Minipiles and Jet Grouting

Harrington Viaduct

Workington, Cumbria

Construction of new Mini-pile foundations for five new piers plus underpinning to strengthen existing abutment foundations

Minipiling

Bachy Soletanche Ltd were awarded a design and construct contract to form piled foundations for five new concrete bridge piers, part of the works involved in replacement of a Victorian railway viaduct. The project was situated in Harrington, a suburb of Workington in Cumbria, where the client, Northwest Structures Alliance, a joint venture of with Network Rail and Edmund Nuttall, were converting the old nine span viaduct into a new five span replacement.

The Design

The challenge was to distribute high moment and lateral loads into piles that had to be positioned and constructed between existing bridge piers with widths as close as 3.5m and beneath the existing deck with a headroom restriction of 3.6m. The choice was to either construct on average 24no. 305mm diameter minipiles per cap or significantly less larger diameter mini-piles. The smaller pile diameter was chosen as it

Installing 305mm dia. Mini-piles beneath viaduct

CLIENT:	Network Rail
MAIN CONTRACTOR:	Structures Alliance (Network Rail / Nuttall)
CONSULTING ENGINEER:	Scott Wilson Kirkpatrick
DURATION OF WORKS:	5 weeks Minipiling, 3 weeks Jet Grouting

WORKS QUANTITIES

Mini-piles	305mm / 265mm 132 No
Total Lm	860 Lm
Jet Grouted columns	1.8m dia 35 No
Total Lm of column	135 Lm
Total m3 of column	344m3

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produced a more economical design solution that did not require heavy pile reinforcement. It also gave Structures Alliance the opportunity to use a smaller size pile cap generating cost savings.

Ground conditions

Generally Sandstone and Mudstone bedrock was found at depths of around 5m, overlain by loose granular fill. Beneath the three most Northern piers Mudstone was encountered as expected with an unconfined compressive strength of up to 5MPa. However, beneath the two most Southern piers white quartz Sandstone was encountered with an estimated strength of up to 100 MPa.

Testing

Away from the viaduct a preliminary sacrificial test pile was constructed and tested in compression and tension. At 2.5 times the working compression load the pile displacement was only a few millimetres, proving the true rock strength and providing the opportunity to reduce the socket length by 1.5m. Further working pile tests taken to 1.5 x working load proved an ample factor of safety was still in place.

Newly Constructed Viaduct Pier

Construction

The restricted working area and variable rock strengths meant that piling rig selection was critical if the tight six week programme was to be met. The two piling rigs chosen for the project were the robust Hutte HBR 202, which generally worked on the piers with the quartz white sandstone, while a more versatile rig, the Klemm KR 701 concentrated on the piles in the softer rock and where access was more restricted.

The pile construction sequence was to use temporary 305mm diameter casings to advance the bore through the loose granular made ground. A down the hole hammer (DTHH) equipped with a 265mm drill bit was employed to drill the rock socket. Once design depth was reached the DTHH was withdrawn and a full length central reinforcement bar was installed into the bore. Pile mortar was then used to fill the pile, introduced via tremmie from the base of the empty bore. The casings were then withdrawn and a reinforcement cage plunged into the top of the pile to cater for lateral loads.

