Pipe Jacking

An introduction to pipe jacking prepared by the
Pipe Jacking Association

Pipe Jacking – General Arrangement

Pipe Jacking is an integrated system linking:

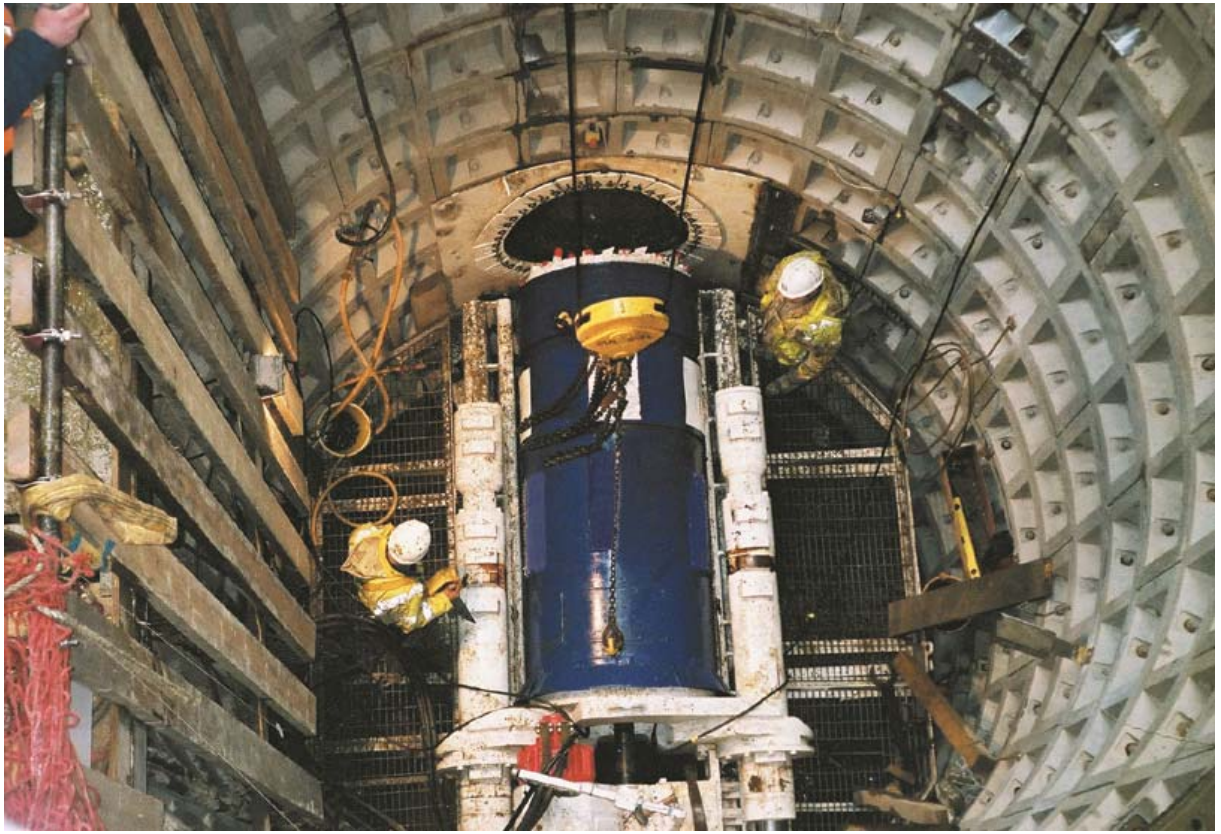
- soils
- jacking shafts
- pipes
- shields
- jacking loads
- engineering

Major Applications

- New sewerage and drainage construction
- Sewer replacement and lining
- Gas and water mains
- Oil pipelines
- Electricity and telecoms cable ducts
- Subways

Pipe Jacking

Pipe Jacking



Microtunnelling

Technical Benefits

- Inherent strength
- Smooth internal finish
- No secondary lining
- Fewer joints
- Watertight
- Inverts for combined systems
- Less settlement
- Minimal surface impact
- Fewer utility diversions

