Balfour Beatty Ground Engineering

Market leading ground engineering

Balfour Beatty
Ground Engineering

- Successful
- Sustainable
- Skilled

Success built on strong foundations

Balfour Beatty Ground Engineering is a UK leading specialist geotechnical contractor providing innovative piling and ground improvement solutions across all sectors.

Providing firm foundations for generations to come

Our ground engineering skills, equipment and experience provide a solid foundation for project of all sizes.

We work across all construction sectors, helping customers achieve cost savings by fully value engineering projects using the latest design technology.

We best demonstrate our capabilities when we're consulted early on, sharing expertise and experience to get your project out of the ground.

Through collaboration with academic institutions, we make sure our techniques are at the forefront of innovation, offering customer's effective solutions to their challenges.

We are proud to be the first ground engineering company able to evaluate our solutions for embedded carbon.


100 Bishopsgate


Blackfriars


Balmore Factory

Focus on piling and foundations

Rotary large diameter piling

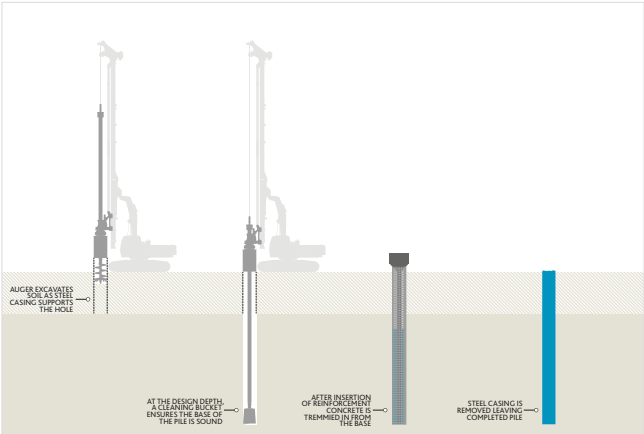
Primarily used for large public, commercial and industrial developments as well as transport infrastructure projects, we are one of the largest contractors in this field. We have particular expertise in delivering large, complex and technically challenging projects.

Balfour Beatty Ground Engineering offer a comprehensive range of piling systems in the UK and Ireland.

- Rotary large diameter piles
- Continuous Flight Auger (CFA) piles
- Driven piles
- Mini piles

Rotary bored piling rig

Rotary bored piling technique



Top down construction is used to speed up construction of multi-storey projects with deep basements. Plunge columns within piles are used to enable the construction of the building above ground level to commence at the same time as excavation for the basement, saving months off the construction period.

Other developments include under reams for very high loads and drilling fluids such as bentonite and vinyl polymer, where the bore requires support during excavation.

To save on the construction of pile caps they can sometimes be removed altogether by embedding the steel structure directly into the top of large diameter piles. These are known as monopiles.

The technique

An auger is used to excavate the soils, whilst a steel casing is inserted to maintain the bore through the top layers of unstable ground. A steel cage or pattern of reinforcing bars is introduced into the bore before the concrete is poured. The steel casing is later withdrawn. Where collapsible conditions are expected at depth, vinyl polymer or bentonite support fluids can be used.

The key strengths of this technique are, the ability to deal with obstructions and the minimal disturbance. This method is suitable for all soil types and ideal for retaining walls.

Rotary bored piling technique capabilities

Dimensions	From	To
Practical Depth	N/A	70m
Diameter	0.45m	3.0m
Typical Load Capacity	1000kN	30,000kN
Rig Height	12.5m	28m
Rig Weight	37,000kg	140,000kg
Rig Length	7m	10m
Rig Width	3m	5m
Noise Profile at 10m	85db	90db

- 267 rotary piles (0.9-2.1m diameter)
- 484m length of diaphragm wall
- 177 Plunge columns

Case Study:

One Nine Elms, Vauxhall, London

One of the largest-ever foundation projects in the UK (c. £46m), to support two high-rise towers up to 57 storeys, overlooking the Thames in Wandsworth. Ground engineering included 267 rotary piles up to 60m deep.

This £1bn mixed residential and commercial scheme for Chinese developer, Wanda UK, (their first in UK) is situated on a site underlain by very complex ground conditions. As well as a deep glacial scour feature, infilled with very weak soils, the team had to contend with 127no. existing piles 900mm diameter and up to 33m deep. These had to be removed by coring (believed to be the largest pile removal programme in the UK), and replaced with a 'synthetic' soil before new piles could be installed. To form the huge 12m deep basement a 0.8m thick diaphragm wall, up to 42m deep was constructed.

