Balfour Beatty

King Sheet Piling - The KSP® Story
A Revolution in 120 Years of Sheet Piling Practice

This document, a compilation of submissions for various Awards for Innovation in 2012, tells the story of KSP's development and early success.

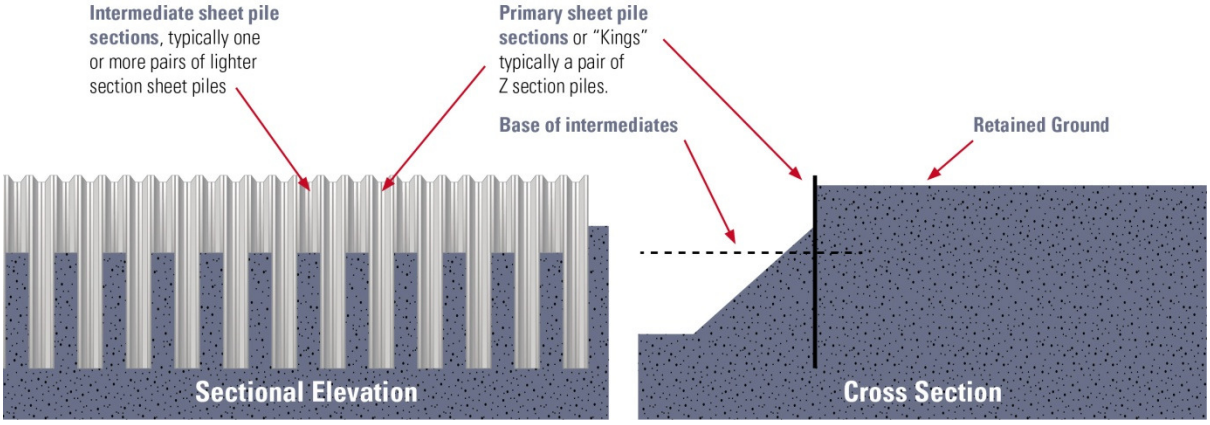
Innovation

Balfour Beatty's King Sheet Piling (KSP®) system proved a resounding success in 25 km of earth retaining walls on the £1 billion design and construction contract to widen 63km of the M25. It provided over £10M of savings shared equally with the Client, the Highways Agency. KSP's impressive speed of installation was key to achieving the critical fast-track programme.

The circa 35% saving on steel and the dramatically improved productivity (typically double and up to four times that planned) represents a step change from the best value engineered retaining wall solution developed by industry experts. Clever thinking challenged established engineering practice and produced substantial economic, environmental and sustainability benefits for the construction industry and its clients.

KSP is a simple, radical innovation that revolutionises 120 years of sheet piling practice. It uses standard sheet piles more efficiently to yield savings of up to 40% of steel, whilst guaranteeing substantial productivity, environmental and sustainability benefits. The KSP system was invented in 2008 by David Baker, then Balfour Beatty's Design and Geotechnical Manager (UK Major Projects). It is covered by one or more patents or patent applications.

The mechanism by which KSP works is simple, as is true of many inventions. Sheet piles are often sized for installation stresses or 'driveability', heavier sections being used than required structurally for the retaining wall function. The KSP concept harnesses the surplus structural capacity by 'thinking laterally', using pairs of Z section piles as 'kings' with lighter, shorter Z section piles spanning horizontally between them.

