Southern Testing
Environmental & Geotechnical

Site Investigation Report



Desk Studies | Risk Assessments | Site Investigations | Geotechnical | Contamination Investigations | Remediation Design and Validation

Site: Worthing Hospital, Worthing, West Sussex

Client: Mansell Plc

Report Date: 7th September 2010

Project Reference: J10309

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SUMMARY

The site comprises two individual areas of intrusive investigation, which are referred to as :-

- Area I, the staff car park, situated on Homefield Road, where it is proposed to redevelop the site with a three to five storey building.

- Area II, on Park Avenue to the north of Worthing Hospital currently comprises two storey semidetached residential properties with associated gardens, which are to be redeveloped into a temporary car park and a two storey Breast Clinic.

Geological records indicate Area I to be underlain by Aeolian Deposits over Upper Chalk and Area II to be underlain by Alluvium over Lambeth Group over Upper Chalk.

A historical Ordnance Survey map search and desk study was not requested.

A single phase of intrusive investigation was carried out.

The soils encountered in Area I comprised a shallow covering of Made Ground over sandy Clay over Chalk.

The soils encountered in Area II comprised Made Ground over soft to firm very low to low strength Clay (Alluvium) over stiff very high strength reddish orange mottled blueish grey Clay.

Groundwater was encountered between 4.2m bgl and 6.5m bgl in Area 1 and between 2.0m bgl and 3.6m bgl in Area II.

The sulphate content of the natural soil was found to fall within Class DS-1. The ACEC classification for the site is AC-1.

NHBC LOW Volume change precautions in Accordance with NHBC Chapter 4.2 will apply in Area 1, NHBC HIGH Volume change precautions will apply in Area II.

A CFA piled foundation solution is considered to be most appropriate for the proposed developments in both Area I and II.

Preliminary calculations for Area I indicate a 350mm diameter CFA pile, with its toe set at 15m bgl would have a safe working load of around 360kN.

Preliminary calculations for Area II indicate a 300mm diameter CFA pile, with its toe set at 10m bgl would have a safe working load of around 165kN.

Contamination Issues are not considered in this report as they were outside the scope of our investigation.

The site investigation was conducted and this report has been prepared for the sole internal use and reliance of Mansell Plc and their appointed Engineers. This report shall not be relied upon or transferred to any other parties without the express written authorization of Southern Testing Laboratories Limited. If an unauthorised third party comes into possession of this report they rely on it at their peril and the authors owe them no duty of care and skill.

The findings and opinions conveyed via this Site Investigation Report are based on information obtained from a variety of sources as detailed within this report, and which Southern Testing

Laboratories Ltd believes are reliable. Nevertheless, Southern Testing Laboratories Ltd cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.





Stuart Pratt CGeol MSc
(Countersigned)

Darryl Kelly MGeol FGS
(Signed)

For and on behalf of Southern Testing Laboratories Limited

STL: J10309
7 September 2010

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A INTRODUCTION

1 Authority

Our authority for carrying out this work is contained in a Domestic Sub-Contract Order dated the 20th July 2010 from Ken Anderson of Mansell Construction Services Ltd.

2 Location

Worthing Hospital is located approximately 0.5km north of Worthing Seafront, Worthing, West Sussex and is situated approximately 300m east of the A24.

The approximate National Grid Reference of the site is TQ 151 031.

3 Proposed Construction

The proposed extensions are taking place in two separate areas on site, which will be referred to as:-

- Area I, the staff car park situated on Homefield Road, where it is proposed to redevelop the site with a three to five storey building.
- Area II, on Park Avenue to the north of Worthing Hospital currently comprises two storey semi-detached residential properties with associated gardens, which are to be redeveloped into a temporary car park and a two storey Breast Clinic.

4 Object

This is a Phase II geotechnical investigation (Tier 1).

The object of the investigation was to assess foundation bearing conditions and other soil parameters relevant to the proposed development.

5 Scope

This report presents our desk study findings, exploratory hole logs, test results and our interpretation of these data.

As with any site there may be differences in soil conditions between exploratory hole positions.

This report is not an engineering design and the figures and calculations contained in the report should be used by the Engineer, taking note that variations will apply, according to variations in design loading, in techniques used, and in site conditions. Our figures therefore should not supersede the Engineer's design.

Contamination issues are not considered in this report.

The findings and opinions conveyed via this Site Investigation Report are based on information obtained from a variety of sources as detailed within this report, and which Southern Testing

Laboratories Limited believes are reliable. Nevertheless, Southern Testing Laboratories Limited cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

The site investigation was conducted and this report has been prepared for the sole internal use and reliance of Mansell Plc and their appointed Engineers. This report shall not be relied upon or transferred to any other parties without the express written authorization of Southern Testing Laboratories Limited. If an unauthorised third party comes into possession of this report they rely on it at their peril and the authors owe them no duty of care and skill.

The recommendations contained in this report may not be appropriate to alternative development schemes.

B DESK STUDY & WALKOVER SURVEY

6 Desk Study

A desk study has not been carried out, however, reference has been made to the BGS geological maps.

6.1 Geology

The British Geological Survey Map indicates that the geology in Area 1 consists of Aeolian Deposits (Brickearth) over Upper Chalk.

The British Geological Survey Map indicates that the geology in Area 2 consists of Alluvium over Lambeth Group over Upper Chalk.

Aeolian Deposits (Brickearth)

Brickearth (loess deposit) is a recent deposit which is so called as it is suited to brick manufacture. It is predominantly an Aeolian deposit; formed during cold, dry climatic conditions. There is evidence that Brickearth has been reworked as part of 'sheet flooding', which helped incorporate flint gravels into the deposit. Brickearth consists mainly of ferruginous silty clay, which is often sandy and may contain some finely divided chalk, scattered flints and gravely seams, or other locally derived material. It is usually poorly consolidated and may contain numerous hollow root tubes and worm burrows.

Alluvium

Alluvium is, geologically speaking, a recent deposit found in association with streams, rivers and other watercourses. It usually consists of soft clays and silts and often has a high organic content. Lenses and bands of peat are commonly found.

It is inherently variable and rapid lateral transitions in soil type should be anticipated, even though borehole sampling may indicate fairly consistent soil conditions.

The soft and variable nature of the soil gives rise to many construction problems. Running sand or silt is often encountered when least expected. Excavations deeper than 1.5 to 2 m are often unstable and close sheeting and strutting is usually required. Bottom heave may be encountered in clayey soils below 3 m.

Lambeth Group

The Lambeth Group formerly known as the Woolwich and Reading Beds are an Early Eocene deposit. They were laid down under fluvial estuarine or lagoon conditions and consist of very variable soils - mainly red, green, grey and brown stiff (high strength) mottled clays, sands and loam. The sands are greenish yellow or brown, and generally alternate with the mottled clays and sometimes bands of lignite. Pebble Beds, locally cemented into conglomerate, and some bands of concretionary ironstone may also be present.

Shells are frequently found in the clays at about the middle to the lower part of the formation. These are sometimes cemented into a limestone bed that may form an obstruction to pile borings. At the base of the beds there can be layer of greenish sands with flint pebbles where they rest directly above the Thanet Beds.

Upper Chalk

Upper Chalk is a well known soft white friable limestone of organic origin which is composed of shell debris embedded in a fine matrix of microscopic calcareous bodies produced by planktonic algae (coccoliths).

Upper Chalk is frequently highly fractured and highly permeable, when excellent drainage can be achieved via soakaways. On the other hand, Chalk Head and Chalk under a cover of Reading Beds may have very poor soakage characteristics.

Chalk is slightly soluble in water and, while it has excellent bearing properties when unweathered, this solubility can lead to deep weathering and softening, producing some undesirable characteristics, as far as a building construction is concerned.

Man has worked the chalk for flints, and for other purposes for thousands of years and any signs of old workings should be carefully investigated.

7 Walkover Survey

A walkover survey was carried out on 6th August 2010.

7.1 General Description and Boundaries

The site in general comprises land belonging to Worthing Hospital. The areas of intrusive investigation were located in separate areas within the hospital grounds.

Area 1 comprises part of the existing staff car park adjacent to the Children's Centre, which at the time of our walkover survey comprised an area of bituminous surfaced car park with several existing drain runs and numerous service trenches. The area is generally flat and level except for minor undulations within the car park itself.

No significant vegetation is situated within the car park area, however there are several mature trees situated off site to the northeast along Homefield Road.

Area II is situated to the north of the main hospital site, on Park Avenue. The area at the time of our walkover survey comprised a row of semi-detached houses and associated back garden areas, which appeared to be in fair structural condition and were disused. This part of the site is situated at a lower elevation than the main hospital buildings.

The back gardens of the properties were over grown and unkept, and at the time of our investigation were being cleared. Along the northern most boundary of the gardens a row of mixed mature shrubs and tress were situated, which included fruit trees, conifers, Leylandi hedging, Lime and semi mature Beech, Willow and Sycamore. Some of the back gardens contained small sheds/garages. Whilst no apparent asbestos containing materials (ACM) were noted a careful watch should be made during demolition for any ACM's.

C SITE INVESTIGATION

11 Method

The strategy adopted for the intrusive investigation comprised the following:

Area I

- 2 No 25m deep boreholes were drilled using a light percussion, 150mm diameter, shell and auger boring rig, with insitu testing and sampling.

Area II

- 1 No 13m deep borehole was drilled using a light percussion, 150mm diameter, shell and auger boring rig, with insitu testing and sampling.
- 3 No. 4-5m windowless sampler boreholes were drilled with insitu testing and sampling.
- 13 No in situ DCP CBR tests were carried out along a proposed car parking area.

Exploratory hole locations are shown in Figures 1 and 2 in Appendix A.

12 Weather Conditions

The fieldwork was carried out between 6th August and 18th August at which time the weather was generally variable with a mixture of sunny spells, showers and heavy rain.

13 Soils as Found

- Area 1 – BH1 and BH2

The soils encountered are described in detail in the attached exploratory hole logs (Appendix A), but in general comprised a covering of Blacktop over Made Ground over sandy Clay over Chalk. A summary is given below.

Depth	Thickness	Soil Type	Description
GL to 0.15m	0.15m	Blacktop	Car Park Surfacing
0.15m to 0.4m/0.5m	0.25m to 0.35m	Made Ground	MADE GROUND comprising dark brown fine sandy clay with occasional flint gravel, brick and

Depth	Thickness	Soil Type	Description
			slate fragments.
0.4m/0.5m to 2.5m/3.0m	2.0 to 2.6m	Clay	Firm to stiff orange brown fine sandy CLAY with rare flint gravel.
2.5m to 4.0m (BH1 Only)	1.5m	Sand	Orange brown clayey fine to medium SAND.
2.5m/3.0m to 5.5m/6.0m	2.5m to 3.5m	Silt (Head)	Firm to stiff orange brown mottled white clayey SILT (HEAD) with frequent fine to medium chalk gravel and fine to coarse subrounded flint gravel.
5.5/6.0m to 25m	19m to 19.5m	Chalk	Recovered as off white putty CHALK with frequent to abundant fine to cobble sized weak to strong chalk gravel. Wakeling Grade IV to I

- Area 2 – DH 1, 2 and 3, BH3.

The soils encountered are described in detail in the attached exploratory hole logs (Appendix A), but in general comprised a covering of Made Ground over soft low strength Clay (Alluvium) over stiff fissured Clay. A summary is given below.

Depth	Thickness	Soil Type	Description
GL to 1.2m/1.6m	1.2m to 1.6m	Made Ground	MADE GROUND comprising dark brown fine to coarse sandy clay with frequent to abundant brick, charcoal and slag fragments.
1.2m/1.6m to 3.4m/4.0m	1.6m to 2.8m	Clay (ALLUVIUM)	Soft to firm very low to low strength orange brown becoming grey CLAY (ALLUVIUM) with frequent pseudofibrous root fragments and fine white calcareous nodules.
3.6m/4.0m to 13.0	9.0 to 9.4m	Clay	Stiff high to very high strength fissured reddish orange mottled blueish grey CLAY with rare fine flint gravel and pseudofibrous root fragments.

14 Groundwater Strikes

Water was struck in the exploratory holes as follows:

Exploratory Hole	Water Strikes
DH1	Water level 3.30m bgl 60 minutes after hole completion.
DH2	Water level 2.0m bgl 60 minutes after hole completion.
DH3	Water level 3.6m bgl 60 minutes after hole completion.
BH1	Seepage at 5.0mbgl, 6.5m after 24 hours when hole at 8.5m.
BH2	Seepage at 7.5m bgl, 4.2m after 24 hours when hole at 7.5m.
BH3	Water struck at 10.5m, level 10.10m bgl after 20 minutes.

D FIELD TESTING AND SAMPLING

The following in-situ test and sampling methods were employed. Descriptions are given in Appendix B together with the test results.

- Dynamic Cone Penetrometer CBR's
- Standard Penetration Tests-with Wakeling Grade Classification.
- Undisturbed Sampling
- Hand Penetrometer
- Disturbed and Bulk Sampling

E GEOTECHNICAL LABORATORY TESTS

The following tests were carried out on selected samples. Test method references and results are given in Appendix C.

- Moisture Content
- Atterberg Limit Test
- Sulphate and pH.
- Triaxial Compression Test

F DISCUSSION OF GEOTECHNICAL TEST RESULTS AND RECOMMENDATIONS

15 Soil Classification and Properties

- Area 1

Soil Type	Depth	Compressibility	VCP	Permeability	Frost Susceptible	CBR	Remarks
Made Ground	GL to 0.4m/0.6m	N/A					Not suitable for foundations
Brickearth (Aeolian Deposits)	0.5m/0.6m to 4m/5.5m	Moderate to High	Low	Low	Yes	Poor (1% to 2% subject to insitu testing)	
Silt (Head)	3.0m/4.0m to 5.5m/6.0m	Low to Moderate	Low	Low	Yes		
Chalk	5.5m/6.0m to 25m	Negligible	Negligible	Fair to Good (subject to insitu testing)	Yes		

- Area 2

Soil Type	Depth	Compressibility	VCP	Permeability	Frost Susceptible	CBR	Remarks
Made Ground	GL to 1.0m/1.6m	N/A					Not suitable for foundations
Alluvium	1.2m/1.6m to 3.4m/4.0m	Moderate to High	High	Low	No	Poor	Not suitable for strip foundations.
Clay	3.4m/4.0m to 13.0m	Low	Medium	Negligible to Low (subject to insitu testing)	No	N/A	

16 Swelling and Shrinkage

- Area 1

Three samples of the Aeolian deposits overlying the chalk underwent plasticity tests and were classified as silt and clay of low plasticity, which have negligible to LOW NHBC Volume Change Potential (VCP). On balance it is considered that NHBC LOW volume change precautions will apply in accordance with NHBC Chapter 4.2.

- Area 2

One sample of the soft low strength Clay (ALLUVIUM) underwent plasticity tests and was classified as Clay of very high plasticity, which has NHBC HIGH VCP. Two samples of the underlying stiff reddish grey Clay soils underlying the soft very low strength Alluvial deposits underwent plasticity tests and were classified as clay of high plasticity, which have NHBC MEDIUM VCP. On balance it is considered that NHBC HIGH volume change precautions will apply in accordance with NHBC Chapter 4.2.

17 Groundwater Levels

Groundwater was struck as seepages in BH1 and BH2 in Area 1 at 5m bgl and 7.5m bgl, but no significant ingress was noted at the time of drilling. Overnight levels were recorded as 6.5m bgl and 4.2m bgl respectively with borehole depths at 8.5m and 7.5m respectively. Groundwater levels vary considerably from season to season and year to year, often rising close to the ground surface in wet or winter weather, and falling in periods of drought. Long-term monitoring from boreholes or standpipes is required to assess the ground water regime and this was not possible during the course of this site investigation.

18 Soakaways

Soakage testing was outside the scope of our investigation, however based on the encountered ground conditions shallow surface water discharge is not considered to be an appropriate form of soakage due to the Clay soils encountered in Area II and the sandy Clay soils encountered in Area I.

Deep bore soakaways into the underlying Chalk are not likely to be consented as discharge would be below the water table. Alternative means of surface water discharge should therefore be considered.

19 Sulphates and Acidity

The recorded pH values are in the range 8.02 to 8.7.

The Design Sulphate Class is DS-1. Groundwater should be assumed to be mobile. The ACEC site classification is AC –1 assuming a former brownfield site use.

20 Bearing Capacity

- Area I

It is understood that the proposed development will consist of a three to five storey column loaded building, which is to be constructed on a piled foundation solution.

