

Technical Note

Site: Boorley Green Phase B3A

Ref: GE17628

Client: Linden Homes

Date: September 18, 2018

The Phase B3A development parcel at Boorley Green has been the subject of filling to raise ground levels to the proposed development level. This process is understood to have comprised the placement of site won soils as engineered fill. Final fill levels were understood to have increased from those originally planned and this has potentially significant implications for foundation options (including type, depth, constructability and spoil generation).

Whilst it is assumed that the earthworks filling operation was undertaken in accordance with an earthworks specification, Geo-Environmental was not involved in preparation of a specification for this particular parcel, nor involved in oversight of the earthworks process. Nonetheless, some post compaction testing results were made available which indicated that a post compaction density of 90% to >100% of the target density was achieved, thereby indicating that fill was compacted even if the post compaction density was somewhat variable. It should be noted that the compaction process removes air from the soil and reduces the overall air voids content to produce a more uniform fill. Compacted fill is still susceptible to settlement following compaction.

The fill would be susceptible to settlement due to self-weight, the magnitude of settlement typically being c. 0.5-1.0% of the placed fill thickness, e.g. 15-30mm for fill 3m thick. In addition, further settlement would occur as a result of imposed loading and the magnitude of such settlement would generally be proportional to the applied load, i.e. the greater the load, the greater the settlement. Moreover, given the variation in the degree of compaction achieved and variation in fill composition, differential settlement would also be likely to occur and could readily be c. 50% of the total settlement value. Both total and differential settlement could exceed tolerable limits for conventional construction. As such, it is considered that the engineered fill would not be suitable for use as a bearing stratum for conventional foundations.

A Geotechnical Engineer from Geo-Environmental attended site on 12th September 2018 to inspect and record the conditions exposed in excavations to be formed on the Phase B3A development parcel. Following discussions with Linden Homes representatives prior to attending site, the purpose of the site visit was not to assess whether the engineered fill was suitable as a bearing stratum for foundations, but to assess the composition and depth of the fill in areas where it was anticipated to be c.2.0-3.0m deep and to assess the short term stability of excavations which passed through the fill into underlying natural soils.

A total of three trenches were excavated at locations agreed with the Client's Structural Engineer who was also present for the excavations. The Geotechnical Engineer recorded the ground conditions exposed in each of the three trenches and copies of the trial pit logs are enclosed.

The ground conditions generally comprised a mantle of Topsoil, placed over an engineered fill, with natural strata at varying depth. Whilst the composition of the placed Topsoil was generally consistent within the three trenches, the composition of the engineered fill, whilst generally a clay, was different in each trench. In Trench 1, the engineered fill included fragments of wood, brick and plastic entrained within the general soil mass, with a fragment of tree branch and survey peg at 2.6m bgl. In Trench 2, the engineered fill comprised a firm clay which was friable upon excavation and whilst no wood, plastic, brick or similar inclusions were observed which could assist in determining the fill base, a change in colour as a distinct orange band was present within the perimeter of the excavation at 1.7m bgl. In Trench 3, the engineered fill included flint gravel, brick fragments, plastic sheeting and tarmac fragments.

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There was similar variation in the natural soils underlying the engineered fill, such that in Trench 1 the natural ground comprised stiff brown fissured clay over stiff light grey and yellow brown slightly sandy silty clay, whilst in Trench 2 the natural strata comprised stiff fissured clay which rapidly became shaley to thinly bedded mudstone, and in Trench 3 the natural strata comprised firm to stiff yellow-brown and green mottled sandy clay. These variations in composition of the natural strata were broadly consistent with variations observed during previous phases of ground investigation across this portion of the site.

Each trench was excavated through the engineered fill and into the natural strata. The excavations were formed with vertical sides which were stable during excavation and also remained stable as observed by the Geotechnical Engineer for up to c. 1 hour after excavation. Each trench was left open for up to c. 3-4 hours following excavation and the Client's Site Representative confirmed that no instability occurred during that timeframe.

On the basis of the ground conditions encountered within the three trenches, the engineered fill is not suitable as a bearing stratum and thus if conventional foundations are to be used on this development phase, they will need to extend into the underlying natural strata. Due to the variation in depth of engineered fill, this is likely to require foundation depths in excess of 3m bgl locally, assuming that the current ground level is not reduced during construction. This also assumes that the placed Topsoil layer is not stripped, which if removed would reduce overall excavation by c. 0.4m based on the average Topsoil thickness.