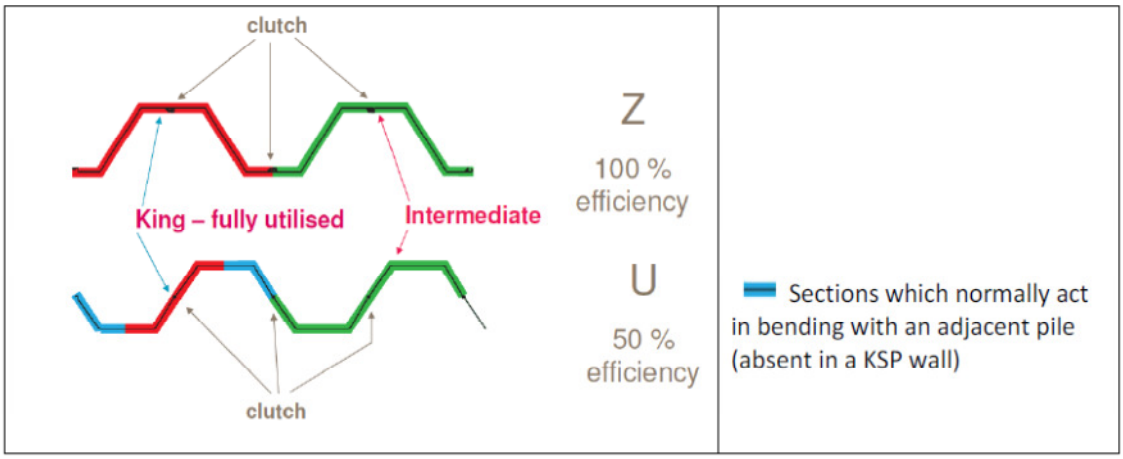


Patents: GB2463079, Others Pending

KSP is a sheet pile wall re-designed on similar principles to a king post wall, but in a much simpler system. A king post wall typically consists of steel H sections ('kings') concreted into bored piles, with planks spanning between the kings to support the retained soil. Sheet piles are inherently efficient as kings. They are wide, strong sections that can be installed in one simple process. Use of sheet pile intermediates in place of planks also simplifies wall construction, speeding completion.

Issues key to the development were:

- Understanding how a sheet pile wall performs structurally. In the UK, U profile piles are traditionally preferred to Z profile piles. In isolation, a pair of U piles is only 50% efficient, as it requires adjacent piles in a continuous wall to mobilise its full bending capacity. In contrast, Z piles in the KSP system can work in isolation and are 100% efficient.



- Recognition that light and heavy sheet pile sections use identical clutches, allowing them to be interconnected.

- Research into the capacity of the clutches to transfer load in shear from intermediate sections.
- Investigation of rotation of the intermediate sections.
- Installation practicality, including potential drag-down of intermediates during driving.

KSP has gained widespread Industry recognition, receiving the following awards in 2012:

Winner

- Constructing Excellence National Innovation award.
- Constructing Excellence London & SE Innovation award.
- Chartered Institution of Highways and Transportation Innovation award.

Highly commended

- British Construction Industry Product Innovation award.
- Ground Engineering Technical Excellence award.

Involvement/Engagement of Stakeholders

The M25 DBFO required rapid widening at a mile a month, at peak spending £1M per day. To persuade all parties on such a fast-track scheme to adopt a new technique without prior trial was a major achievement. Both designers and sheet piling subcontractors were consulted to obtain their buy-in. Primary stakeholders - designer, Client, Client's engineer, construction team and Connect Plus were convinced. All accepted KSP in principle, with most reservations from the construction team, understandable considering what was at stake. The difficulty was persuading the team to commit to an untried system on which a day's delay could cost over £350k in liquidated damages and overheads. Committing to KSP would lock in both design and construction and require a commitment to purchase an initial 6,865 tonnes of steel before the system was even trialled.

Achieving this commitment involved working closely with all stakeholders to address potential concerns and assure the confidence of all.

The successful outcome owed much to the buy-in of all parties, not least the sheet piling subcontractors and ArcelorMittal, the steel supplier. The commitment of all parties was achieved by adopting an open collaborative approach from the outset. A piling subcontractor was engaged under a preliminary services agreement to iron out in advance all potential construction issues. This process was central to success. The logistics were crucial as every wall varied in length throughout. The steel supplier committed to supplying pre-cut steel in the exact lengths required for the various walls, based on a comprehensive schedule. The multiple lengths, sections and grades were tracked from mill to storage compounds and handled in a highly efficient manner to ensure just-in-time delivery to the worksites.

