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Dear Mr Philip

Proposed Lidl Store, Bankwood Way, Birstall, West Yorkshire

Introduction

GB Card & Partners (GBCP) have been commissioned by Beam Consulting Engineers Ltd (Beam Consulting) (the Client) to undertake a geotechnical assessment of the proposed ground improvement works at the above site.

Available Information

The following documents have been reviewed as part of this assessment, provided to GBCP by the Client:

- a) *Development Platform Retaining Walls Indicative Height Plan*. (Drawing Number 09-148-402, dated 25 November 2020), issued by Beam Consulting;
- b) *Development Platform Performance Criteria*. (Drawing Number 09-148-205, dated 13 November 2020), issued by Beam Consulting;
- c) Birstall Lidl + Retail Store – *Ground Improvement Works Technical and Financial Proposal* (Ref. FB/V2647/CMC+BMC, dated 30 October 2020), issued by Vibro Menard;
- d) *Combined Phase 1 & Phase 2 Ground Investigation Report* (Ref. 076893-CUR-00-XX-RP-GE-002-V01, dated 16 October 2020), issued by Curtins Consulting Ltd (Curtins);
- e) *Proposed Site Levels* (Drawing Number 09-148-401, dated 27 August 2020), issued by Beam Consulting;
- f) *Geo-Environmental Assessment* (Project No. 14-0672.03, dated 24 July 2018), issued by Delta Simons Environmental Consultants Limited (Delta Simons);
- g) *Proposed Site Plan* (Drawing Number 7404-SMR-00-ZZ-DR-A-8014-S3-P8, undated), issued by SMR Architects.



Proposed development

It is proposed to construct a new Lidl retail food store in the southeast area of the site, with associated parking in the eastern corner area. A second retail unit, with attached garden centre, is proposed in the western are of the site, with associated parking to the north. The proposed layout is shown in Figure 1.