- Area II

Significant thicknesses of soft very low to low strength Clay (Alluvium) soils down to a maximum depth of 4.0m bgl were encountered during our intrusive site investigation. These soils are not considered to be suitable for conventional spread foundations (strip/trench/pad) and consideration should be given to a piled foundation solution.

Preliminary pile capacities are given below.

21 Piling

In terms of a piled foundation discussions should be held with selected piling contractors to discuss the technical and financial merits of their various systems. With respect to overall resources, the equipment available for the soils described and anticipated should be appropriate to achieve the depths and diameters considered with an adequate safety margin.

From the viewpoint of pile type a bored pile is considered to be the most appropriate. In terms of bored piles either an augered pile with casing or a continuous flight grout injected pile (CFA) would be best suited to the ground conditions encountered in both Areas I and II. It should be noted that sub-surface obstructions from any previous development on these sites or bands of flint gravel/sheet flints (within the Chalk in Area I) may be encountered and the piling contractor should use appropriate techniques to ensure the depths required are achieved.

In terms of actual pile design and the estimation of the working capacity of the piles, we have provided a plot of SPT versus depth (mBGL) on a linear regression line. For the purpose of providing preliminary estimates of pile capacities, we have assumed the following simplified soil model, which is based on the findings of our borehole.

- Area I

Depth to Base (m BGL)	Soil Type
0.6m	Made Ground Soils (no contribution to pile capacity)
4m	Sandy Clay/Silt (Head)
25m	Chalk

Groundwater was encountered during our intrusive site investigation at 5.0m bgl in BH1 and at 7.5m bgl in BH2. Groundwater rose to 4.2m bgl in BH1 after 24 hours. Therefore groundwater and has been assumed to be at 4m bgl for the pile design model.

On the basis of the pile capacities given in table P-1, it is estimated that a 350mm diameter pile with a toe set at 15m bgl would have a safe working load of around 360kN, assuming a factor of safety of 2.5.

The above pile capacities are for individually loaded piles and should not supersede the piling specialist design loads.

- Area II

Depth to Base (m BGL)	Soil Type
4m	Made Ground and Alluvium (Nil Skin Friction)
13m	Clay

Groundwater was encountered within the Alluvial soils overlying the plastic Clay during our intrusive site investigation. Sixty minutes after hole completion groundwater levels were recorded at 3.30m bgl in DH1, at 2.0m bgl in DH2 and at 3.6m bgl in DH3. Groundwater was encountered at 10.1m bgl in BH3, groundwater levels within the alluvial soils were not recorded due to the casing in the top 7.5m of the borehole.

On the basis of the pile capacities given in table P-2, it is estimated that a 300mm diameter pile with a toe set at 10m bgl would have a safe working load of around165kN, assuming a factor of safety of 2.5.

The above pile capacities are for individually loaded piles and should not supersede the piling specialist design loads.

22 Settlement

Settlement for a piled foundation solution will be low.

23 Excavations and Trenching

Statutory support will be required in all excavations where personnel must work. Made ground and alluvial soils (soft clays and silts) will be particularly unstable in open excavations and close support will be required. Below the water table, soils may 'run' and dewatering will be required in addition to close support.

24 Road Construction

As part of the proposed redevelopment of Area II a temporary Car Park is due to be constructed adjacent to the proposed Breast Clinic. A series of Dynamic Cone Penetrometer CBR's were undertaken in the back gardens of the properties situated along Park Avenue where the car park is due to be constructed.

The results of the insitu CBR tests are attached in full in Appendix B. However, in general there were several areas where 'soft spots' or voids were encountered where blow counts of zero and one were recorded over a depth of approximately 200-300mm. No resistance or skin friction was apparent over this depth and the probing rod was able to move up and down freely. CBR values lower than 1% were recorded at depths ranging from 450mm to 1000mm at CBR 3, 4, 11 and 13. It is likely that these results reflect the presence of loose made ground.

We would recommend that the areas of suspected voiding be investigated further with mechanical excavator prior to carrying out pavement designs.

Subject to further investigation, where a car park is to be constructed on variable made ground with known areas of soft material/voids, in order to reduce potential problems associated with differential settlement, such as drainage and general serviceability a suitable procedure could be as follows :-

1. Excavate to a depth of 600mm.

2. Proof roll and compact the exposed formation, selectively removing any soft spots that are detected in the rolling operation, and backfilling same with suitable granular material (or locally thicken the subbase layer).

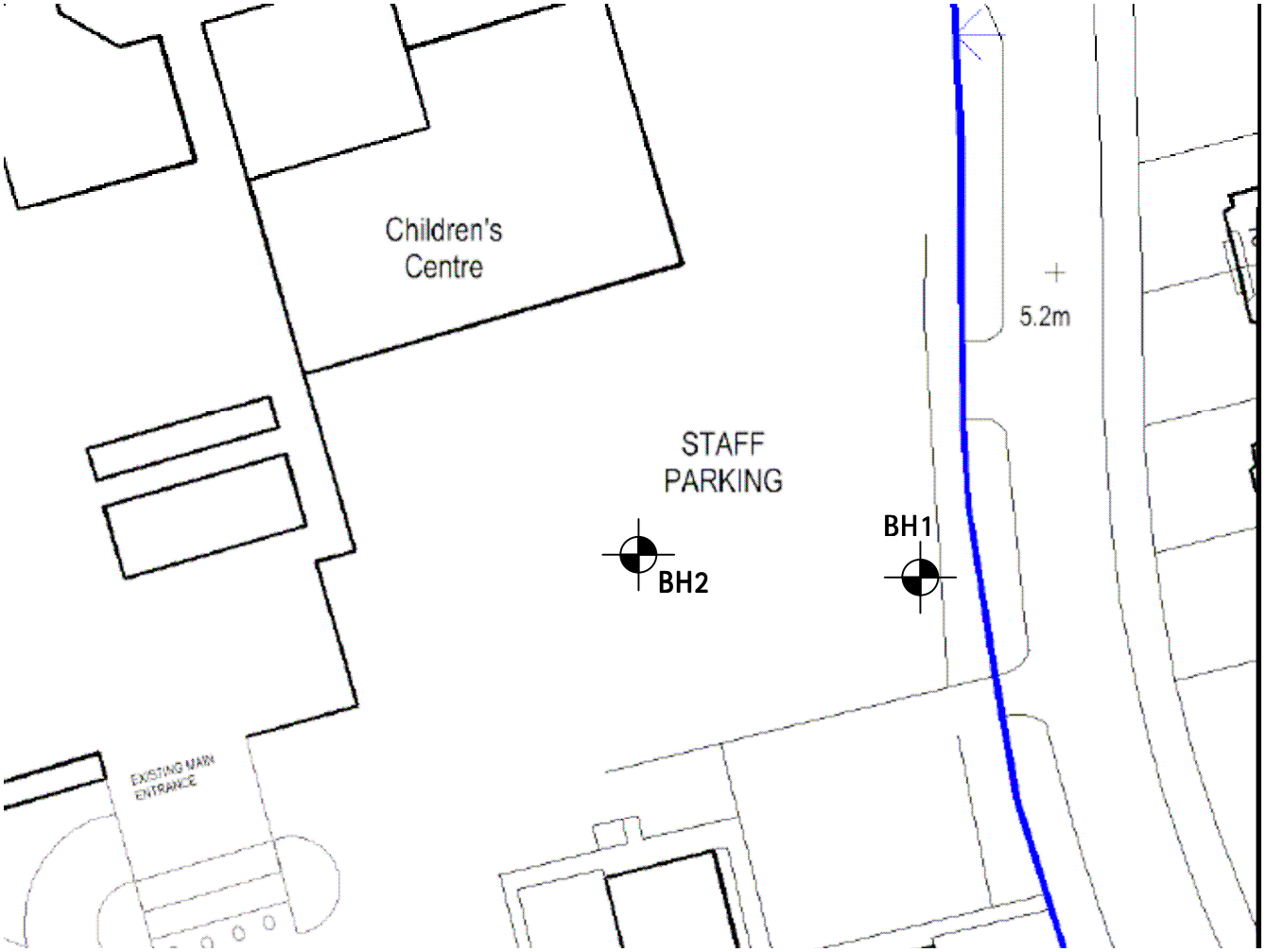
3. Place and compact sub-base and surfacing to maximum falls for longterm drainage.

4. Any drainage pipework should also be laid with generous falls to minimise any subsequent settlement.

If the car park is to be adopted then this method should be approved with the adopting authorities before implementation.

APPENDIX A

Site Plans and Exploratory Hole Logs



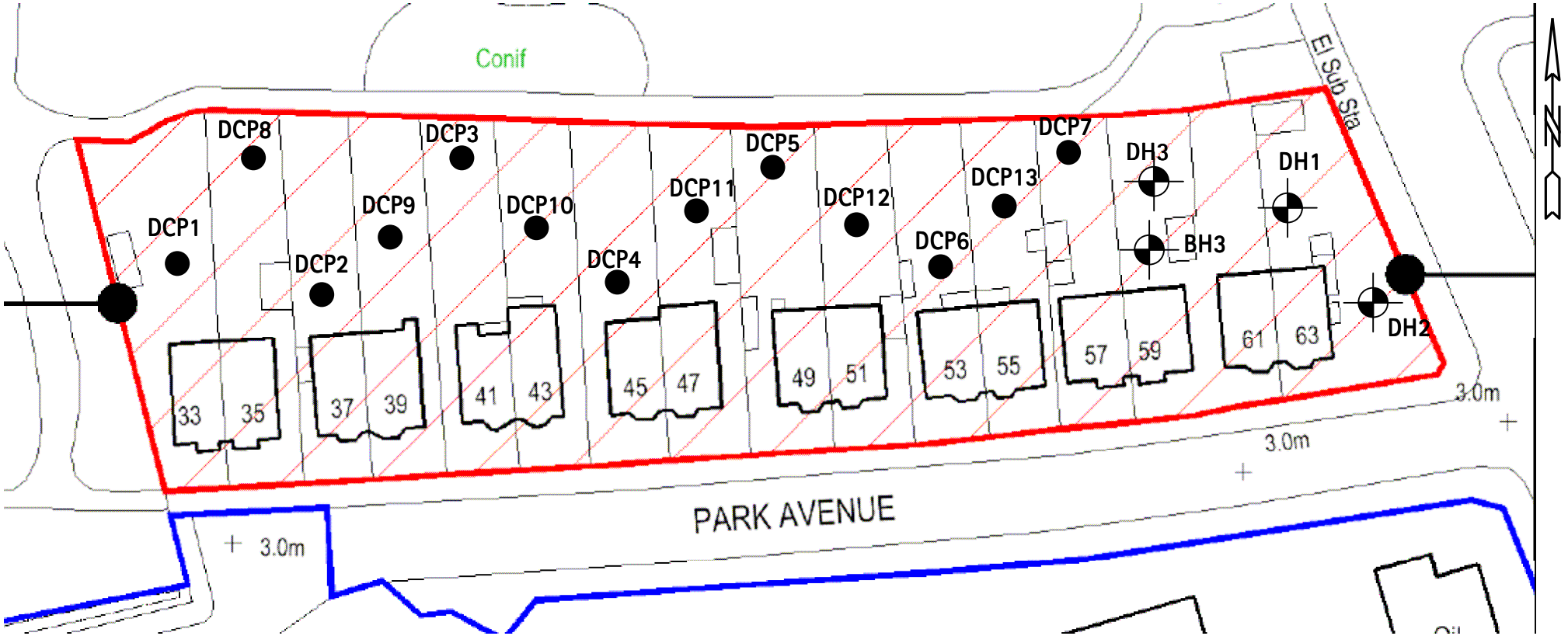
NB: Positions of Boreholes are only indicative unless dimensioned

Site: Area 1, Worthing Hospital, Worthing, West Sussex.	STL: J10309 / Fig No: 1
Date: 07 September 2010	Area 1 – Location of cable percussion boreholes.

Southern Testing

Southern Testing: Keeble House, Stuart Way, East Grinstead, West Sussex RH19 4QA
ST Consult: Twigden Barns, Brixworth Road, Creaton, Northampton NN6 8NN

ST Consult



NB: Positions of Boreholes and/or Trial Pits are only indicative unless dimensioned

Site: Worthing Hospital (Area II- Breast Clinic)	STL: J10309	Fig No: 1
Date: 07 September 2010	Area 2 – Location of Exploratory boreholes and Dynamic Cone CBR tests	

Southern Testing

Southern Testing: Keeble House, Stuart Way, East Grinstead, West Sussex RH19 4QA
ST Consult: Twigden Barns, Brixworth Road, Creaton, Northampton NN6 8NN

ST Consult

Southern Testing
Environmental & Geotechnical

Job No: **J10309** Hole No: **1**

National Grid Reference		TQ 151 031	
Start date	09/08/2010	End date	12/09/2010
Ground level		Backfill date	12/09/2010
Logged by	DK	Engineer	DK
Final depth	25.00	Page	1 of 1

Site : Worthing Hospital

Client : Mansell PLC

Drilling Method : Shell and Auger (150mm)

Piezometer or Monitoring well	Testing		Samples		Strata				
	Depth	SPT/SPT(c) (N value) U(blows)	Depth	Type	Thickness	Level	Legend	Depth	Strata Descriptions
					0.15			**0.15**	**BLACKTOP** Blacktop
					0.25			**0.40**	**MADE GROUND** MADE GROUND comprising dark brown sandy clay with occasional flint gravel and brick fragments.
	1.50	SPT (10)	1.50	D	2.10				
	1.50	UCS (120)	2.00	D					**CLAY** Firm to stiff orange brown fine to medium sandy CLAY with rare flint gravel.
			2.50	D				**2.50**	
			3.00	D					**SAND** Orange brown clayey fine to medium SAND with frequent fine to coarse flint gravel.
			3.50	D	1.50				
			4.00	D				**4.00**	
	4.50	SPT (10)	4.50	D					**SILT** Soft to firm orange brown mottled white clayey SILT (HEAD) with frequent fine to medium weak chalk gravel and fine to coarse subrounded flint gravel.
			5.00	D	2.00				
			5.50	D					
	6.00	U (50)	6.00	D				**6.00**	**CHALK** Recovered as off white putty CHALK with abundant coarse to cobble sized (8-10cm) moderately strong to strong chalk gravels.
			6.00	U					
			6.50	D					
			7.00	D					From 4.5m to 13.5m Wakeling Grade IV.
	7.50	SPT (20)	7.50	D					
			8.00	D					
			8.50	D					
			9.00	D					
			9.50	D					
			10.00	D					
	10.50	SPT (15)	10.50	D					
			11.00	D					
			11.50	D					
			12.00	D					
			12.50	D					
			13.00	D					
	13.50	SPT (48)	13.50	D					
			14.00	D					
			15.00	D					
					19.00				
			16.00	D					
	16.50	SPT (43)							
			17.00	D					
	18.00	U (50)	18.00	D					
			18.00	U					
			18.30	D					
	19.50	SPT (47)	19.00	D					
			20.00	D					From 13.5m Wakeling Grade I.
			21.00	D					At 7.5m abundant coarse to cobble sized flint gravel.
			22.00	D					
	22.50	SPT (73)							From 14-15m abundant fine to coarse subangular strong chalk gravels.
	23.00	U (50)	23.00	D					
			23.00	U					From 17m to 19m frequent to abundant coarse flint gravel.
			23.30	D					
			24.30	D					
	25.00	SPT (75)						**25.00**	End of Borehole

Hole Diameters		
Depth (m)	Hole (mm)	Casing (mm)
4.50	200	200
24.00	150	150

Water Strikes						
Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)	
09/08/10	5.00					

Chiselling Time		
From (m)	To (m)	Time (hrs)

General Remarks

1 hour laying sheets and sand bags, 2 hours skipping slurry cleaning down and moving sand bags

Groundwater encountered at 5.0m bgl on 9/8/2010

Groundwater level 4.2m bgl after 24 hours.