CGI Image of finished buildings

Innovation

A number of ground-breaking innovations were developed on this flagship project, all of which improved efficiencies and provided a safer working environment:

- Drones carried out rig and crane mast inspections and aided site planning
- Plastic Tremie hoppers
- First large-scale use of 'Superlatch' safe splicing system on D-Wall
- Synthetic soil developed for backfilling the 127no., 900mm diameter piles

Sustainability

To minimise disturbance to the surrounding community, we used an off-site consolidation centre and batched materials on site to maximise transport efficiency. A centrifuge was used to reduce bentonite waste and refurbished stop ends were used in D-Wall construction. Plunge columns facilitated top-down construction to accelerate the programme.

New Pile Testing

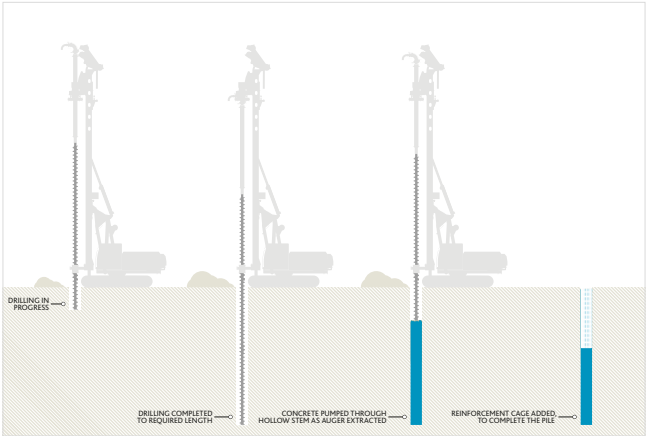
Due to the variable ground conditions and the underlying glacial scour feature, extensive pile testing was necessary. Along with the UK's largest use of Osterberg Pile tests on a single site (5no.), a new type of pile testing was introduced. The TIP (Thermal Integrity Test) provides results at an earlier stage than other techniques.

Continuous Flight Auger (CFA) piles

This solution is ideal for noise and environmentally sensitive sites for both load bearing piles and excavation support. Suitable for all soil types and fast to install, it is ideal for retaining walls as it causes minimal disturbance so posing limited risk to adjacent structures.

CFA piling rig

Continuous Flight Auger (CFA) piling technique



Our integrated rig instrumentation system allows us to monitor installation and measure data such as depth, concrete pressure, volume and productivity. We use this data to produce graphical representations of pile conformity as a historical reference.

- CFA piling
- Auger displacement piling

The technique

A hollow stemmed continuous flight auger is rotated into the ground to the required depth. As the auger is withdrawn, concrete is pumped down the hollow stem under balancing pressure forming a shaft of liquid concrete to ground level. A reinforcing cage is then inserted by hand or vibrator.

Two significant factors can influence the load bearing capacity of CFA piles – the sophistication of the equipment used and the experience of the operators on the ground. Our depth of experience and investment in research and development are both key strengths in this area.

Continuous Flight Auger (CFA) piling technical capabilities

Dimensions	From	To
Practical depth	n/a	Max 34m
Diameter	0.35m	1.2m
Load capability	Dependent on depth and ground conditions	
Minimum working height	10m	34m
Typical rig weight	38,000kg	87,000kg
10m Noise Profile at 10m	85db	90db

Case Study:

Reading Viaduct

The new £40 million Reading Viaduct was part of a redevelopment of the whole of Reading Station. Constructed by Balfour Beatty, it will ease congestion by taking fast mainline trains over freight and relief lines.

> "Over 20,000 linear metres of piling has been completed by the Balfour Beatty Ground Engineering piling crews. The fact that all of it has been successfully completed within 15m of the operational railway, without any impact on train operations or driver concerns is a major contribution to the satisfaction of passengers on this key route."
>
> Jim Weeden, Reading Station and Area Redevelopment Project Director, Network Rail

The £3.8 million foundations package included the installation of 980 continuous flight auger piles up to 1,050mm diameter and 24m deep through to the chalk bedrock, all required to support the viaduct structure.