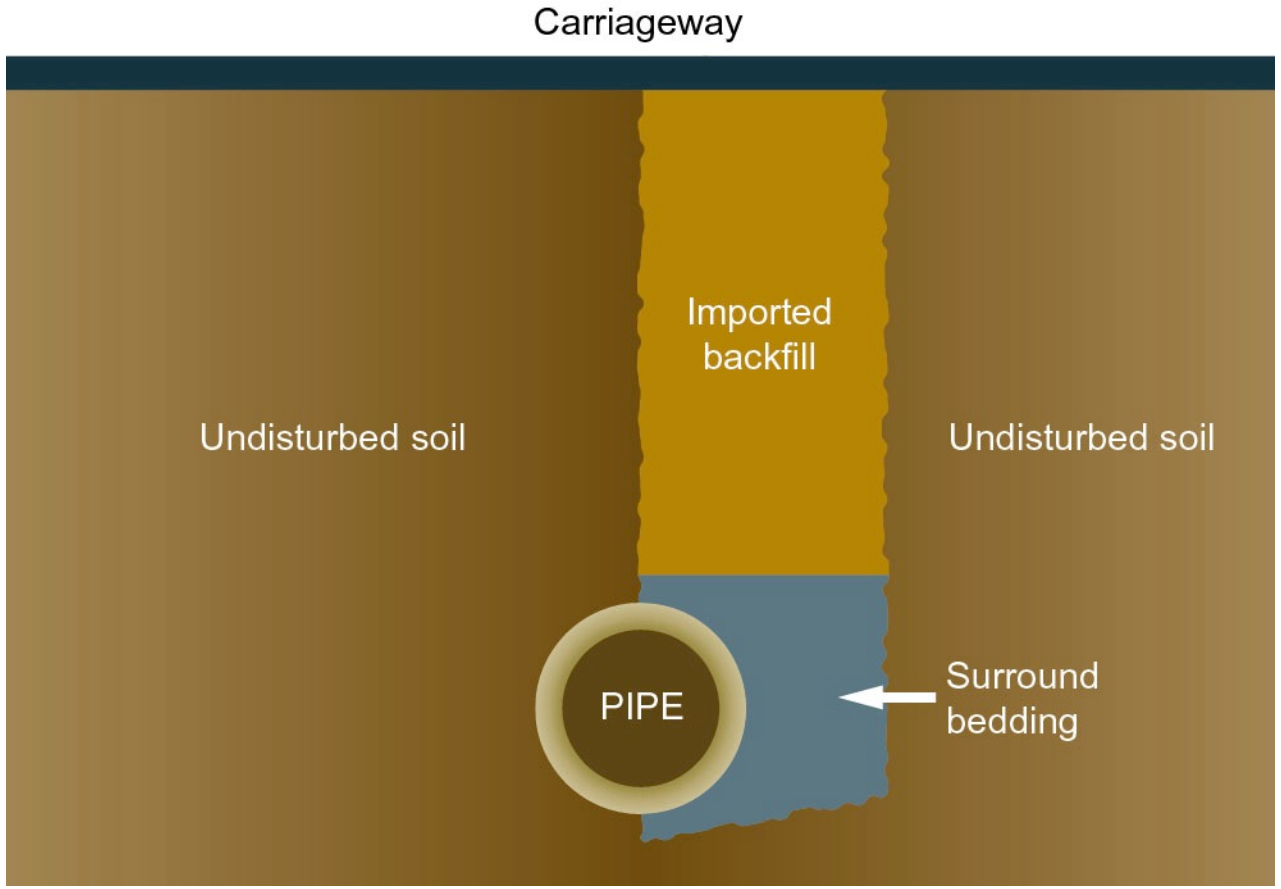
Safety Benefits

- Inherently safer method
- Quicker installation
- Reduced labour input
- Utility strikes minimised
- Public interface reduced
- Reduced confined space man hours

Sustainability: Environmental and socio-economic benefits

- Reduces disruption
- Reduces damage to services
- Maintains highway integrity
- 90% fewer vehicle movements
- Less spoil
- Less quarried material
- Reduced CO_2 emissions
- No secondary lining
- Economic alternative to deep open cut
- Socially acceptable

Open trench vs Pipejacking



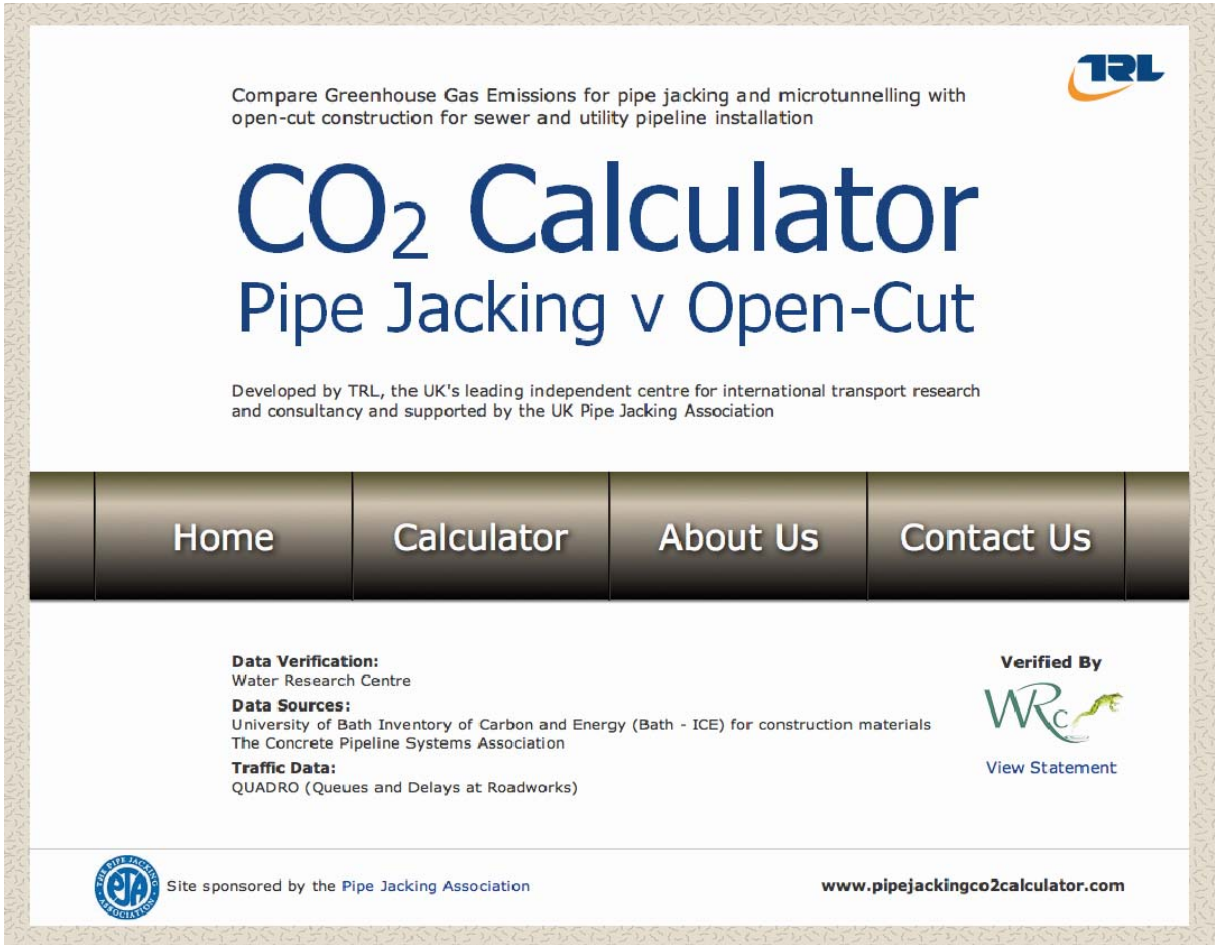
Open trench vs Pipejacking

Lorry Movements

	600mm ID pipeline 4m deep, 100m length		1200mm ID pipeline 4m deep, 100m length	
Aspect	Open trench	Trenchless	Open trench	Trenchless
Excavated width	1400mm (trench width)	760mm (OD of jacking pipe)	2350mm (trench width)	1450mm (OD of jacking pipe)
Reinstatement width	1700mm	None	2650mm	None
Excavated volume per metre of pipeline	6.1m^3	0.5m^3	10.28m^3	1.65m^3
Imported stone fill and coated stone per metre of pipeline	11.9 tonnes	None	18.27 tonnes	None
Number of 20 tonne lorry loads per 100m pipeline (muck away and imported stone)	136	8	220	21