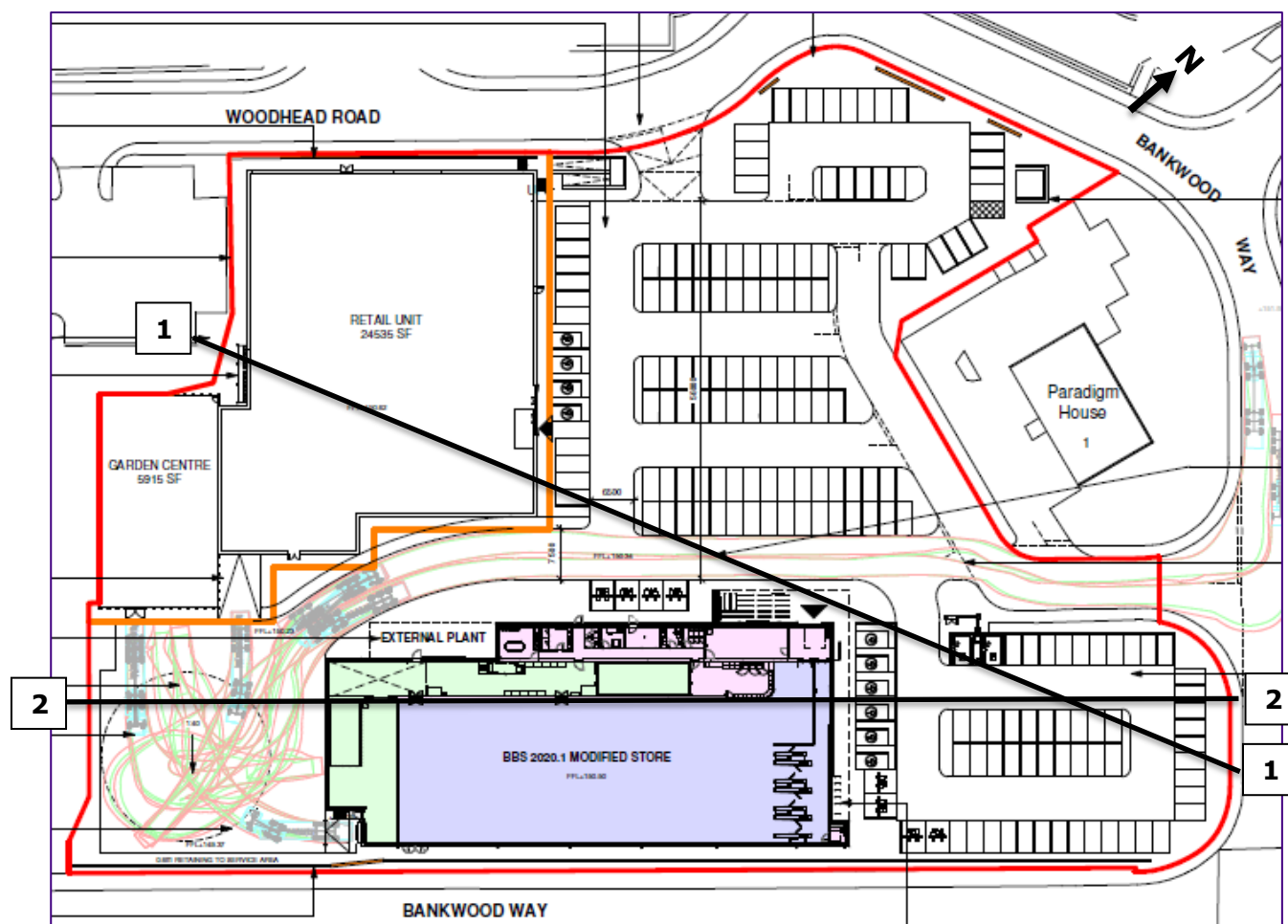


Figure 1: Proposed site layout and cross-section locations

Site History

The earliest available historical Ordnance Survey mapping, dated 1852, indicates the site to be undeveloped, comprising mainly fields with a small area of woodland in the east area of the site. Numerous coal pits, quarries and other mining features are shown in the vicinity of the site at this time, the nearest within approximately 70m of the western site boundary. By 1893, an excavation is indicated in the south-eastern area of the site. Further excavation is indicated on the 1956 edition mapping, with an area of steeply sloping ground shown trending south-east to north-west across the northern margin of the site.

Environmental records indicate landfilling operations (Nab Lane Refuse Disposal Tip) commenced in 1970 at the site, accepting inert, industrial, commercial, liquid and household waste. A further record lists the site as a registered landfill from 1982. Neither record indicates



when operations ceased. Between 1988 and 1990, however, the site appears to have been infilled, with recorded development of several buildings labelled 'Centre 27 Business Centre' shown by 1992.

Publicly available aerial imagery appears to show the business centre being demolished during 2018, with several stockpiles of what appear to be demolition rubble present by 2019. It is understood that the buildings were demolished due to ongoing settlement issues, first recorded in 2001.

Site Geology

British Geological Survey (BGS) information indicates the site to be underlain by the Pennine Lower Coal Measures Formation; the Emley Rock unit is shown to outcrop in the western and northern areas of the site. The Pennine Lower Coal Measures Formation are described as interbedded grey mudstone, siltstone and pale grey sandstone, commonly with mudstones containing marine fossils in the lower part, and more numerous and thicker coal seams in the upper part. The Emley Rock unit is described as fine-grained flaggy sandstone with mudstone partings.

The Flockton Thin Coal seam is shown to outcrop on the site, trending approximately south to north from the southern corner of the site, before turning abruptly in an approximately easterly direction, crossing the site boundary in the area of the eastern corner.

The natural bedrock geology is shown to be overlain by infilled ground, described as mainly former opencast site, brick pits and quarries.

One BGS borehole record is positioned on site (SE22NW744), dated 1981, which describes boulder clay present to a depth of 1.25m, underlain by a succession of sandstones, siltstones and mudstones, to the base of the borehole (29.65m bgl). Potential coal, denoted '? Coal', is recorded between depths of 27.15m and 27.5m bgl.

Coal Mining

The site is located within a Coal Mining Development *High Risk* Area and a Consultants Coal Mining Report was therefore obtained from the Coal Authority by Curtins. An earlier Coal Mining Risk Assessment, produced by Delta Simons, was not made available at the time of writing this report.