The ground improvement phase required the installation of 1,685 vibro concrete columns (VCCs) to support the ramps at the Eastern and Western ends.

The VCCs were up to 8m deep, toed into the terrace gravels and required a 600mm diameter enlarged head to support a geogrid load transfer platform which helped support the overlying embankment.

Working alongside the live railway, safety and logistics have been key to planning the project. One of the most critical stages was the installation of piles neighbouring the trackline on the main London to Swansea line and Reading commuter routes. These created a pinch point which required careful planning to accommodate rigs and handling cranes in such a restricted area.

"Careful planning was essential to this project, and our use of lean visual management has enabled us to closely monitor and control activities as well as provide instant updates to Network Rail."

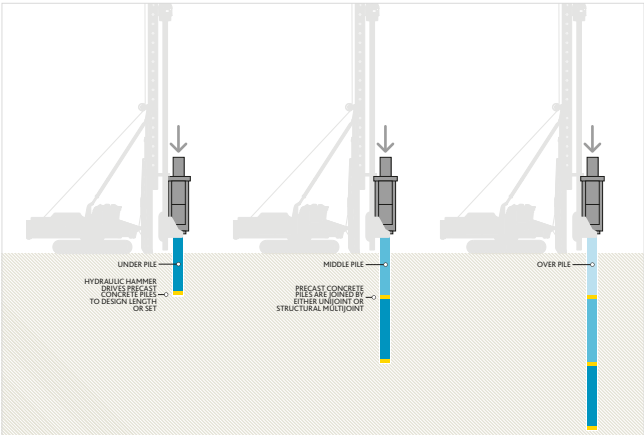
Rob Cannon, Project Manager, Balfour Beatty Ground Engineering

Driven piles

Due to their versatility, driven piles are widely used and are suited to most ground conditions. They are particularly suited where the founding strata is overlain by soft alluvial deposits or made ground. Driven piles are unaffected by ground water and don't generate spoil on site.

Driven precast concrete piling

Precast driven piling technique



Adaptions that can be made to deal with contaminated land include a tapered shoe at the end of the precast pile to minimise risk of aquifer contamination in line with Environment Agency guidelines. In areas where environmental disturbance needs to be kept to a minimum we offer the most up-to-date enclosed hydraulic hammers which significantly reduce noise.

Steel tube and H-piles can be used as well, to deal with obstructive ground or where high shear loads need to be taken.

- Precast concrete piles
- Steel tube piles
- Steel H-piles

The technique

Precast concrete piles are manufactured by Balfour Beatty Ground Engineering off site in standard lengths up to 15m, and driven into the ground using a hydraulic hammer until the required depth/resistance is reached. Where a greater depth is required, the lengths are jointed together using the Multijoint or a pinned UNIjoint. In this way, piles can be as long as required to meet the load bearing specifications. Driven piles can also be raked up to 1:3 depending on hammer weight and pile size.

Enlarged heads are an add-on to precast piles that help spread the load of a building or embankment over a greater area and ensures that increased loads can be placed on the piles without the risk of the pile puncturing the slab or geo-membrane. Significant savings in slab reinforcement and thickness can be realised when using enlarged heads on piles.

Precast driven piling technical capabilities

Dimensions	From		To		
Practical depth	Min 2.5m		Unlimited (72m longest to date)		
Standard pile sizes	190mm square	235mm square	275mm square	350mm square	400mm square
Load capability (typically) (in the right conditions, piles would be capable of carrying loads 25% higher than the above indicated figures)	300kN	500kN	800kN	1,200kN	1,500kN
Pile segment length	Normally between 3m and 15m in one metre increments				
Minimum working height	12m		23m		
Typical rig weight	36,000kg		67,000kg		
Noise profile at 10m	77-82db at rear of rig		85-90db at front of rig		

Customer
Grove Developments

Duration
4 months

Value
£1.2 million

Works delivered
1,800 driven precast concrete piles

Case Study:

Arora hotel development, London

Engineering excellence delivers savings – A re-engineered piling solution reduced the cost of foundations by £1.25 million for a new 24-storey hotel, a 26-storey apartment block and a ballroom complex next to the O2 Arena.

A value engineered solution

The original foundation design used a bored pile solution that was unviable due to its cost of £2.45 million.