Carbon Calculator

- Easy to use
- Options:
  - Feasibility
  - As designed
  - As built



Open trench vs Pipejacking

CO_2 Savings – 100 metres

Project Data **4m** depth to invert	**600mm diameter pipeline 100m length x 4m deep**		**1200mm diameter pipeline 100m length x 4m deep**	
Method	Open cut	Pipejacking	Open cut	Pipejacking
Tonnes CO_2	66.7	27.1	110.6	69.7
CO_2 saving	39.6 tonnes = **59% saving**		40.9 tonnes = **37% saving**	

Project Data **6m** depth to invert	**600mm diameter pipeline 100m length x 6m deep**		**1200mm diameter pipeline 100m length x 6m deep**	
Method	Open cut	Pipejacking	Open cut	Pipejacking
Tonnes CO_2	92.7	30.4	148.1	77.4
CO_2 saving	62.3 tonnes = **67% saving**		70.7 tonnes = **48% saving**	

Open trench vs Pipejacking

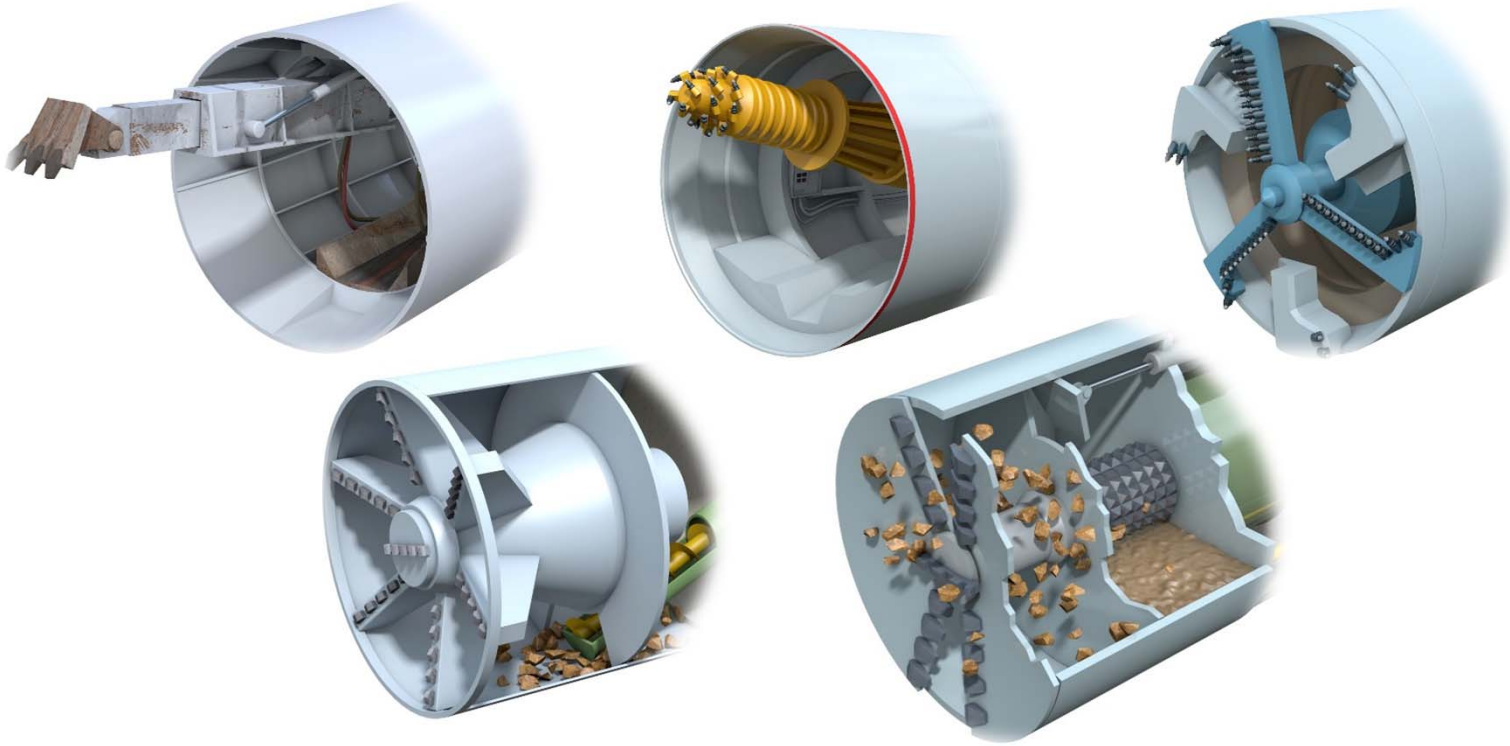
CO_2 Savings – 500 metres

Project Data **4m** depth to invert	**600mm diameter pipeline 500m length x 4m deep**		**1200mm diameter pipeline 500m length x 4m deep**	
Method	Open cut	Pipejacking	Open cut	Pipejacking
Tonnes CO_2	351.4	113.3	570.6	301.8
CO_2 saving	238.1 tonnes = **68% saving**		268.8 tonnes = **47% saving**	

