

**Project: Great Jackson Street, Manchester HPD**

**Pressuremeter Testing Factual Report**

**Client: GeoAssist Ltd**

**Contract No.: P1210114**

| Issue | Date       | Description | Prepared | Checked | Approved |
|-------|------------|-------------|----------|---------|----------|
| 01    | 26/05/2021 | Draft       | MT       | JH      | RC       |
|       |            |             |          |         |          |
|       |            |             |          |         |          |

Date: 26<sup>th</sup> May 2021

Our Ref: P1210114

**GeoAssist Ltd**

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**St Leonards on Sea**

**East Sussex TN38 9UH**

**Attention: Matthew Benson**

**Pressuremeter testing at  
Great Jackson Street, Manchester HPD**

We have pleasure in providing a digital copy of our report for the above project.

We hope that you are satisfied with the performance of our staff, equipment and reporting on this project. If you should have any queries about any aspect of the works carried out, please do not hesitate to contact us. We look forward to being of service to you in the future.

Yours faithfully,

**In Situ Site Investigation Limited**



Darren Ward

Director

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## ABBREVIATIONS

| Pressuremeter types |                           |
|---------------------|---------------------------|
| <b>HPD</b>          | High pressure dilatometer |
| <b>SBP</b>          | Self-boring pressuremeter |
| <b>DPM</b>          | Driven pressuremeter      |

| In situ horizontal stress ( $\sigma_h$ ) |                                                                                                     |
|------------------------------------------|-----------------------------------------------------------------------------------------------------|
| <b><math>p_o</math></b>                  | Cavity reference pressure                                                                           |
| <b><math>\sigma_h</math> (M&amp;R)</b>   | In situ horizontal stress from Marsland & Randolph (1977) analysis (where $P_{yield} = P_L - S_u$ ) |
| <b><math>\sigma_h</math> (LO)</b>        | In situ horizontal stress from lift-off analysis (SBP)                                              |
| <b><math>\sigma_h</math> (H&amp;W)</b>   | In situ horizontal stress from unloading curve (Houlsby & Withers, 1988; DPM)                       |
| <b><math>\sigma_h</math> (CM)</b>        | In situ horizontal stress from curve modelling (Whittle, 1999; SBP)                                 |

| Undrained shear strength (kPa)      |                                                                                          |
|-------------------------------------|------------------------------------------------------------------------------------------|
| <b><math>S_u</math> (loading)</b>   | Shear strength from loading curve, via Gibson & Anderson (1961) analysis                 |
| <b><math>S_u</math> (M&amp;R)</b>   | Shear strength from Marsland & Randolph (1977) analysis (where $S_u = P_{yield} - P_L$ ) |
| <b><math>S_u</math> (unloading)</b> | Shear strength from unloading curve, via Jefferies (1988) analysis (DPM & SBP)           |
| <b><math>S_u</math> (H&amp;W)</b>   | Shear strength from unloading curve, via Houlsby & Withers (1988) analysis (DPM)         |
| <b><math>P_L</math></b>             | Limit pressure via Gibson & Anderson (1961) analysis                                     |
| <b><math>P_L</math> (H&amp;W)</b>   | Limit pressure via Houlsby & Withers (1988) analysis (DPM)                               |

| Shear modulus parameters       |                                                                                               |
|--------------------------------|-----------------------------------------------------------------------------------------------|
| <b><math>G_i</math></b>        | Initial shear modulus (MPa) derived from steep linear section of loading path, prior to yield |
| <b><math>G_{ur}</math></b>     | Shear modulus (MPa) derived from unload-reload loop                                           |
| <b><math>\epsilon_c</math></b> | Cavity strain range over the unload-reload loop                                               |
| <b><math>\beta</math></b>      | Exponent of elasticity, after Bolton & Whittle (1999), where 1 is linear elastic              |
| <b><math>\alpha</math></b>     | Shear stress constant (MPa), after Bolton & Whittle (1999)                                    |

| Other                         |                                                                                      |
|-------------------------------|--------------------------------------------------------------------------------------|
| <b><math>P_{max}</math></b>   | Maximum test pressure reached prior to instrument unloading (MPa)                    |
| <b><math>P_{yield}</math></b> | Pressure at which material yield is assessed, defined as end of linear loading curve |