Southern Testing
Environmental & Geotechnical

Job No: **J10309** Hole No: **2**

National Grid Reference		TQ 151 031	
Start date	12/08/2010	End date	14/08/2010
Ground level		Backfill date	14/08/2010
Logged by	DK	Engineer	DK
Final depth	25.00	Page	1 of 1

Site : Worthing Hospital

Client : Mansell PLC

Drilling Method : Shell and Auger (150mm)

Piezometer or Monitoring well	Testing		Samples		Strata				
	Depth	SPT/SPT(c) (N value) U(blows)	Depth	Type	Thickness	Level	Legend	Depth	Strata Descriptions
					0.15			**0.15**	**BLACKTOP** Blacktop
					0.45			**0.60**	**MADE GROUND** MADE GROUND comprising dark brown sandy clay with occasional flint gravel and brick fragments.
	1.50	SPT (9)	1.50	D	2.40				**CLAY** Firm to stiff orange brown fine to coarse sandy CLAY with rare flint gravel.
			2.00	D					
	2.50	SPT (29)	2.50	D					
			3.00	D				**3.00**	**SILT** Stiff orange brown mottled white clayey SILT (HEAD) with frequent fine to medium weak chalk gravel and fine to coarse subrounded flint gravel.
			3.50	D					
			4.00	D	2.50				
	4.50	SPT (16)	4.50	D					
			5.00	D					
			5.50	D				**5.50**	**CHALK** Recovered as off white putty CHALK with abundant fine to medium chalk gravels and occasional fine flint.
	6.00	U (45)	6.00	D	1.00				
			6.00	U				**6.50**	**CHALK** Recovered as off white putty CHALK with abundant fine to coarse moderately strong chalk gravels and occasional fine flint.
			6.50	D					
	7.50	SPT (18)	7.00	D	1.50				
			7.50	D				**8.00**	**CHALK** Recovered as coarse to cobble sized subangular moderately strong CHALK gravel (4-10cm) in an off white silty matrix.
			8.00	D					
			8.50	D					From 4.5m to 13.5m Wakeling Grade IV.
			9.00	D					
			9.50	D					
			10.00	D					
	10.50	SPT (17)	10.50	D					
			11.00	D					
			11.50	D					
			12.00	D					
			12.50	D					
			13.00	D					
	13.50	SPT (32)	13.50	D					
			14.00	D					From 13.5m to 16.5m Wakeling Grade II.
	15.00	U (50)	15.00	D					
			15.00	U					
			16.00	D					
	16.50	SPT (50 for 75mm)	16.50	D	17.00				
			17.00	D					
			18.00	D					
			19.00	D					
	19.50	SPT (66)							
			20.00	D					From 16.5m Wakeling Grade I.
			21.00	D					At 8m frequent coarse to cobble sized flint gravel.
			22.00	D					From 12m to 14m frequent to abundant fine to coarse flint gravel.
	22.50	SPT (50 for 75mm)	23.00	D					
			23.40	D					
			24.50	D					
	25.00	SPT (78)						**25.00**	End of Borehole

Hole Diameters		
Depth (m)	Hole (mm)	Casing (mm)
4.50	200	200
24.00	150	150

Water Strikes						
Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)	
12/08/10	7.50					

Chiselling Time		
From (m)	To (m)	Time (hrs)

General Remarks

1 hour laying sheets and sand bags, 2 hours skipping slurry and spoil, moving bags and sheets.

Groundwater encountered at 7.5m bgl on 12/8/2010

Groundwater level 6.5m bgl after 24 hours.

U100 at 23.00m failed.

Southern Testing
Environmental & Geotechnical

Job No: **J10309** Hole No: **3**

National Grid Reference		TQ 151 031	
Start date	17/08/2010	End date	18/08/2010
Ground level		Backfill date	18/08/2010
Logged by	DK	Engineer	DK
Final depth	13.00	Page	1 of 1

Site : Worthing Hospital

Client : Mansell PLC

Drilling Method : Shell and Auger (150mm)

Piezometer or Monitoring well	Testing		Samples		Strata					
	Depth	SPT/SPT(c) (N value) U(blows)	Depth	Type	Thickness	Level	Legend	Depth		Strata Descriptions
			0.30	D	0.30			0.30	TOPSOIL	Brown silty TOPSOIL with frequent fine roots and fine flint gravel. Rare fine brick fragments.
			0.50	D	0.70				MADE GROUND	MADE GROUND comprised of dark brown mottled orange silty clay with occasional brick fragments, flint gravel, chalk gravel and charcoal.
	1.00	UCS (200)	1.00	D				1.00	CLAY	Stiff high strength pale greenish brown fissured CLAY with frequent fine roots.
	1.50	U (8)	1.50	U	1.00					
	2.00	UCS (<50)	2.00	D				2.00	CLAY	Soft to firm very low to low strength blueish grey organic CLAY (ALLUVIUM) with frequent pseudofibrous root fragments.
	3.00	SPT (1)	3.00	D	2.00					
	4.00	UCS (60)	4.00	D				4.00	CLAY	Firm low to medium strength blueish grey mottled orange CLAY (ALLUVIUM) with frequent pseudofibrous root fragments.
	4.50	U (42)	4.50	U						
	5.00	UCS (100)	5.00	D	2.00					
	6.00	SPT (31)	6.00	D				6.00	CLAY	Stiff very high strength grey mottled red CLAY.
	6.00	UCS (290)								
	7.00	UCS (460)	7.00	D						
	7.50	U (50)	7.50	U						
			8.00	D						
	8.50	UCS (360)								
	9.00	SPT (50 for 150mm)	9.00	D						
					7.00					
	10.00	UCS (300)	10.00	D						
	10.50	U (50)	10.50	U						
			11.00	D						
	12.00	SPT (50 for 225mm)	12.00	D						
	12.50	UCS (400)								
	13.00	SPT (50 for 150mm)	13.00	D				13.00		End of Borehole

Hole Diameters		
Depth (m)	Hole (mm)	Casing (mm)
7.50	150	150

Water Strikes					
Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
17/08/10	10.50	7.50	20	10.10	

Chiselling Time		
From (m)	To (m)	Time (hrs)
GL	1.20	1

General Remarks

30 mins standing waiting for access to BH.

Southern Testing
Environmental & Geotechnical

Job No: **J10309** Hole No: **DH1**

National Grid Reference		TQ 151 031	
Start date	06/08/2010	End date	06/08/2010
Ground level		Backfill date	06/08/2010
Logged by	DK	Engineer	DK
Final depth	5.45	Page	1 of 1

Site : Worthing Hospital

Client : **Mansell PLC**

Drilling Method : Windowless Sampler

Piezometer or Monitoring well	Testing		Samples		Strata				
	Depth	SPT/SPT(c) (N value) U(blows)	Depth	Type	Thickness	Level	Legend	Depth	Strata Descriptions
			0.30	D	0.60				**MADE GROUND** MADE GROUND comprising brown clay with frequent brick charcoal and slag fragments.
			0.80	D				**0.60**	**MADE GROUND** MADE GROUND comprising reworked orange brown sandy clay with occasional pockets of fine to coarse sand and fragments of brick and charcoal.
	1.00	SPT (5)			0.90				
	1.60	UCS (140)	1.60	D				**1.50**	**CLAY** Firm medium becoming low strength pale grey mottled orange CLAY (ALLUVIUM) with occasiona white calcareous nodules.
	1.80	UCS (150)							
	2.00	SPT (0)			1.10				
	2.00	UCS (<50)							
	2.50	UCS (<50)	2.50	D				**2.60**	**CLAY** Soft to firm grey organic plastic CLAY (ALLUVIUM) with occasional fine roots and white calcareous fragments.
	2.90	UCS (70)							
	3.00	SPT (3)	3.00	D	0.90				
	3.50	UCS (120)						**3.50**	**CLAY** Stiff medium strength grey organic plastic CLAY (ALLUVIUM).
					0.50				
	4.00	SPT (11)	4.00	D				**4.00**	**CLAY** Stiff high strength blueish grey mottled orange fissured silty CLAY with rare fine flint gravel.
	4.00	UCS (180)							
					1.45				
	5.00	SPT (9)							
								5.45	End of Borehole

Hole Diameters		
Depth (m)	Hole (mm)	Casing (mm)

Water Strikes					
Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
06/08/10			60	3.30	

Chiselling Time		
From (m)	To (m)	Time (hrs)

General Remarks

Samplers wet from 4m bgl

Hole backfilled to 4.5m

Unable to recover sampler from 5m

No standing water at end of drilling

Southern Testing
Environmental & Geotechnical

Job No: **J10309** Hole No: **DH2**

National Grid Reference		TQ 151 031	
Start date	06/08/2010	End date	06/08/2010
Ground level		Backfill date	06/08/2010
Logged by	DK	Engineer	DK
Final depth	6.45	Page	1 of 1

Site : Worthing Hospital

Client : **Mansell PLC**

Drilling Method : Windowless Sampler

Piezometer or Monitoring well	Testing		Samples		Strata				
	Depth	SPT/SPT(c) (N value) U(blows)	Depth	Type	Thickness	Level	Legend	Depth	Strata Descriptions
			0.20	D					**MADE GROUND** MADE GROUND comprising dark brown fine to coarse sandy clay with frequent to abundant brick charcoal and slag fragments.
			0.50	D					
					1.60				
	1.00	SPT (2)	1.00	D					
			1.50	D					
								1.60	
	1.80	UCS (120)							**CLAY** Firm medium becoming low strength pale grey mottled orange CLAY (ALLUVIUM) with occasional white calcareous nodules and rare fine roots.
	2.00	SPT (3)	2.00	D	0.80				
	2.20	UCS (80)							
								2.40	
	2.50	UCS (70)							**CLAY** Soft to firm very low to low strength blueish grey silty CLAY (ALLUVIUM) with occasional greenish mottling and rare shell fragments.
	3.00	SPT (4)	3.00	D	1.30				
	3.00	UCS (60)							
	3.50	UCS (50)							
								3.70	
	4.00	SPT (9)	4.00	D					**CLAY** Stiff very high strength reddish orange mottled blueish grey plastic CLAY with occasional pseudofibrous root fragments.
	4.00	UCS (320)							
	4.50	UCS (460)							
	5.00	SPT (25)	5.00	D	2.75				
	5.00	UCS (500)							
	5.50	UCS (500)							
	6.00	SPT (18)	6.00	D					
	6.00	UCS (540)							
								6.45	End of Borehole

Hole Diameters		
Depth (m)	Hole (mm)	Casing (mm)

Water Strikes					
Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
06/08/10			60	2.00	

Chiselling Time		
From (m)	To (m)	Time (hrs)

General Remarks

Samplers wet from 4m bgl

No standing water at end of drilling

Southern Testing
Environmental & Geotechnical

Job No: **J10309** Hole No: **DH3**

National Grid Reference		TQ 151 031	
Start date	06/08/2010	End date	06/08/2010
Ground level		Backfill date	06/08/2010
Logged by	DK	Engineer	DK
Final depth	5.45	Page	1 of 1

Site : **Worthing Hospital**

Client : **Mansell PLC**

Drilling Method : Windowless Sampler

Piezometer or Monitoring well	Testing		Samples		Strata				
	Depth	SPT/SPT(c) (N value) U(blows)	Depth	Type	Thickness	Level	Legend	Depth	Strata Descriptions
			0.30	D					**MADE GROUND** MADE GROUND comprising brown mottled orange fine to coarse sandy clay with frequent to abundant brick charcoal and slag fragments. Frequent shattered glass throughout.
			0.50	D	1.20				
	1.00	SPT (7)	1.00	D				**1.20**	
	1.50	UCS (90)	1.50	D					**CLAY** Firm medium becoming low strength pale grey mottled orange CLAY (ALLUVIUM) with occasional white calcareous nodules.
	2.00	SPT (0)			1.40				
	2.00	UCS (60)							
	2.50	UCS (50)	2.50	D				**2.60**	
	3.00	SPT (4)	3.00	D	0.80				**CLAY** Firm very low to low strength blueish grey silty CLAY (ALLUVIUM) with frequent fine to coarse subangular flint gravel.
	3.00	UCS (50)							
	3.50	UCS (320)	3.50	D				**3.40**	**CLAY** Stiff very high strength reddish orange mottled blueish grey plastic CLAY with occasional pseudofibrous root fragments.
	4.00	SPT (12)							
	4.00	UCS (340)							
			4.50	D	2.10				
	5.00	SPT (13)							
	5.00	UCS (500)						**5.50**	End of Borehole

Hole Diameters		
Depth (m)	Hole (mm)	Casing (mm)

Water Strikes					
Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
06/08/10			30	3.60	

Chiselling Time		
From (m)	To (m)	Time (hrs)

General Remarks

No standing water at end of drilling

APPENDIX B

Field Sampling and in-situ Test Methods & Results

Field Sampling and in-situ Test Methods

Disturbed Samples

Disturbed samples were taken from the trial holes intervals and stored in sealed glass jars and polythene bags, as appropriate.

Undisturbed U100 Samples

Undisturbed U100 samples were taken in the clay soils at appropriate intervals. These samples are taken in a 100 mm diameter, 450 mm long, thin-walled steel tube, and are sealed with paraffin wax and tightly fitting end caps for transporting to the laboratory.

Standard Penetration Test

The Standard Penetration (SPT) Test is specified in BS EN ISO 22476-3 : 2005. In this test, a 51mm diameter open-ended tube is driven into the ground by a 63.5 kg hammer falling freely through 760 mm. The tube is seated by driving to a penetration of 150mm, or by 25 standard blows, whichever occurs first. It is then driven for a maximum of a further 300mm and the number of blows is termed the penetration resistance (N). If 300mm penetration cannot be achieved in 50 blows (100 blows in soft rock), the test drive is terminated.

When testing in gravels, a conical end piece is attached to the tube. The test is then called an SPT(C).

This test provides an indirect method of assessing the properties of cohesionless soils, and the following table (after Terzaghi and Peck) gives the approximate condition:-

Number Blows (N)	Density
0 - 4	Very Loose
4 – 10	Loose
10 – 30	Medium Dense
30 – 50	Dense
Over 50	Very Dense

Clay

An approximate value for the shear strength of clay may be obtained using Stroud (1974), which paper indicates that the cohesive strength is a function of plasticity and SPT 'N' value. The relation is:

$C_u = f_i \times N$ kPa

C_u = undrained shear strength

f_i = factor related to plasticity index and ranging from 4 to more than 6

The SPT test is not generally accepted as giving a reliable indication of the strength of cohesive soils but it does give a guide; often the following table:-

Number Blows (N)	Soil Strength
Less than 2	Very Soft (Very Low Strength)
2 – 5	Soft (Low Strength)
5 – 10	Firm (Medium Strength)
10 – 15	Stiff (High Strength)
15 – 30	Very Stiff (Very High Strength)

Hand Penetrometer Test

The hand penetrometer consists of a spring loaded and calibrated plunger which is forced into the soil. A reading of unconfined compression strength (equal to twice cohesion) is given on a calibrated scale. In common with other hand methods of strength assessment (eg. the shear vane) it does not give an accurate indication of bearing capacity in stiff or fissured soils, because of the small test area. The figures are used for strength classification according to the table below

.

Hand Penetrometer Value (kPa)	Undrained Shear Strength cu (kPa)	Undrained Shear Strength of Clays
Less than 20	Less than 10	Extremely Low
20 to 40	10 to 20	Very Low
40 to 80	20 to 40	Low
80 to 150	40 to 75	Medium
150 to 300	75 to 150	High
300 to 600	150 to 300	Very High
More than 600	More than 300	Extremely High

Dynamic Cone Penetrometer (DCP) CBR Test

The CBR value is the result of an empirical test on soil that can be used for road design purposes. In the field the definitive test requires the use of a reaction load, usually a four-wheel drive vehicle, excavating plant, a CBR jack, and load measuring equipment. The dynamic cone CBR test uses light portable equipment and is used to provide a continuous record of the penetration resistance of each layer in the ground for a depth of a metre from the surface. The penetration resistance provides a measure from which CBR values may be calculated using formulae published by the Transport Research Laboratory.

In the test a 22 mm diameter 60° cone is driven into the ground to a depth of up to one metre by a 9 kg weight, freely falling over 600 mm. The number of blows is recorded for each successive 50mm penetration increment.

A plot of the cumulative number of blows versus depth penetrated is drawn. This plot usually takes the form of a series of straight lines, the slopes of which are measured and expressed as penetration in mm per blow. Several authors have prepared relationships between the DCP readings and the CBR

and it is the practice of this laboratory to adopt the lower of two values derived from formulae established by Kleyn & Van Heerden, and by the TRL.

$$CBR = 10^{(2.632 - 1.28 \mathrm{Log}_{10}(mm/blow))} \quad \text{(K\&VH)}[1]$$

$$CBR = 10^{(2.48 - 1.057 \mathrm{Log}_{10}(mm/blow))} \quad \text{(TRL)}[2]$$

The test is an adaptation of the Perth Penetrometer Test developed for the granular soils in Perth West Australia in the 1960s, and in the UK by this laboratory since 1973. It is similar to the Victoria Country Roads Board Penetrometer, the Transvaal Road Department Penetrometer, and the TRL dynamic cone penetrometer. It has been used for the determination of CBR values, after calibration for the local soil, and for compaction comparisons. In UK conditions it has been found to give consistent results for granular soils. It has the advantage that, as it can be driven through bituminous surfacings, granular road base, sub base and hardcore, the strength and thickness of each layer can be estimated.

