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Grouting Philosophy

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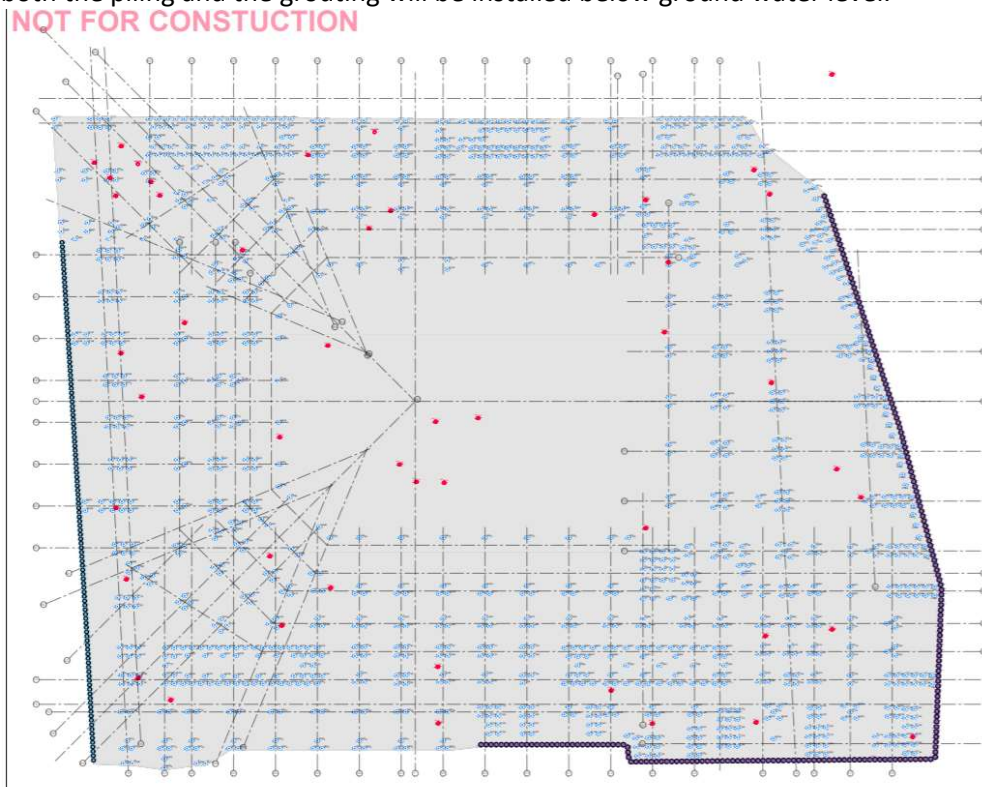
1.0 INTRODUCTION

The Project Bradford site is approx. 21,000m². The site is roughly rectangular in shape and bounded to the south by the Ashton Canal, to the east by Alan Turing Way (A6010), to the west by Joe Mercer Way, which is a pedestrian walk way leading to the City of Manchester Stadium.

The site is located above two main coal seams, the Bradford Four Foot and the Bradford Three-quarter seams. Consideration / confirmation of the 18 inch seam will be needed for the deeper pile toes. Historically 2 No shafts have been located on the site and treated, Ref 386398-003 (grouted and capped) and Ref 386398-010 (grouted). There is potentially a third shaft (the ghost shaft), however previous investigations have been unable to locate it.

There have been several previous grouting contracts on areas of site to treat the coal seams, however the validation of these works cannot be adequately assessed and there could be a risk that should any remaining voids be encountered during the proposed piling works this will impact on the installation of the piling. The proposed drilling and grouting works are to validate the previous grout works and treat any open voids encountered.

Currently the longest proposed piles, are in the north west corner of the site and have a toe level of 26.6m AOD, with a seam indicated around 16.98m AOD, we are therefore anticipating 42m deep probes in this area working, based on approx. 59m AOD working platform. From the meeting with the EA and the ground water levels given in BH Appendix B Ground Water Risk Assessment in association with proposed grouting work, both the piling and the grouting will be installed below ground water level.