In summary, the Coal Mining Report identifies that the Flockton Thin coal seam is recorded as being 0.91m in thickness and to outcrop at the site. The Top Fenton seam is recorded as being 0.60m in thickness, present at a depth of 30m. The seams are recorded as last being worked in 1877 and 1911, respectively. Several further seams are present beneath the site, though these are at depths considered unlikely to affect the development of the site.

An adit is recorded in the eastern corner of the site, apparently intercepting the Flockton Thin coal seam in a north-easterly direction. The reports indicate that further, unrecorded, shallow workings and/or mine entries are probable.

Ground Conditions

The ground conditions encountered at the site during both the Delta Simons and Curtins ground investigations are summarised below. Should further information be required, the original reports should be referred to.



Beneath a surface covering of hardstanding and sub-base (Delta Simons, 2018) or demolition waste (Curtins, 2020), Made Ground was encountered, to a maximum depth of 14m bgl, underlain by deposits of the Pennine Lower Coal Measures Formation, to a maximum proven depth of 38.75m bgl.

The Made Ground comprised either reworked natural material, present to depths of up to 14m bgl in the east of the site, or landfill waste materials, encountered to a maximum depth of 12.5m and limited to the southern area of the site. The reworked natural material is described as firm to stiff dark greyish brown slightly sandy slightly gravelly clay. The granular component comprised mudstone, and rarely coal, brick, sandstone, timber and plastic bags.

The landfill waste is described as comprising plastic bags, carpet, rubber, timber, plastic, metal, metal wire, with cobbles of brick, sandstone and concrete, within a black clayey matrix.

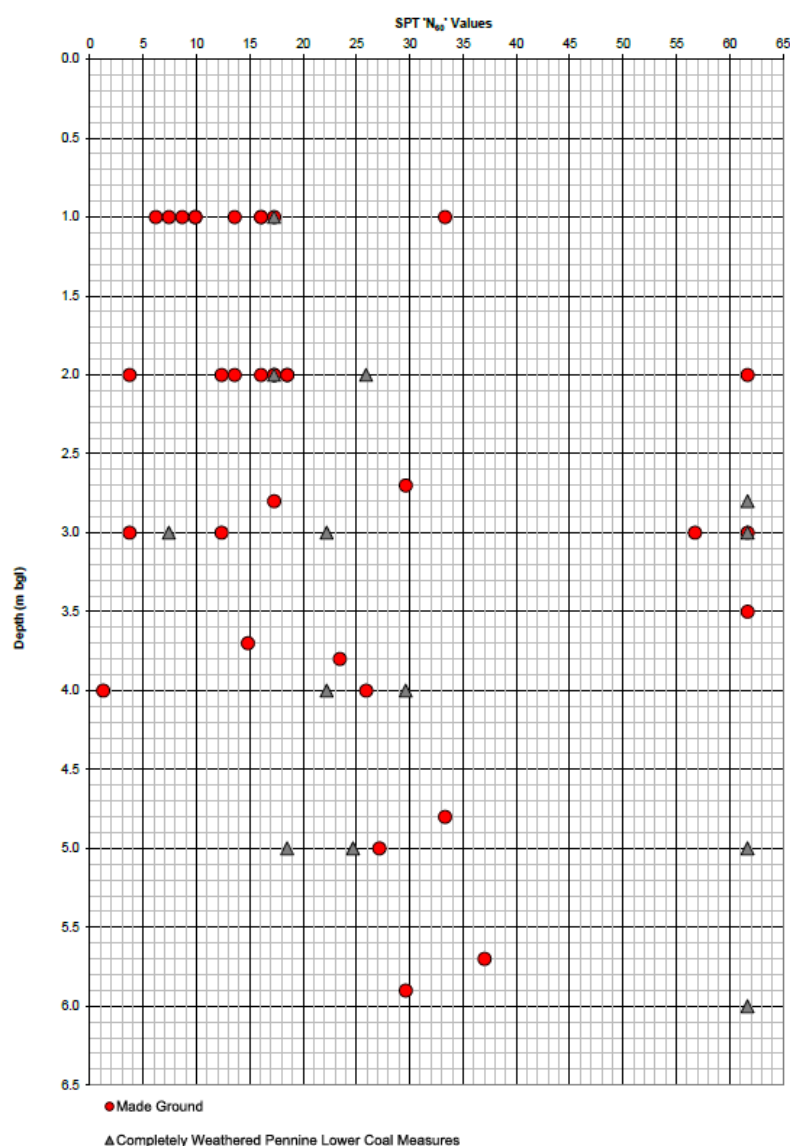


Figure 2: SPT N₆₀ plotted against depth (reproduced from Delta Simons report)



Generally, SPT N-Values increased with depth (see Figure 2), typically from around 10 to around 30. However, N-Values as low as 1 were recorded within the reworked material, and >50 within both the reworked and landfill materials.