Project Data **6m** depth to invert	**600mm diameter pipeline 500m length x 6m deep**		**1200mm diameter pipeline 500m length x 6m deep**	
Method	Open cut	Pipejacking	Open cut	Pipejacking
Tonnes CO_2	492.4	124.6	765.5	328.3
CO_2 saving	367.8 tonnes = **75% saving**		437.2 tonnes = **57% saving**	

Machine Technology

Machines are available for pipe jacking in most ground conditions



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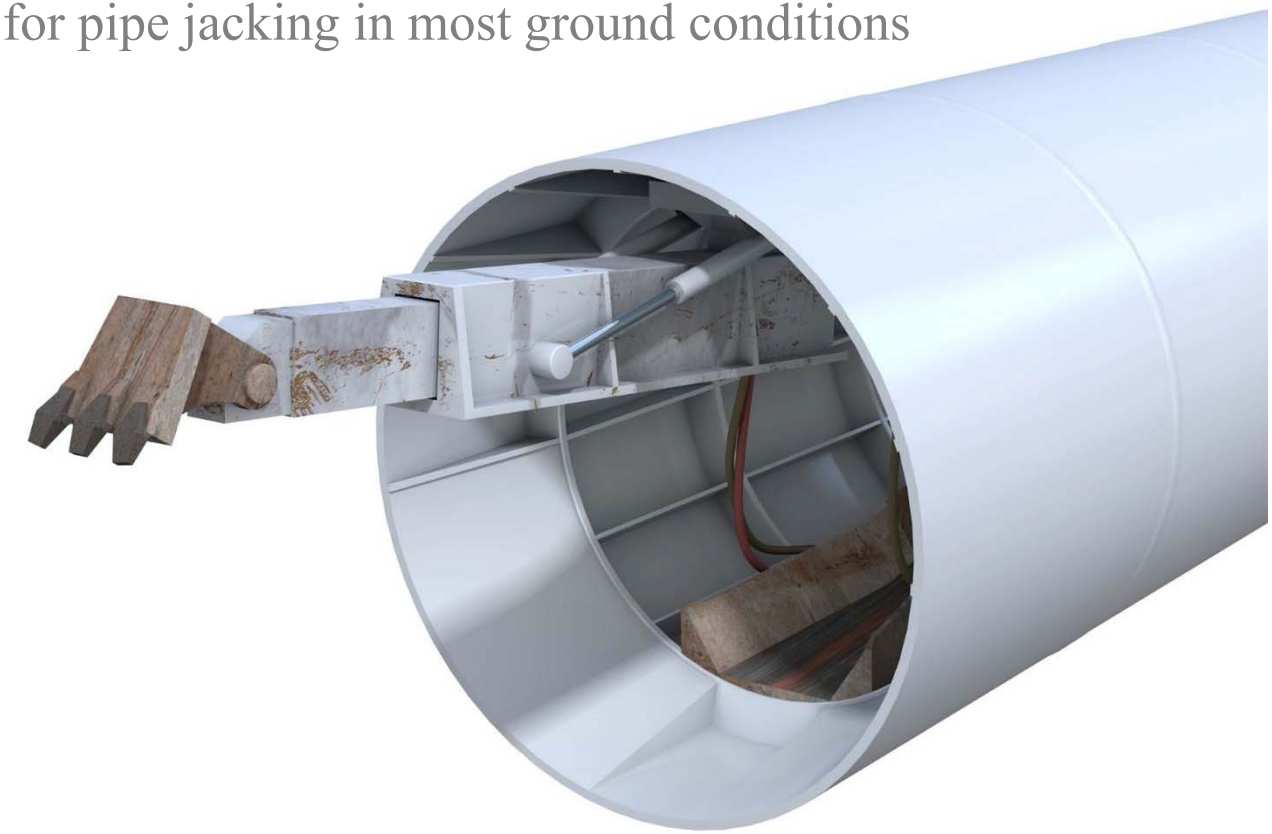
- Backacters



Machine Technology

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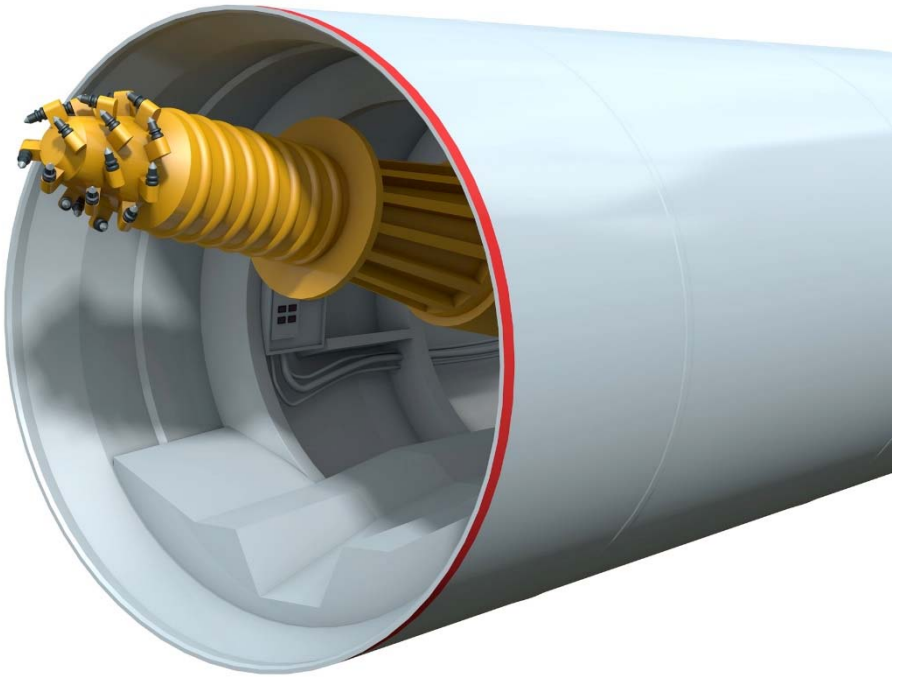
- Backacters
- Open face cutter booms