2.0 SCHEDULE OF DRAWINGS

Buro Hapold Drawings

- BRA-BHE-ZZ-PL-DR-S-0700_P02 Piling GA
- BRA-BHE-ZA-PL-DR-S-0701_P02 Piling Zone A
- BRA-BHE-ZB-PL-DR-S-0702_P02 Piling Zone B
- BRA-BHE-ZC-PL-DR-S-0703_P02 Piling Zone C
- BRA-BHE-ZD-PL-DR-S-0704_P02 Piling Zone D

Cementation Skanska Drawing

- 22D990-CSL-00-F1-SK-X-0008 P01 Bearing Pile arrangement with local boreholes
- 22D990-CSL-00-F1-SK-X-019 C03 Grout Layout

BAM Drawing

- Exclusion zones / UU/ Canal/Vegetation etc

3.0 GROUTING PHILOSOPHY

The purpose of the drilling and grouting works is to mitigate the risk of voids during the installation of the piling and protect the foundations from the future effects of ground instability caused by void migration from the potential collapse of mining-related voids at depth beneath the site by the consolidation of voided and broken ground by the injection of cementitious grout.

Records indicate that the Bradford Four Foot Bradford Three Quarters Seam have previously been grouted on part of the site. Previous grouting and validation work on the site footprint have treated up to 30m depth identifying two seams of coal.

A shallow seam was identified between +45.0mAOD and to +25.8mAOD at thicknesses of between 0.08m – 1.15m. It is assumed that this seam is the Bradford Three Quarter. Information taken from the Coal Mining Risk Assessment BRA-BHE-XX-XX-RP-CG-0005

A deeper seam was identified at a depth of between +43.4m AOD to +10.1m AOD with an approximately thicknesses of 0.01 – 1.62m. It is assumed that this seam is the Bradford Four Foot. Information taken from Coal Mining Risk Assessment BRA-BHE-XX-XX-RP-CG-0005

Due to the depth of the piles in some areas of the site, consideration has been given to the potential treatment of the deeper 18inch seam. The initial probing will be used to assess the required depth of treatment

The grouting proposals are based on the requirement for treatment to install the pile design based on the loads provided in BRA-BHE-XX-XX-SC-S-0010_P02 Stage 4a Pile Schedule.

Based on the Stage 4a pile design the site has been zoned into pile lengths as detailed on Cementation Skanska Drawing 22D990-CSL-00-F1-SK-X-0008 P01. A summary of the initial probe depths are detailed in Appendix A. Actual depth will be amended dependent on the depth and thickness of the seams encountered on site. Initial probing will be taken to one depth for each area, based on the deepest pile toe and closest boreholes.

Whilst any voids will be grouted during the initial probing, the 21m grid will be used to confirm seam levels and thickness across the site and assist in treatment depths.

The grouting philosophy will adapt to the ground conditions encountered. The drilling approach will initially follow the corresponding boreholes and the below guidance.

Initial probe bore drill depth determination parameters

- 10 x pile diameter (750mm assumed) below the designed pile toe (minimum)
And
- Until the most significant seam and 1.0m below (which ever the greater)

Note: If seam is encountered and potentially worked 10 x theoretical seam thickness will be proven to ensure that once grouted sufficient rock cover will be provided below the pile toe.

Following the initial probing the results will be reviewed and drill depth adjusted for the remainder of the bores.

- Once 10 x seam is proven the adjacent bores will be drilled to seam plus one meter.
- A select number of the 7.0m grid bores will be taken to full depth where additional information is deemed required.

An observational approach to achieving satisfactory treatment is an integral requirement of the works. Records will be provided to BAM as detailed in this document. In addition, regular progress/review meeting will be held to review the works undertaken and advise on changes to the grouting strategy.

4.0 SEQUENCE OF DRILLING AND GROUTING

4.1.1 The anticipated sequence of drilling and grouting is as follows;

4.1.2 Initial probe drilling shall be undertaken on a 21m radial grid, to determine the effectiveness of the previous grouting on the site. The depth of the probe holes will be based on the Stage 4 pile lengths, the requirement for rock cover of ten times the seam thickness beneath the toe of the piles and the depth and thickness of the seams indicated in the Site Investigation. The assumptions made in the design of the grouting works will be reviewed and any necessary amendments made to the grouting layout as works progress.

4.1.3 Drilling and grouting of holes will be carried out within the Bradford Four Foot and the Bradford Three-quarter seams and potentially the 18 inch seam. The holes will be installed to the predetermined infill pattern, progressing to a 14m, 7m and 3.5m radial grid where open workings are encountered. Hole layouts and depth will be amended following the initial probing and reviewed as works progress.