Chalk Classification and S.P.T. Values

In chalk, bearing properties are often assessed in the same way, according to charts prepared by Wakeling, and the condition of chalk is assessed according to the following table:-

Grade	Brief Description	SPT Value
VI	Extremely soft structureless chalk containing lumps of intact chalk	Below 8
V	Structureless remoulded chalk containing lumps of intact chalk	8 - 15
IV	Rubbly, partly weathered chalk, with bedding and jointing. Joints 60mm apart, open to 20mm, and often infilled with soft remoulded chalk fragments.	15 - 20
III	Rubbly to blocky unweathered chalk. Joints 60-200mm apart, open to 3mm.	20 - 25
II	Blocky, medium hard chalk. Joints more than 200mm apart and closed.	25 - 35
I	Blocky, hard and brittle chalk. Joints more than 200mm apart and closed.	Over 35

Chalk Description based on Visual Inspection

[1] Kleyn & Van Heerden
[2] TRL

Southern Testing

Southern Testing: Keeble House, Stuart Way, East Grinstead, West Sussex RH19 4QA
ST Consult: Twigden Barns, Brixworth Road, Creaton, Northampton NN6 8NN

ST Consult

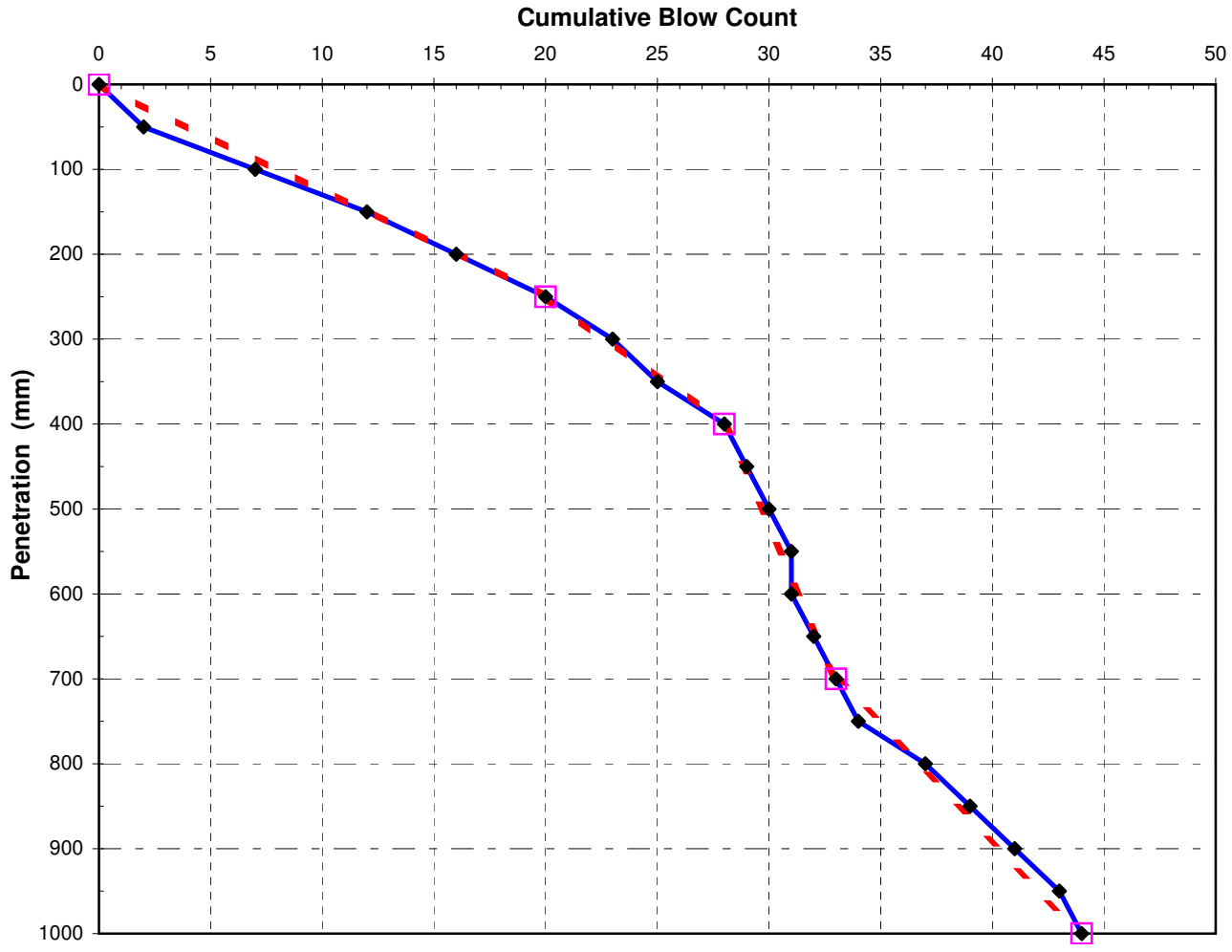
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 1

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count



Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	250	250	20	20	12.5	17		
2	250	400	150	28	8	18.8	10		
3	400	700	300	33	5	60.0	2.3		
4	700	1000	300	44	11	27.3	6.2		

Client:	**Mansell PLC**		**Job No:**	J10309	
Site:	**Worthing Hospital**		**Date:**	05/03/2004	**Fig.**

Southern Testing

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ST Consult

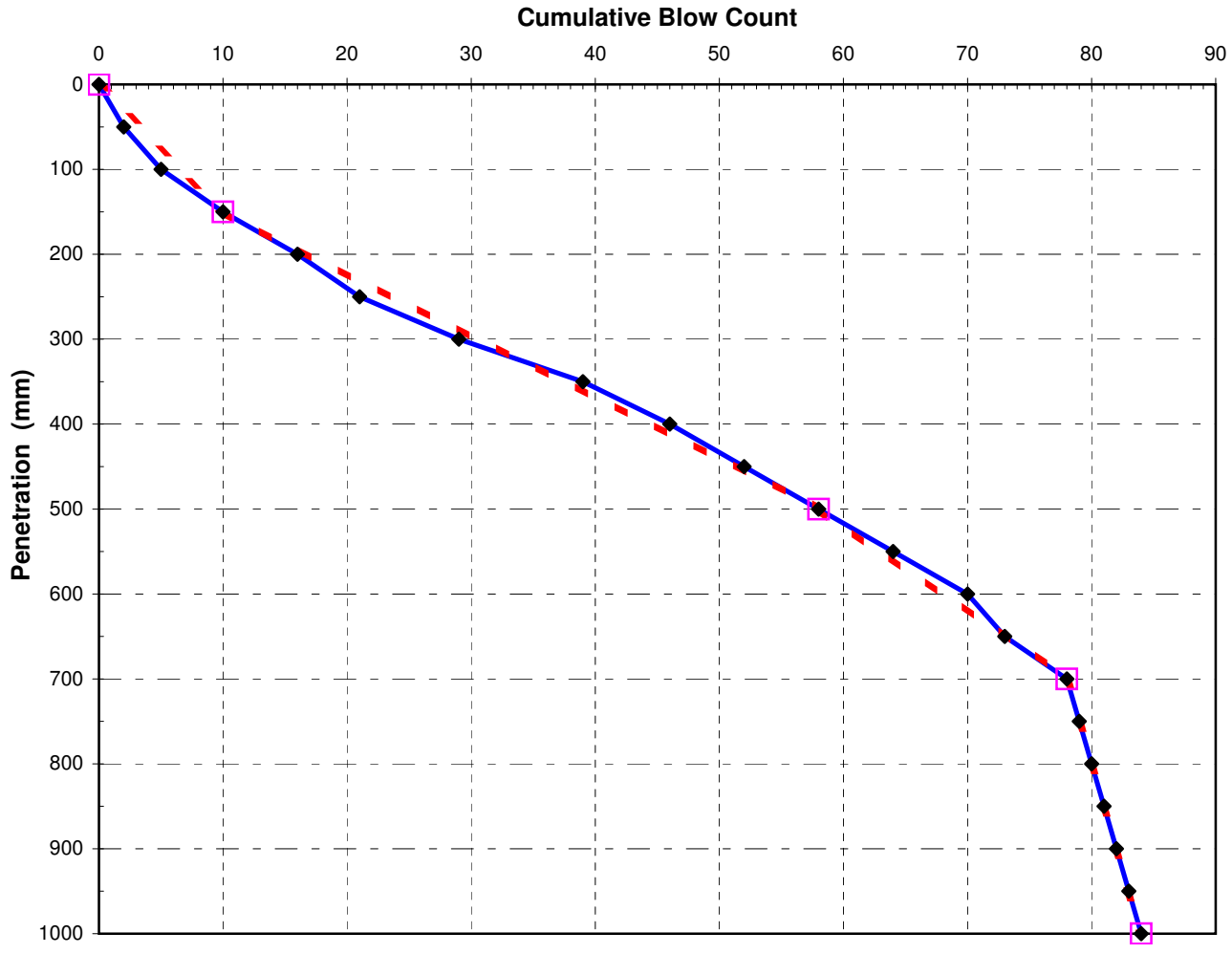
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 2

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count



Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	150	150	10	10	15.0	13		
2	150	500	350	58	48	7.3	34		
3	500	700	200	78	20	10.0	22		
4	700	1000	300	84	6	50.0	2.9		

Client:	**Mansell PLC**		**Job No:**	J10309	
Site:	**Worthing Hospital**		**Date:**	05/03/2004	**Fig.**

Southern Testing

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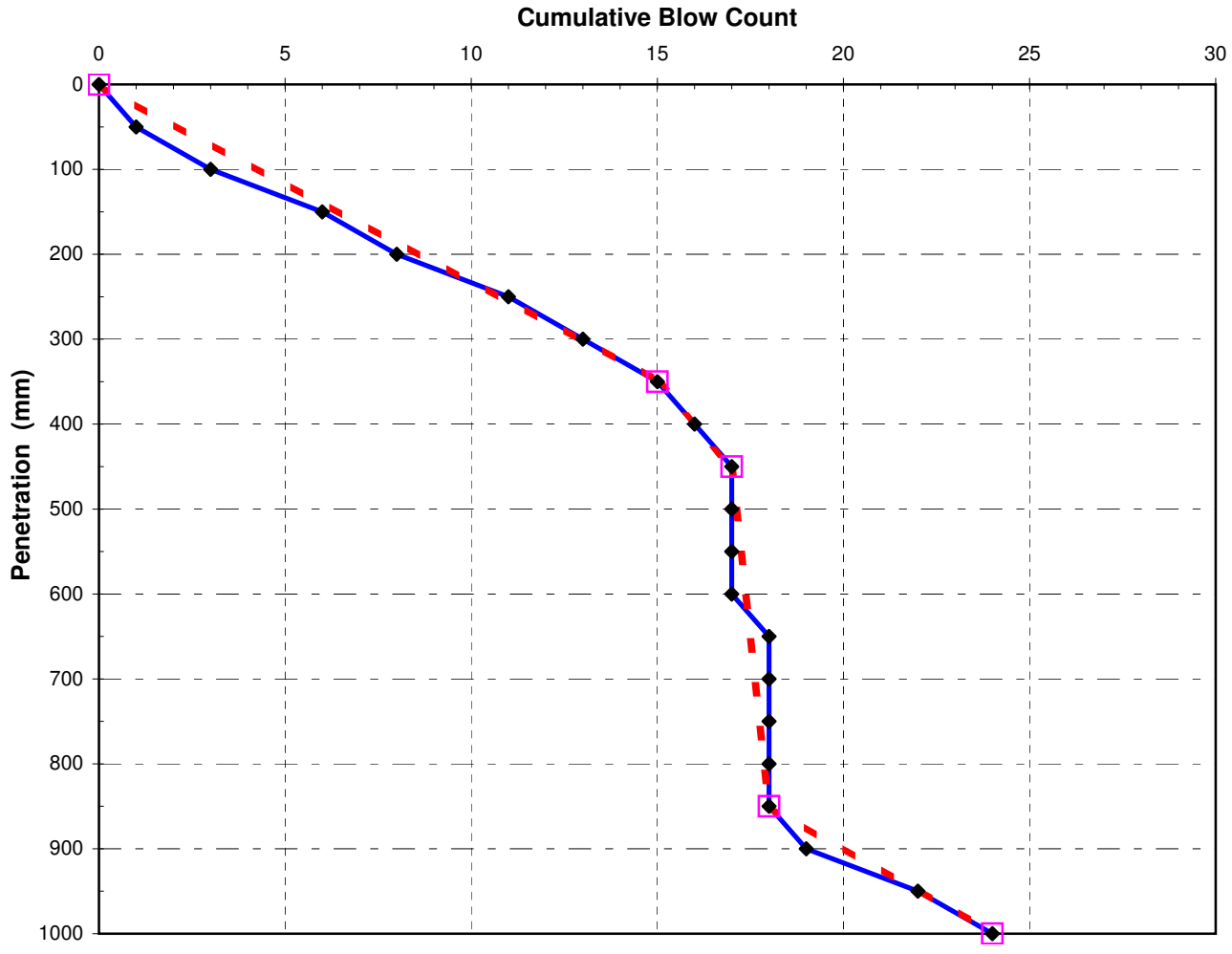
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 3

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count



Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	350	350	15	15	23.3	7.6		
2	350	450	100	17	2	50.0	2.9		
3	450	850	400	18	1	400.0	0.2		
4	850	1000	150	24	6	25.0	7.0		

Client:	**Mansell PLC**		**Job No:**	J10309	
Site:	**Worthing Hospital**		**Date:**	05/03/2004	**Fig.**

Southern Testing

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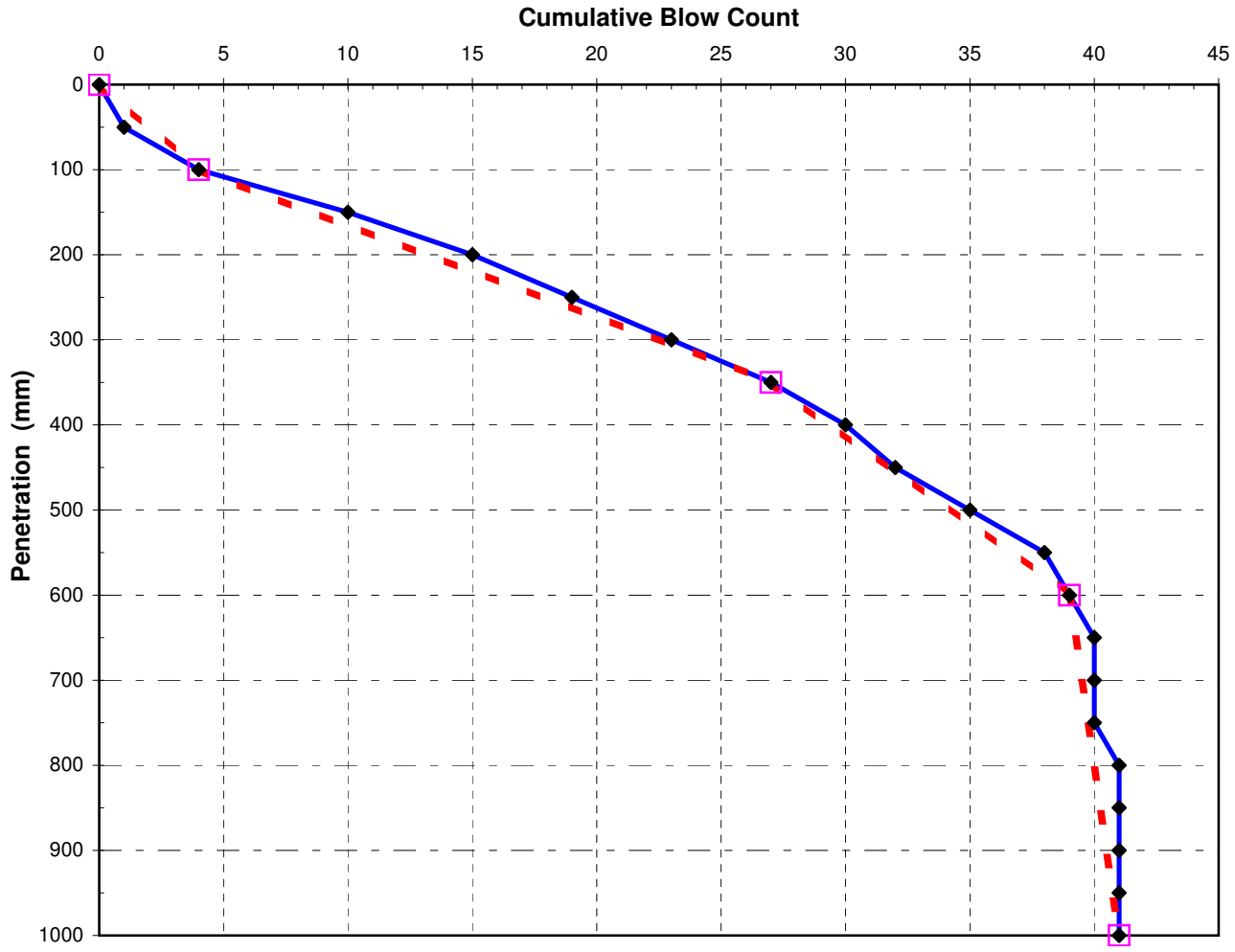
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 4

