Faithful Retainer

Diaphragm walling is an established technique for basement construction. David Puller and Nick Wharmby examine its development and the advantages it brings.

When oil industry technology was transferred to applied civil engineering in the 1960s it opened the way to the use of slurry-supported excavations in construction of earth and water retaining structures. The technology was developed by Italian companies building cut-off dams in the 1930s and was first used in the UK in 1962 at London’s Hyde Park Corner. Now, after 50 years, the technique can be considered a mature and well-understood process.

It did not take engineers long to realise the design advantages of these slurry-supported, rectangular elements over walls formed from interlocking, cast bored piles. Soon embedded walls were being built with Thin-Shape panels, cast-in-situ and cellular walls, precast and even prestressed diaphragm walls.

Increased structural efficiency was being achieved with an associated reduction in other forms of temporary and permanent earth support such as props and ties and backfills. In water-bearing ground the reduced number of wall joints compared with a bored pile wall is considered advantageous with regard to potential water ingress. Nevertheless, a potential water path still exists between panels and the incorporation of a continuous waffle bar system is recommended. CWB is such a system which also provides guidance to the grab excavation.

Connections to retaining walls are more readily achieved where diaphragm walling is adopted when compared with piled walls. Bottom-out, pull-out bars and couplers can be incorporated into the cage and relatively accurately positioned. This can be particularly advantageous in cases of top-down construction.

The resulting finished diaphragm wall surface can, under certain circumstances, be acceptable, with limited treatment, as the final internal surface. This is often the case in cut and cover tunnel and metro station boxes or even underground car parking structures. The construction of precast diaphragm walls can provide an even better surface finish if required.

Development

Progress has nearly always been led by plant manufacturers with the development first of cable operated and hydraulic grab site diggers and stiff soils. In the 1970s, hydrocrane technology made possible excavation rates of up to 400 m in a single shift, unheard of in very dense granular strata and weak rocks. Bentoconcrete treatment plant technology was developed to handle the associated increased throughput, as slurry was used not only to support the excavation but also as a spoil transportation medium.

Improvements in mud seals, vertically-controlled devices and instrumentation pushed back the limits. Panel depths of more than 100 m became achievable, together with improved dimensional accuracy of up to 1 in 500 with the hydrocraw.

Reduced height cutter frames resulted in compact equipment that made excavation in limited space feasible. Wall thickness of 1,000 mm and even 1,500 mm also became practicable.

Most recently, the attachment of rock roller bits to conventional cutting wheels has enabled cost-effective excavation of hard rock with a uniaxial compressive strength of over 150 MPa.

Logistics and Environmental Constraints

Many practical issues can impact heavily on the design of diaphragm walls and seeking the advice of a specialist contractor is strongly advocated. The panel layout is fundamental to the whole process as it influences wall alignment, panel stability, bentonite storage capacity, construction sequence, reinforcement cage detailing, cage fabrication area, handling crane size, productivity and thus cost. In normal circumstances panel lengths of between 6m and 7m are adopted for the mechanical and productivity reasons.

The shape in plan of the proposed bulk excavation can influence the cost-effectiveness and practicality of the system. As most digging tools excavate a 2.1 m length of wall in a single “cine” a panel is made up of multiple “cines” with an overhang.

Bentonite storage and management is essential to maintain productivity levels. Storage volumes need to be about four times the volume of a panel. This can be provided by lagoons or tanks.

Bentonite conditioning is an ongoing process. It should be noted that where a hydrocraw is used the cleaning plant must be able to adequately clear 60 lpm per hour per horizontal, as the spoil is carried in suspension within the bentonite drilling fluid. In this case the mud handling requirements are far more demanding than when digging with a grab, especially in fine sands and silts.

Without exception, specialist contractors will detail any or re-detail reinforcement cages to suit specific, trench pipe locations, lifting preferences and so on. They will also decide whether the cages are lifted in one section or joined together over the trench.

Hydraulically driven diaphragm wall contractors can be fast, even in difficult ground.