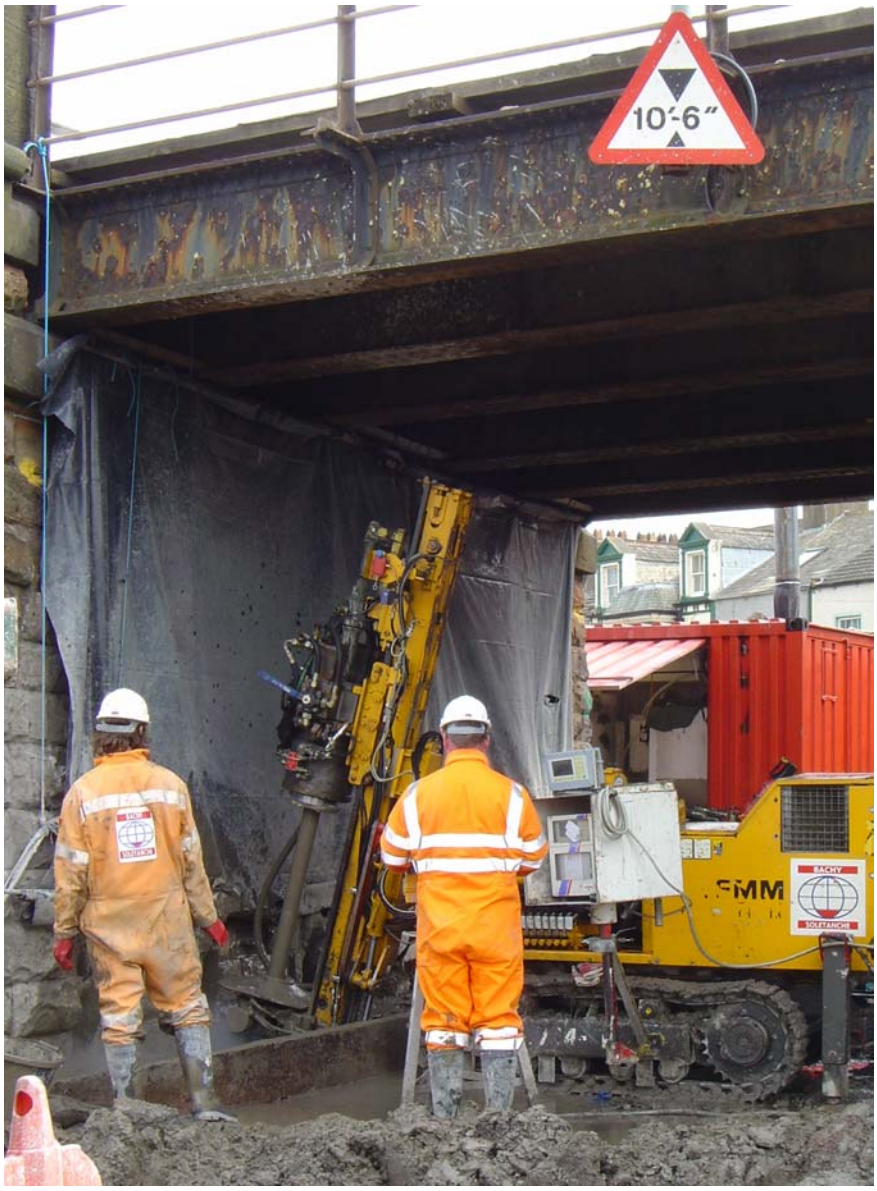
New Viaduct Pier Base

Jet Grouting

Introduction

As a follow on to the successful mini-piling contract BSL were again approached to provide an innovative solution to underpin the existing North abutment which was to be retained as part of the new structure but needed to carry increased loadings. Traditional underpinning solutions had been considered by the client but were dismissed as being too complicated with a long programme time thus also increased cost.

BSL proposed a jet-grouted solution which allowed the underpinning to be carried out with minimal additional works. This provided for a short construction period which was crucial to the client as they only had one blockade date in which they could close the railway lines and replace the whole of the viaduct. The blockade was due to start only three days after programmed completion of the jet grouting so it was imperative that the operation went with success.