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count



Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	100	100	4	4	25.0	7.0		
2	100	350	250	27	23	10.9	20		
3	350	600	250	39	12	20.8	8.8		
4	600	1000	400	41	2	200.0	0.5		

Client:	**Mansell PLC**		**Job No:**	J10309	
Site:	**Worthing Hospital**		**Date:**	05/03/2004	**Fig.**

Southern Testing

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ST Consult

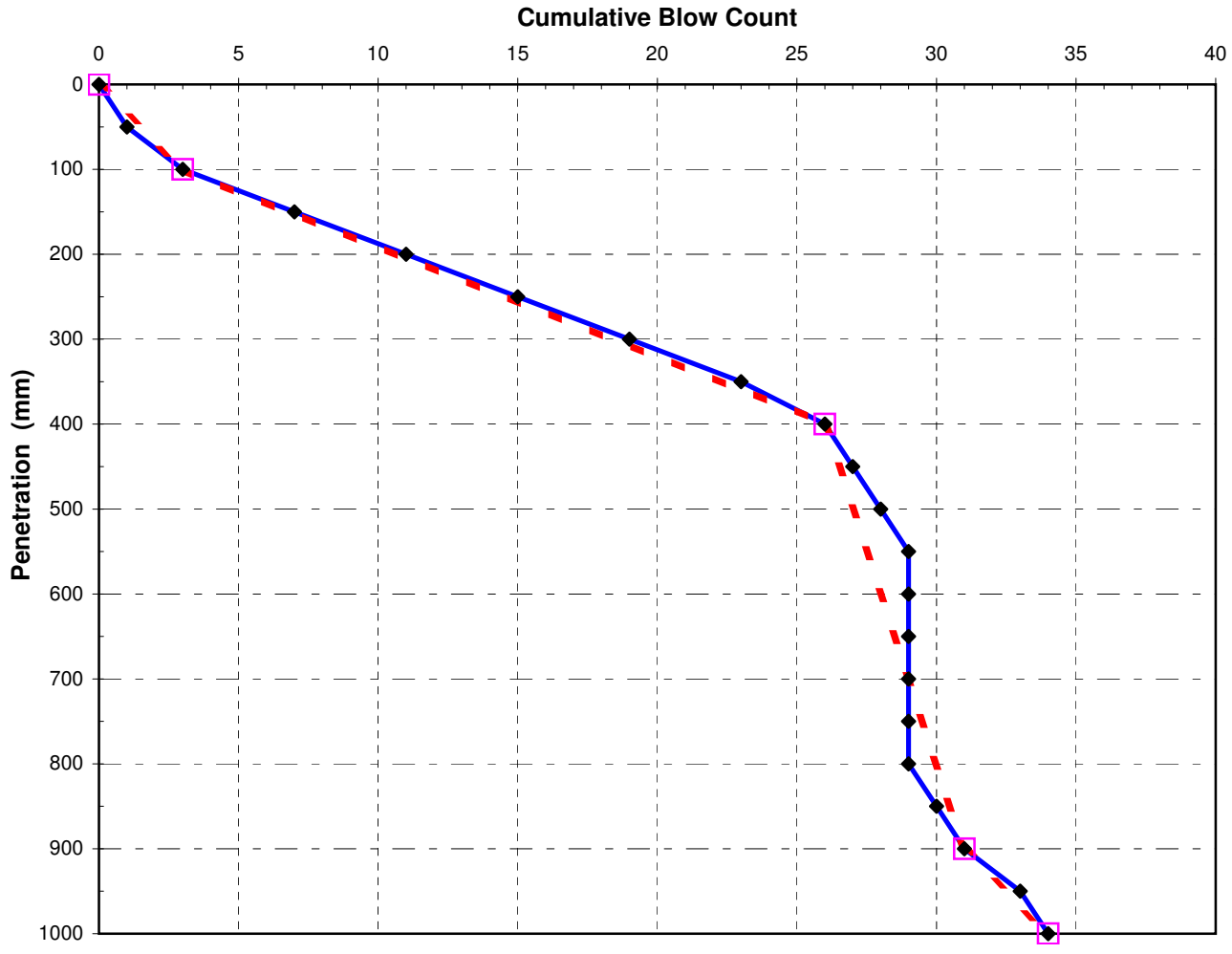
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 5

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count



Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	100	100	3	3	33.3	4.8		
2	100	400	300	26	23	13.0	16		
3	400	900	500	31	5	100.0	1.2		
4	900	1000	100	34	3	33.3	4.8		

Client:	**Mansell PLC**		**Job No:**	J10309	
Site:	**Worthing Hospital**		**Date:**	05/03/2004	**Fig.**

Southern Testing

Southern Testing: Keeble House, Stuart Way, East Grinstead, West Sussex RH19 4QA
ST Consult: Twigden Barns, Brixworth Road, Creaton, Northampton NN6 8NN

ST Consult

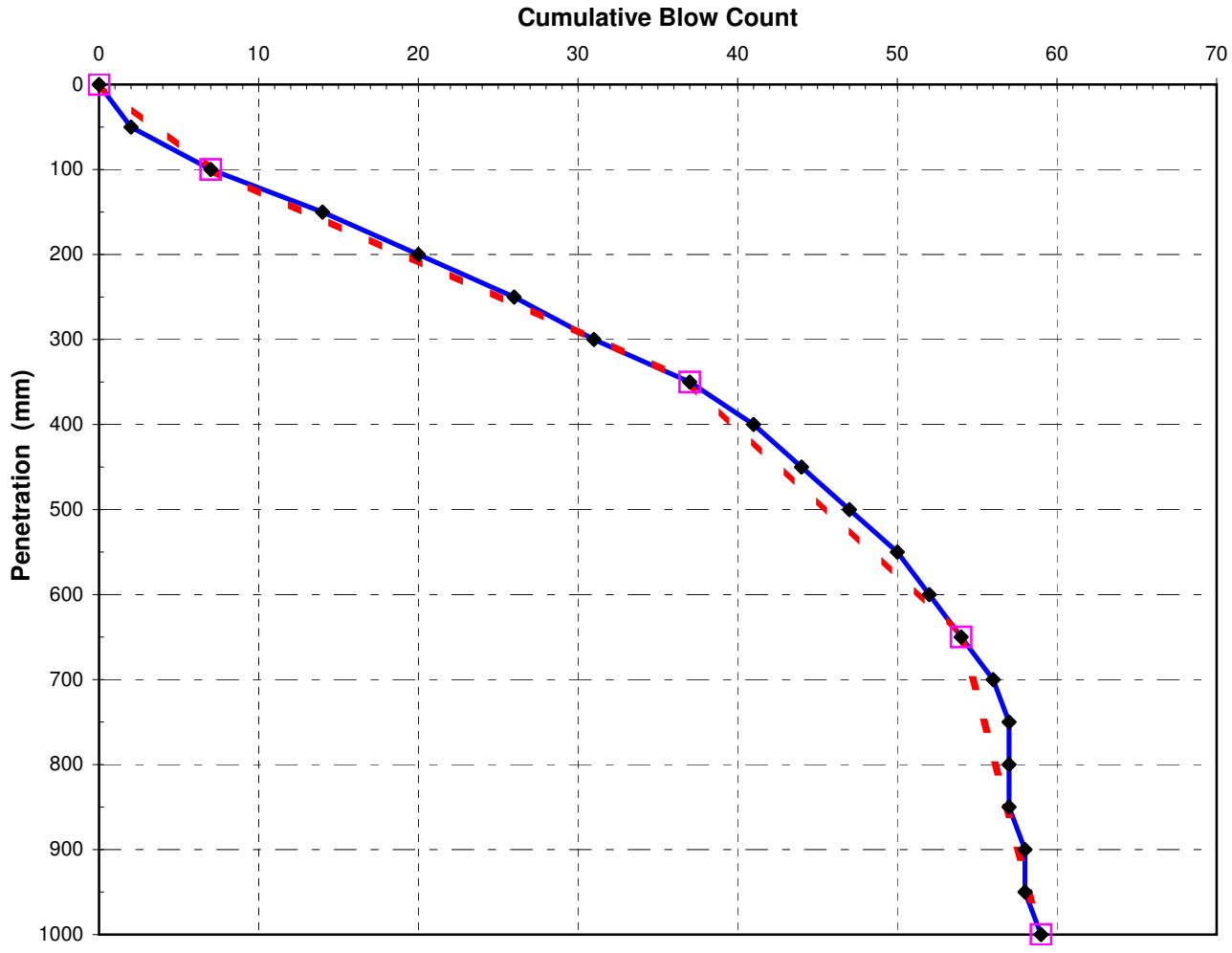
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 6

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count



Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	100	100	7	7	14.3	14		
2	100	350	250	37	30	8.3	28		
3	350	650	300	54	17	17.6	11		
4	650	1000	350	59	5	70.0	1.9		

Client:	**Mansell PLC**	**Job No:**	J10309	
Site:	**Worthing Hospital**	**Date:**	05/03/2004	**Fig.**

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ST Consult

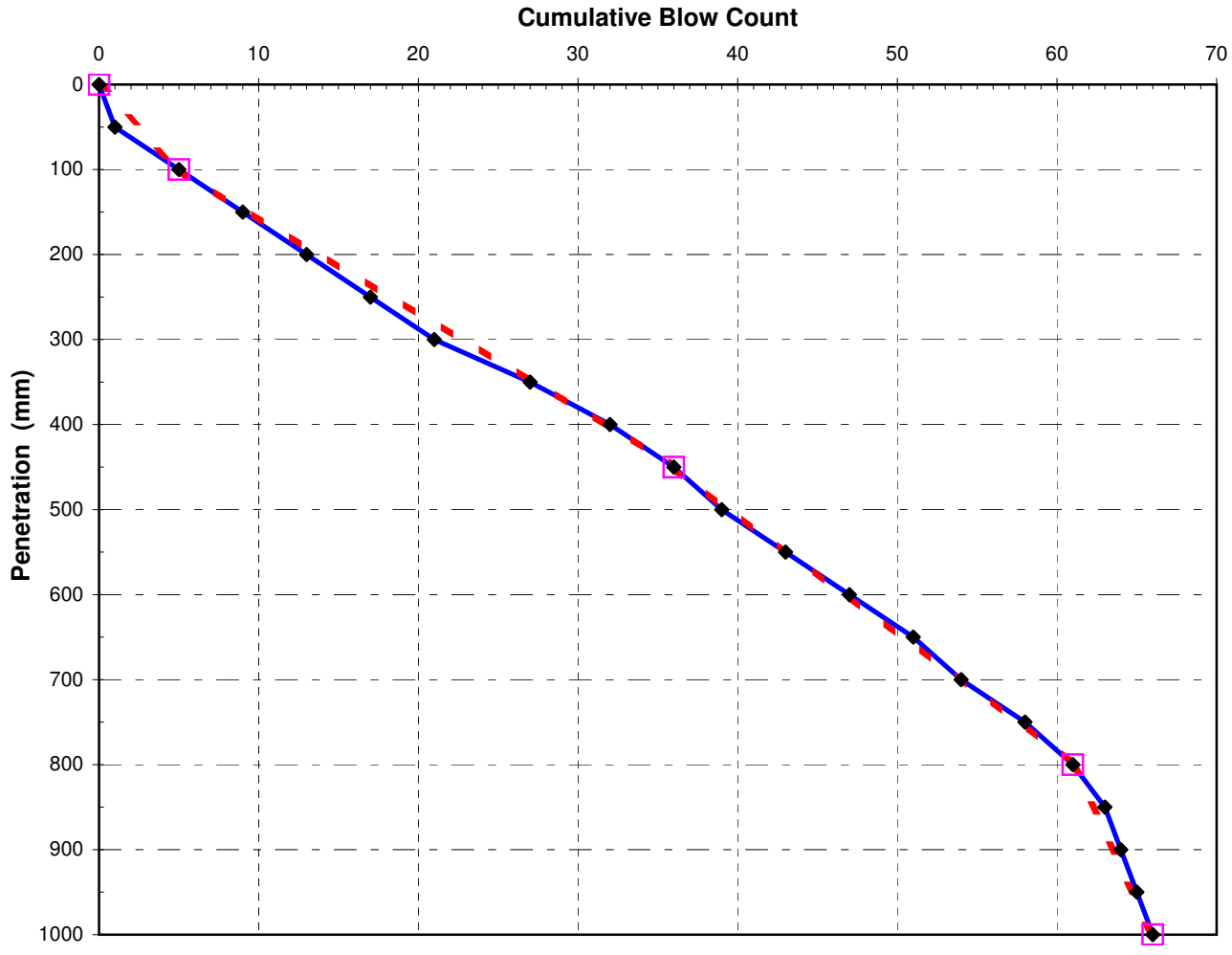
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 7

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count



Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	100	100	5	5	20.0	9.3		
2	100	450	350	36	31	11.3	19		
3	450	800	350	61	25	14.0	15		
4	800	1000	200	66	5	40.0	3.8		

Client:	**Mansell PLC**		**Job No:**	J10309	
Site:	**Worthing Hospital**		**Date:**	05/03/2004	**Fig.**

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ST Consult

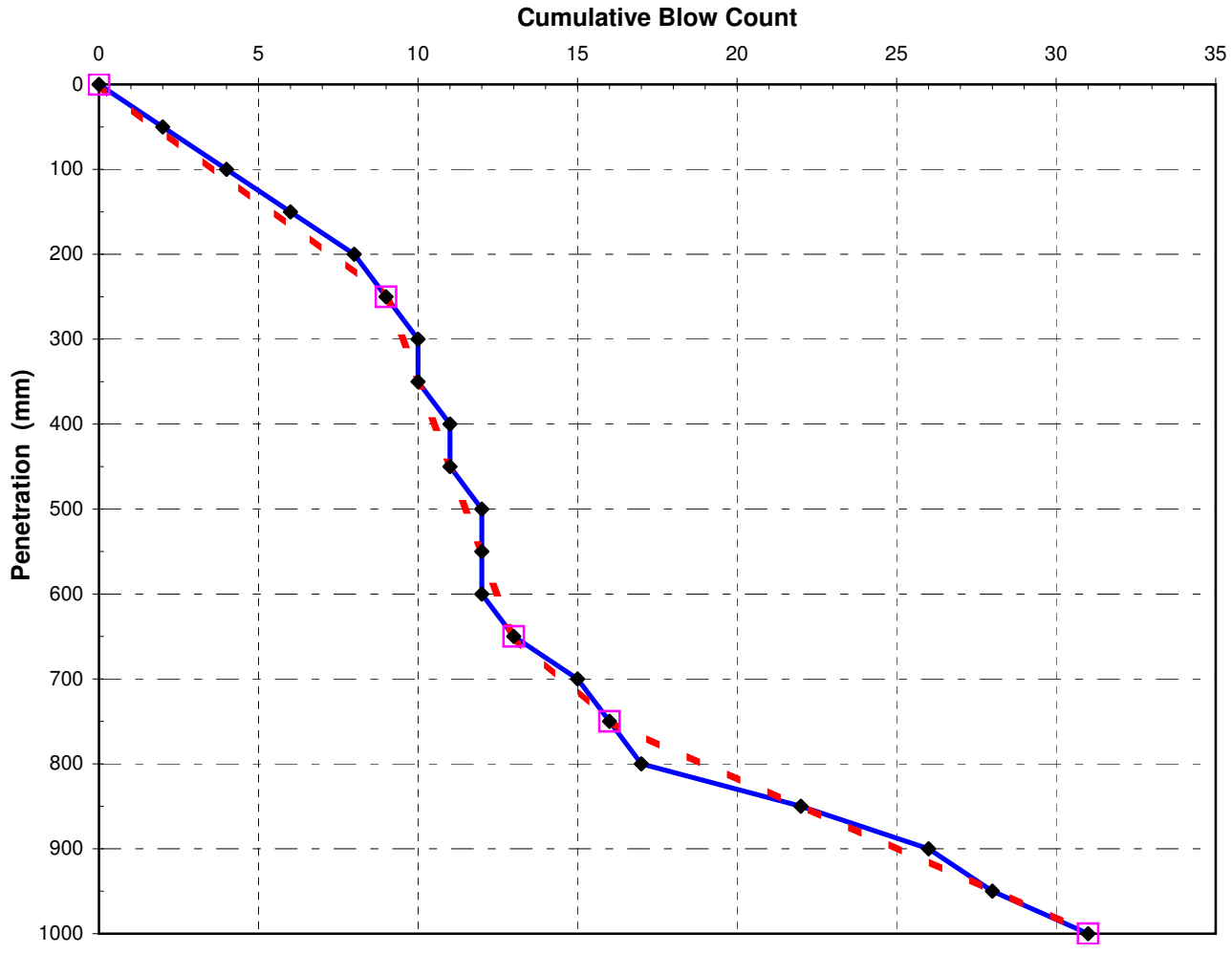
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 8

