix

- Highly pumpable cohesive mix, to pass through 2 in. hoses and a 1-3/8" aperture in the hammer shank.
- Slump: 7 in. to collapse.
- Retarder: 6 hours (open life of mix is essential during pump downtime).



Grout Injection through the pile bore during driving



Cutaway Options for grout injection piles

Accessories

End plug

End plugs are the standard pile-caps for non-grouted piles.

Rock Point

Rock points are an alternative to end plugs, if the non grouted piles are driven through a harder material, e.g. weathered rock

Grout shoe

Grout shoes are used if a grouted pile is installed. Grout shoes have a bigger

diameter than the pile, creating an annulus around the pile, which enables the placement of fine-aggregate concrete over the full length of the pile shaft.

Coupler

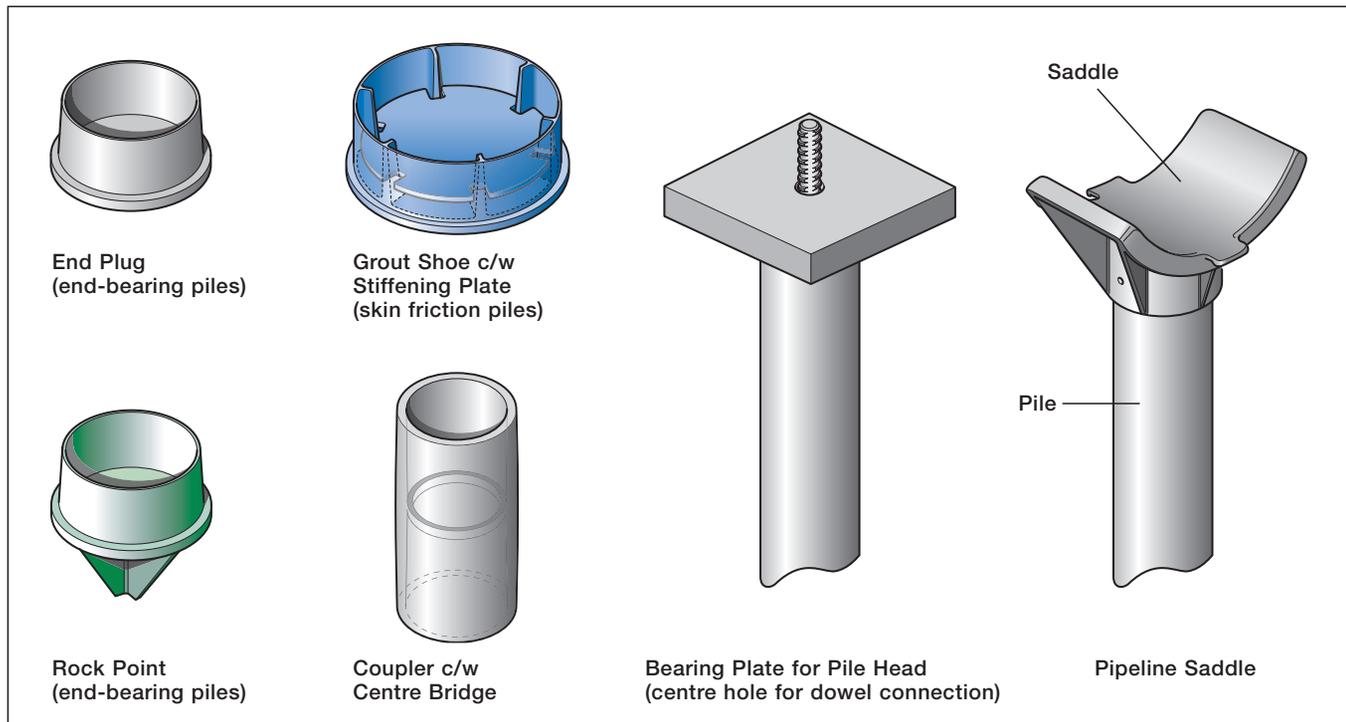
Couplers can be used if two short pile sections must be connected in the place of the standard spigot and socket joint, e.g. if piles are driven in limited head room applications where the pile sections have to be cut.