The 21m grid will provide initial confirmation of the seams, workings etc. The 14 and 7 m grid (effectively a staged 7m grid) will then be installed to the depths determined by the initial 21m probing grid. The grid will then be closed down, effectively a 14m primary with 7m secondary grid, to provide a 7m grid. 3.5m grid will then be carried out upon review of the drilling and grout takes. The 10:1 grout will allow the grout to flow to ensure the smaller voids are targeted.

Cementation Skanska Drawing 22D990-CSL-00-F1-SK-X-019 P03 Preliminary Grout Layout details the initial treatment layout.

It is envisaged that drilling will be undertaken from north to south, however completion requirements for follow on activities will be reviewed as works progress.

4.1.4 It should be noted that perimeter grouting is not envisaged at this stage, however should open voids in excess of 0.5m height be encountered in close proximity to the site boundary this will be subject to reviews as the works progress.

4.1.5 The location of the ghost shaft has been investigated a number of times, without success. There is uncertainty over the existence of the shaft and whether it is a duplicate of another shaft on site. We would propose to complete the treatment of the site, to identify any evidence of an additional shaft. Should there be no indication of the shaft's location after the works, additional probing will be considered to a shallow depth 10-15m primarily focused on pile positions in the suspected location.

4.1.6 Upon completion of the grouting the hole will be backfilled to surface.

5.0 CONSTITUENT MATERIALS FOR GROUTING

5.1.1 Water to be used in grout shall be from the public supply of potable water and shall be at least to the quality specified in BS EN 1008:2002.

5.1.2 Ordinary Portland Cement (OPC) will comply with BS EN 197-1:2000.

5.1.3 PFA will be conditioned hopper ash, or dry powder ash, to BS3892: Part 3 of a type suitable as a constituent for grout and obtained from an approved supplier.

5.1.4 Whilst the use of sand is not currently proposed should a localised perimeter cut off be considered the following will apply. Sand shall generally comply with BS EN 12620:2002 and be of a grading suitable for use in the Contractor's plant.

6.0 STORAGE AND USE OF MATERIALS

6.1.1 Cement will be delivered in bulk and stored in a silo to prevent contamination and deterioration.

6.1.2 Bulk delivered of PFA will be stored and handled such that a dust hazard is not created. The PFA will be contained within storage area set consisting of storage containers. Water spray to douse stockpiles will be employed where necessary.

6.1.3 Materials with a limited shelf life will be disposed of off the site immediately, following expiry of the manufacturer's time limit for their use

6.1.4 A central storage area is proposed for the mixing of the grout, no materials will be stored within 30m of the Ashton Canal

7.0 GROUT MIX

7.1 Grouting Plant

7.1.1 Grout materials shall be introduced into the mixer via approved weight batching equipment. The grout mixer shall comprise a two component mechanically agitated colloidal grout mixer capable of producing a homogenous mix, all particles being thoroughly wetted without segregation occurring. Mixing time shall not be less than 5 minutes. A positive displacement grout pump shall be used for all grouting operations.

7.1.2 Provision shall be made for monitoring the quantity of grout being delivered from the grouting plant using calibrated flow meters or similar approved. The Contractor shall supply details of the method of monitoring and calibration of equipment.

7.2 Grout Mix Design

7.2.1 The grout mixes to be employed in the execution of the works are as detailed below, subject to satisfactory performance in the grouting trial. All proportions are presented by weight and are based on neat OPC cement: water mixes. Should PFA or other pozzolans be substituted for OPC the contractor should submit detailed grout mix design information to the Designer for review and comment.

7.3 Infill Grout

7.3.1 Infill grouting will commence with 10 :1 PFA Cement grout mix. Subject to grout takes this may be reviewed and thickened progressively to prevent excessive grout flow

7.3.2 Grouting in any hole shall be terminated at a maximum take of 5m³. Thereafter grouting may recommence after a period of 6 hours.

7.4 Perimeter curtain wall grout (if required)

7.4.1 Cement : PFA : 1 : 9 (Cement: PFA: Sand = 1 : 6 : 1, where cavities exceeding 500 mm in height are found).

7.4.2 Sand may be added in place of PFA where grout consumption or spread is required to be limited.

7.4.5 Cubes will be taken for testing at 3, 7, 14 and 28 day to confirm the strengths of the grout. Crushing strengths shall be not less than 1.0 MN/m² at 28 days.

7.5 Grout Flow Properties

7.5.1 The water : cement ratio shall range between 0.5 : 1 - 2.0 : 1. Grout flow properties will vary significantly with water : cement ratio but will be ascertained during initial grout trials and monitored routinely during production / injection operations.