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count



Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	250	250	9	9	27.8	6.1		
2	250	650	400	13	4	100.0	1.2		
3	650	750	100	16	3	33.3	4.8		
4	750	1000	250	31	15	16.7	12		

Client:	**Mansell PLC**		**Job No:**	J10309	
Site:	**Worthing Hospital**		**Date:**	05/03/2004	**Fig.**

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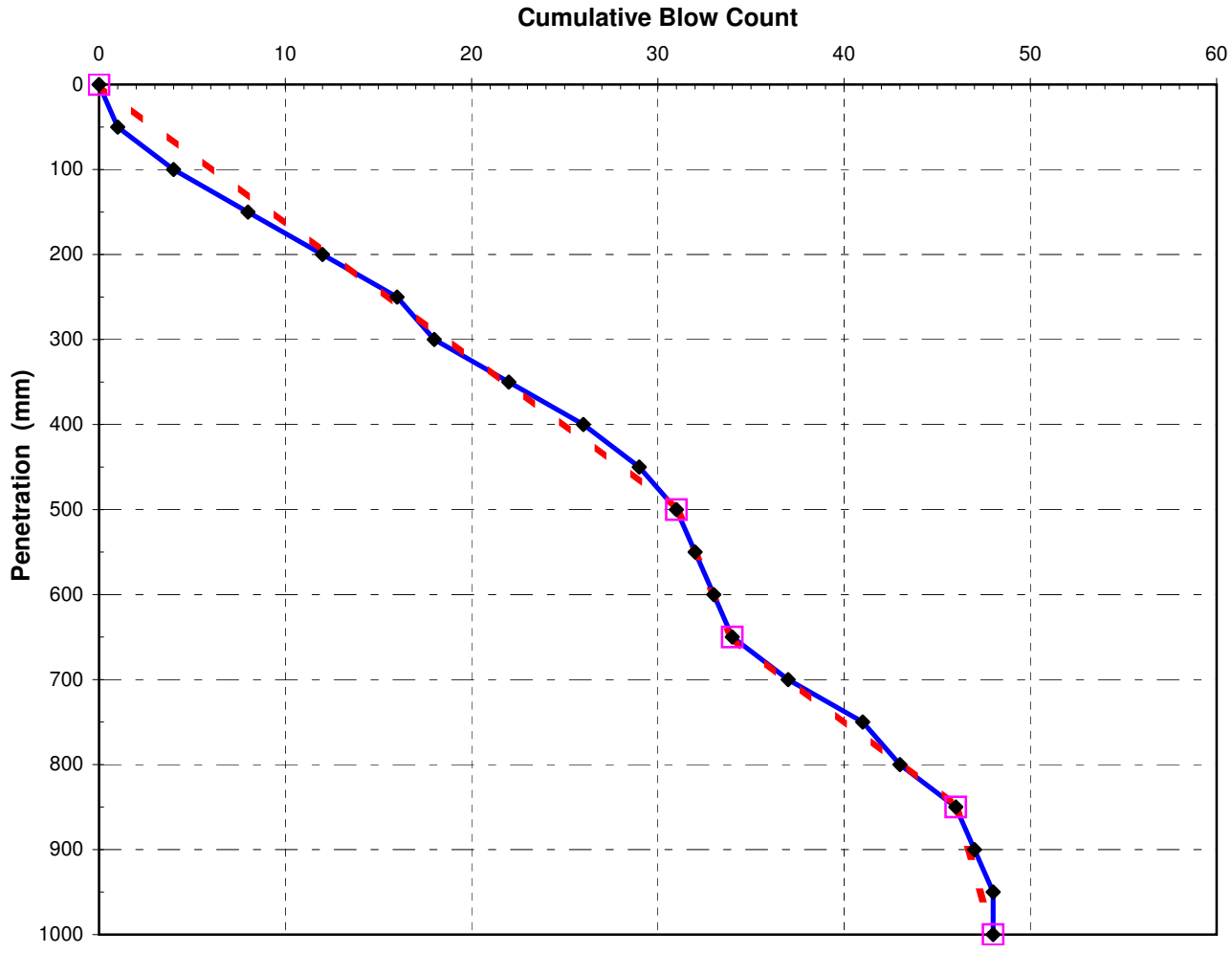
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 9

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count



Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	500	500	31	31	16.1	12		
2	500	650	150	34	3	50.0	2.9		
3	650	850	200	46	12	16.7	12		
4	850	1000	150	48	2	75.0	1.7		

Client:	**Mansell PLC**		**Job No:**	J10309	
Site:	**Worthing Hospital**		**Date:**	05/03/2004	**Fig.**

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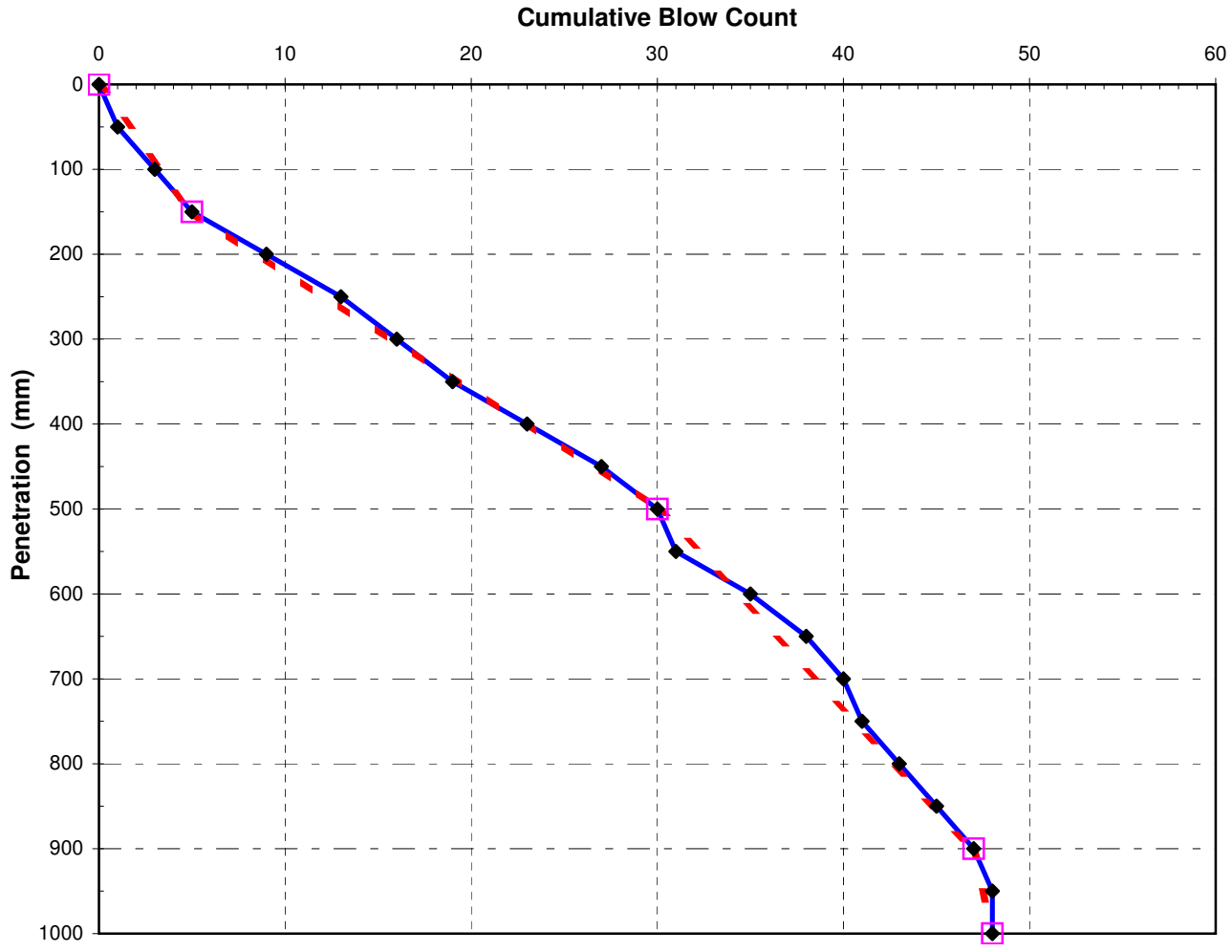
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 10

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count



Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	150	150	5	5	30.0	5.5		
2	150	500	350	30	25	14.0	15		
3	500	900	400	47	17	23.5	7.5		
4	900	1000	100	48	1	100.0	1.2		

Client:	**Mansell PLC**	**Job No:**	J10309	
Site:	**Worthing Hospital**	**Date:**	05/03/2004	**Fig.**

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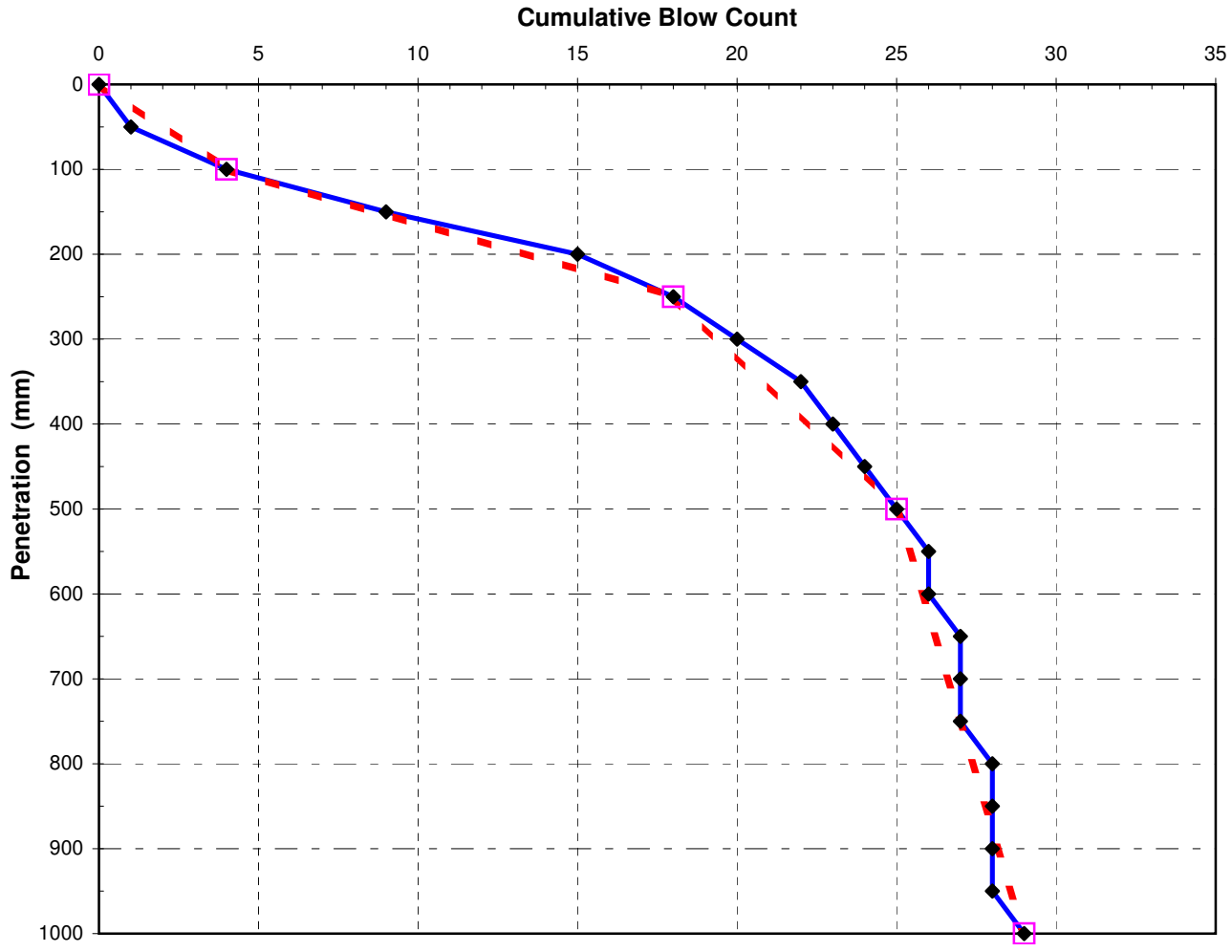
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 11

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count



Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	100	100	4	4	25.0	7.0		
2	100	250	150	18	14	10.7	21		
3	250	500	250	25	7	35.7	4.4		
4	500	1000	500	29	4	125.0	0.9		

Client:	**Mansell PLC**		**Job No:**	J10309	
Site:	**Worthing Hospital**		**Date:**	05/03/2004	**Fig.**

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ST Consult: Twigden Barns, Brixworth Road, Creaton, Northampton NN6 8NN

ST Consult

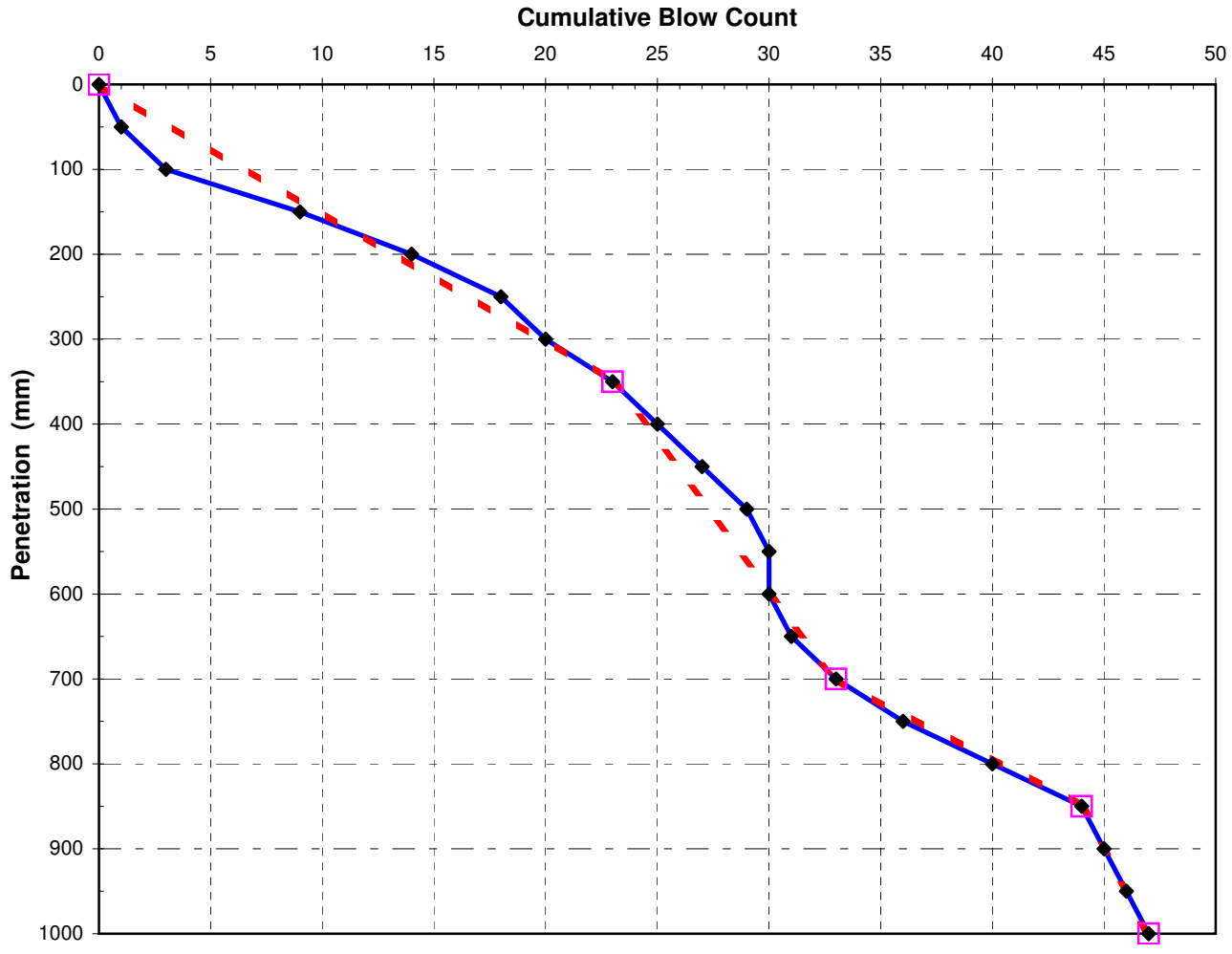
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 12

