

**DYWIDAG
Ductile Iron Piles**



DYWIDAG Ductile Iron Pipe System

The DYWIDAG Ductile Iron Pipe is a driven pile system, utilising high strength ductile cast iron. Pipe 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 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 Pipe can accommodate a range of different ground conditions.

Key features include:

Spigot and Socket Joint

Unique design (with internal shoulder) ensures a very stiff joint, with high resistance to bending.

No Breakdown of Pile Head

There is no breakdown of the pile head as in CFA or Precast concrete piles. The pile is simply cut to level with a disc cutter.

Pitch and Drive Speed

Piles can be pitched and driven in quick succession. The connection of each new section is made easy with the spigot and socket joint.

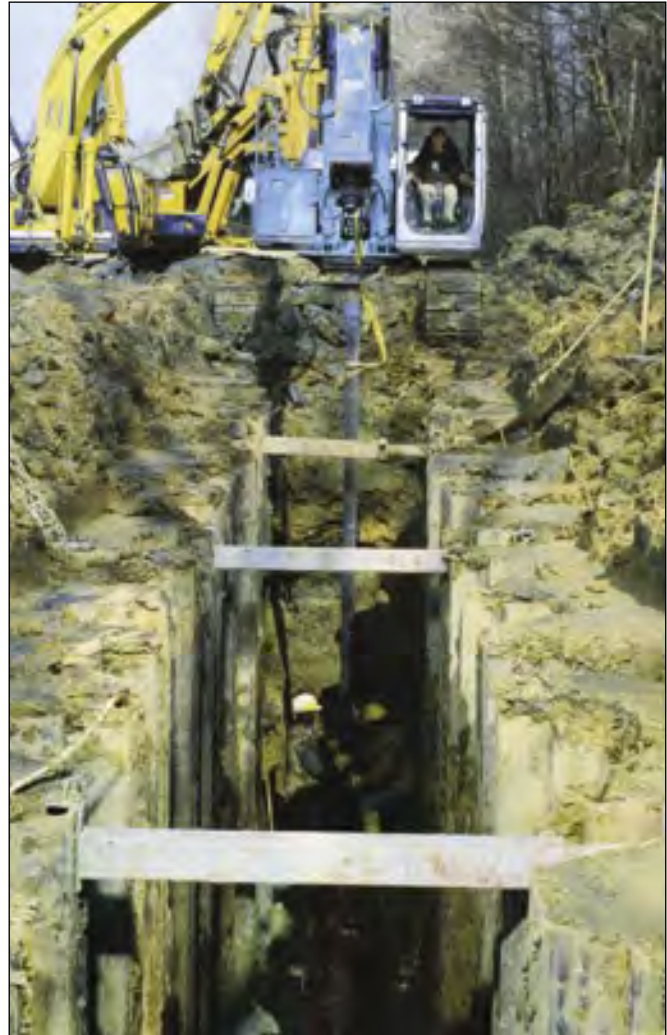
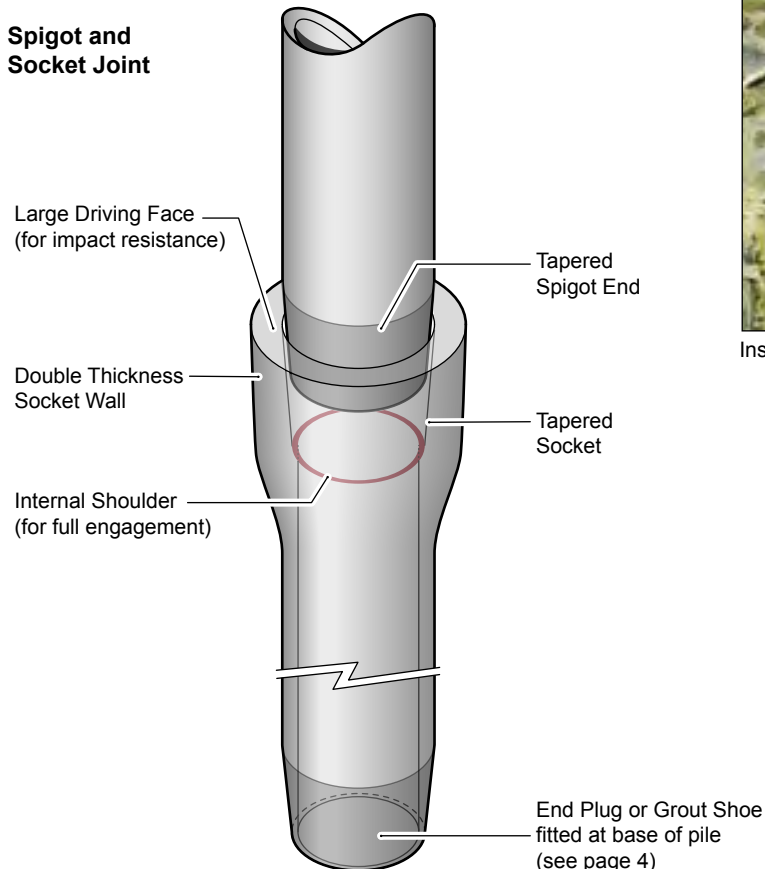
Installation by Excavator

