



## Site Investigation Report



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

## Site: Shaftesbury Theatre, London, WC2H 8DP

## Client: Shaftesbury Theatre

## Report Date: 29 January 2018

Project Reference: J13424

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## **SUMMARY**

The site comprises The Shaftesbury Theatre which is located on the western end of High Holburn, incorporating the existing building, basement and auditorium below. It is proposed to undergo a redevelopment involving changes to the existing structure and therefore a change in the applied bearing pressures on the underlying soil.

Geological records indicate the site to be underlain by the Lynch Hill Gravel Member over London Clay Formation.

Foundation inspection trial pits were excavated by others. Two pits were left open, through which handheld window sampler boreholes and dynamic probing were undertaken.

The soils encountered comprised Made Ground from 0.1-0.5 mbgl, overlying the Lynch Hill Gravel Member, overlying London Clay Formation. The top of the London Clay was about 2.3-2.7 mbgl.

Groundwater was not encountered during this site investigation.

An allowable bearing pressure for the Lynch Hill Gravel Member and London Clay of 150 kN/m<sup>2</sup> is recommended. Consideration should be given to widening the existing foundations to minimise any additional pressure, and hence settlement to the underlying London Clay.

The site investigation was conducted and this report has been prepared for the sole internal use and reliance of Shaftesbury Theatre 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 Ltd. 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.

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For and on behalf of Southern Testing Laboratories Limited

STL: J13424 29 January 2018

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## A INTRODUCTION

## 1 Authority

Our authority for carrying out this work is contained in an instruction letter signed by James Williams of Shaftesbury Theatre dated the 7<sup>th</sup> December 2017.

## 2 Location

The site is located in central London, 0.3km east of Tottenham Court Road Underground Station. The approximate National Grid Reference of the site is TQ 30129 81364, as shown on Figure 1 (Appendix A).

## 3 Proposed Construction

It is understood that it is proposed to alter the existing structure of the theatre, and that several trial pits have been excavated to expose the footings of the existing structure.

## 4 Object

This is a geotechnical investigation. The object of the investigation was to assess the bearing capacity of the founding soils. A contamination investigation was not part of the scope of this investigation.

### 5 Scope

This report presents our exploratory hole logs and 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 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.

The site investigation was conducted and this report has been prepared for the sole internal use and reliance of Shaftesbury Theatre 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 Ltd. 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. The contamination screening values used are valid at the time of writing but may be subject to change and any such changes will have implications for the assessments based on them. Their validity should be confirmed at the time of site development.

## 5.1 Geology

The British Geological Survey Map, (London, No 283) indicates that the site geology consists of the Lynch Hill Gravel Member over London Clay.

## Lynch Hill Gravel Member

The Lynch Hill Gravels, or formerly the fourth River Terrace Gravels, are of fluviatile origin and were laid down by the Thames when the climate was much wetter and cooler than at present. The terraces consist of sheets of gravel and sand with an overlying deposit of Brickearth (really an ancient alluvium). Some variability in soils is to be expected at junctions with the various terraces, as riverbanks existed there. The remains of these former riverbanks can be soft and silty or contain clay.

The gravels have often been worked in the past, on a piecemeal basis. The former gravel pits were usually infilled with rubbish and are very difficult to detect by random excavations, although intensive geophysical testing is often successful. It should be noted that deeper foundations may be required in some areas, and that some noxious fill may also be found.

## London Clay

London Clay is a well-known stiff (high strength) blue-grey, fissured clay, which weathers to a brown colour near the surface. It contains thin layers of nodular calcareous mudstone – "claystone" – from place to place, and crystals of water clear calcium sulphate (selenite) are common. Although slopes will stand in the clay at steep angles in the short term, the long-term stable slope angle is about  $7^{\circ}$  for grassed, or cleared slopes, and a few degrees more for wooded slopes.

## 6 Site Description

The site comprises of Shaftsbury Theatre; which is located at the western end of High Holborn where it intersects the A400. The site is comprised of a three to four storey building with a basement and auditorium. The theatre is attached to buildings comprised of retail businesses and flats to the north. Grape Street runs along the eastern boundary of the theatre; High Holborn along the southern boundary, and the A400 along the western boundary. The northern boundary is shared with the adjoining buildings.

## **B** SITE INVESTIGATION

## 11 Method

The strategy adopted for the intrusive investigation comprised the following:

- 2 No. boreholes excavated by hand held window sampler to 3.6m, within situ testing and sampling.
- 2 No. handheld dynamic probes, one adjacent to each of the two boreholes.

The boreholes and probes were drilled through the base of two trial pits which had been excavated by others prior to our arrival on site.

Exploratory hole locations are shown in Figure 2 (Appendix A).

