The Actively Stressed Soil Nail System
Complete with Corrosion Protection

Tony Barley¹, Devon Mothersille²
¹ Director, Single Bore Multiple Anchor Ltd, Harrogate, UK
(Website: www.sbmaysystem.com)
² Director, Geoserve Global Ltd, London, UK
(Website: www.geoserveglobal.com)

Abstract

The difference of performance of steep or vertical faces retained by prestressed anchors and passive nails is generally identified by the difference in stiffness and strength of the wall facing and the amount of face movement encountered. In steep or vertical faces restrained by “passive nails” prestress if frequently applied to the nail at the head solely as a comfort factor. This will result in the debonding of the nail into the upper active zone and the transfer of initial load into the active zone but not into the passive zone.

A new Actively Stressed Soil Nail which controls the load distribution in the nail has been developed and is particularly suited to usage in steep nailed faces and where long nails are installed

Keywords: Slope, Soil Nails, Prestress, actively Stressed Soil Nails

Presented at the Conference on Slope Engineer; 6th to 9th August 2006 at Kuala Lumpur, Malaysia
The Actively Stressed Soil Nail System
Complete with Corrosion Protection

Tony Barley¹, Devon Mothersille²

¹ Director, Single Bore Multiple Anchor Ltd, Harrogate, UK
(WWW: www.sbmaysystem.com)
² Director, Geoserve Global Ltd, London, UK
(WWW: www.geoserveglobal.com)

Abstract

The difference of performance of steep or vertical faces retained by prestressed anchors and passive nails is generally identified by the difference in stiffness and strength of the wall facing and the amount of face movement encountered. In steep or vertical faces restrained by “passive nails” prestress if frequently applied to the nail at the head solely as a comfort factor. This will result in the debonding of the nail into the upper active zone and the transfer of initial load into the active zone but not into the passive zone.

A new Actively Stressed Soil Nail which controls the load distribution in the nail has been developed and is particularly suited to usage in steep nailed faces and where long nails are installed

Keywords: Slope, Soil Nails, Prestress, actively Stressed Soil Nails

Introduction

Early development in soil nailing utilised fully bonded, passive tensile members for retention of active zones of soil. Surface soil slippage was initially controlled by placement of geogrids or similar materials over the exposed slope surface, with the grid often restrained by driven pins (Figures 1). The active zone was, consistent with design approach, tied to the passive zone by the soil nail (Figure 2).

As the use of cut faces became steeper, surface soil retention extended to semi-flexible and stiff facing systems: most commonly provided by shotcreting (Figure 3). The concept of constructing such facing and leaving both the face retention and the soil nail in a passive state, gave reason for concern. Face movement would initially be required to develop the necessary retention forces in the proximal end of the nail. In some instances contractors chose to prestress the head of the nail in an effort to reduce face movement (Figure 3). However load cannot be applied directly to a fully bonded elastic tensile member without the occurrence of debonding progressing along the nail. This results in the initial face retention force being resisted by partial debonding along the nail and transfer of load only into the active zone of the soil mass.

Concern with regard to this phenomenon and the resulting excessive movement of a retained face adjacent to a large electrical cable tower was reported by Pirooz Barar (2001). As a consequence it was chosen to construct the top down wall using alternate anchor and soil nails distributed along each row level. The use of over 7 such levels in a 15m deep basement construction involving the application of prestress provided a safe
solution with very limited face movement. Furthermore the capability to increase load in the stressable components provided an additional safeguard throughout the excavation works.

**The Actively Stressed Soil Nail**

For reasons outlined above the demand for an “actively stressed nail”, somewhere in between a passive nail and a prestressed ground anchor in single grouted borehole has long been present in the industry. A simple approach available was the two stage grouting of the steel member: initial grouting, application of prestress against a face or reaction block, second stage grouting followed by prestress relaxation. This method has been used to a limited extent in nailing but was used extensively in the early days of anchoring, particularly in high capacity dam anchors. It is no longer used in permanent anchoring owing to the absence of corrosion protection of the steel members.

The latest nail technology now offers a system with the grouted borehole containing two tensile members: one member is debonded from the grout throughout the active zone; the other member is fully bonded over its entire length (Figure 4).

On completion of construction of a reaction block or shotcrete face the active tensile member is prestressed and the applied load is transferred deep in the soil mass in the passive zone. During this load application no borehole grout is in contact with the rear of the facing in order to prevent any strutting effect. At this stage the soil behind the facing or reaction block is stressed and retained by the applied force.

On completion of prestressing of the active member the void in the borehole behind the facing is fully grouted. The amount of applied prestress can be optimized to suit allowable bearing pressure behind the facing and that required to retain the soil in contact with the face.

Typically a tendon and nail design can accommodate prestress ranging from 50 to 150 kN. A recent test program on actively stressed nails installed in New Zealand attained 840 kN on the half nail length pull-out test (Plate 1 and 2). In such circumstances the applied prestress can considerably exceed the 150 kN.

Where top down construction of an actively stressed nailed face takes place, the face will already be partially prestressed. This will inevitably reduce the extent of further face movement should any increase in face retention force be required. During such a period the dual tendon arrangement will operate simultaneously; the passive member will become loaded as the active soil zone deforms; the load in the actively loaded member will increase and transfer any load increase into the passive zone.

The actively stressed nail tendon system is available for both temporary and permanent works. Tendons may consist of steel bars or strand, or fibre reinforced plastic bar or strand. When steel members are used for permanent works they can be fully protected against corrosion over their entire length by encapsulation in a corrugated plastic duct (figure 4). Special techniques have been developed for simultaneous in situ grouting of the protective duct and the annulus without the use of conventional tremie pipes.
Summary

The Geotechnical Industry has long awaited a soil retention member that lies somewhere between a prestressed anchor and a passive soil nail. The use of the patented actively stressed soil nail allows controlled transfer of load from the facing or the reaction block to deep into the passive zone in the soil mass. It also ensures the active soil zone is tied to the passive zone as is normal in conventional nails. The application of the new system is particularly suited for usage in areas where face and surface movements are critical. This situation typically occurs when buildings or services exist adjacent to old or newly formed slopes or faces.

Frequently the behaviour of the top level of nails is highly influential on the wall movement. Even the installation of actively stressed nail at this level alone would show benefits.

Other areas of benefit are when soil nails are particularly long and excessive surface movement would normally be required for a passive nail to gradually transfer load deep into the soil mass.


Plate 1 Rig installing trial nails before excavation provides an 80° soil nailed face
Plate 2 Sacrificial testing of the dual-tendon, actively stressed soil nail prior to excavation. Note the proximity of adjacent high level development which will be undercut by 14m face.