Pipeline saddle

The pipeline saddle enables the DYWIDAG Ductile Iron Pile to be used as a support to pipelines in poor ground. The saddle provides uniform support for five pipe diameters from 7.8 to 19.6 in.

Bearing plate

The bearing plate is the standard fitting for compression piles. A center hole in the plate is required, to fix the plate horizontally with a dowel, to ensure correct alignment when casting the pile cap or beam.



► Dimensions

Pile Type	End Plug (O.D.)	Grout Shoe (O.D.)	Rock Point (O.D.)	Bearing Plate	Coupler
[mm] / [in.]	[mm] / [in.]	[mm] / [in.]	[mm] / [in.]	[mm] / [in.]	[mm] / [in.]
118 / 4.65	120 / 4.72	200 / 7.87	120 / 4.72	200 x 200 41 / 7.87 x 7.87 x 1.625	165 dia. x 400 L / 6.5 dia. x 15.75
170 / 6.69	175 / 6.89	250 / 9.87	175 / 6.89	250 x 250 x 41 / 9.84 x 9.84 x 1.625	220 dia. x 450 L / 8.66 dia. 17.71 L

Notes:

1. End Plugs and Rock Points are specific to the wall thickness of each pile section.
2. Grout Shoes fit over the outside of the pile end. 200mm dia (7.787 in.) shoe fits both 118/7.5 and 118/9.0 pipes, 250mm dia. (9.84 in.) shoe fits both 170 pipes.
3. Coupler features a tapered internal bore at both ends, together with a center stop. Couplers are also used to connect field cut (off-cut) pipe sections or as a connection to the hammer shank. Note that the spigot ends of the pipe sections should be removed, to ensure full engagement against center stop.

Installation Plant and Equipment



Grout injection shank with grout box
Used for installation of grouted piles. Piling mix concrete (with a max. aggregate size of 4 mm) is pumped through the pile as it is driven, ensuring that the annulus between the pile shaft and the ground is fully grouted



Dry driving shank
Used for installation of end bearing piles. The dry driving shank is fitted into the excavator hammer, in place of the standard chisel. Piles are driven to a set and then filled with a concrete with 10 mm (3/8 in) aggregate.

► Excavation and Hammer Data

Pile type [mm] / [in]	Excavator Size [tonnes] / [tons]	Hammer Type Krupp / Atlas Copco	Hammer Power [Joules] / [ft-lbs]	Hammer Blows per minute	Hammer Length [m] / [ft]	Hammer Weight [tonnes] / [tons]
118 / 4.56	25 / 28	HM 1000 / MB 1700	4020 / 2965	320-600	2.0 / 6.56	1.7 / 1.9
170 / 6.69	30 / 34	HM 1500 / MB 2200	4950 / 3651	280-550	2.2 / 7.22	2.2 / 2.46

Note:

Excavators must have sufficient boom / jib height, to handle the hammer length plus the pipe section. Minimum jib heights: 118 pile = 24 ft, 170 Piles = 24.61'.

Pile Testing



Static pile test

Both static and dynamic tests can be used to establish the ultimate bearing capacity of end-bearing and skin friction piles.

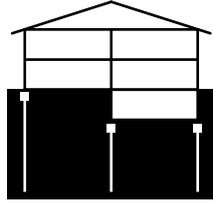
The static pile test provides comprehensive data in respect of the pile's performance. Kentledge or anchor piles are required to provide a reaction, against which the pile can be loaded.

Dynamic pile testing enables the pile to be tested more quickly, using wave equation, but requires special considerations in respect of ductile piles (re. lateral support at the head of the pile and sufficient contact area for the hammer)

Applications

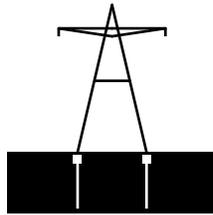
Housing apartments or factory units

With working loads between 112 kips and 290 kips, the DYWIDAG Ductile Iron Piles offer comparable loads to conventional mini piles.



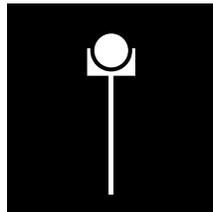
Pylons or Wind Turbines

Power transmission towers can be built on small foundations, which transfer the vertical loads into the ground via the DYWIDAG Ductile Iron Piles.