Machine Technology

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- Backacters
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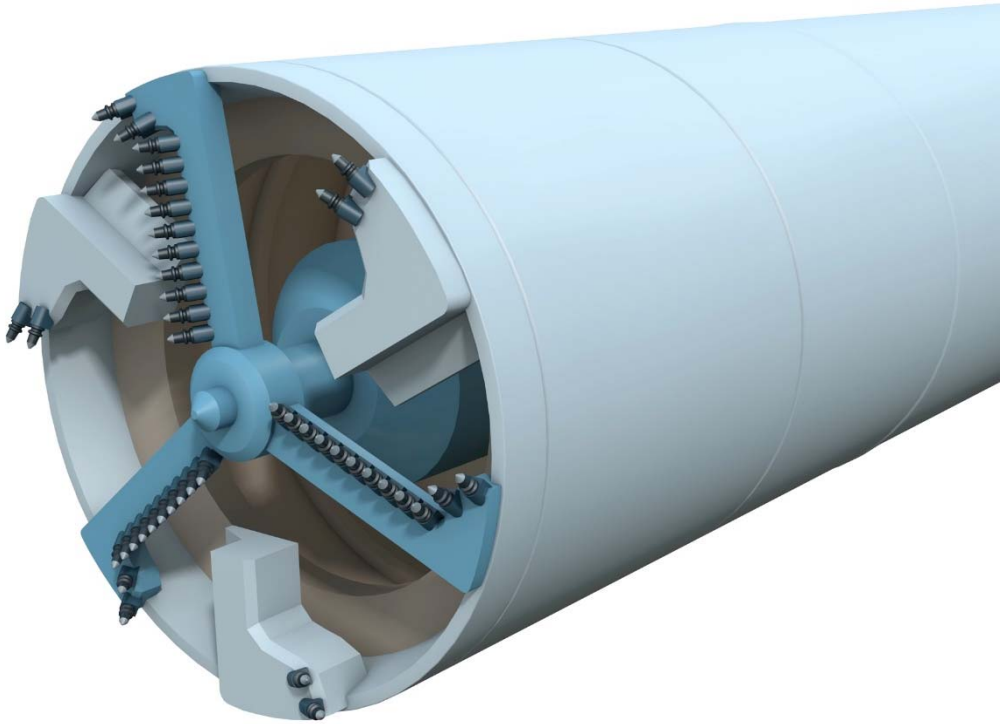
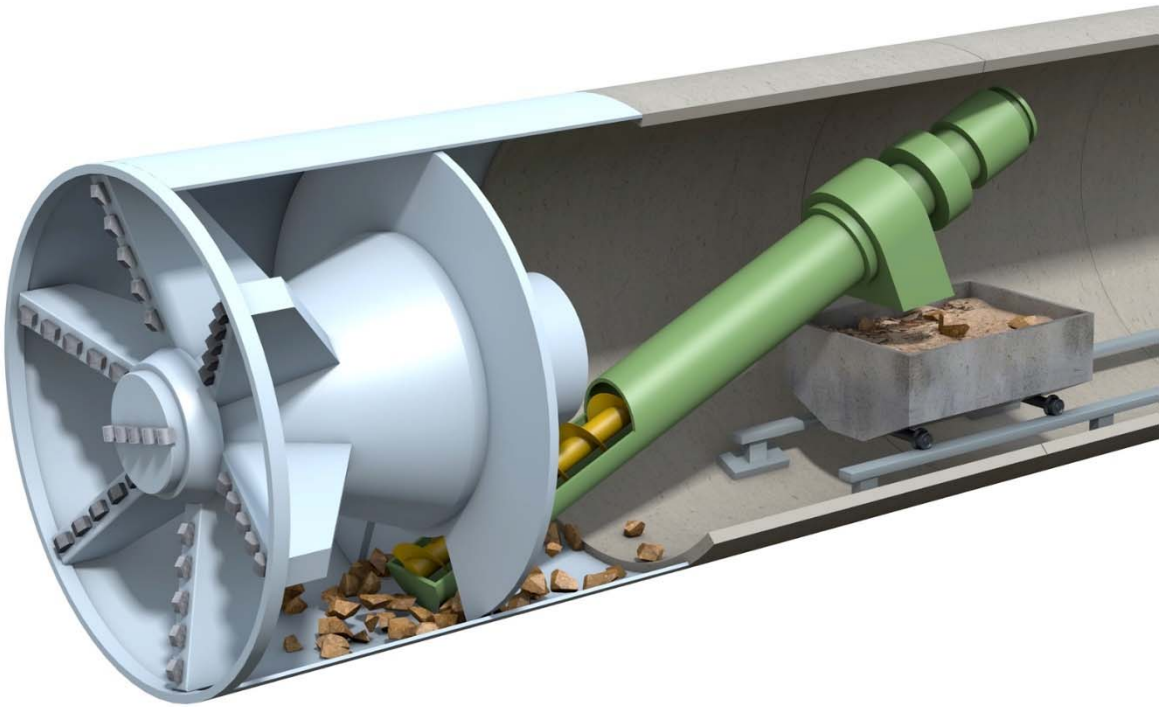
- Tunnel boring machine