The deposits of the Pennine Lower Coal Measures Formation were described as firm to stiff brown mottled orange and grey slightly gravelly clay, up to 1.0m in thickness, underlain by extremely weak to strong, becoming stronger with depth, thinly laminated orangish brown mottled grey mudstone and siltstone with bands of medium strong to strong grey fine-grained sandstone. Coal was encountered within the natural geology at depths of 5.7m bgl and 37m bgl, 0.1m and 0.3m in thickness, respectively. Possible voids or collapsed workings were encountered in the northeast and southwest of the site, from depths of between 2.2m and 3.8m, between 1.4m and 2.8m in thickness.

Figure 3 provides a cross section, reproduced from the Delta Simons report, from the west-southwest of the site to the east-northeast (see Figure 1 for cross-section 1 location). The profile of the infilled excavation is shown, along with the inferred former location of the Flockton Thin Coal seam, having since been removed by either opencast or underground mining.

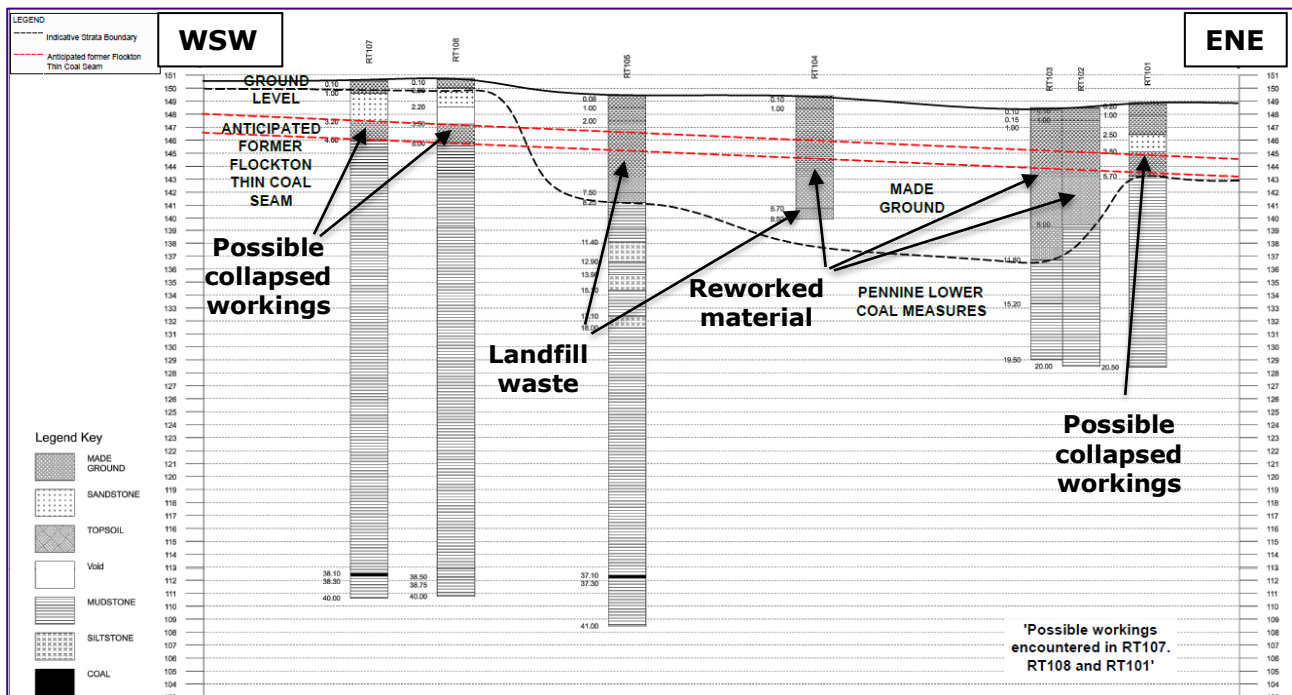


Figure 3: Cross-section 1 (reproduced from Delta Simons report)