Health and Safety

Zero Harm is a core Balfour Beatty principle, aligning fully with the goals of our JV partner Skanska and our Client, the Highways Agency. A key driver in any method of hard retaining wall construction is assuring safety of the workforce and general public. Any method proposed is scrutinised closely for compliance with this objective. KSP scored highly on safety for the following reasons:

- It is a simple construction process, with a limited number of operations and interfaces, leading to reduced risk of unplanned work, hence safer operation.
- Limited need for change ensures safety briefings do not need amending.
- By allowing simple pitch and drive rather than panel driving, KSP minimises working from height, a major cause of site accidents.
- Once the piles are driven and a simple non-structural steel capping beam attached, the wall is essentially complete, allowing completion of drainage and other works.
- No safety incidents have been reported during construction.
- No routine future maintenance is required.

Constructability

KSP has many proven constructability advantages:

- It can be installed by simple pitch & drive methods.
- Maintaining wall alignment is straightforward, avoiding time-consuming panel driving.
- The shorter, wider intermediates reduce driving time and cost.
- Clutch friction is largely eliminated, speeding installation and reducing driving effort.
- Noise from percussive hammer driving, where required, is more than halved.
- There is a substantial increase in productivity.
- KSP is non-weather dependent, in contrast to earthworks widening alternatives.
- No Departure from Standards is required.

Vision

Whilst the immediate focus of KSP development was the challenging M25 DBFO project, the vision behind KSP was that it would provide clients worldwide the alternative of a quicker, cheaper, more environmentally friendly and sustainable retaining wall system.

Balfour Beatty is a socially responsible contractor, with sustainability high on its corporate agenda. It is for this reason that the company has decided to make its KSP innovation widely available under licence for the greater benefit of society. The license fee charged will help cover the cost of developing and promoting the system whilst also providing a return for making the company's intellectual property freely available.

Commercial Success

On the M25 widening, adoption of KSP resulted in the use of about 9,000 tonnes less steel, whilst simplifying installation and increasing safety and productivity. The resulting saving of over £10M is equivalent to the target profit on a £300M construction project. Within Civil Engineering, this is a substantial achievement for the first application of an innovative idea.

Subsequently, incorporation of KSP in a re-designed pumping station on the A421 saved £880k and avoided a 10 week programme over-run. Under the NEC Target Cost type contract, net saving to the Client was £2.7M. On the M4/M5 Managed Motorway contract, KSP maximised safety and minimised loss of valuable vegetation barriers that screen nearby communities. To date, KSP has saved the taxpayer over £13M.

Assuming KSP captures 5% of the estimated current sheet pile market in territories covered by granted or pending patents, it would save about 265,000 tonnes of steel, worth £205M, over the remaining life of the patent, enough to make 340,000 cars.

Benefit to the Community

KSP is quicker, cheaper, more environmentally friendly and more sustainable than a standard sheet pile retaining wall. It offers a number of constructability advantages that enhance safety and productivity. A key one is that clutch friction is largely eliminated, speeding up driving and reducing the effort required. This contributes to some of the following sustainability and environmental benefits that KSP brings to the worldwide community:

- Embedded carbon is reduced through use of less steel, easier driving and reduced transport.
- Installation energy is substantially reduced.
- Noise of hard driving, where required, is at least halved.
- Vibration is substantially reduced.
- Disruption is reduced due to faster installation.
- Less steel is shipped and there is less lorry traffic.
- Excavation, material import and waste export are all less than in other walls.
- Selected EU sourced sheet piles are 100% re-cycled steel and can be re-used or re-cycled in the future.

The community benefits directly or indirectly from the substantial cost savings from KSP's increased productivity and reduced steel and installation costs. The environmental impact of sheet pile walling is also reduced by the consumption of typically 35% less steel, with an equivalent reduction in embedded carbon. All these gains accrue to the worldwide community in perpetuity. Indeed, KSP is a revolution in 120 years of sheet piling practice!

KSP is a standard bearer for the UK Government's 'More for Less' and Green Construction Board initiatives.

A brochure on the KSP system is available at https://www.ksp-piling.co.uk/downloads_links.html.