

Compensation Grouting

King's Cross Station, London

United Kingdom



King's Cross Station redevelopment – Phase 2 Settlement Mitigation Compensation grouting for tunnel works

Introduction

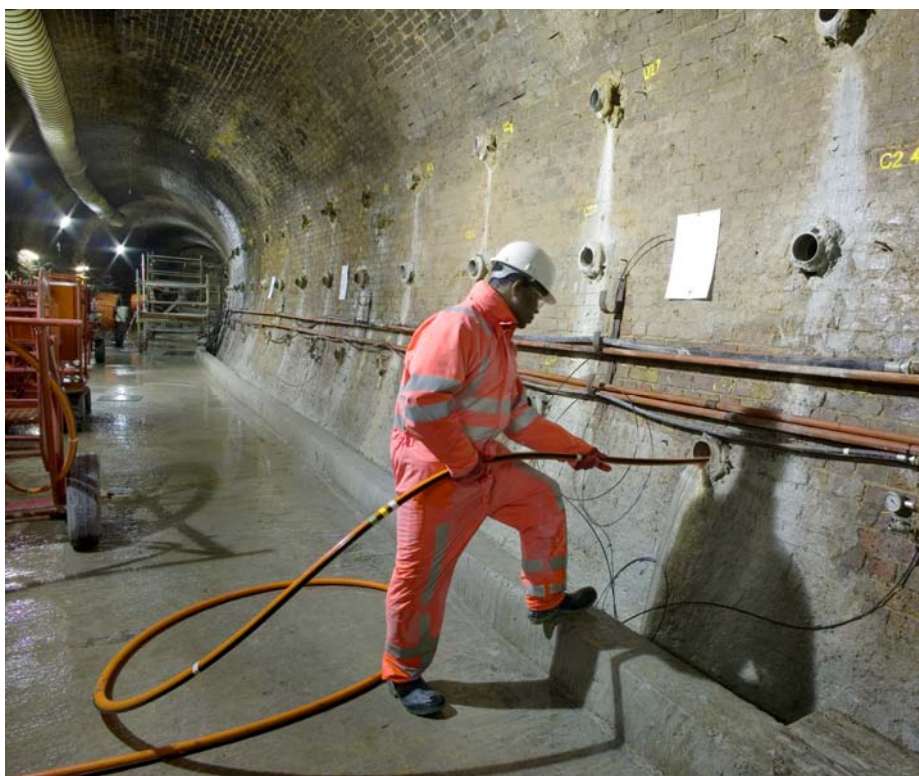
Compensation grouting works to the Northern line access (NLA) and Piccadilly line access (PLA).

Bachy Soletanche carried out a two-year, £5 million project for Morgan Bemo to design and deliver an innovative compensation grouting system below King's Cross station on behalf of London Underground Limited.

The works were undertaken to limit the effects of tunnelling induced ground displacements below the King's Cross train shed (PLA works), and the Great Northern Hotel (NLA works), arising from the construction of new underground passenger walkways, lifts, and escalators excavated at shallow depth below existing Listed Station structures and live rail tracks.

Tunnels were dug at a very shallow depth, just 6m below live rail track; and two brick built historic buildings, the Great Northern Hotel, and the highly sensitive Kings Cross terminus.

Predicted face loss associated with this tunnelling could have resulted in significant surface settlements, causing distress to existing structures and disruption of rail services.



