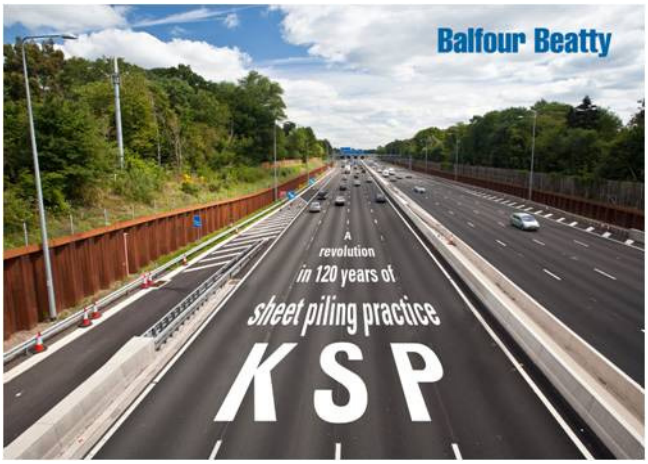
CASE STUDY: King Sheet Piling (KSP®) M25 DBFO Widening



CONTRACT INFORMATION:

Sector type: *Infrastructure – roads*

Location: Greater London

Client: Highways Agency

Principal Designer: Atkins

Principal Contractor: JV Skanska / Balfour Beatty

Contract Value: £1.1bn

THE PROJECT:

The £6bn M25 DBFO contract consists of widening the northern sector of the M25 to four lanes with hard shoulder, refurbishing the Hatfield Tunnel and the operation and maintenance of the 400 km of motorway and major feeder roads for 30 years. Balfour Beatty and Skanska UK each maintain a 40% share in the Connect Plus consortium formed with Atkins and Egis Projects to deliver these services and together made up the Construction JV which carried out the £1.1bn construction contract for the Initial Widening Sections.

The tunnel refurbishment and the 63km of motorway widened between Junctions 16-23 and 27-30 were completed in May 2012, three months ahead of schedule.

THE BENEFITS:

The innovative KSP retaining wall system de-risked the critical widening programme, saved typically 35 to 40% of steel and delivered substantial constructability, safety, environmental and sustainability benefits.

Invented by David Baker, Balfour Beatty Major Civil Engineering's Design and Geotechnical Manager, the simple, yet radically innovative King Sheet Piling (KSP) system (Patent Pending) uses standard Z profile sheet piles more efficiently to yield savings of 30 to 40% of the steel used in a conventional sheet pile wall, whilst guaranteeing dramatic productivity, environmental, safety and sustainability benefits. This is a revolution in 120 years of sheet piling practice.

Introducing an untried new system on such a high profile programme-critical project was a major achievement that owed its success to substantial pre-planning and collaborative working between all parties – designer, main contractor, steel supplier, earthworks subcontractor and piling subcontractor, to name but a few. KSP rapidly proved its worth, with a four-fold increase in productivity routinely achieved in chalk on Section 1. Overall, linear installation speed was at least doubled. The result is 25 km of novel KSP wall forming the largest land-based use of sheet piles in Europe. Savings of over £10M have been shared between Client and Contractor. Most importantly, the ease and speed of installation meant a programme saving of at least 8 weeks, removing hard retaining walls from the critical path and assuring the fast-track programme was met and exceeded. The faster installation rate improved safety by reducing working time in the high-risk environment adjacent to live motorway traffic.

Circa 20,000 tonnes of CO_2e were saved through the substantial reduction of steel in the KSP walls. A further 22,000 tonnes (circa 20,000t) was saved through the use of piles fabricated from 100% scrap steel in a highly efficient electric arc furnace in Europe rather than sourcing steel from the Far East.

END USER FEEDBACK

At a presentation on KSP to the Highways Agency Knowledge Sharing Round Table conference in November 2011, HA Forum leader, Nick Hopcraft, referred to KSP as a concept that would inevitably become widely known and taken up throughout the industry. Geotechnical Engineer and former ICE Chairman, Quentin Leiper, described KSP as "an elegant solution".

THE PROCESS: Use of the KSP Sheet Piling System (GB2463079; Other Patents Pending)

The widening of the M25 motorway had to be carried out while maintaining three lanes of traffic in both directions for the 150,000 vehicles that use it every day. Keeping the widening within the existing highway boundary allowed it to be carried out under the Highways Agency's 'permitted development' classification, but this required a significant length of retaining wall to be constructed to provide the additional 3m of space to widen into. Use of the KSP system for most of the retaining walls made it simple to maintain the accelerated programme, with the operation being largely independent of other trades and operations.

The team achieved a sustainable solution by using the patented King Sheet Pile (KSP®) retaining wall system. KSP revolutionises 120 years of sheet piling practice by taking advantage of spare structural capacity in sheet piles sized for driveability, using thinner, shorter sheet piles spanning horizontally between full length "king" sheet piles. Typical steel saving is 35% to 40%, directly reducing embodied carbon in steel used, transportation and installation energy.

A major benefit of the short intermediates was the virtual elimination of clutch friction, which contributes substantially to the energy required to drive sheet piles, particularly in ground such as the Chalk at M25 where large flints can cause piles to deviate slightly during installation. As a result, installation rate on some sections was routinely four times the planned rate and generally installation rate was at least doubled. An important benefit was that the majority of the piles could be driven to full depth using a vibratory hammer without recourse to the noisy percussive impact driving often required for a conventional sheet pile wall. In the limited cases where impact driving was still required, the noise and energy consumption was more than halved, with major benefits to residents and the environment. In summary, benefits are:

<u>Sustainability & Environmental</u>

- Sheet piles are 100% re-cycled steel and can be re-used or re-cycled
- Embedded carbon reduced through less steel, easier driving and reduced transport
- Installation energy substantially reduced
- Need for hard driving substantially reduced, reducing noise.
- Where hard driving is still required, noise is more than halved
- Vibration substantially reduced
- Reduced disruption due to faster installation
- Less steel shipped and less lorry traffic
- Reduced excavation, material import and waste export compared to other walls

<u>Constructability</u>

- Can be installed by simple pitch & drive
- Easy to maintain wall alignment without time-consuming panel driving
- Safety enhanced, reduced working at height
- Shorter, wider, shallow intermediates reduce driving time
- Clutch friction largely eliminated, speeding drive and reducing driving effort
- Substantial reduction in need for percussive hammer driving
- Dramatic increase in productivity
- Safety increased by fewer interfaces
- Working area minimised; wall can be constructed as separate operation, reducing interfaces with other trades. This aids both productivity and safety.
- The substantially reduced time spent working adjacent to the live carriageway provided obvious safety benefits.

By incorporating a small sacrificial thickness to the piles, the exposed faces required no initial treatment or ongoing maintenance. The use of a simple steel capping beam in place of traditional reinforced concrete further simplified the process, increasing safety and reducing embedded carbon.

KEY LEARNING POINTS / BEST PRACTICE

The innovative KSP retaining wall system delivers massive programme benefits for motorway widening and similar applications, saves substantial steel and embedded carbon, reduces cost, increases safety, both directly and through its simplicity and lack of trade interfaces and reduces disruption and noise for the public. On the M25 it delivered multi-million pounds savings for the taxpayer and helped ensure the motorway opened not only on time, but three months early.