8.0 PREPARATION WORKS

8.1.1 Prior to the grouting works the ground will be stripped (as may be necessary) and a stable working platform established, taking cognisance of the potential for subsidence due to collapse of mine workings. This will be undertaken by BAM prior to Cementation Skanska mobilising to the work area.

9.0 DRILLING PROCEDURES

9.1.1 All drill holes used for the injection of grout into rock will be drilled by rotary percussive techniques down to 1.0m below the pavement of the target workings. Holes will be installed with 76mm casing and 48mm button bit rods.

9.1.2 Grout injection holes will be cased through the superficial deposits to 1.0m depth below rockhead. Grout holes will be kept open by means of a series of temporary steel casings placed to rock head until grout injection into the workings is complete.

9.1.3 Where a hole proves abortive because it becomes obstructed, or because of the failure to progress the hole, a new hole drilled and cased in close proximity. The amended position of the hole will be recorded

9.1.4 Where vegetation, existing services and structures are present on site, drill holes will be raked to ensure exclusion zones are maintained whilst the target treatment area is drilled.

9.1.5 A noise and vibration assessment will be carried out by others to determine services and structures that may require monitoring during the works. An additional requirement will be agreed prior to works commencing on site

10.0 GROUTING PROCEDURES

10.1 General

10.1.1 Immediately prior to grouting each hole, the grouter will check that the tremie and/or temporary casing is unobstructed to the required depth to receive the tubing or pipe for grout. Obstructions shall be dealt with as described in section 9.1.3 above.

10.1.2 Grout will be tremmied into position down each hole via a series of steel/alkathene tubes placed to the bottom of the hole. The grout line at the surface is attached to an approved T-connection with an attached pressure gauge fixed to the top of the drill hole. The quantity of grout being delivered in the line will be recorded so that both the flow rate and total injected volume are known. Grouting pressures will be monitored at ground level close to the point of injection.

10.1.3 The grout shall be injected into rock until either

- (a) A limiting pressure in the range of 50 -200kN/m² is reached dependent on hole depth(or a lower pressure if the base of the drill hole casing is within 5m of ground level), the pressure will be reflected the depth of the seam treated with a pressure of 10kN/m² per metre up to a maximum of 200kN/m² ie 20m depth of treatment
- (b) A maximum grout take of 5m³ is attained, or
- (c) Grouting is terminated in the event of grout being expelled from the ground.

10.1.4 If the selected refusal pressure (typically in the range of 50-200kN/m²) is not attained after the injection of 5m³ of grout, the grout tube or pipe will be removed from the hole and injection suspended.

After a period of at least 6 hours, up to a further 5m³ of grout shall be injected. Injection shall again be suspended for at least 6 hours and the process shall be repeated with further quantities of 5m³ .

If the hole is still accepting grout after a total of 20m³ of material has been injected without any sign of the hole being completed, a review will be undertaken to determine whether the injection is to be continued or other measures such as secondary or test holes are required.

10.1.5 Care shall be taken to ensure that uplift pressures are not allowed to develop under the railway track, any adjacent services, during grout injection. Dependent on the sensitivity of the structure is required monitoring will be undertaken by others

10.2 Infilling

10.2.1 The grouting of infill holes will proceed systematically from the deepest point of the workings. Once the down dip perimeter has been confirmed, sequencing of the drilling maybe amended to meet operational requirements (test piles, preparations works) This will be agreed with BAM in advance of works commencing.

Whilst a perimeter curtain is not currently envisaged this will be determined by initial probing. If required a localised perimeter will be installed to ensure that grout does not migrate off the site footprint.

10.2.2 Grout injection will be carried out as described under the general procedure, but immediately the grout tubes, or pipes are withdrawn, the T-connection shall be attached to the top of the casing lining the hole down to rockhead, and further grout shall be injected up to the specified pressures.

10.2.3 Upon completion of the grout hole it will be backfilled to surface

11.0 GROUT TESTING

11.1.1 The viscosity of the grout on site will be monitored during injection operations. A minimum of two tests will be undertaken every 24 hours for each grout mix used.

11.1.2 Grout bleed will be recorded at hourly intervals from 2 hours after monitoring starts for not less than 6 hours, until settled conditions occur.