Jet Grouting To North Abutment

Design

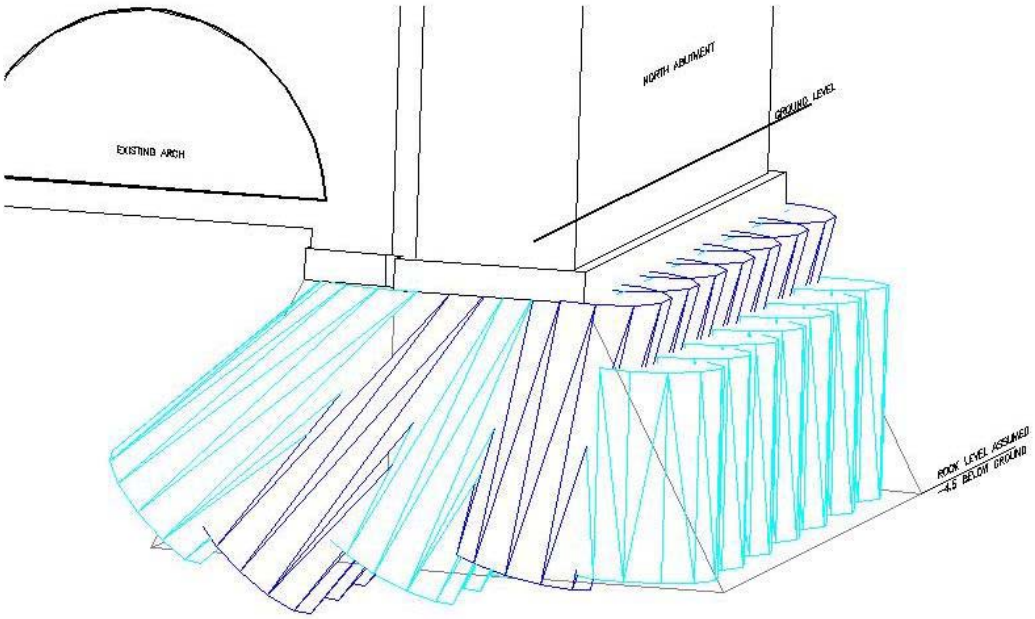
One of the challenging aspects of the design was to get the spread of jet grout columns beneath the existing foundation with drill rig access only available from one side of the abutment. All columns had to be installed from the adjacent roadway, under a headroom of 3.6m beneath the existing deck.

The jet-grouted block was designed in fans of 5No. columns, each of 1.8m diameter, with angles of inclination ranging from vertical up to 49°. There were 7No. fans in total, spaced at 1.3m centres, to form the jet-grouted block of soil which was founded on the underlying rock and extended up to the underside of the foundation. Ground conditions at the North end of the viaduct were found to be similar to those encountered during the minipiling with granular-alluvial material overlying sandstone.

Construction

The locality of the works was always of great importance, being right in the centre of Harrington with the nearest houses approximately 50m away and the harbour a similar distance. Access for both pedestrians and vehicles had to be maintained around the work area and under the viaduct at all times. Particular attention also had to be paid to the environmental issues being so close to the harbour. A number of containment and removal procedures were put in place for the spoil handling.

To enable full contact to the underside of the foundation, the 3 most inclined holes had to be pre-cored through the sandstone blocks of the abutment and foundation. Therefore 21No. 200mm diameter holes were pre-cored up to depths of 3.9m through to the granular material immediately beneath the foundation. This also allowed a picture of the actual foundation profile to emerge as no historic



Elevation of North Abutment

records existed and trial pits had shown variable foundation depths. This information was important to guarantee the contact of the jet columns with the existing foundation.

A Klemm 704-1-E drilling rig was used in low headroom guise, equipped with Enpajet, our latest in-house computer control and recording equipment for jet grouting. The use of this electrically powered rig also led to less environmental impact for the local residents with reduced noise and emissions.

The pre-drilled hoes were extended down to rock using rotary methods under a grout flush. A 0.5m rock socket was formed so that the nozzle level coincided with the rock interface from where the column should be formed. A total of 35No. columns, 1.8m in diameter and up to 6.0m long, were constructed on a traditional hit and miss underpinning sequence to ensure constant support to the structure. Up to four sets of jetting parameters were used taking into account differences in strata, proximity to foundation level and whether primary or secondary columns were being constructed. The injection pressures used to form the columns ranged from 250bar to 400bar.

A monitoring system consisting of electro-level beams and total station targets were installed by Structures Alliance at various locations on the abutment and inside the adjacent arch. Minimal movement was measured throughout the jet grouting which was completed two days early giving a head start for the rail blockade preliminary works.