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count



Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	350	350	23	23	15.2	13		
2	350	700	350	33	10	35.0	4.5		
3	700	850	150	44	11	13.6	15		
4	850	1000	150	47	3	50.0	2.9		

Client:	**Mansell PLC**		**Job No:**	J10309	
Site:	**Worthing Hospital**		**Date:**	05/03/2004	**Fig.**

Southern Testing

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ST Consult

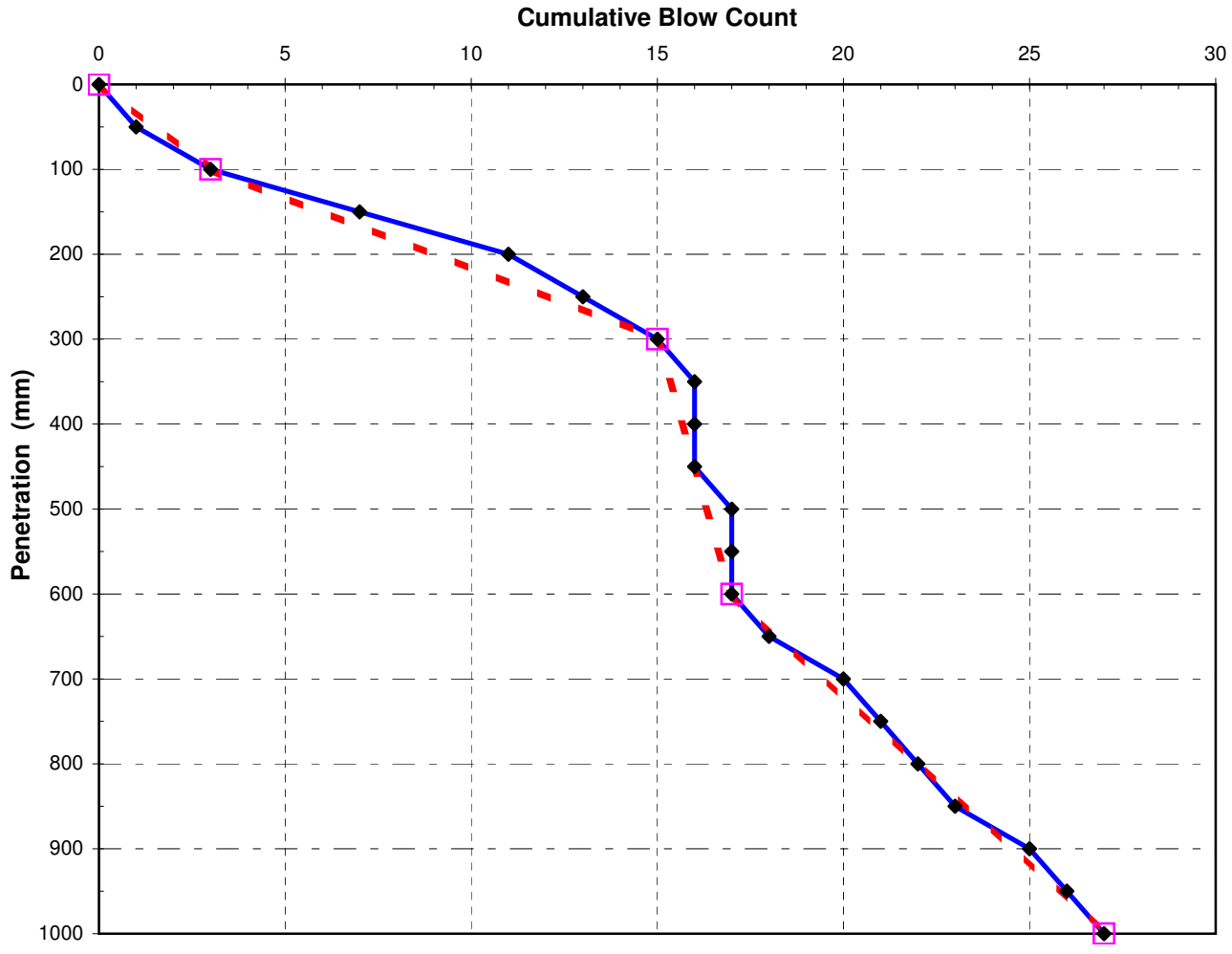
Dynamic Cone Penetrometer (DCP) Test Results

Test No: 13

Chainage:
Start Layer: GL
Soil Condition:
Notes:

Tested By:
Checked By: DK
Test Date:

Perth Cone CBR Penetration *vs* Cumulative Blow Count

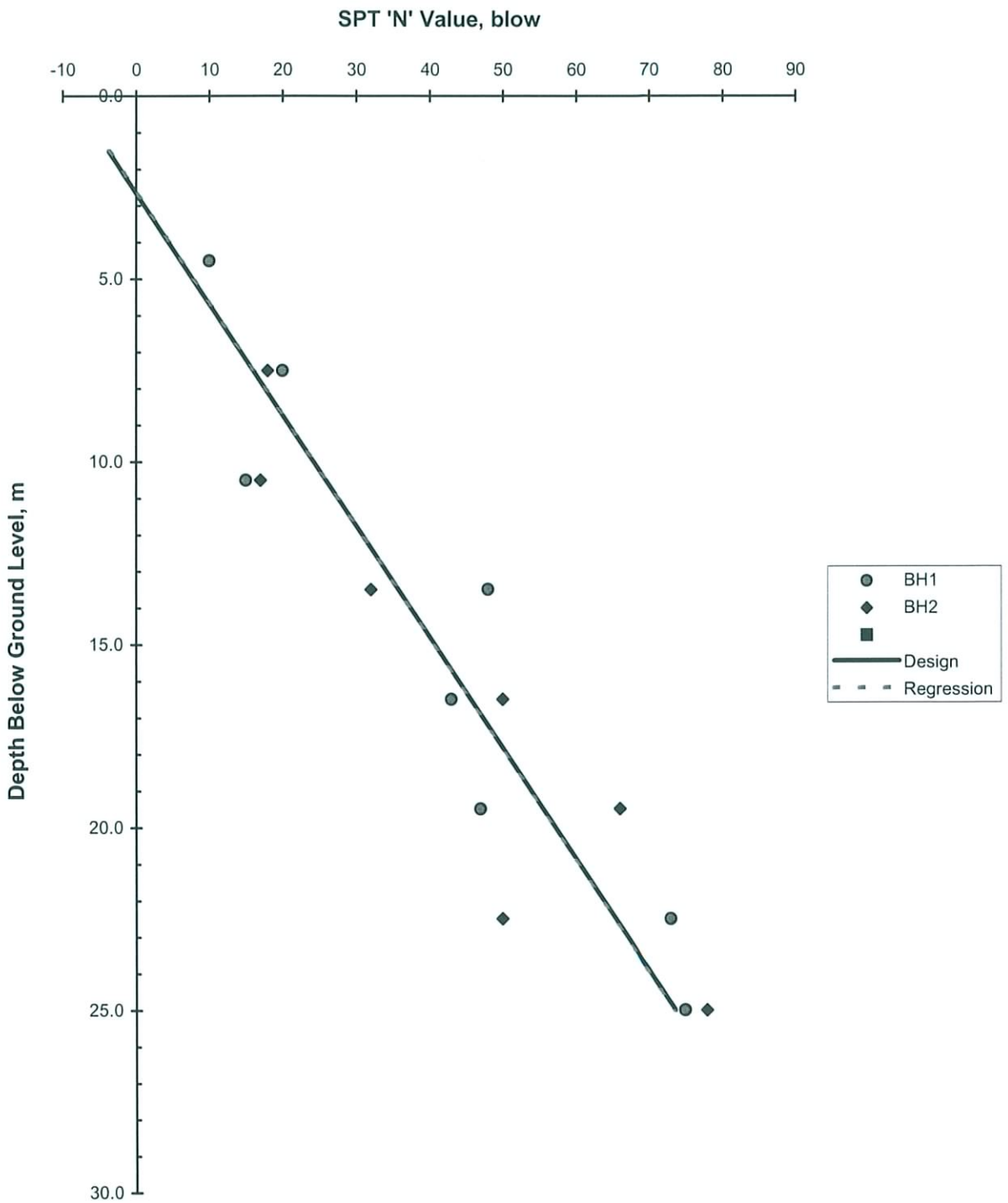


Evaluated CBR Values from DCP Test Results

Layer No	From *(mm)*	To *(mm)*	Depth *(mm)*	Blow Count	No. of Blows	DCP *mm/blow*	CBR *%*	Soil Type	Remarks
1	0	100	100	3	3	33.3	4.8		
2	100	300	200	15	12	16.7	12		
3	300	600	300	17	2	150.0	0.7		
4	600	1000	400	27	10	40.0	3.8		

Client:	**Mansell PLC**		**Job No:**	J10309	
Site:	**Worthing Hospital**		**Date:**	05/03/2004	**Fig.**

SPT 'N' Value *vs* Depth Below Ground Level



Linear Regression of the Test Results : *Slope =* 3.29 *blow/m,* *Zero intercept =* -9 *blow*

Suggested Line for Pile Design : *Slope =* 3.29 *blow/m,* *Zero intercept =* -9 *blow*

Client:	Mansell PLC	**Site:**	Worthing Hospital		
Job No:	J10309	**Date:**	19/08/2010	**Figure No:**	

Site : Worthing Hospital **Client :** Mansell PLC

Job No : J10309 **Date :** 26/08/10 **Table :** P-1

Bearing Capacity for CFA Piles in Chalk

Pile Length	Ultimate Skin Friction, *kN*						Ultimate Base Resistance, *kN*						Allowable Load, *kN*					
	Pile Diameter, mm						Pile Diameter, mm						Pile Diameter, mm					
m	300	350	400	450	500	600	300	350	400	450	500	600	300	350	400	450	500	600
6.0	8	10	11	13	14	17	139	189	246	312	385	554	45	60	80	100	120	170
7.0	19	22	25	29	32	38	148	202	264	334	412	594	55	75	90	115	140	195
8.0	34	40	45	51	57	68	164	223	292	369	456	656	70	90	115	140	170	235
9.0	53	62	71	80	88	106	198	269	351	445	549	790	90	120	145	180	215	295
10.0	76	89	102	115	127	153	231	315	411	520	642	924	115	150	185	225	270	365
11.0	104	121	139	156	173	208	282	384	501	634	783	1128	150	190	235	285	340	460
12.0	136	158	181	204	226	271	349	475	620	785	969	1396	190	240	300	360	430	580
13.0	172	200	229	258	286	344	416	566	740	936	1156	1664	235	295	365	440	520	705
14.0	212	247	283	318	353	424	445	606	792	1002	1237	1781	265	340	415	500	590	790
15.0	257	299	342	385	428	513	445	606	792	1002	1237	1781	280	360	455	545	640	850
16.0	305	356	407	458	509	611	445	606	792	1002	1237	1781	300	385	480	585	695	915
17.0	358	418	478	538	597	717	445	606	792	1002	1237	1781	320	410	510	615	735	985
18.0	416	485	554	623	693	831	445	606	792	1002	1237	1781	345	435	540	650	770	1045
19.0	477	557	636	716	795	954	445	606	792	1002	1237	1781	370	465	570	685	815	1095
20.0	543	633	724	814	905	1086	445	606	792	1002	1237	1781	395	495	605	725	855	1145
21.0	613	715	817	919	1021	1226	445	606	792	1002	1237	1781	425	530	645	770	905	1205
22.0	687	802	916	1031	1145	1374	445	606	792	1002	1237	1781	455	565	685	815	955	1260
23.0	766	893	1021	1148	1276	1531	445	606	792	1002	1237	1781	485	600	725	860	1005	1325
24.0	848	990	1131	1272	1414	1696	445	606	792	1002	1237	1781	515	640	770	910	1060	1390
25.0	935	1091	1247	1403	1559	1870	445	606	792	1002	1237	1781	530	680	815	960	1120	1460

Note: 1. Nil skin friction on the pile shaft within made ground or fill was assumed to a depth of 4m.

2. Skin friction effects from soil overlying chalk were ignored to a depth of 4m.

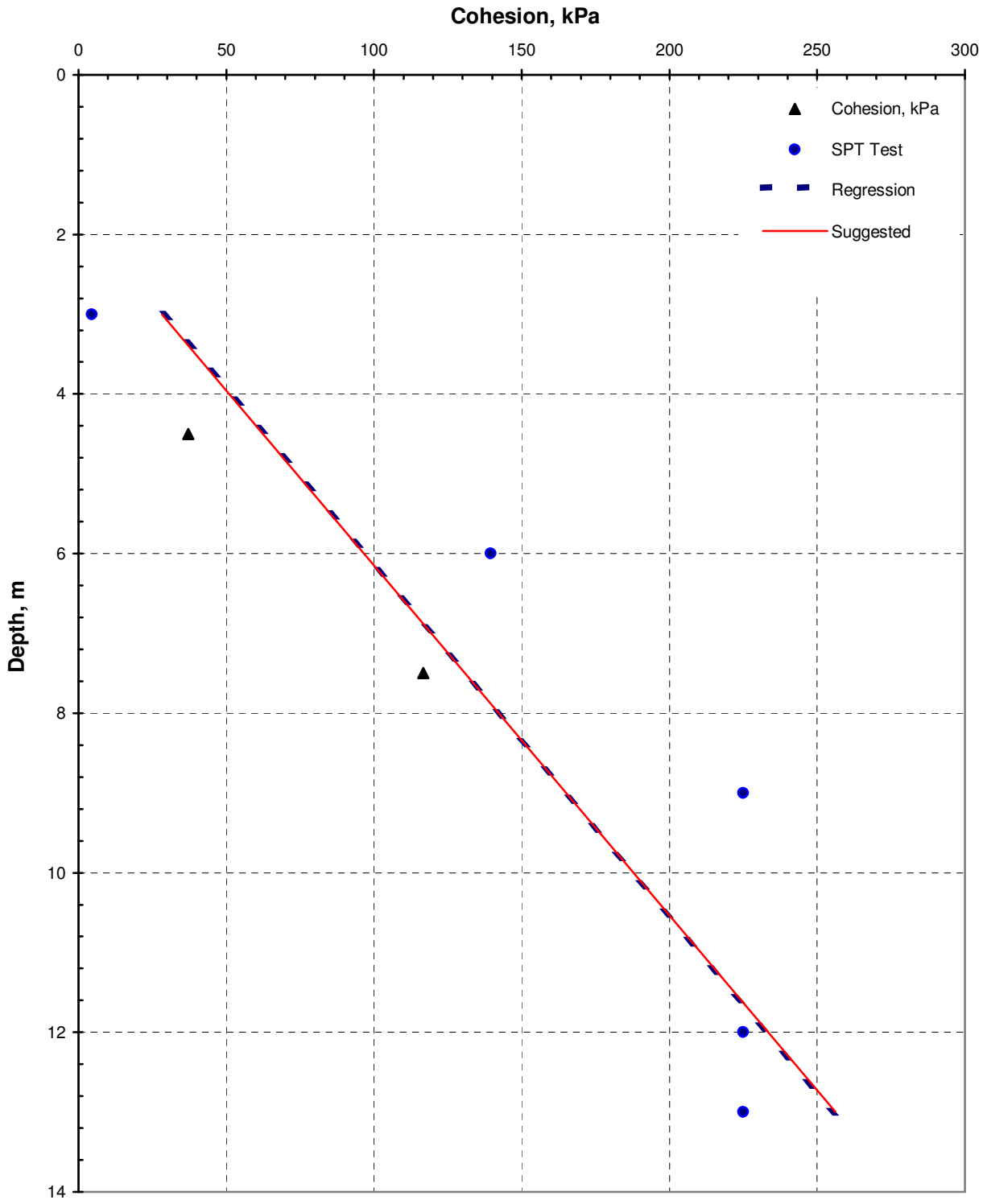
3. The chalk was assumed below a depth of 4m, with ground water table at 4m

4. The allowable load with underline represents Maximum working load for an allowable concrete stress of 7.50MPa.

5. The factors of safety adopted for calculating allowable loads are in accordance with *CIRIA Project Report 11* .

THE ABOVE FIGURES MUST NOT SUPERCEDE THE ENGINEER'S DESIGN

Plot of Cohesion vs Depth



Linear Regression of the Test Results: *Slope =* 22.8 *kPa/m,* *Zero intercept =* -40.0 *kPa*

Suggested Design Line: *Slope =* 22.8 *kPa/m,* *Zero intercept =* -40.0 *kPa*

Client: Mansell PLC	**Site:** Worthing Hospital	
Job No: J10309	**Date:** 26/08/2010	**Figure No:** 2

Site : Worthing Hospital **Client :** Mansell PLC
Job No : J10309 **Date :** 26/08/10 **Table :** P-1

Bearing Capacity of CFA Piles (kN)

Pile Length	Factor of Safety = 2.0						Factor of Safety = 2.5						Factor of Safety = 3.0					
	Pile Diameter, mm						Pile Diameter, mm						Pile Diameter, mm					
m	300	350	400	450	500	600	300	350	400	450	500	600	300	350	400	450	500	600
5.0	35	45	55	70	80	110	30	35	45	55	65	90	25	30	35	45	55	75
6.0	60	75	90	110	125	170	50	60	70	85	100	135	40	50	60	70	85	115
7.0	90	110	130	155	180	240	70	85	105	125	145	190	60	75	90	105	120	160
8.0	120	150	180	210	245	320	100	120	145	170	195	255	80	100	120	140	165	215
9.0	160	195	235	275	315	410	130	155	185	220	255	325	105	130	155	185	210	275
10.0	205	250	295	345	395	510	165	200	235	275	315	405	135	165	195	230	265	340
11.0	250	305	360	420	485	615	200	245	290	335	385	495	170	205	240	280	320	410
12.0	305	370	435	505	580	735	245	295	350	405	460	590	205	245	290	335	385	490
13.0	360	430	510	590	675	855	285	345	405	470	540	685	240	290	340	395	450	570

Note: 1. Nil skin friction on the pile shaft was assumed to a depth of 4.00 m.
2. The calculated cohesion depth line gave a zero intercept of -40.0 kPa and slope of 22.8kPa/m.
3. A value of 7.50 was used for bearing capacity, and 0.45 for adhesion, for the clays.
4. An allowable load with underline represents Maximum working load (allowable stresses of 7.50MPa adopted).