Heave protection measures would be required on any foundations in excess of 1.5m bgl. In addition, given the variation in composition of the natural strata underlying the engineered fill, it is recommended that reinforcement is included in foundations. Both the inclusion of heave protection and reinforcement would require a safe system of work to be developed and followed to protect construction personnel.

Suspended floor slabs would be required throughout due to the depth of engineered cohesive fill.

A plot by plot foundation depth assessment has been undertaken by the Structural Engineer and this identified 21 plots where foundations in excess of 3m deep would be required, one of which (Plot 192) would require a foundation depth of c. 4.1m bgl.

Whilst the trenches remained stable during the site inspection, they were formed in relatively short lengths (up to 4.4m long) compared to the trenches likely to be excavated for foundations. It should also be noted that these trenches were excavated during dry conditions, at locations remote from any existing ground works, structures or construction activity, each of which could reduce stability substantially. The construction strategy should look wherever possible to reduce the potential for trench instability by measures such as limiting the total depth of excavation, the length of trench left open at any given time and keeping unsupported trenches open for as short a time period as possible prior to mass filling with concrete. The Structural Engineer has identified 21 plots where foundation excavations would be in the range 3-4m deep (including one, Plot 192, in excess of 4m deep) and the likelihood of instability arising during construction on these plots is markedly higher (significant hazard and risk) than for shallower foundations. Whilst it may technically be possible to construct foundations at depths in excess of 3m bgl, the risks in terms of cost, programme, failure at inspection, failure once constructed and H&S implications of construction are substantially increased and any such option must also be considered in a commercial context (including H&S implications). In addition, under CDM Regulations, the Client and Designer have a duty to design out H&S risks wherever possible. The Ground Works Contractor would also be required to undertake a risk assessment and identify mitigation measures to minimise the potential for trench instability occurring.

If there is scope to undertake any form of reduced dig across plots requiring deep strip foundations, this may reduce the risk of instability and also potentially address some H&S issues around deep excavations. As noted above, it is assumed that the placed Topsoil would be stripped prior to construction and a localised reduced dig of c. 0.6-1.1m across key plots would effectively reduce foundation excavations by c. 1-1.5m. Ground levels would then need to be restored to the required development in due course, possibly as block work rises, and so this would have commercial (financial and

programme implications). Backfilling the reduced dig area could also require an additional phase of compaction to mitigate the risk of post construction settlement (total and differential) of fill.

Ground works should be designed in such a manner to avoid any requirement for construction or maintenance personnel to enter into or work within excavations. If such work cannot be avoided, then it should only be permitted once a safe system of work, supported by a robust risk assessment, has been determined and implemented. The Ground Works Contractor's risk assessment should include continuous observation of excavation stability and if any excavations become unstable (including indicators such as trench side bulging, settlement of adjacent ground, tension cracks at ground level, spalling or the like) works should stop immediately and the trench be backfilled to prevent further instability. Further advice should then be sought.

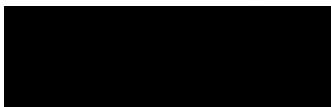
Whilst construction of a deep strip solution is technically viable, there are commercial issues which the Client would need to resolve. These include the increased cost of concrete over and above a 'normal' foundation and the volume of surplus spoil generated from excavations for deep strip foundations as well as constructability and H&S issues. It is understood that there is already a possible surplus of fill to be generated for development of the wider Boorley Green site and so removal of excess spoil from site could be required and incur additional costs.

A limiting depth of 3m bgl has been recommended by the Structural Engineer as the cut-off for conventional foundations and Geo-Environmental concurs with this recommendation.

Whilst it is understood not to be favoured by the Client, a piled foundation solution would be a suitable alternative to deep strip foundations. Both CFA and driven pile solutions have been used on other parcels on the Boorley Green development. As noted above and also identified by the Structural Engineer, it is considered that any plots where foundation depths would exceed 3m bgl are unsuitable for conventional foundations and a piled foundation solution is recommended. Use of a conventional piling rig may require construction of a temporary working platform and this should be accounted for. The actual thickness of the working platform would be dependent on the rig used. In addition to CFA or driven piles, it may be possible to utilise a driven steel tube pile solution, which can be installed using a smaller piling rig and thereby reduce mobilisation and construction costs, remove a requirement for a piling mat and also reduce the overall volume of spoil generated for foundation excavations. Once installed, the driven steel tube pile would require grouting from the base up or concreting from the top to complete the pile construction.