Figure 4 provides a cross section, reproduced from the Delta Simons report, from the southwest of the site to the northeast (see Figure 1 for cross-section 2 location). The section shows the steeply-sloping highwall in the northeast of the site, and the thicker landfill waste deposits in the southwest. The possible collapsed mine workings to the northeast of the highwall are also shown.

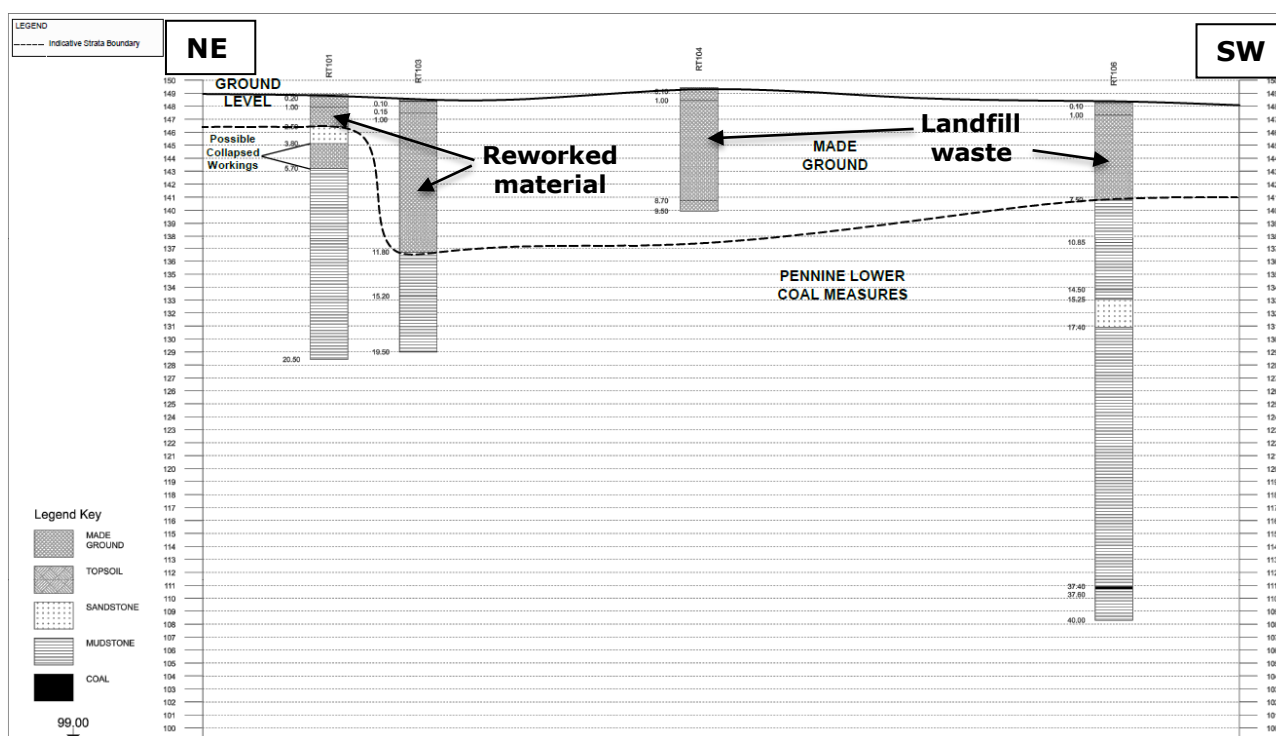


Figure 4: Cross-section 2 (reproduced from Delta Simons report)

Proposed Ground Improvement

As an alternative to piled foundations, a ground improvement solution has been proposed by Vibro Menard. The solution utilises Controlled Modulus Columns (CMCs) beneath the building footprints and service yard, and Bi-Modulus Columns (BMCs) beneath pavement areas.