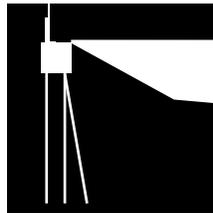
Pipeline support

Pipelines can be laid easily, precisely and free of settlements on special pipeline saddles, which can be mounted directly onto the DYWIDAG Ductile Iron Piles.



Infrastructure projects

DYWIDAG Ductile Iron Piles are used for the foundations and the strengthening of new or existing roads, railway lines and bridges.

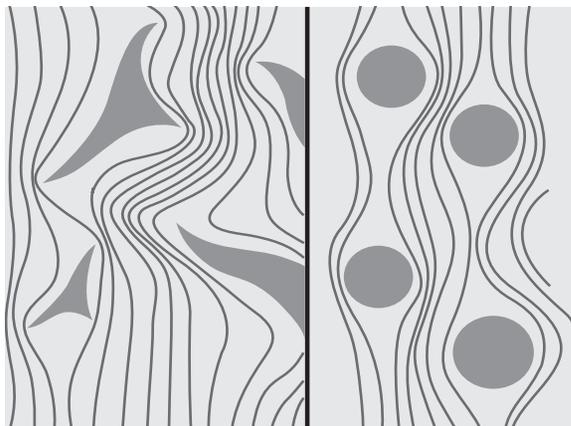
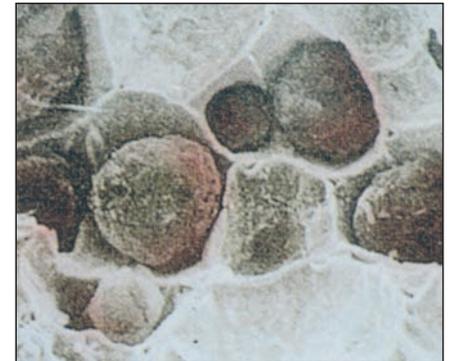
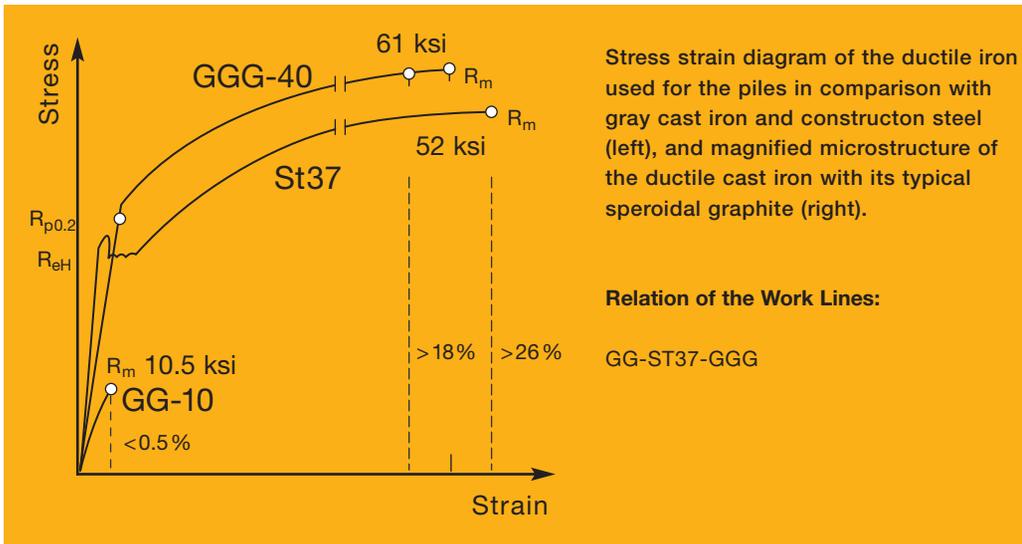


Material

Ductile cast iron is a development of gray cast iron, a material which has been used for pipeline construction for centuries because of its high

resistance against chemical and mechanical influences. Through its very high ductility, the ductile cast iron is capable of withstanding the high

impact energies of the pile driving process.