Considerably lighter and far more versatile than conventional piling plant, excavators offer greater flexibility and faster rates of installation.

Composite Pile

Ultimate pile strength is a combination of the strength from the ductile iron pipe, together with the concreted bore.

Spigot and Socket Joint



Installation of Ductile Iron Piles for pipeline support



Simple cut down of pile head using a disc cutter

Technical Data

1. Ductile Iron

Pile Type	O.D. mm	Wall Thickness mm	Socket O.D. mm	Cross Sectional Area ^(a) mm ²	Grade of Ductile Iron ^(b) N/mm ²	Ultimate Strength kN	Yield Strength kN	Working Load ^(c) kN	Weight per Section ^(d) kg
118 / 7.5	118	7.5	160	2604	320 / 420	1093	833	524	133
118 / 9.0	118	9.0	160	3082	320 / 420	1294	986	621	145
170 / 9.0	170	9.0	218	4552	320 / 420	1911	1456	917	242
170 / 10.6	170	10.6	218	5309	320 / 420	2229	1698	1069	250

Notes:

- Cross sectional areas based on minimum values (values can increase by 17-22%).
- Yield stress and ultimate stress values in accordance with Approval Certificate (Deutsches Institut für Bautechnik, Z-34.25-202).
- Working load of Ductile Iron calculated from yield stress x minimum cross sectional area, with EC1 factors applied.
- Weight tolerance: maximum section weights quoted.

Modulus of Elasticity: E = 160,000 N/mm²

Section Lengths: 5.0m for all piles; O.A.L. of 118 pile sections = 5.155m, O.A.L. of 170 pile sections = 5.215m.

2. Internal Strength of Composite Pile (i.e. Ductile Iron + Concreted Bore)

Pile Type	Cross Sectional Area of Concrete Bore mm ²	Concrete Grade (cylinder / cube)	Concrete Cylinder Stress N/mm ²	Ultimate Strength ^(a) (of concrete bore) kN	Working Load ^(b) (of concrete bore) kN	Working Load of Composite Pile ^(c) (Ductile Iron + Concrete Bore) kN
118 / 7.5	8333	28/35	28	233	95	619
118 / 9.0	7855	28/35	28	219	90	711
170 / 9.0	18148	28/35	28	508	208	1125
170 / 10.6	17392	28/35	28	486	199	1268

Notes:

- Ultimate compressive strength of concrete (f_{cu}) based on cylinder stress value, in accordance with EN 206 (C28/35 concrete). Alternative concrete grades e.g. C32/40 may also be used, depending on site requirements.
- Working load of concrete calculated from ultimate stress (of cylinder), with EC1 factors applied.
- Working load of Composite Pile: working load of ductile iron pile section (from table 1, above) + working load of concrete bore (table 2).
N.B. Requisite working loads should be calculated in accordance with project requirements.

All loads are quoted as Internal Loads. Achievable pile loads on site are dependant upon ground conditions.

Minimum shear strength of 10 kN/m² required (in cohesive soils only), for lateral restraint of the pile shaft against buckling.