To produce a viable solution we designed and successfully installed 1,800 350mm square driven precast concrete (DPC) piles – saving £1.25 million in comparison to the original design.

In addition, a further £1 million was saved on the overall project cost as there was no need to remove 15,000m^3 of contaminated soil from site. This also improved safety on site and reduced carbon emissions by eliminating vehicle movements that would have been required to remove the contaminated soil.

Installing the piles for the new hotel

Increasing operational efficiency through spiking

As the site was a disused tar manufacturing and storage facility there were a significant number of underground obstructions.

To identify any possible obstructions, an H beam was driven into the ground by a sheet piling rig to find their locations and depths.

Following this process, known as spiking, obstructions close to the surface were excavated. Where the obstructions were deeper the piles were relocated to avoid them.

This reduced operational timescales and improved the overall cost effectiveness of the project.

The first step in project delivery

The works completed by our Ground Engineering specialists were the first step in the delivery of the £121 million complex on the Greenwich Peninsula.

As main contractor, we are currently on site delivering the remaining works for the mixed use regeneration scheme, with completion anticipated in summer 2015.

House foundations

This workstream focuses on full design and build foundation packages for housing, as well as for schools, community amenities and light commercial buildings.

Designing pile and ground beam packages from architectural drawings

Ground beams at Bushby, Leicestershire for Gateway Homes

We offer bespoke design packages from pile only schemes to full pile, ground beam and block floor solutions. For housebuilders, using a single point of service for all the foundation work saves time and money and ensures that projects can be managed effectively and safely on site.

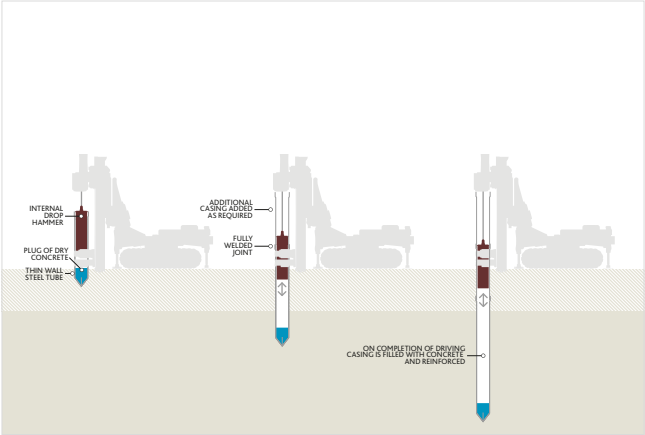
Utilising the architectural drawings with wall line loads, our team of experienced engineers can design the optimum configuration of piles and precast concrete ground beams to suit each scheme. Using quality assured factory components which are produced and installed to ISO5000 standards, our customers are assured that the system is compliant with all NHBC and LABC standards.

Mini piles

A wide range of high capacity, small diameter piles which can be formed in almost any type of ground. Typically used where access or working space is restricted these rigs require minimal site preparation.

Bottom driven mini piling

Bottom driven mini piling technique



We offer the largest fleet of modern mini piling rigs in the UK:

- Bottom driven mini piles
- Augered mini piles
- Drilled mini piles
- Self-drilled micro-piles

The technique

A thin walled steel tube, closed ended, is driven in lengths of 1.5m to 6m using an internal drop hammer on to a dry concrete plug. The tubes are joined by a full fillet weld as the installation proceeds. The depth of the piles are designed using a predetermined set or length criteria.

Once the required depth is reached the tube is filled with high slump concrete or grout. A single steel reinforcing bar, cage or CHS (Circular Hollow Section) is then inserted.

Bottom driven mini piling technical capabilities

Dimension	From	To
Diameter	150mm	450mm
Pile loads	n/a	up to 1,500kN
Height of rig	2.2m	8.0m
Length of rig	1.8m	3.3m
Width of rig	0.7m	1.6m
Operating distance from face of wall to centre of pile	350mm	500mm

Case Study:

Beauly-Denny overhead line tower bases, Scottish Highlands

On the Beauly-Denny Replacement Transmission Line project more than 220km of overhead power lines have been upgraded.

Of the 166 load bearing piles, 67 had plunge columns installed, each inserted to an average vertical tolerance of 1 in 800 which has set new standards in the industry.