Course of the Strain Lines:

Cast iron with lamellar graphite (gray cast iron = GG)
Cast iron with spheroidal graphite (ductile cast iron = GGG)
Construction steel (52 ksi = St 37)

Cast Iron with Spheroidal Graphite (GGG)

In the melted cast iron mass graphite is converted from a tapered lamellar (toothlike) shape (gray cast iron) into a spheroidal shape (ductile cast iron). Thus the mechanical characteristics are significantly changed, strength is increased and the material becomes more ductile.

► Specifications

Pipe Dia.	Pipe Thickness	Pipe Length	Weight per Pipe	Cross Section Area	Tensile Stress	Yield Stress	Ultimate Load	Yield Load	Section Modulus	Moment of Inertia
[mm] / [in.]	[mm] / [in.]	[m] / [ft]	[kg] / [lb]	[mm ²] / [in ²]	[MPa] / [ksi]	[MPa] / [ksi]	[kN] / [kip]	[kN] / [kip]	[cm ³] / [in ³]	[cm ⁴] / [in ⁴]
118 / 4.56	7.5 / 0.30	5 / 16.4	105 / 231	2604 / 4.04	420 / 61	300 / 44	1093 / 246	781 / 176	68 / 4.15	399 / 9.59
118 / 4.65	9 / 0.35	5 / 16.4	123 / 271	3082 / 4.78	420 / 61	300 / 44	1294 / 291	925 / 208	78 / 4.76	461 / 11.08
118 / 4.65	10.6 / 0.42	5 / 16.4	142 / 313	3576 / 5.54	420 / 61	300 / 44	1502 / 338	1073 / 241	88 / 5.37	521 / 12.52
170 / 6.69	9 / 0.35	5 / 16.4	186 / 410	4552 / 7.06	420 / 61	300 / 44	1912 / 430	1366 / 307	174 / 10.62	1480 / 35.56
170 / 6.69	10.6 / 0.42	5 / 16.4	213 / 470	5308 / 8.23	420 / 61	300 / 44	2229 / 501	1592 / 358	199 / 12.14	1683 / 40.43

Notes:

1. Cross sectional areas are based on minimum values.
2. Section Lengths: 5.0m (16.4 ft) for all piles; Overall length of 118 pipe sections = 5.155m (16.914 ft), Overall length of 170 pipe sections = 5.215m (17.11 ft).
3. Working load of Ductile Iron calculated from yield stress x minimum cross sectional area, with standard code factors applied.
4. Modulus of Elasticity: E = 160,000 N/mm² (23,206 ksi)
5. Brinell Hardness: 230 HB max.
6. Density: 7.05 g/cm³ (0.255 lb/in³)

Corrosion Assessment for DYWIDAG Ductile Iron Piles

Non-grouted piles are exposed to the surrounding ground, thus certain corrosion rates for the piles have to be considered.

Most of the existing tables for corrosion of piles and/or sheet piles are set up for steel components. Cast iron behaves differently with respect to corrosion. First of all the corrosion speed of cast iron is generally lower and secondly the casting crust is an additional barrier which slows corrosion.

In Austria, where the Driven Ductile Iron Piles have been used for many years,

sacrificial corrosion values are published in the standard ONR 22567 (as determined by MA39, i.e. Material Testing Authorities, Vienna).

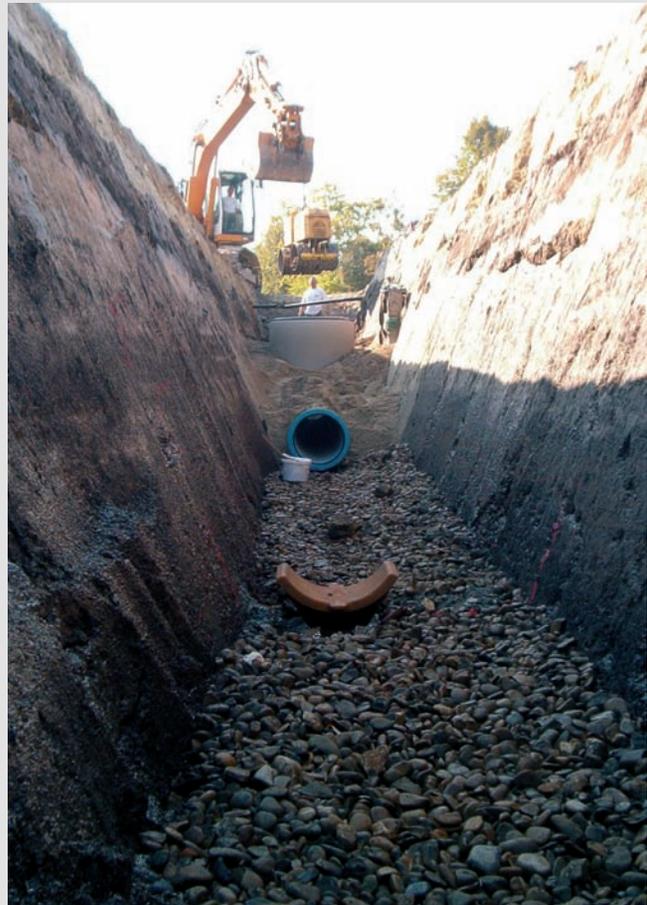
Corrosion rates are dependant upon aggressivity levels of the ground and should be calculated on a site by site basis, to establish residual load bearing capacities. Additional corrosion protection measures include:

- stepping up to the thicker wall pile,
- use of the grout injection pile (external annulus of the pile is fully grouted)



References

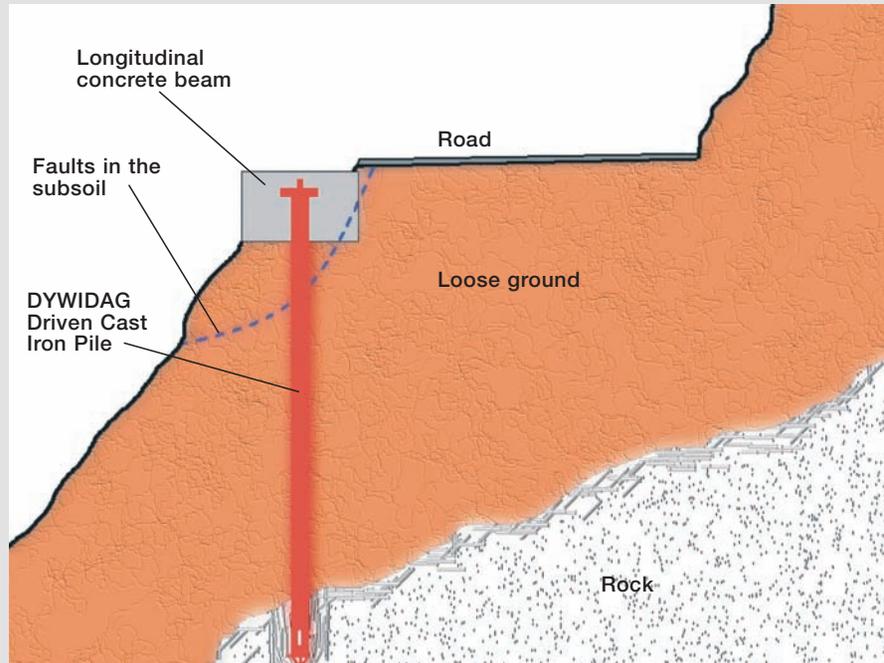
Sewer Line on Piles, Erbach



References

First Use of DYWIDAG Ductile Iron Piles in France

Stabilization of a road connection in the Pyrenees



i **Owner** Department Council of the High Pyrenees, France +++ **Contractor** Cabinet d'Etudes technique Jean Frugier, France +++
Company LTP, France
DSI Services Supply of DYWIDAG Ductile Iron Piles with an overall length of 160 m, Ø 170 mm and accessories, technical assistance

Noerpel Forwarding Agency Warehouse, Ulm



i **Client** Motz Construction Co.
DSI Services Supply of 865 DYWIDAG Ductile Iron Piles, 6.500 m, skin-grouted

References

Furnishing House Gamerding, Böblingen



i Client Keller Grundbau
DSI Services Supply of 332 DYWIDAG Ductile Iron Piles, 3.500 m, not-grouted

Housing Apartments, Monaghan, Ireland



i Client PJ Edwards
DSI Services Supply of 36 DYWIDAG Ductile Iron Piles, each 12-15 m long, non-grouted, technical support and site supervision

References

Coombedown, near Bath, UK



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