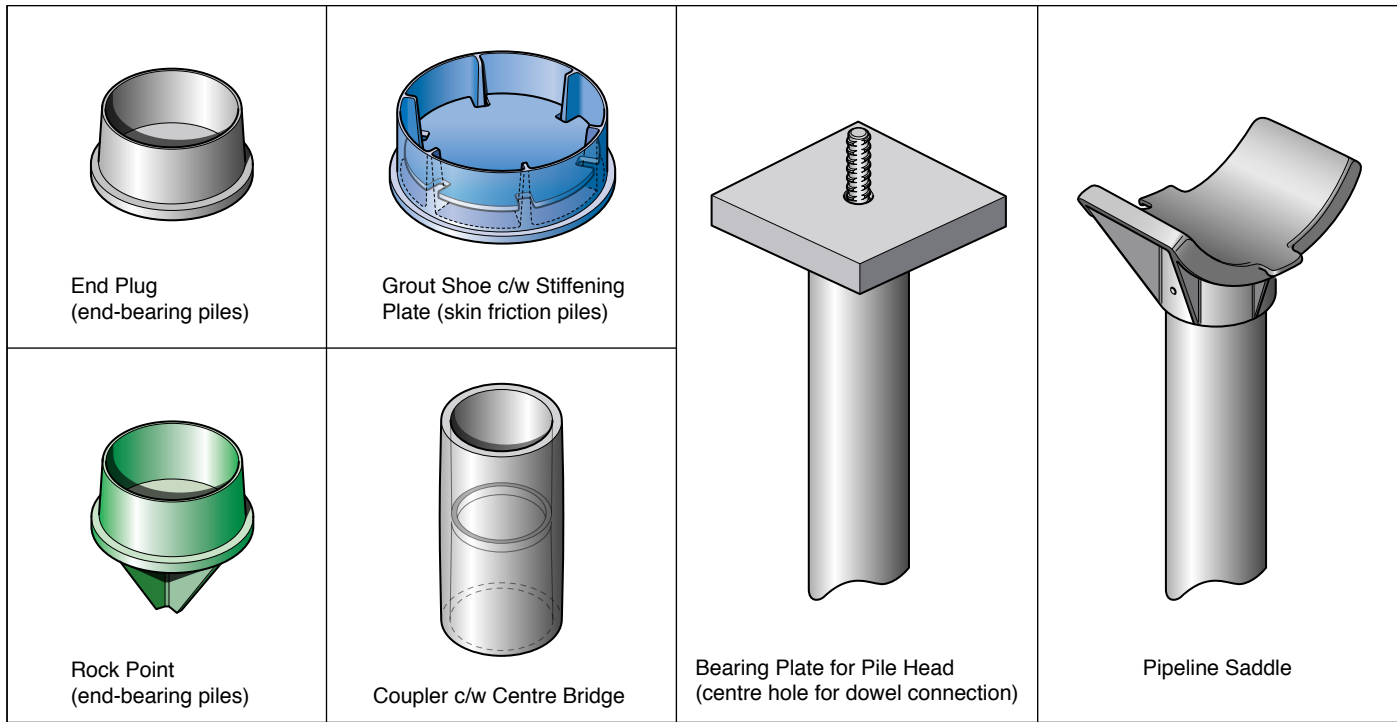


Grout injection piles for a factory unit



Ductile Iron Piles driven at formation level of ground beams

Ductile Iron Pile Accessories



Pile Type	End Plug (O.D.)	Grout Shoe (O.D.)	Rock Point (O.D.)	Bearing Plate	Pipeline Saddle (Pipe Ø)	Coupler
118	120	200	120	200 x 200 x 40	200, 250, 300, 400, 500	Ø 165 x L 400
170	175	250	175	250 x 250 x 40	N / A	Ø 220 x L 450

Notes:

- End Plugs and Rock Points are specific to the wall thickness of each pile section (i.e. 118 / 7.5, 118 / 9.0 or 170 / 9.0, 170 / 10.6).
- Grout Shoes fit over the outside of the pile end. Ø 200 shoe fits both 118 / 7.5 and 118 / 9.0 piles, Ø 250 shoe fits both 170 piles. Internal stiffening plate included with both shoe types.
- Couplers are used for limited headroom applications or where re-drive of a damaged section is required. Coupler features a tapered internal bore at both ends, together with a centre bridge. Also used to joint off-cut pile sections or as connection to the hammer shank. N.B. The spigot ends of pile sections should be removed, to ensure full engagement against centre bridge.

Corrosion Assessment for Ductile Iron Piles

Ductile Iron Piles have superior corrosion resistance to steel piles. Lifespans are typically based on sacrificial corrosion rates applied to the outside diameter of the pile, the internal diameter is not subject to corrosion as it is filled with concrete.

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).

Vibration

The vibratory response from the excavator mounted hammer is low. Whilst the hammer frequency is quite high (up to 10 Hz), the percussive energy is low (up to 4950 J), when compared with conventional piling hammers (30,000 J). As a result the recorded PPV (Peak Particle Velocity) values are low, even when classified as Continuous Vibration.