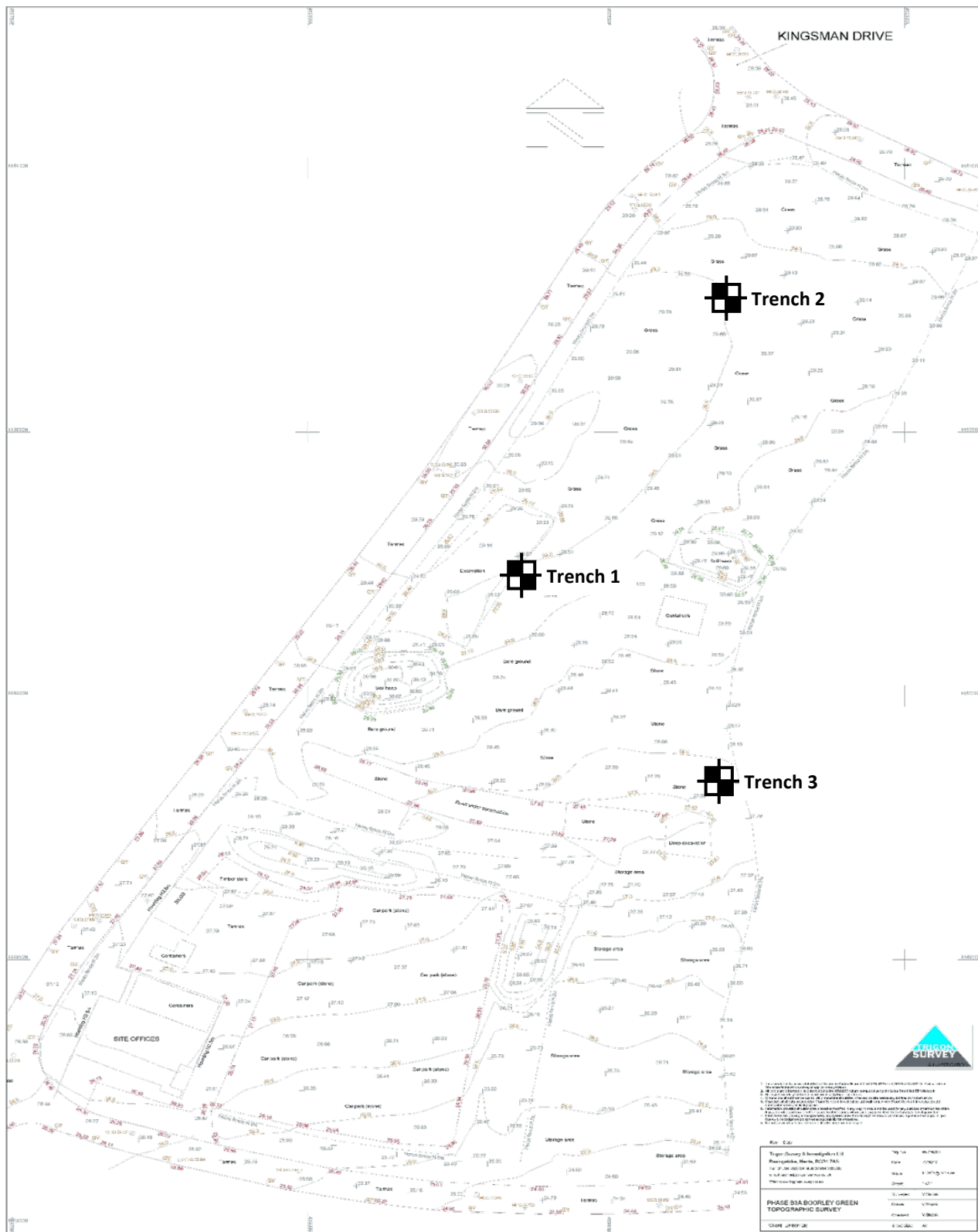
In conclusion, it is considered that strip and deep strip foundations may be suitable for the majority of the plots on this development parcel, subject to caveats and controls regarding trench stability, constructability and H&S limitations. However, a limiting depth of 3m bgl should be used for conventional foundations and for the 21 plots which would require foundations in excess of this depth, a piled foundation solution is required.