THE ABOVE FIGURES MUST NOT SUPERCEDE THE ENGINEER'S DESIGN

APPENDIX C

Geotechnical Laboratory Test Methods & Result

Sulphate Test (Gravimetric)

The gravimetric method of analysis is used for acid extracts, water extracts (normally 2 to 1), and ground water samples. In this method a 5% solution of Barium Chloride is added to the acid or water extract and the precipitate of Barium Sulphate that is formed is collected, dried and weighed. The sulphate content is calculated from the mass of material used and the mass of barium sulphate precipitated.

Atterberg Limit Tests

This is a valuable classification test, which is used to determine the moisture contents at which a soil changes from a liquid through a plastic to a solid state and gives an indication of the clay quantities present in the soil.

Moisture Content

A sample of soil is dried to constant dry weight at a temperature of 105 degrees centigrade and the moisture content determined.

Triaxial Compression Test

Shear characteristics of the soil are obtained by the undrained triaxial test. In this test, 38mm diameter or 100mm diameter samples were tested in compression under a series of varied lateral pressures, and the angle of shearing resistance and apparent cohesion obtained.

Atterberg Limits Test Result Summary Sheet

Test carried out in accordance with BS 1377: 1990: Part2 Test No 4.3, 4.4 & 5

Job No : J10309 **Checked By :** CAT **Date:** 6-Sep-2010

Site : Worthing Hospital

Client : Mansell PLC

Plot No	Hole No *or* Sample ID	Depth *(m)*	Moisture Content *(%)*	Liquid Limit *(%)*	Plastic Limit *(%)*	Plasticity Index *(%)*	Class-ification	% Passing 425µm *(%)*	Visual Description
1	BH1	1.50	18.9	30	17	13	CL	99	Firm,medium strength orange brown mottled brown black sandy CLAY with occasional flint gravel
2	BH1	2.50	19.8	29	19	10	CL	95	Soft,very low strength yellow brown very sandy CLAY with occasional flint gravel
3	BH2	4.00	12.6	19	14	5	ML	90	Very stiff,very high strength buff SILT with frequent intact chalk fragments and occasional flint gravel
4	BH3	2.00	23.3	84	26	58	CV	95	Very soft,extremely low strength brown grey CLAY with occasional flint gravel
5	BH3	5.00	29.4	65	26	39	CH	100	Firm,medium strength light grey CLAY
6	BH3	11.00	18.0	52	19	33	CH	100	Hard,extremely high strength red brown mottled grey CLAY

Southern Testing

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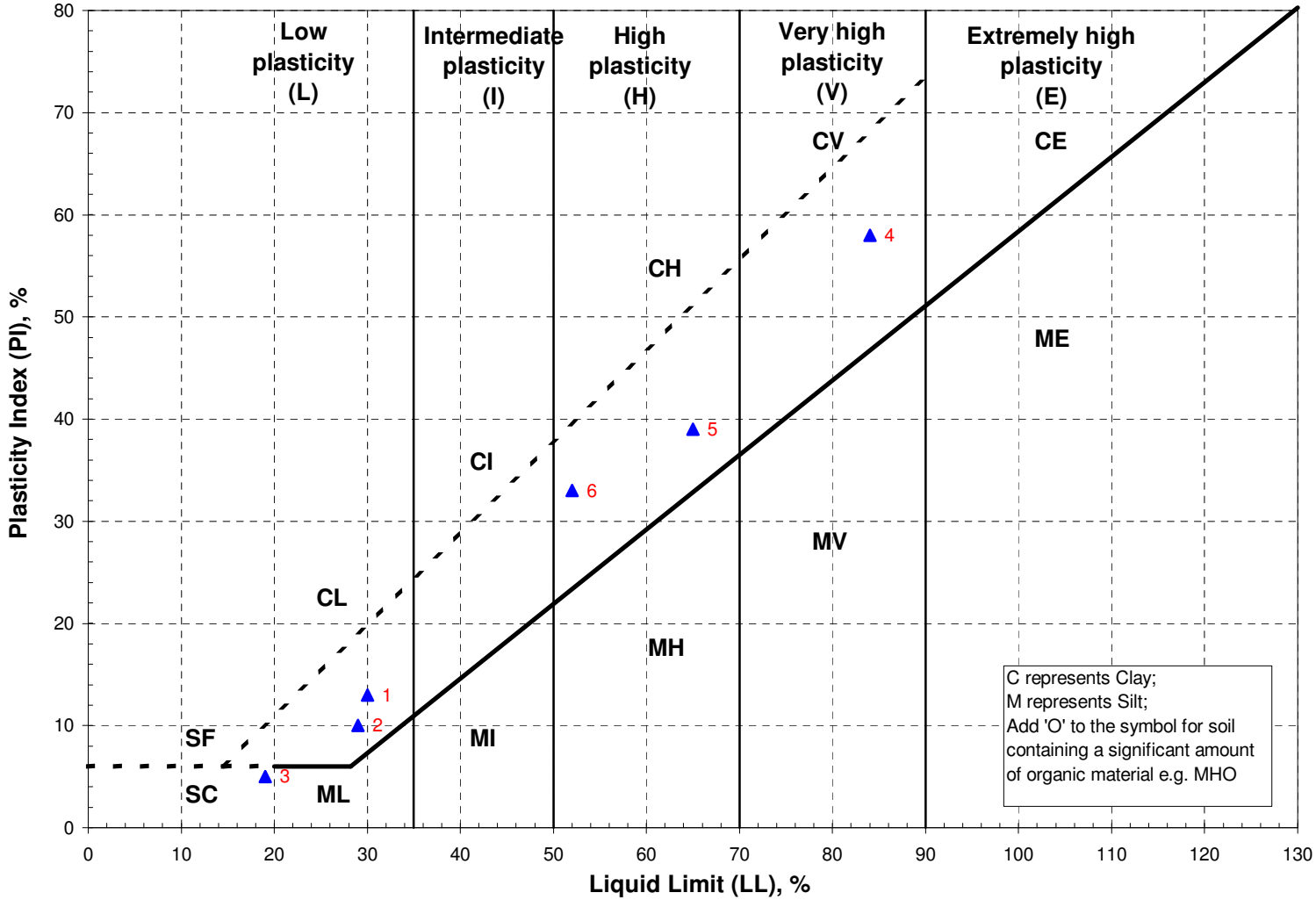
Plasticity Chart for Atterberg Limit Test Results



Sample List

1	BH1@1.5m
2	BH1@2.5m
3	BH2@4m
4	BH3@2m
5	BH3@5m
6	BH3@11m

Statistics

Liquid Limit	
Max	84
Min	19
Average	47
Plastic Limit	
Max	26
Min	14
Average	20
Plasticity Index	
Max	58
Min	5
Average	26

Site:	Worthing Hospital	Job No:	J10309	Engineer:	DK
Client:	Mansell PLC	Date:	06/09/2010	Figure No.	2

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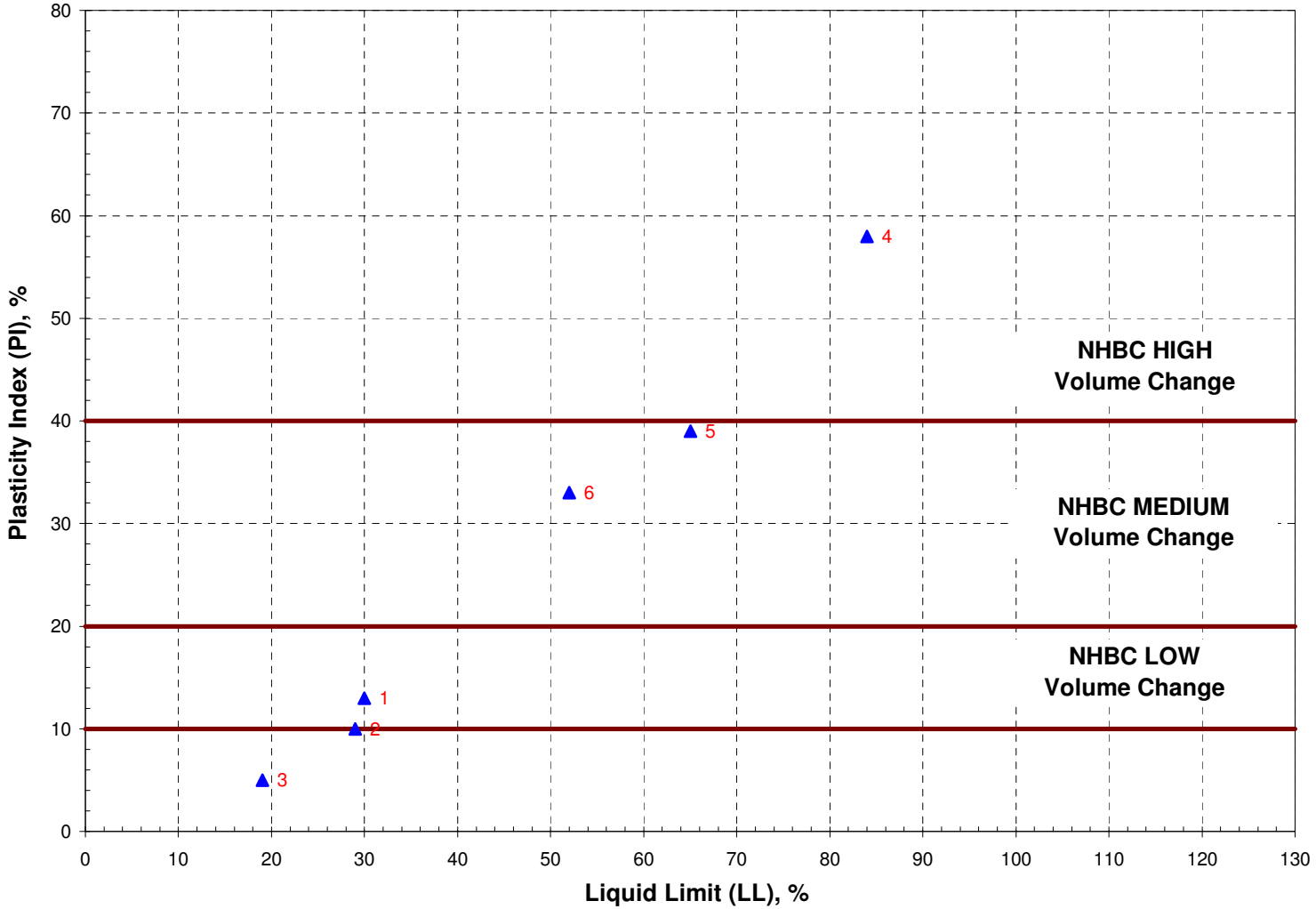
Plot Relating Soil Plasticity to NHBC Classification for Volume Change Potential



Sample List

1	BH1@1.5m
2	BH1@2.5m
3	BH2@4m
4	BH3@2m
5	BH3@5m
6	BH3@11m

Statistics

Liquid Limit	
Max	84
Min	19
Average	47
Plastic Limit	
Max	26
Min	14
Average	20
Plasticity Index	
Max	58
Min	5
Average	26

Site:	Worthing Hospital	Job No:	J10309	Engineer:	DK
Client:	Mansell PLC	Date:	06/09/2010	Figure No.	3

Southern Testing

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ST Consult

Summary Sheet ... Triaxial Compression Test Results

Job No: J10309 **Site:** Worthing Hospital **Checked By:** CAT **Date:** 25/08/2010

Hole No	Depth (m)	Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)	Cell Pressure (kPa)	Deviator Stress (kPa)	Apparent Cohesion; C_u (kPa)	Apparent Angle of Friction; ϕ_u (deg)	Visual Description	Sample Type	UCS by Hand Pen (kN/m^2)
BH3	4.5	31.2	1.92	1.46	90	74.5	37.2		Firm,medium strength light grey speckled black CLAY	U100	140
BH3	7.5	17.8	2.12	1.80	150	233.5	116.7		Hard,extremely high strength red brown mottled light grey CLAY	U100	>600

Soil / Groundwater Sulphate Content Test Results

Test carried out in accordance with BS 1377 : 1990 : Part 3 Test No 5.3, 5.4 & 5.6

Job No : J10309 **Client :** Mansell PLC

Site Location : Worthing Hospital

Tested By : ST Lab **Checked :** BSK **Date :** 26/08/2010

Hole No/ Sample ID	Depth (m)	Sample Type	Soil Sulphate in 2:1 Water Extract		Groundwater Sulphate		Total Potential Sulphate		pH Value
			g / l SO_3	BRE mg / l SO_4	g / l SO_3	BRE mg / l SO_4	% SO_3	BRE % SO_4	
BH1	7.00		0.07	25					8.02
BH1	24.30		0.08	49					8.44
BH2	15.00		0.06	106					8.28
BH3	4.50		0.23	140					8.70
BH3	7.50		0.26	181					8.33

Southern Testing

Southern Testing: Keeble House, Stuart Way, East Grinstead, West Sussex RH19 4QA
ST Consult: Twigden Barns, Brixworth Road, Creaton, Northampton NN6 8NN

ST Consult

Soil / Groundwater Sulphate Content Test Result Summary Sheet

Test carried out in accordance with BS 1377 : 1990 : Part 3 Test No 5.3, 5.4 & 5.6

Job No : J10309 **Client :** Mansell PLC

Site Name : Worthing Hospital

Location of Site:

Sample Group :

Checked By : BSK **Date :** 26/08/2010

Hole No/ Sample ID	Depth	Sample Type	Soil Sulphate in 2:1 Water Extract		Groundwater Sulphate		Total Potential Sulphate		pH Value
	(*m*)		*g / l SO_3*	*BRE mg / l SO_4*	*g / l SO_3*	*BRE mg / l SO_4*	*% SO3*	*BRE % SO4*	
BH1	7.00		0.07	25					8.02
BH1	24.30		0.08	49					8.44
BH2	15.00		0.06	106					8.28
BH3	4.50		0.23	140					8.70
BH3	7.50		0.26	181					8.33

Characteristic Values and Design Classes for the Location

Location for Samples : **Brownfield**		Groundwater : **Mobile Water**		
Characteristic Values :	**200**			**8.15**
Basic Sulfate Classes :	**DS-1**			

Design Sulfate Class for Location : DS-1

ACEC Class for Location : AC-1