Insertion of Grouting Line with packer into the lower pre-drilled grouting hole

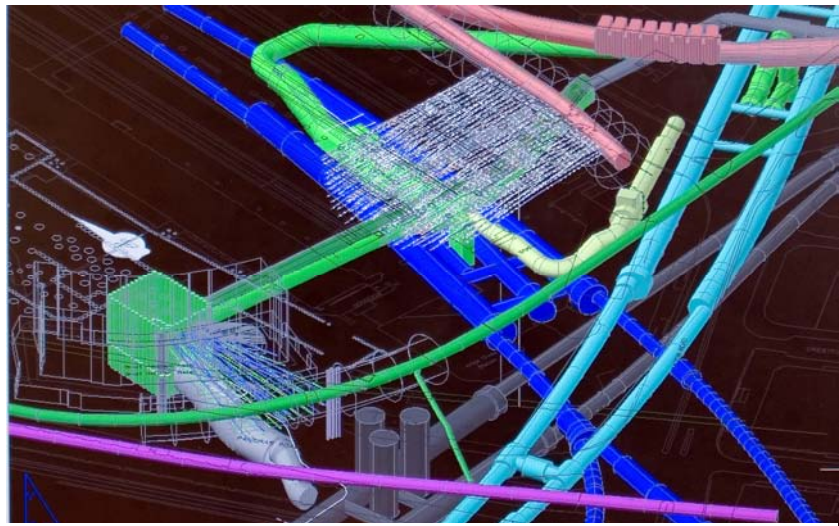
CLIENT:	London Underground & Metronet SSL
MAIN CONTRACTOR:	Morgan Est/Beton und Monierbau JV
CONSULTING ENGINEER:	Arup
DURATION OF WORKS:	24 months

Scope of Works

Design and installation of a settlement reducing Compensation grouting system for a pedestrian tunnel installed less than 6m below Grade 1 Listed King's Cross Station in Central London.

The BSL solution was to provide compensation grouting, using the very latest state of the art computer aided technologies in process control to ensure optimum settlement mitigation.

The effectiveness of this work was confirmed by the real time automated monitoring of surface and sub-surface movements, using an array of 14no. automated total station theodolites linked to a computer, using in-house software to report movements.



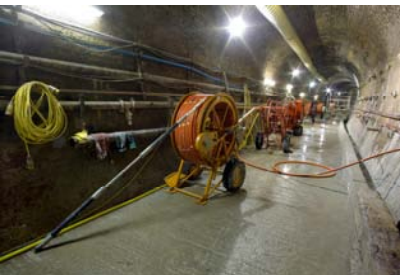
Grouting arrays and other sub-surface infrastructure



Drilling grouting array

The new walkways provide a direct link between the Piccadilly, Northern, and Victoria line stations, King's Cross, St Pancras, and Thameslink rail stations. They form an essential component of the King's Cross/St Pancras Underground station redevelopment programme, supporting the Channel Tunnel Rail Link move to St Pancras, whilst also providing additional capacity for the 2012 Olympics.

The success of the project was achieved by ensuring the continuous close co-operation between the client/owner, engineer, main contractor and other stakeholders in order to co-ordinate an adequate response to the onset of ground relaxation as tunnelling works were advanced.



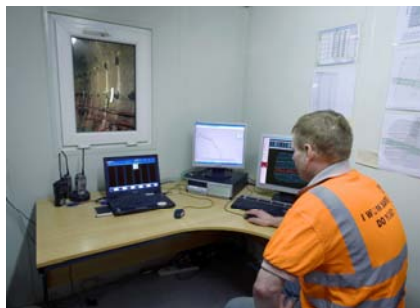
Grout Lines with packers

Working with all the stakeholders BSL worked to design a compensation grouting scheme that would fit within the complex array of existing infrastructure. This successful project has maintained the two Grade 1 and 2 heritage listed buildings well within the specified settlement limits, whilst at the same time allowing the daily operations of trains and travelling passengers to continue without disruption from the construction works being undertaken.



Grout Mixing Equipment

Injection arrays were installed at three different levels to overlap in plan creating a grid effect for maximum interaction. The passive effect of the overlapping borehole arrays resulted in reduced settlements. All boreholes were drilled using the ENPASOL drilling parameters recording system.



Computer control of the compensation grouting works

Our very restricted access drilling works, required long distance horizontal drilling up to 60m, to a tolerance of 1:80 which proved a real challenge. Each borehole position was plotted using 3-D modelling, so that subsequent drilling works could be adjusted to suit those already installed.

A polymer flush system for drilling was developed, to keep flushing pressures to a minimum, to avoid softening the clay and washing fines from any granular materials.

In-house SPHINX, SPICE and COGNAC software was utilised to control the grouting. This highly sophisticated suite of software was developed during the project to accommodate the particular contract conditions.

Final residual settlements were restricted to a maximum of 5mm for the Great Northern Hotel and 8mm for the King's Cross train shed. This compared well with the projected settlements of 70mm and 95mm respectively had compensation grouting not been implemented.

The compensation grouting technology proved to be a flexible and responsive tool.