The CMC system (see Figure 5) comprises a grid of 320mm nominal diameter concrete columns which are intended to improve the bearing properties of the soil mass as a whole, reducing total settlements by partially relieving the soils of load, and differential settlements by evenly distributing loads across a load distribution platform at the surface. The columns are formed using a displacement auger, which pushes soils outwards, rather than bringing them to the surface, locally increasing the strength and stiffness of the soil around the column. The base of the columns are to be drilled at least 0.5m into the weathered deposits of the Pennine Lower Coal Measures Formation. The ground treatment process will allow the use of shallow foundations once complete, with an SLS bearing capacity of 200kN/m².

The BMC process (see Figure 6) is similar to that described above, but with an upper section (1.5m to 2.0m) of 400mm to 500mm wide vibro stone column (VSC). The wider profile of the stone column, together with a load distribution platform, help to efficiently spread loads across the improved soil mass.

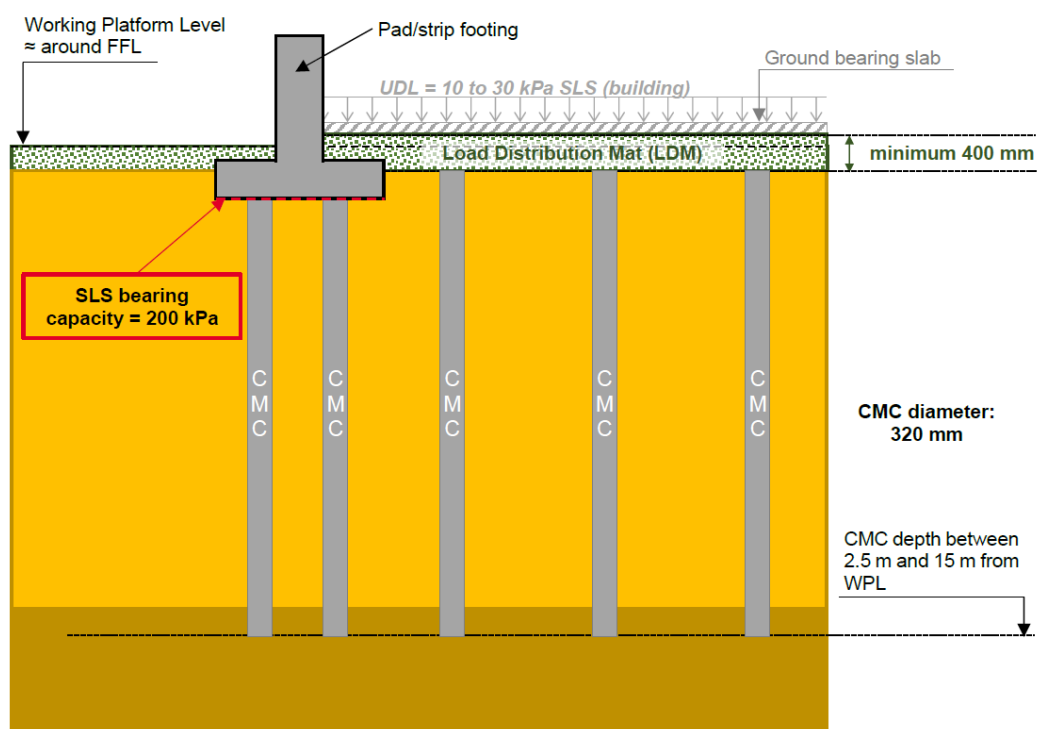


Figure 5: Typical cross-section of foundation and ground floor slab over CMCs

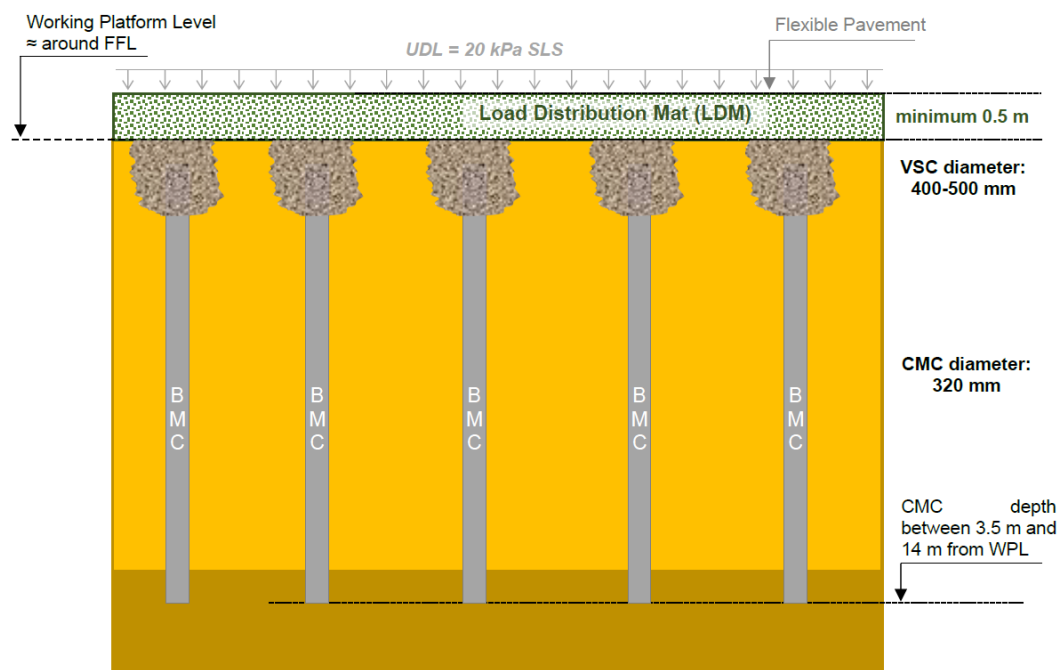


Figure 6: Typical cross-section of foundation and ground floor slab over CMCs



Recommendations

The proposed ground improvement works are suitable as an alternative to piled foundations. However, a number of potential issues have been identified, which should be considered during the design and installation of the system. These are described below.

1. The profile of the Pennine Lower Coal Measures Formation varies significantly across short distances. It will therefore be necessary to consider how the base of the columns will be installed without deflection and with sufficient penetration into competent natural material around the edge of the former opencast workings, where interacting with the highwall.
2. It is noted that the waste is described as being within a clay matrix. The clay matrix will generally dominate the geotechnical engineering behaviour of the waste albeit variation will occur given the heterogeneity of the material composition. With landfilling at the site potentially continuing until the early 1990s, it is possible that any biodegradable putrescible materials in the waste are still degrading, albeit most of the degradation