Machine Technology

Machines are available for pipe jacking in most ground conditions

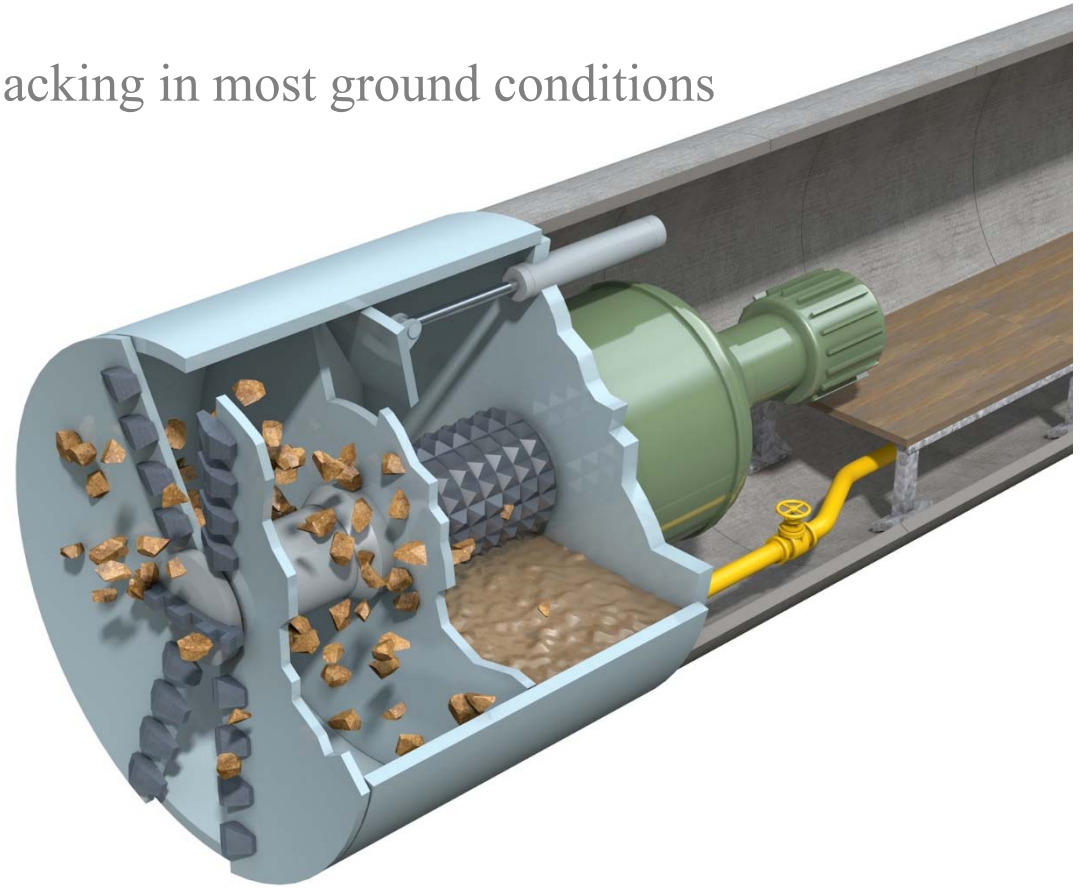
- Backacters
- Open face cutter booms
- Tunnel boring machine
- Earth pressure balance



Machine Technology

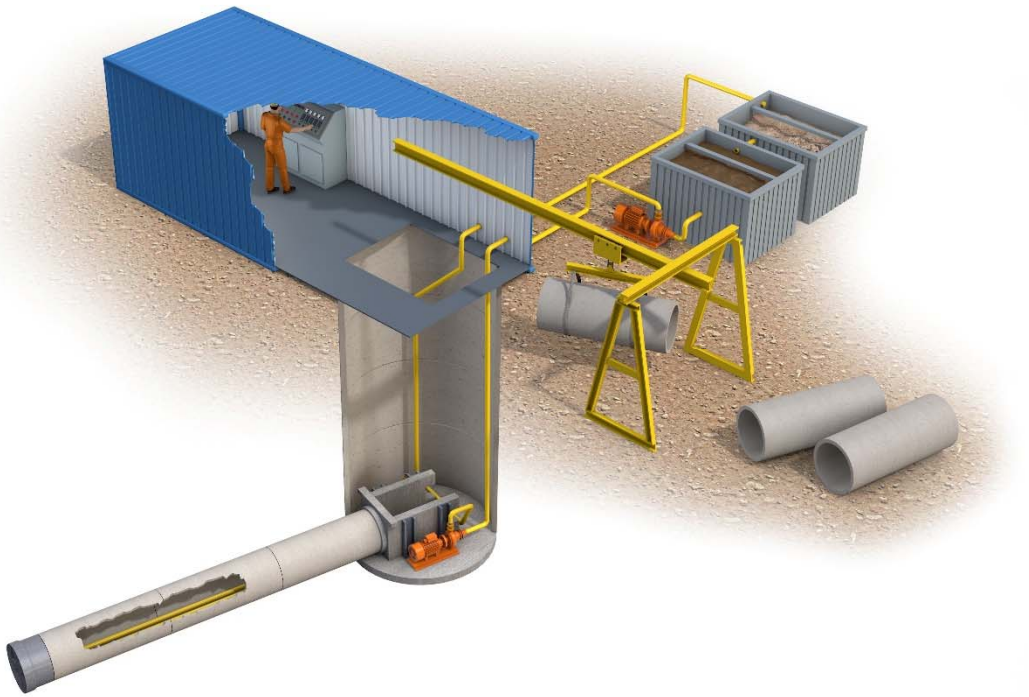
Machines are available for pipe jacking in most ground conditions

- Backacters
- Open face cutter booms
- Tunnel boring machine
- Earth pressure balance
- Pressurised slurry



Microtunnelling

- Fully guided machines
- Controlled from surface
- 1000mm id and below
- Non man entry
- Two options:
  - Pressurised slurry
  - Screw auger



Advantages of Mechanisation

- Significantly safer working
- Efficient
- Hand arm vibration eliminated
- Quicker installation
- Ground support
- Remote control
- Risks mitigated