Each of the plunged column piles were designed to carry a working load of up to 24,000kN and employed to facilitate top-down construction saving over six months on the construction programme. The three level basement was retained using 388 no. 900mm diameter hard/firm secant piles, and these also supported the final structure.

Coring of existing underreamed piles and foundations also presented challenges that were overcome using bespoke coring equipment.

Mini piling Beauly-Denny

The project stretches from Beauly near Inverness, to Denny, near Falkirk in often challenging terrain and includes the installation of approximately 532 new towers. Using eight of our mini piling fleet, Balfour Beatty Ground Engineering installed a combination of drilled mini piles, top-driven steel tubes and precast concrete piles to support the foundations for over 160 of the new towers.

The geology was varied and the rocks are extremely strong. Initial progress was slow, despite using four rigs. The cage required for the horizontal loads dictated a 300mm diameter pile in the rock. By revisiting the entire design philosophy, we were able to reduce this diameter by utilising a heavy Ischebeck bar instead of the cage, at the same time as reducing pile numbers and overall drilling depth at each tower leg.

The reduction in diameter also improved the quality of positional tolerance control. The overall result of our changes resulted in a 50% increase in pile production on the project. Where access and ground conditions permit the more cost-effective driven steel tube and precast concrete piling solutions was used.

Focus on retaining walls

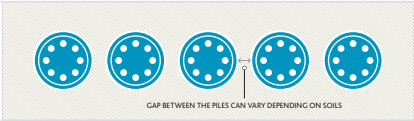
Bored pile retaining walls

Used most frequently for building basements, we can combine this technique with the installation of plunge piles to enable top down construction and thereby reduce the programme.

Secant pile wall, Narborough, Leicestershire

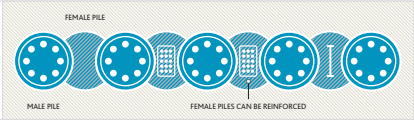
Contiguous pile walls

Used in locations where water retention is not a consideration and soils are stable, contiguous bored walls dispense with interlocking piles completely. Typically a gap of 150mm to 300mm is left between the piles.



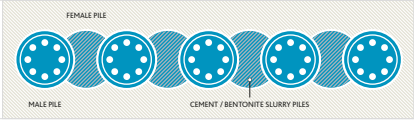
Secant pile walls (Hard/Hard and Hard/Firm)

Secant walls are particularly suitable where high water retention is a consideration as they have a positive interlock between adjacent concrete piles. Both male and female piles can be reinforced enabling high lateral loads to be supported.



Secant pile walls (Hard/Soft)

This wall is used where considerations of height and lateral deflection are less critical. Female piles use self hardening slurry or unreinforced concrete to provide the seal between the reinforced concrete male piles.



We are able to combine a variety of piling and grab techniques for excavation support projects.

- Bored pile retaining walls:
  - Contiguous
  - Secant
- Diaphragm walls
- King post retaining walls

The technique

Either open bored or continuous flight auger techniques can be used to create retaining structures to cater for all ground and water conditions. There are three broad types of wall. Essentially primary piles are installed at suitable spacing to allow secondary piles to be installed between.

King post walls

Largely used as temporary retaining walls, this system uses a king post (open bore filled with concrete to form a base for steel H-pile). Panels of timber sleepers, precast concrete or steel sheets can then be slotted into the H-piles to form the retaining wall.

Where ground and environmental conditions permit the steel H-pile (king post) may be installed using driven techniques.

Diaphragm walls

Diaphragm walls are underground structural elements commonly used as retention systems and permanent foundation walls. They can also be used as groundwater barriers. A reduced number of joints means that diaphragm walls have improved water tightness compared to secant walls. Diaphragm walls tend to be used for retaining deep excavations as they can be designed to take high structural loads.

Our experience in diaphragm walling is extensive with projects ranging in size from 2,000 to 50,000m² and from a few metres to over 50m deep. We are experienced in carrying out complex operations on restricted urban sites and have installed diaphragm walls at Heathrow Terminal 2B, Royal Arsenal Woolwich, Marble Arch Place and One Nine Elms, London.

Case Study:
Heathrow Terminal 2B

This huge project required construction of a 2km diaphragm wall, over 700 piles and over 160 plunge columns for the new terminal building.