should have occurred over the past 30 years. Following improvement, the long-term residual degradation of landfill waste materials, resulting in potentially uneven loss of strength within the soil mass, should be considered. Where long-term settlement occurs within the waste mass, confirmation should be provided that any reduction of support and/or movement will not adversely affect the proposed solution, resulting in excessive movement or collapse of the stone column section.
3. It is acknowledged that anticipated total and differential settlements are to be reduced through the application of the proposed method. It is recommended that the design considers the transition between differing foundation types (CMC's/BMC's) to minimise potential differential movements and to maintain transition gradients within acceptable tolerances. It is anticipated the use of the load transfer mat will mitigate the majority of these potential effects.
4. The potential for ground gas migration, particularly within the vibro stone column element of the BMC columns, should also be considered when designing the system. For example, it may not be feasible to locate the base of the stone columns within the landfill waste material, encountered from depths as shallow as 0.8m bgl, which may mean varying the depth of the stone columns across the site.
5. It is understood that the identified shallow mine workings are to be treated by injection grouting prior to ground improvement works taking place. The interaction between the treated mine workings, including the adit recorded in the northeast of the site, but not identified by either ground investigation, and the ground improvement works should be considered to ensure the performance of the ground treatment is not adversely affected.
6. Excessive heave should be mitigated against during the ground improvement works, as this will reduce the effectiveness of the improvement of soils surrounding the columns. It is assumed the surcharge loading from the addition of the load distribution mat will be minimal and supported by the columns and will therefore not significantly increase consolidation settlements.



We trust the above is satisfactory for your purposes. Please do not hesitate to contact us should you have any comments or require further information.

Yours sincerely

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Dr Geoffrey B Card, Managing Director
GB Card & Partners