Both BS 5228-4 and DIN 4150-3 state acceptable PPV values for working in the close proximity of buildings. In all cases, PPV values recorded during the installation of Ductile Iron Piles were below those stated for each type of building, including historic buildings.



Banksman and staff for driving alignment

Driven Piles (with concreted bore) – End Bearing

Driven installation using the 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	Hammer Size Krupp / Atlas Copco	Hammer Power Joules	Rate of Penetration mm / minute
118	HM1000 / MB 1700	3577	30 / 1
170	HM1500 / MB 2200	4950	30 / 1

Notes:

- Set should be proven by 3 No. re-drives on first five piles, thereafter once or twice, in conjunction with monitoring of adjacent driven pile lengths.
- 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	Ø End Plug mm	Contact Bearing Area of End Plug mm ²	Ø Pile Socket mm	Extra Bearing Area of Socket ⁽¹⁾ mm ²
118	120	11311	160	8797
170	175	24055	218	13275

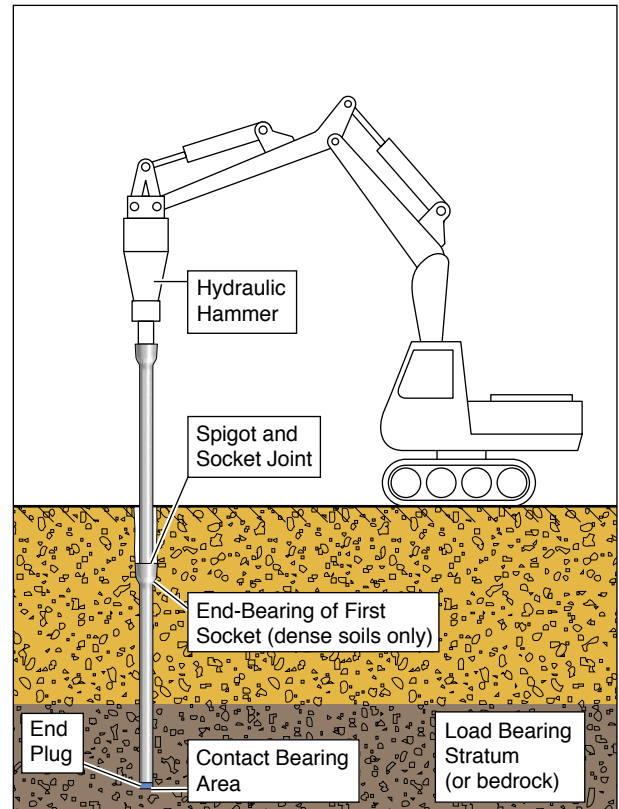
Notes:

- Extra end-bearing area at underside of socket, only applicable to the first pile socket, in dense soils. Area calculated from full socket area less area of the end plug.
- End-Bearing performance of driven Ductile Iron Piles based on contact bearing stress at the end plug. Additional bearing stress, from the underside of the first socket, only applicable where the socket is in a load bearing zone (i.e. deep piles in dense soils).

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 10mm aggregate and high fines content is typically used to concrete the bore of the pile. Slump of 150 to 175 or collapse, ensures full placement in the bore. Concrete strength: C32/40 or as required (see page 3).



Driven Piles (end-bearing) for apartment blocks



Installation of Ductile Iron Piles for new housing development and hotel

Grout Injection Driven Piles – Skin Friction

Grout Injection 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 sanded grout, to mobilise shaft friction.