For and on Behalf of Geo-Environmental



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Enc. Figure 1 Trench Location Plan
Trial Pit Logs Trenches 1-3



NOTE: Locations are approximate only

Project:	Booreley Green Phase B3A	Title	Trench Location Plan
Client:	Linden Homes	Geo-Environmental Services Ltd Unit 7 Danworth Farm, Cuckfield Road Hurstpierpoint, West Sussex BN6 9GL +44(0)1273 832972 www.gesl.net	
Ref No:	GE17628		
Revision:	1.0		
Drawn:	GR		
Date:	18/09/2018	 Geo-Environmental	
Figure:	1		
Scale:	NTS		



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Trial Pit Log

TrialPit No
Trench 1
Sheet 1 of 1

Project Name: Boorley Green Phase B3A

Project No.
GE17628

Co-ords: -
Level:

Date
12/09/2018

Location: Boorley Green, Hampshire

Dimensions (m): 3.40

Depth
3.60

0.60

Scale
1:25

Logged
GR

Client: Linden Homes South

Water Strike	Samples & In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
	Depth	Type	Results					
				0.50			Dark greyish brown clayey silty sand with rootlets. Placed Topsoil.	
							Firm varying to stiff light brown orange-brown and grey mottled silty clay with occasional but variable minor proportions of brick wood and plastic. Darker grey from 2.5m bgl with possible pockets of relic Topsoil and fibrous matter. Wood comprising a branch fragment c. 200-250mm long and 75-100mm diameter and survey peg at 2.6m bgl.	1
				2.70			Stiff to very stiff brown closely fissured CLAY with rare rounded flint gravel	2
				3.20			Stiff light grey and yellowish brown mottled fissured slightly sandy silty CLAY	3
				3.60			End of Pit at 3.60m	4
								5

Remarks Hole left open and Client's Site Representative reported it to remain stable over c.3-4hours.

Stability Stable





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Trial Pit Log

Trial Pit No
Trench 2
Sheet 1 of 1

Project Name: Boorley Green Phase B3A

Project No.
GE17628

Co-ords: -
Level:

Date
12/09/2018

Location: Boorley Green, Hampshire

Dimensions (m): 4.40

Depth
3.40

0.60

Scale
1:25

Logged
GR

Client: Linden Homes South

Water Strike	Samples & In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth	Type	Results				
				0.40			Dark greyish brown clayey silty sand with rootlets. Placed Topsoil.
				1.70			Light brown light grey yellow and orange brown mottled silty clay. Friable texture and loose as dug. Variable firm to stiff strength of intact lumps. Shaley fragments of gravel size from 1.5m bgl. Orange brown colouration at 1.7m bgl.
				3.40			Stiff to very stiff light brown orange-brown yellow and grey fissured sandy CLAY becoming shaley clay to fractured and thinly bedded mudstone with depth.
							End of Pit at 3.40m

Remarks Hole left open and Client's Site Representative reported it to remain stable over c.3-4hours.

Stability Stable





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Trial Pit Log

TrialPit No
Trench 3
Sheet 1 of 1

Project Name: Boorley Green Phase B3A

Project No.
GE17628

Co-ords: -
Level:

Date
12/09/2018

Location: Boorley Green, Hampshire

Dimensions (m): 3.40

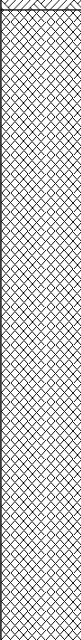
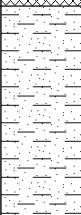
Depth
3.20

0.60

Scale
1:25

Logged
GR

Client: Linden Homes South

Water Strike	Samples & In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
	Depth	Type	Results				
				0.40			Dark greyish brown clayey silty sand with rootlets and rare plastic. Placed Topsoil.
							Firm light brown grey and yellow-brown sandy clay with green and bluish green clayey sand pockets and some medium to coarse gravel of flint brick fragments rare plastic sheeting and rare tarmac fragments
				2.50			Firm to stiff yellow brown and green mottled sandy CLAY
				3.20			End of Pit at 3.20m

Water Strike	Rose to (img)	Remarks	Hole left open and Client's Site Representative reported it to remain stable over c.3-4hours.
Depth Strike		Stability	Stable