Drive Lengths and Diameters - HSE Recommendations

<table>
<tr><th>EXCAVATION TECHNIQUE</th><th><0.9M</th><th>0.9M</th><th>1.0M</th><th>1.2M</th><th>1.35M</th><th>1.5M</th><th>1.8M</th><th>>1.8M</th></tr>
<tr><td rowspan="2">Pipe jack – machine; remote operation from surface</td><td colspan="3">Drive length limited only by capacity of jacking system</td><td rowspan="2" colspan="2">250m</td><td rowspan="2">400m</td><td rowspan="2" colspan="2">>500m</td></tr>
<tr><td colspan="2">Man entry not acceptable</td><td>Avoid man entry</td></tr>
<tr><td>Pipe jack – machine; operator controlled below ground</td><td colspan="3">Not Acceptable</td><td>125m</td><td>200m</td><td>300m</td><td>500m</td><td>>500m</td></tr>
<tr><td rowspan="3">Pipe jack – hand dig</td><td colspan="3" rowspan="3">Not Acceptable</td><td>25m</td><td>50m</td><td>75m</td><td colspan="2">100m</td></tr>
<tr><td colspan="3" rowspan="2">2 drive lengths</td><td colspan="2">1 drive length</td></tr>
<tr><td colspan="2">Use minidigger if > 2.1m</td></tr>
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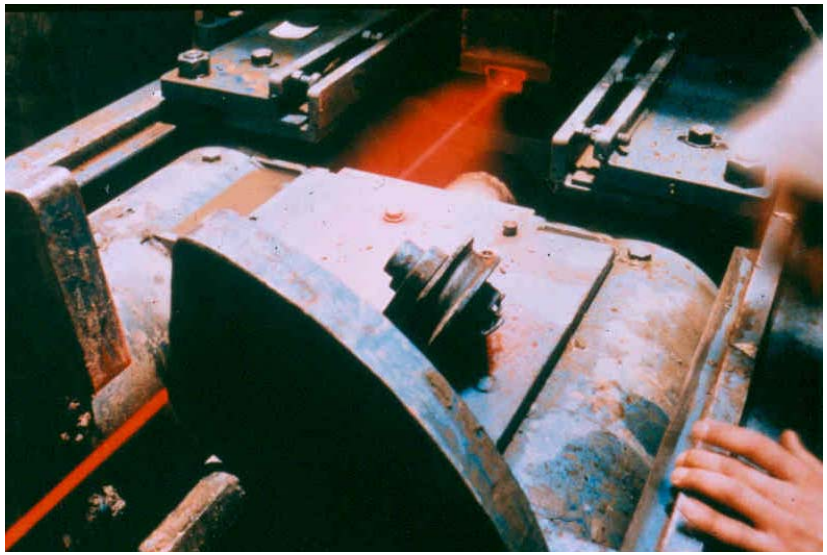
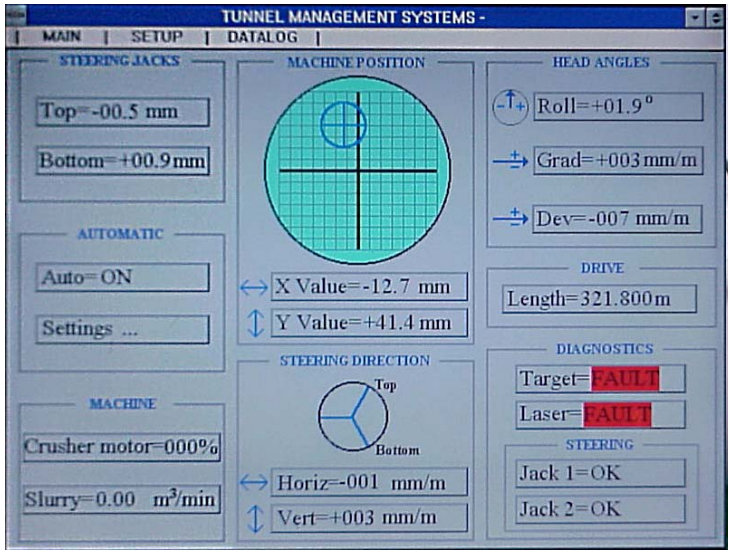
Laser Guidance

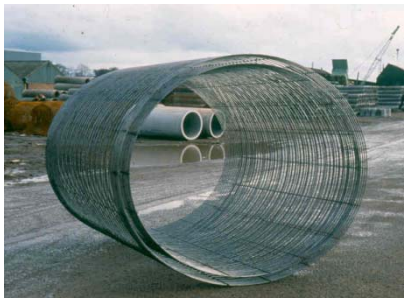
- Real-time line and level checks
- Maintains accuracy in difficult ground
- Allows remote operations