### 12 Soils as Found

The soils encountered are described in detail in the attached exploratory hole logs (Appendix A).

In general, the soils comprised a covering of Made ground, overlying Lynch Hill Gravel Member, over London Clay. A summary is given below.

Depth to base (m)	Thickness (m)	Soil Type	Description
GL-0.1	0.1	Concrete	Concrete
0.5	0.4	MADE GROUND	Brown to dark brown sandy fine to coarse, subangular to surrounded GRAVEL. Gravel is sunangular flint, brick and blacktop.
2.3/2.7	1.1	LYNCH HILL GRAVEL MEMBER	Brown sandy fine to coarse subangular to subrounded flint GRAVEL. Sand is fine to coarse.
			Below 1.6m bgl: Becoming loose, orangey- brown gravelly SAND. Sand is fine to coarse. Gravel is angular fine to medium flint.
3.6 +	0.9-1.3 +	LONDON CLAY	Stiff, brown mottled grey, slightly sandy CLAY. Sand is fine.

### 13 Groundwater Strikes

No water strikes were recorded during the investigation.

## C 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 Probing (DPL)
- Hand Penetration Tests
- Disturbed sampling

3

## D GEOTECHNICAL LABORATORY TESTS

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

- PSD Wet Sieve Preparation
- 4 Point Plasticity Index
- Natural Moisture Content

## E DISCUSSION OF GEOTECHNICAL TEST RESULTS AND RECOMMENDATIONS

### 14 Soil Classification and Properties

Soil Type	Depth to base (m)	Compressibility	VCP	Permeability	Frost Susceptible
Made Ground	0.1-0.5	Potentially high	Variable	High and variable	Possible
Lynch Hill Gravel Member	2.3/2.7	Low	Negligible	High and variable	N/A
London Clay	3.6 +	Moderate	High	Very Low	N/A

## The Lynch Hill Gravel Member

These soils are variably graded, comprising of fine sand up to coarse gravels. The deposits are variable in their silt content, with a measured 1-10% of fines less than 63mm. The anticipated properties of the sand are as follows:

- They have poor to good drainage characteristics depending on the fines content. On balance, the drainage will be generally good.
- They have negligible swelling and shrinkage properties where affected by tree roots.

#### London Clay

With a measured liquid limit of 60 - 62% and a plasticity index of 18 - 24%, the London Clay is classified as a clay of high plasticity.

The anticipated properties of the soil are:

- 1. They have high swelling and shrinkage properties
- 2. They are non-frost susceptible.
- 3. They have poor drainage characteristics.

## 15 Dynamic Probing

The dynamic probes were drilled using handheld equipment (DPL), and commenced at the base of the trial pits. Both probes refused within the Lynch Hill Gravel Member at depths of 2.2m (TP1) and 2.0m (TP3) mbgl. From these results, the Lynch Hill Gravel Member appears to be relatively in nature.

## 16 Swelling and Shrinkage

There are no trees or other vegetation present on site, and as such the soils will not be affected by seasonal swelling and shrinkage caused by tree roots.

## 17 Groundwater Levels

No groundwater was encountered in either borehole. Groundwater conditions were not therefore established.

Groundwater levels vary considerably from season to season and year to year, often rising 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 Bearing Capacity

Due to the presence of a relatively thin layer of Lynch Hill Gravel Member between the base of the foundations and the top of the London Clay (about 1.3m), allowable bearing pressures would be largely controlled by the strength of the clay. It is assumed that the founding soils will have already consolidated during the lifespan of the Shaftesbury Theatre under existing loadings. Structural loads will therefore be transferred down, via the Lynch Hill Gravel Member, to the London Clay.

Based on the hand penetrometer, and dynamic probe data, an allowable bearing pressure for the London Clay of 150kN/m<sup>2</sup> is recommended. It is recommended that the foundations are widened, rather than deepened, to accommodate any additional loads. This would act to reduce or maintain the pressure applied to the London Clay, and hence minimise any induced settlement.

## 19 Settlement

There may be some additional settlement where additional loads are applied.

# APPENDIX A

Site Plans and Exploratory Hole Logs





## Key to Exploratory Hole Logs

#### General

All soil & rock descriptions in general accordance with BS5930, BS EN ISO 14688 and BS EN ISO 14689 The Geology Code is only provided where positive identification of the sampled strata has been made.