One test shall be carried out each day on each grout mix used. Bleed capacity will be measured in a clear plastic or glass graduated cylinder, which has an internal diameter not less than 50 mm, with a volume of approximately 1000ml. Bleed capacity will not exceed 5%.

11.1.3 For strength testing, a sets of six test cubes will be taken from the grouting pipe at surface positions every 24 hours.. The cubes shall be marked, handled, stored and tested by an approved independent testing laboratory in accordance with BS 1881. The Contractor shall provide projected 3, 7, 14 and 28 day strengths of the grout. Crushing strengths shall be not less than 1.0 MN/m² at 28 days.

11.1.4 For each test there shall be a record of the results including:

1. Date.
2. Contract Title.
3. Area Identification.
4. Test position, co-ordinates and level.
5. Method of Test used.
6. All information required by the appropriate British Standard test procedure

12.0 IN SITU TESTING

12.1.1 Grout acceptance testing will be checked by drilling validation holes in positions to be agreed with the BAM / BH. An allowance of 1 No validation hole per 1000m² has been allowed for.

Grout will be injecting through casings set into rockhead, under typical pressures of 50kN/m² as outlined in the requirements for infill grouting.

The injection pressure will be held for an appropriate period of time (approximately 5 minutes). Appropriate casing, capable of sustaining the test pressures, will be used. Unacceptable voidage will be determined as present within the ground should grout takes into the ground exceed 1 tonne. If this is encountered additional validation hole will be drilled and grouted in the immediate vicinity.

12.1.2 After satisfactory testing, validation holes will be back filled in accordance with the requirements for grouting infill holes.

13.0 RECORDS

13.1.1 The following records are to be provided by the Contractor:

1. Drilling Records (to be provided for each shift);
2. Grouting Records (to be provided for each shift);

13.1.2 As work proceeds, separate records will be maintained for 'Drilling', for 'Grouting' and for 'Materials and Plant Received'. The records will be submitted to BAM within 24 hours of the completion of each shift.

13.2 Daily Drilling Records

13.2.1 The following daily drilling records will be provided for each hole and contain the following information:

1. Job title and location.
2. Hole reference number.
3. Date.
5. Plant in use, crew members and hours worked.
6. Method of boring or drilling, flushing medium and type of drill bit.
7. Type, diameter and depth of casing used.
8. Diameter and depth of hole at the beginning and end of each working day or shift.
9. Nature of flush returns to surface.
10. Loss of any flushing medium during drilling.
11. Standing time, with reason, or time lost overcoming obstructions.
12. Details of underground services located.
13. Details of any settlement or ground heave.
14. Daily and cumulative length drilled.

15. Description, with identification, of the stratum and whether it is intact or broken.
16. Depths at which groundwater is encountered (if apparent).
18. Details of any voids or suspended workings.
19. Details of any emissions of gas, water etc.
20. Depth of completed hole.

13.3 Daily Grouting Records

13.3.1 Daily grouting records shall be provided for each hole and contain the following information:

1. Job title and location.
2. Hole reference number.
3. Date.
4. Contractor's name.
5. Plant in use, crew member and hours worked.
6. Details of type of injection and grout-line dimensions (e.g. tremie injection through 25mm diameter line).
7. Type of grout mix and volumetric quantity injected.
8. Bleed Capacity Readings as outlined in Section 11.2.
9. Grout viscosity readings.
10. Grout pressures recorded, with the corresponding depths.
11. Details of casing abandoned.
12. Completion status of the grouting operation.

13.4 Material and Plant Records

13.4.1 The records of 'Materials and Plant Received' shall show in particular that shifts quantities by weight of each type of material and the cumulative quantities from the commencement of the Works.

13.4.2 Notwithstanding the information listed above, the Contractor shall provide any other information required by Designer.

14.0 METHOD STATEMENTS

14.1.1 Prior to commencing works on site a Works Execution Plan (including method statements and risk assessments will be submitted to BAM for approval.

The following aspects of the works will be covered by the method statements

1. Method and types of access arrangements.
2. Safe working procedures including fail safe methods for working in proximity to railway Overhead Line Equipment.
3. Drilling methods.
4. Grouting methods (materials, mixes, mixing and injection arrangements).

5. Record-keeping formats.
6. An outline sequence of working covering the formation of perimeter and primary grout holes and secondary check holes.

15.0 COMPLETION REPORT

Following completion of the works a completion report will be produced detailing the work undertaken including

1. As built drilling and grouting records
2. As built drawings of holes drilling and volume of grout injected
3. QA records and validation