Over 43,000m³ of concrete and 7,800 tonnes of prefabricated steel cages were used to construct the piles. There were over 1,100 deliveries to the site for the cages alone.

The diaphragm wall was split into 320 panels with the length ranging from 3.1m to over 7m. All the panels were 1m wide and constructed to a maximum depth of 25m. In total over 39,00m³ of concrete was poured and 6,795 tonnes of steel, made up of 615 prefabricated reinforcement cages were installed. The cages included casting ducts for the anchor construction and couplers for up to three slab connections. The slab connection couplers were installed to a tight tolerance of +/-50mm.

The diaphragm wall was excavated using a hydraulic grab, mounted on the end of a Telescopic Kelly Bar, carried on a heavy duty base unit. Bentonite fluid was used to provide support to the sides of the excavation to prevent it from collapsing.

A total of 705 large diameter piles were installed over a period of seven months, this equates to around 35km of total bored length (roughly the distance from Dover to Calais!). The piles were 1,200mm, 1,500mm and 1,800mm in diameter with the average depth being 50m.

The piles were all constructed from the existing ground level with the pile cut-off level being between 10 and 15m below this ground level.

Over 43,000m³ of concrete and 7,800 tonnes of prefabricated steel cages were used to construct the piles. There were over 1,100 deliveries to the site for the cages alone.

We installed 163 plunge columns during the Heathrow Terminal 2B project, the largest number ever installed on a project in the UK. The columns were plunged into large diameter piles that were 1,800mm in diameter. Each column weighed approximately 15 tonnes and was up to 17m in length. The columns had to be installed to a strict vertical tolerance of 1 in 400 and with just a +/-10mm level tolerance.

Columns were installed using two plunge frames during both day and night shift leading to the completion of the plunge columns two weeks ahead of schedule.

Focus on ground improvement

Vibro stone columns

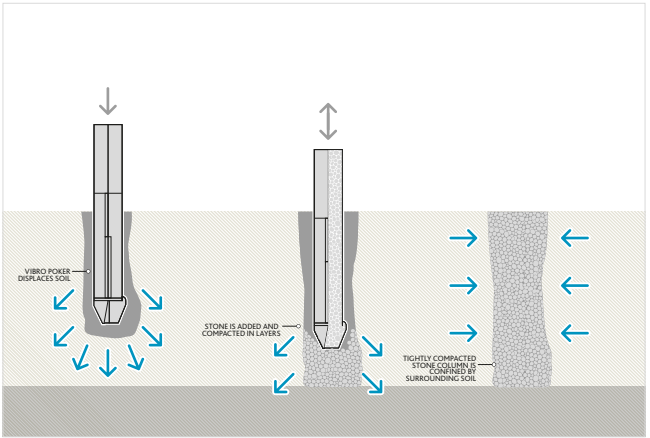
The Vibro stone column system is the most common ground improvement technique in the UK. Fast and efficient it can treat a wide range of weak soils and offers significant savings over piling.

We provide a comprehensive range of ground improvement solutions using state-of-the-art equipment ideal for engineering brownfield sites and areas of weak compressible soil.

- Vibro stone columns
- Vibro compaction
- Vibro concrete columns
- Dynamic deep compaction
- Pencol™
- Marine ground improvement

Vibro stone columns - top feed

Vibro stone columns bottom feed technique



Our ground improvement solutions offer the following benefits:

- Simplified sub structure design and construction
- Little or no spoil generated – avoiding the need for expensive disposal costs
- Reduced project time through fast design and implementation
- Around 30% of the aggregates we use come from recycled sources, contributing to the sustainability requirements of projects
- Treatment of a wide range of soil types
- Specifically developed equipment for restricted access and limited headroom situations

The technique

A vibrating poker attached to a purpose-built vibropiling rig is inserted into the ground using a combination of its own mass and the pull-down facility of the rig. Once refusal or design depth is achieved the vibroflot is removed and a charge of graded stone is tipped into the hole. The vibrating poker then re-enters the hole to compact the stone into the soil. The process is repeated until a very tightly compacted stone column is formed. Where collapsible soils are present, such as soft clay and sands with a high water table, then the bottom feed system is used to form the stone column.

