Minipiles & Permeation Grouting

Thirlmere Aquaduct, Nab Scar

GRASMERE, CUMBRIA, U.K.

Remedial Grouting and Minipile works to stabilise slope

Introduction

Bachy Soletanche Limited's Anchor, Grouting and Mini-piling division (AGM), were employed by United Utilities as main contractor to carry out remedial works to stabilise the conduit section of the Thirlmere Aqueduct at Nab Scar and undertake internal concrete repairs.

The Thirlmere Aqueduct was constructed over 110 years ago to provide water from the Lake District to the city of Manchester some 95 miles away. The aqueduct remains, to this day, a key piece of infrastructure in the distribution of 250,000m^3/day of raw water in the north-west of England. A short section of the aqueduct at Nab Scar, on the slopes above Rydal Water, was identified as being in poor condition during a planned inspection by the client

At the point of the aqueduct in question, spoil originally arising from sections of the tunnel, was used to cover the aqueduct. As time went by the spoil weakened, posing a danger of slope movement and subsequently causing damage to the aqueduct. Consequently, a permanent solution was required to provide support to the conduit and remove any potential ground movement immediately above and below. All of which required getting the necessary machinery up the 440m Nab Scar fell and creating a platform off the down slope.

Ground Conditions

The ground conditions encountered during construction consisted of generally 1m of fill and broken rock with underlying hard Volcanic Tuff to depth.

Minipiling on a steep slope

CLIENT :	United Utilities (U.U.)
MAIN CONTRACTOR :	Bachy Soletanche
CONSULTING ENGINEER :	MWH
DURATION OF WORKS :	4 months

Scope of Works

- Mini-piles:34no. 196mm dia. (17 Raked)
- Permeation Grouting: 27no. TaMs
- Aqueduct & Slope Movement Monitoring

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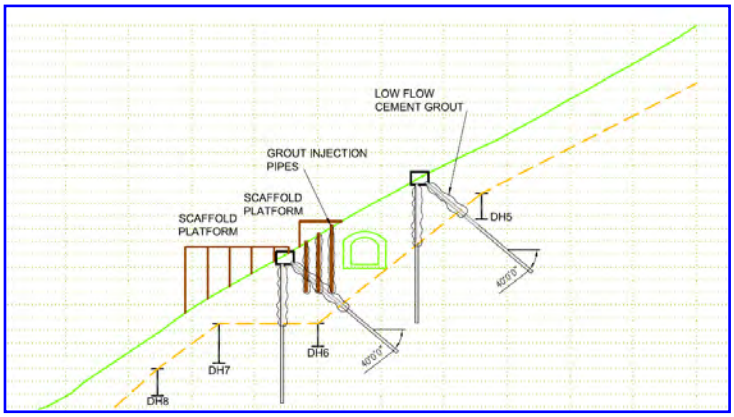

Design

The in-house design used an A-frame pile arrangement with two piles, one vertical acting in compression and one raking, acting in tension. Materials were scheduled in lengths that could be man-handled to facilitate the movement and placement of the components without extensive lifting plant. The selection of a small diameter pile also allowed the use of a light weight rig that could access the steep slopes on the site. Pile caps also needed to be designed so they would quickly blend in to the heath vegetation.

Construction

a) Permeation Grouting

The first stage was to stabilise the ground immediately adjacent to the conduit on the down slope side, to provide temporary support to the structure, to minimise the loss of fine materials during subsequent construction activities. Our team installed three rows of Tube a Manchettes (TaMs) grout holes into the ground from which to grout from. The holes were drilled using a foam flushing medium with a 150mm diameter rotary cased technique down to the rockhead.

b) Mini-piling

During the second stage, we were to provide permanent support to the down slope wall of the conduit. Our solution was to install a row of paired passive piles, with one vertical pile and one inclined pile in each pair to form an 'A' frame. An individual low profile pile cap at the surface of the slope joins the two piles in any pair. The arrangement of the two piles in each pair was such that the vertical pile acts in compression and the inclined pile acts in tension with the pile cap acting as a pin joint, connecting the two piles together and enabling the pair to act as a unit. Each pile was founded well into solid rock below the fill and had a grouted zone around it in the fill to provide further stiffening against any bending load applied by ground movement. There were 18 piles installed below the aqueduct and 16 piles installed above the conduit following the installation of the pile caps at the lower level.

Monitoring

During the piling works, care had to be taken to ensure that no site work would cause further movement of the ground surrounding the aqueduct and/or damage it. Real time movement monitoring was carried out by our sister company & monitoring specialists, Sol Data.

Deep seated movement within the hill slope was recorded via Inclinometers. Surface movements were monitored via a fully automated, computer controlled total station system that observed prismatic targets. Monitoring of the aqueduct structure, was carried out by precise levelling points, rod extensometers, electro-levels, in place inclinometers, tilt meters and crack width gauges.