**FPS Guidance Note**

**Self-Drilling Hollow Bar Systems Considered for Use as Grouted Ground Anchors, Micropiles or Soil Nails: Application, Benefits and Limitations**

**Scope**

This note provides an overview of self-drilling hollow bar systems, their application, benefits and limitations, together with comment on the design and execution of grouted ground anchors, micropiles and soil nails used as tension elements in the UK. These elements all have their place within the design and execution of stabilisation or foundation works however their performance characteristics and durability considerations are different.

**Self-Drilling Hollow Bar Systems**

Self-drilling hollow bar systems are not new, and have been available in the UK since the late 1990s. With self-drilling hollow bars there are significant benefits in respect of installation cost and drilling time and as the system is ideally suited to loose overburden drilling their use has become widespread in recent years. The self-drilling technique combines the placement of reinforcement and grouting in a single pass; without the need for a casing in ground conditions where boreholes are prone to collapse.

Key features of self-drilling hollow bar systems include:

* Typically installed with rotary percussion drilling, using the simultaneous drill and grout technique, where grout is pumped through the bore of the bar to the drill bit as drilling is advanced. With the grout flush being a part injection / part flush system, the grout may also permeate the local strata around the bar, depending on the soil type. Permeation can be extensive in granular soils but very limited or non-existent in cohesive soils;
* Difficulty in achieving fully debonded *free lengths,* as it is not possible to debond couplers in a practical way. Therefore the apparent free length (derived from the extension characteristic following stressing) is unlikely to correspond with the theoretical free length. As a result load shedding will occur in the active zone, or free length, with an element of bond capacity in the stable zone or fixed length remaining unproven;
* Limitations in achieving corrosion protection as this can only be provided by sacrificial corrosion allowance, galvanizing and borehole grout cover (where cover has been achieved). Grout cover can be problematic at coupler locations and at the mouth of the borehole in inclined boreholes, where the grout tends to settle to the underside of the bar. It is not possible to achieve double corrosion protection for hollow bar systems due to the abrasion damage that occurs during rotary percussive installation.

**Grouted Ground Anchors**

* May be constructed with cased or un-cased drilling systems to form the borehole into which the anchor components are inserted and grouted;
* Have a defined *free length* which is isolated from the ground and is free to extend elastically when the anchor is stressed and then throughout its working life;
* Derive their resistance from a *fixed length* which is bonded to the ground;
* Are stressed after installation and locked-off to a predetermined load to give an active resistance force which may be used to control deflection of the supported structure;
* For permanent works, are constructed with two independent barriers, to provide Double Corrosion Protection to all the steel elements of the anchor, over its design life, up to 120 years. The barriers should either be plastic sheathing or factory applied grout within an encapsulation sheath. Borehole grout, sacrificial corrosion allowance or galvanizing are not acceptable as corrosion barriers as either their integrity cannot be verified or they lack sufficient predictability or lifespan to fulfil the design requirements of permanent ground anchors. It is the area of least cover that defines the level of protection provided.

The following standards cover the design and execution of grouted ground anchors.

BS EN 1997-1:2004 + A1:2013 Geotechnical Design (and relevant UK National Annex)

BS 8081:2015 Code of Practice for Grouted Anchors

BS EN 1537:2013 Execution of Special Geotechnical Works - Ground Anchors

**Tension Micropiles**

* May be constructed with cased or un-cased drilling systems to form the borehole into which the tension reinforcement is inserted;
* Do not have a defined *free length* and therefore are fully bonded to the ground within the borehole over their entire length;
* Provide passive support, as they cannot be effectively stressed after installation due to the pile being fully bonded. Micropiles become loaded by movement of the supported structure and thus cannot offer the same degree of deflection control as grouted ground anchors;
* Corrosion protection options include sacrificial corrosion allowance, galvanizing or double corrosion protection where there is a corrosion risk or the loads are high. Concrete or grout may crack under tension forces and the implications of this should be considered where appropriate.

The following standards cover the design and execution of tension Micropiles

 BS EN 1997-1:2004 + A1:2013 Geotechnical Design (and relevant UK National Annex)

BS 8004:2015 Code of practice for foundations

 BS EN 14199:2015 Execution of Special Geotechnical Works – Micropiles

**Soil Nails**

* May be constructed using either solid reinforcement within open-hole or cased boreholes, or self-drilling hollow bar. Bars are fully grouted within the borehole;
* Defined as reinforcing elements installed into the ground, usually at a sub-horizontal angle,
that mobilise resistance with the soil along their entire length;
* Provide lightly loaded passive support, as they are not stressed after installation, but become loaded by movement of the slope or supported structure;
* Corrosion protection options include sacrificial corrosion allowance, galvanizing, borehole grout or concrete cover, or occasionally double corrosion protection for aggressive soils conditions.

The following standards cover the design and execution of soil nails

 BS 8006-2: 2011 Code of Practice for Strengthened / Reinforced Soils. Part 2: Soil Nail Design

 CIRIA C637 2005 Soil Nailing - Best Practice Guidance

**Summary**

Whilst it is impossible to give hard and fast rules regarding the appropriateness of a defined system in a given situation, the following aspects should be considered when selecting and designing tension elements for geotechnical applications-

* Is the long term durability of the tension element important? If so, either a grouted anchor with double corrosion protection or a tension pile with the reinforcement in a grouted encapsulation duct (impermeable corrugated plastic sheathing) may be required;
* Is a prestressing force required (to control the deflection of the supported structure)? A conventional grouted ground anchor, with its independent sheathing and coupler cover tubes within the free length, should provide the required level of debonding to enable a prestress to be applied and locked-off in the anchor tendon. Load testing can be used to check the required level of debonding is achieved. For temporary applications (where long term durability is not a concern) a self-drilling hollow bar system is often the preferred solution, subject to the limitations of free length extension outlined above;
* Is passive (as opposed to pre-stressed) tension support sufficient? If so, a tension pile or self-drilling bar system may be acceptable;
* Re-classification of a permanent ground anchor as a tension pile, in order that a lower level of corrosion protection may be applied, is likely to reduce the lifespan of the installation, will affect the extension characteristic under service loadings and preclude the use of effective pre-stressing which may be important in controlling deflection in the supported structure.