<u>Sampling</u>	
ES	Environmental Sample (taken in appropriate sampling container)
D	Disturbed Sample
В	Bulk Sample
LB	Large Bulk for Earthworks testing
С	Core Sample
U	Undisturbed Sample (number of blows indicated in results column)
SPTLS	SPT Liner Sampler
Р	Piston Sample
W	Water Sample
Insitu Tests SPT SPT (C) PT PPT UCS () IVN PID MEXE	Standard Penetration Test in accordance with BS EN ISO 22476-3 Cone Penetration Test in accordance with BS EN ISO 22476-3 Penetration Test - STL documented equivalent SPT N Value Perth Penetration Test - STL in house documented method (N Value) Unconfined Compressive Strength measure by hand penetrometer (kN/m <sup>2</sup> ) Hand Vane (kPa) Photo Ionisation Detector Results (ppm) Mexecone CBR Result

#### **Drilling Records**

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otal Core Recovery (%) Solid Core Recovery (%) Rock Quality Index (%) Fracture Index



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# 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 at intervals and stored in sealed glass jars and polythene bags, as appropriate.

### **DPL Light Penetration Test**

The DPL is a lightweight penetrometer which complies with BS EN ISO 22476-2: 2005.

In use, a cone is attached to rods and is driven into the ground by a free falling hammer. The number of blows to penetrate each successive 100 mm is recorded (called the  $N_{10}$  value). It is similar in concept to the Mackintosh Prospector but has a higher and more uniform driving energy, and as the rods are flush coupled there is less friction. This produces a more consistent end result. The details are:

Driving Cone	: 90°
Area	: 10 sq cm
Rods	: Solid 22 mm flush coupled
Anvil	: Solid 4 kg
Hammer	: 10 kg
Hammer Drop	: 500 mm

# APPENDIX C

Geotechnical Laboratory Test References & Results

Sout	hern Test		Consult BS1377-2 cl.3.2, 3.3	<b>bisture Content Sum</b> , 4.2, 4.3 & BS EN ISO 1789	mary 92-1					AGS
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Clier	nt	Shaftesbu	ry Theatre		PE	TL	Date I	ssued	18-Jan-18	
Location	Depth m	Sample Type	Visual Description	Comments	Natural MC %	Liquid Limit %	Plastic Limit %	Plasticity Index	Classi- fication	Passing 425 micron %
TP1	2.30	D	Stiff dark brown patched light brown CLAY.		25	62	24	38	СН	100
ТРЗ	3.50	D	Stiff dark grey brown slightly gravelly CLAY. Gravel consists of fine subangular flint.		26	60	18	42	СН	98

Southern Testing Laboratories Limited, East Grinstead is registered under BS EN ISO 9001:2008 BSI ref: FS29280

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Visual Descrip Light brown ve sandstone and	ption of Sa ry sandy fin I quartzite G	mple: to coarse suban GRAVEL.	ngular to ro	o.oo1	Fine	0.01 Medium SILT 1 Part Test N Wet & cl.9.2 &	Coarse icle Densi Coefficier lethods: Dry Gradin 9.3 & BS I	0.1 Fine ty (Assure the of Uni g BS1377 EN ISO 1	Medium SAND 37 med) Mg/m formity 7-2 7892-4	1 Coars	e Fine	10 Medi GRA 63	um Coarse VEL 3 Locatio Depth ( Sample T	100 on (m) Type By	100 COBBLES 0 TP3 1.60 B STL Lab

	n Testing			PA	RTICLI To	E SIZE D BS1377-2:1	<b>ISTRIB</b> 1990(2003	UTION 3) cl. 9.2·	I REPORT 9.5					AG	is
Project Name	e Shafte	sbury Theatre										Project Nu	nber	J13424	
Client Name Shaf		sbury Theatre							PE	TL		Date Issu	ed	18-Jan-18	
								Partic	le Size Dis	tribu	tion Ch	nart			
Р	article Size	% Passing		100 90									•• •		
	125mm	100													
	75mm	100		80											
	63mm	100	bu	70							/				
	50mm	100	ssi	60											
	37.5mm	100	Ба	50							r				
	20mm	100	ge	50											
	14mm	91	Itaç	40									++++		
	6.3mm	72	Sen	30											
	2mm	57	ero	20											
	630µm	44	<u>م</u>	20					•						
	200µm	18		10			•								
	63µm	10		0				<u> </u>							
				CLAY	Fine	Medium	Coarse	Fine	Medium Co	barse	Fine	Medium Coarse	_	COBBLES	7
						3IL1 10	10				J3		0		
						10			47			43		0	1
Visual Description of Sample: Brown clayey/silty very gravelly fine to coarse SAND. Gravel consists of				sts of	Particle Density (Assumed) Mg/m <sup>3</sup> N/A				Locat	Location		]			
fine and medium angular flint and sandstone.					Coefficient of Uniformity					Depth	Depth (m)				
						Toot Methodo						Sample	Sample Type		
						Wet & D	ernoas: ry Grading	BS1377	-2						
Comments:					cl.9.2 &	9.3 & BS E	ISU 17	892-4			Teste	d By	STL Lab	1	
												Checke	ed By	AnnaS	1