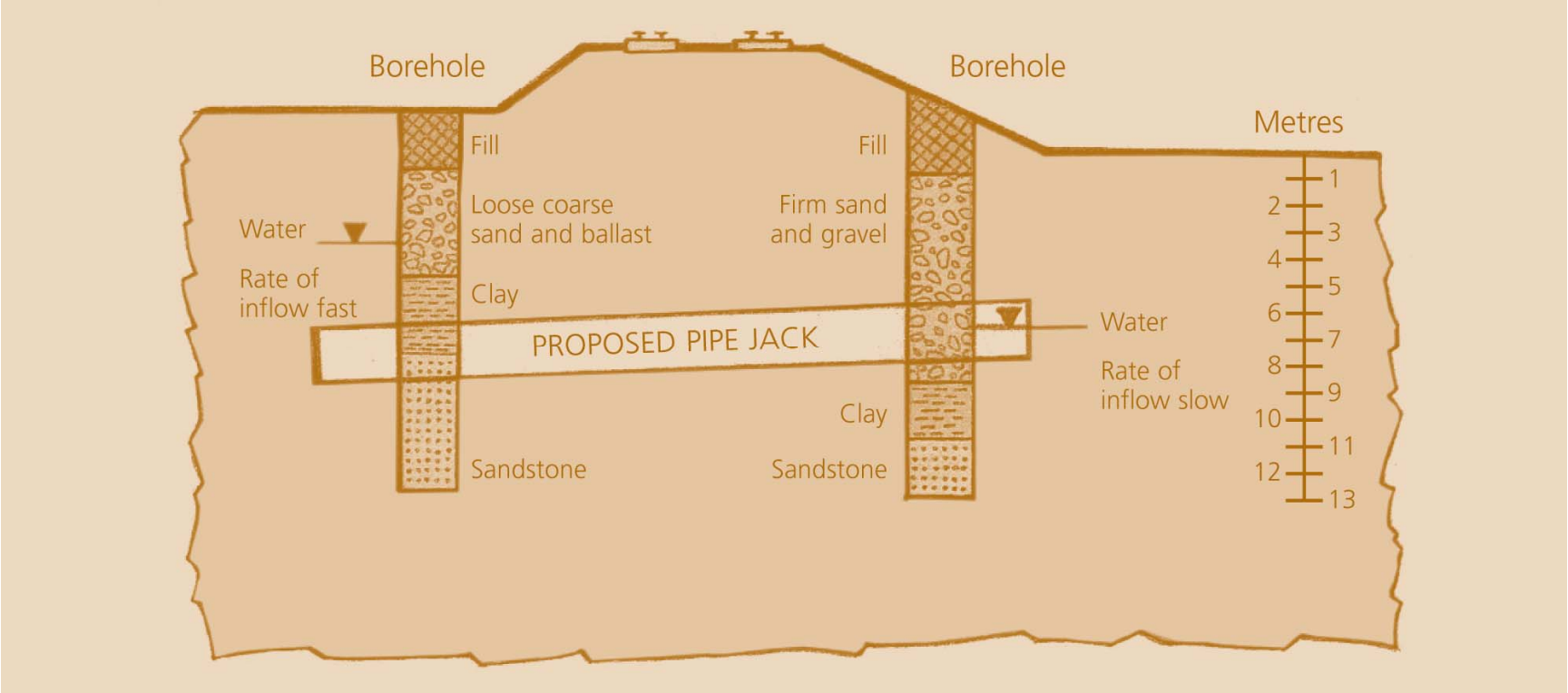


Pipe Jacking Pipes

- Concrete jacking pipes: BS EN 1916
- Clay pipes: BS EN 296-7 and BS EN 12899: 2000
- Installation forces are key
- Follow manufacturers recommendations
- Steel pipes: sleeves for pressure mains



Site Investigation



Soil Conditions

Test	Non-Cohesive Soils	Cohesive Soils	Mixed Soils	Fill Material	Rock
Unit weight and moisture content	✔	✔	✔	✔	✔
Angle of friction	✔		✔	✔	
Particle size distribution	✔	✔	✔	✔	
Abrasivity	✔	✔	✔	✔	✔
Cohesion		✔	✔	✔	
Types and proportions of minerals	✔	✔	✔	✔	✔
Standard penetration tests	✔	✔	✔	✔	
Permeability and nature of ground water flows (seasonal/tidal changes)	✔		✔	✔	✔
Toxic/hazardous constituents in the ground/groundwater	✔	✔	✔	✔	✔
Frequency and physical properties of boulders, cobbles or flints	✔	✔	✔	✔	✔
Pump down tests	✔		✔	✔	✔
Presence of gases				✔	✔
Compressive strength					✔
Rock quality designation (RQD)					✔
Core logging (TCR, SCR, FI)					✔
Tensile strength					✔
Specific energy (excavatability)					✔
Slake durability					✔
Geological description	✔	✔	✔		✔
Plasticity indicees (SL, PL, PI)		✔	✔		

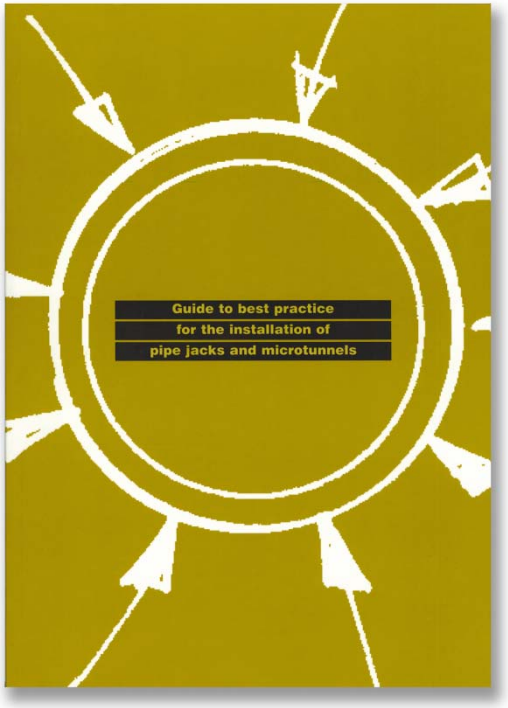
Research Projects at leading universities

University research programme initiated in 1986 – projects include:

- Laboratory testing of model jacked pipes
- Field testing of performance of pipes
- Finite element analysis of concrete jacking pipes
- Full scale testing of concrete pipes
- Soil conditioning and lubrication materials
- Field testing of soil conditioning and lubrication methods
- Slurry management

Guide to Best Practice

- Soils investigation
- Excavation systems
- Temporary and permanent works
- Jacking lengths and friction forces
- Best installation practice
- Worked examples and checklists



Additional Applications

Box Sections

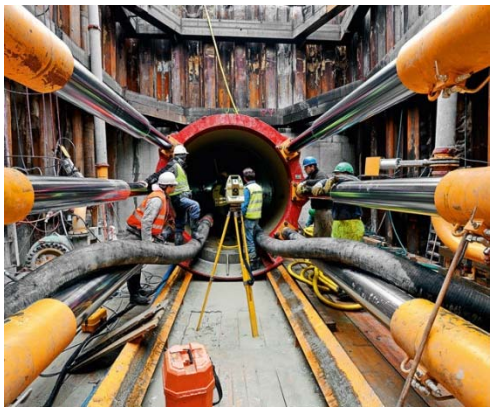
- Subways
- Roadways

Other uses

- Jacked arches
- Bridge slide foundations

Summary

- Engineering integrity
- Low capital costs
- Low maintenance
- Cost-effective
- Safe installation
- Environmental benefits
- Reduced CO_2 emissions
- Extensively used
- 150mm to 3m diameters
- Long drive lengths
- Engineering performance

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