Vibro stone columns technical capabilities

Dimension	From	To
Practical depth	1.5m	15m – rig mounted) / 30m – crane mounted
Diameter	0.3m	1.3m
Ground bearing capacity	Typically up to 200kN/m^2 (higher in granular soils)	
Minimum working height	7m	Varies
Typical rig weight	22,000kg	58,000kg

Case Study:
National Indoor Sports Arena and Velodrome, Glasgow

The National Indoor Sports Arena and Velodrome was the main indoor sports facility at the 2014 Commonwealth Games, providing competition venues for track cycling and badminton.

Glasgow Velodrome

One stop shop

The £116m project was built in the east end of Glasgow, close to Celtic's Parkhead ground.

Balfour Beatty Ground Engineering were awarded the work by main contractor Sir Robert McAlpine after a value engineered solution was proposed utilising:

- Dynamic compaction
- Vibro stone columns
- Large diameter rotary bored piles
- CFA piles
- Driven precast concrete piles

One of the main advantages to the client was that we could provide all the required techniques. This meant the programming, communication and coordination required was much simpler when compared to the alternative of appointing different subcontractors for each technique.

The ground improvement works commenced first with dynamic compaction undertaken for the floor slab. The slab is lightly loaded and the granular ground conditions meant the dynamic compaction technique was suitable to achieve a bearing capacity of 15kN/m² in this area.

For the curved design of the Sir Chris Hoy Velodrome cycling track 1,287 vibro stone columns were installed using both top and bottom feed methods.

The structure was supported by a combination of Rotary Bored Piles (bores supported using Vinyl Polymer fluid), and driven precast concrete piles.

Focus on sustainable alternatives

Sustainable solutions

Balfour Beatty Ground Engineering offer a wide range of sustainable solutions and aim to ensure that the products and services we deliver help to contribute towards our customers' sustainable targets.

Our Factories

Our two factories in Scotland and Nottinghamshire manufacture all our precast piles. This means that as well as having full quality control we are also able to ensure they are sustainable. This includes the use of 100% harvested rainwater, 99% recycled steel reinforcement and a minimum of 25% cement replacement in the production of all our precast piles. Having our own factories also means that we are able to produce non standard pile sizes and reinforcement to meet specific needs, as well as setting up modular pile production units as required.

Geothermal Piles

Providing geothermal piles for use in ground storage systems is one way that we can help with the provision of renewable energy and reduce carbon emissions.

Geothermal loops within CFA piles

Zero waste piling

We launched the UK's first precast concrete pile cutting system which has the potential to reduce waste to zero.

The patent pending system works by diamond-tipped twin blades neatly cutting precast concrete piles to within 100mm of ground level. If this was used on all projects it could save up to 2,000 tonnes of harmful CO^2 emissions per year.

Re-use of existing piles

When redeveloping urban areas we often encounter old foundations and existing piles, which cause obstruction and are problematic.

Using a combination of rigorous integrity, materials and load testing can often lead to existing piles being deemed suitable for re-use, with appropriate warranties given.

Pencol™

Pencol™ offers a highly economical and sustainable alternative to piling. It is a new and effective ground improvement technique developed to provide enhanced bearing capacity and settlement control in very weak soils. It works in conjunction with a load transfer mattress which shares the load between the columns and soil.

Leading by example we developed the first use of geothermal precast concrete driven piles in the UK which are being used to provide energy for the our office in Scotland.

Focus on testing and analysis

Providing surety of delivery

We are established providers of specialist technical services to the construction industry.

Pile testing

Through our UKAS accredited team who have a proven track record built from over 30 years' experience, we offer:

- Static load testing
- Dynamic load testing
- Integrity testing
- Sonic logging
- Thermal integrity profiling

Noise vibration and air quality monitoring

Our comprehensive range of noise, vibration and air quality monitoring capabilities include prediction, measurement and control of both environmental and workplace exposures. We stock the latest monitoring equipment which offers web-based access to data and exceedance alerts when required.

Static load testing

Working Platform Assessment

As part of the Balfour Beatty Zero Harm initiative we can undertake tests to assess working platforms and piling platforms constructed with unbound material. Tests include:

- Plate Load
- Testing
- Light Weight Deflectometer (LWD)

Structural monitoring

We undertake pre and post condition surveys to identify and record any defects. We can offer structural monitoring for a wide range of structures including retaining walls, modern and historic buildings.

Olympics Aquatics Centre – supported on Continuous Flight Auger piles

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