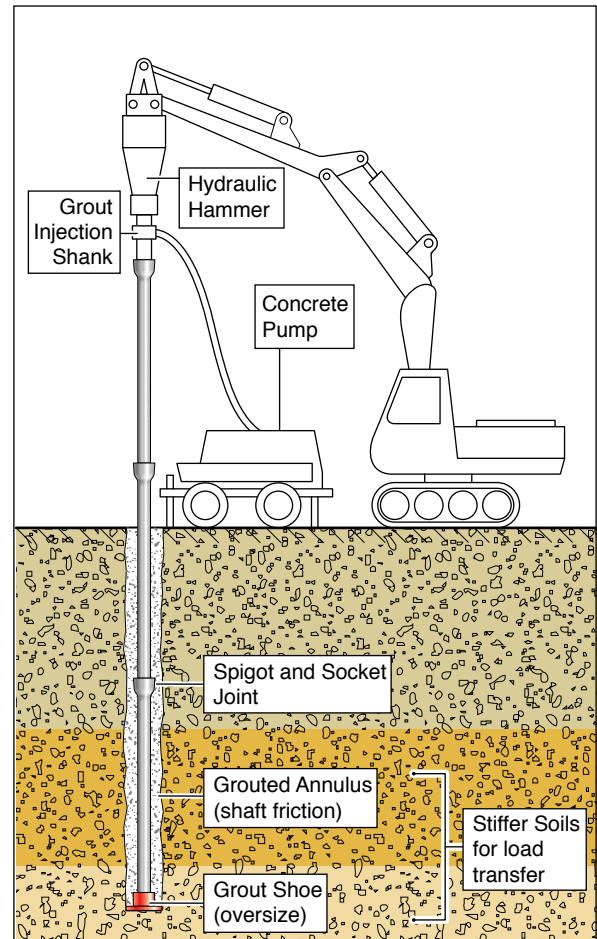
Installed by the simultaneous drive and grout technique, grouted piles can be used in ground conditions where other systems are not suitable (i.e. high ground water or contaminated sites).

Indicative Driving Rates and Skin Friction Values

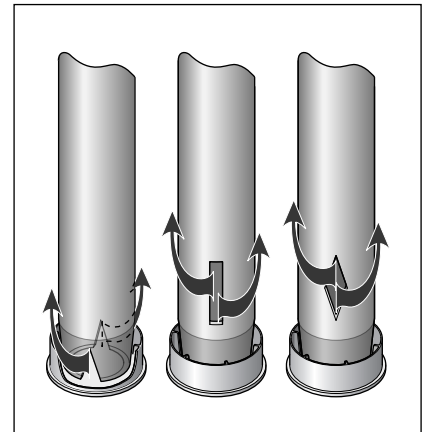
Soil Grade		SPT (N) Value	Driving Rate seconds / metre	Skin Friction N/mm ²
Cohesive	Stiff (75-150 kPa)	10-14	10-15	(0.04)
	V. Stiff (150-300 kPa)	16-30	15-30	0.07
	Hard (>300 kPa)	>30	>30	0.1
Granular	Medium Dense	10-30	10-20	0.08
	Dense	30-50	20-30	0.12
	V. Dense	>60	>30	0.15

Notes:

1. Driving rates based on grout shoe (Ø200 for 118 piles, Ø250 for 170 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 is informative only, not used for pile loading.
4. Skin friction values are based on approximate stresses, with S_v of 2 applied. Site trials should be conducted to establish true values.



Grout injection through the pile bore during driving



Cutaway options for grout injection piles



Visible return of sanded grout (118/7.5 pile)

Sanded Grout Mix

Highly pumpable cohesive mix, to pass through 50mm hoses and a 35mm aperture in the hammer shank. Slump: 175 to collapse. Retarder: 6 hours (open life of mix is essential during pump downtime).

Typical Mix	1.0m ³
Mortar Sand (0-3mm)	800 kg
Washed Sand (3-4mm)	700 kg
Cement 80% PFA 20%	410 kg
Plasticiser (0.8% of cement)	3.3 kg
Water	255 Ltr

Installation Plant and Equipment

Excavator and Hammer

Pile Type	Excavator Size Tonnes	Hammer Type Krupp / Atlas Copco	Hammer Power Joules	Hammer Blows Per Minute	Hammer Size Length (m) / Weight (t)
118	25	HM1000 / MB 1700	4020	320-600	2.0 / 1.7
170	30	HM1500 / HB 2200	4950	280-550	2.2 / 2.2

N.B. Excavators must have sufficient boom / jib height, to handle the hammer length plus the pile section. Minimum jib heights: 118 Piles = 7.3m, 170 Piles = 7.5m.

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 10mm concrete.



Grout Injection Shank with Grout Box

Used for installation of grout injection piles (skin friction). A sanded grout, with 4mm aggregate, is pumped through the pile as it is driven, ensuring the annulus between the pile shaft and the ground is fully grouted.



Concrete pump and agitator for grout injection driven piles (pump performance: 20 Ltr / hr, 20-40 bar)



Pitching of a pile (note: lifting sling, shackled at the nose of the hammer)



Excavator and hammer for pile installation

Pile Testing

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 analysis, 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).



Static pile test

DYWIDAG Ductile Iron Pile - Applications



Silo Bases



Pipeline support



Piles for power transmission towers



Housing apartments or factory units



Machine bases



Raked piles

Issue 1.0 06.2005

Quality Assurance

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