## **1.0 INTRODUCTION**

### **1.1 Site Details**

At the request of GeoAssist Ltd, In Situ Site Investigation Limited (In Situ S.I.) carried out pressuremeter testing as part of the Great Jackson Street, Manchester project. The works form part of the ongoing residential redevelopment of the site, located close to Manchester City Centre, Lancashire.

The pressuremeter testing was attempted in two boreholes. The fieldwork was carried out on site between 19<sup>th</sup> and 29<sup>th</sup> April 2021.

This report presents the factual records of the pressuremeter testing, together with an interpretation of the test results to derive material parameters. Further specific details relating to the ground investigation, i.e., borehole locations and exploratory hole logs, are provided in the GeoAssist Ltd report.

## 2.0 FIELDWORK

### 2.1 General

Nine pressuremeter tests were carried out in boreholes constructed using a rotary drilling rig, operated by GeoAssist Ltd. The tests were carried out using a high-pressure dilatometer (HPD). The testing was carried out in general accordance with BS EN ISO 22476-5 (2012) and BS 5930 (2020). The test depths were scheduled by the Client. A summary table of the tests is presented below.

**Table 2.1.** Summary of pressuremeter tests.

| Borehole Reference | Test Reference | Date       | Test Depth | Probe          | Operator | Remarks                                                              |
|--------------------|----------------|------------|------------|----------------|----------|----------------------------------------------------------------------|
| BH1R               | T01            | 20/04/2021 | 13.30m     | HPD 04 Eleanor | A Lewins | Membrane calibration. No material yield. Membrane leak test aborted. |
| BH1R               | T02            | 21/04/2021 | 15.70m     | HPD 04 Eleanor | A Lewins | Sudden jump in expansion test aborted.                               |
| BH1R               | T03            | 21/04/2021 | 19.20m     | HPD 04 Eleanor | A Lewins | No material yield.                                                   |
| BH1R               | T04            | 22/04/2021 | 24.30m     | HPD 04 Eleanor | A Lewins | No material yield.                                                   |
| BH1R               | T05            | 23/04/2021 | 32.60m     | HPD 04 Eleanor | A Lewins | No material yield.                                                   |
| BH4R               | T01            | 26/04/2021 | 10.70m     | HPD 04 Eleanor | A Lewins | No material yield.                                                   |
| BH4R               | T02            | 27/04/2021 | 16.50m     | HPD 04 Eleanor | A Lewins | No material yield.                                                   |
| BH4R               | T03            | 28/04/2021 | 22.30m     | HPD 04 Eleanor | A Lewins | Partial material yield.                                              |
| BH4R               | T04            | 29/04/2021 | 31.20m     | HPD 04 Eleanor | A Lewins | Partial material yield.                                              |

### 2.2 High Pressure Dilatometer (HPD)

The HPD is a cylindrical 95mm diameter probe which is inserted into a cored 99 to 101mm diameter test pocket, drilled using a T6-H or T6-101 core barrel. The HPD is therefore termed a pre-bored type instrument. The probe, approximately 1.5m in length, has a central section which is covered by a rubber membrane. Pressure applied to the inside of the instrument, via compressed air, forces the membrane to expand against the test pocket wall. The radial

displacement of the inside boundary of the membrane is measured at six points equally distributed around the centre of the expanding section, by free moving arms. This displacement, and the pressure necessary to cause the movement, is continuously monitored by transducers contained within the instrument. The HPD is linked to the ground surface via a combined pressure hose and electrical power/communication umbilical cable which connects the instrument to the pressure source and readout unit.

Analogue to digital conversion of the displacement and pressure transducers is carried out within the pressuremeter electronics package. The pressuremeter output comprises a multiplexed signal which connects through the pressuremeter interface unit to the USB port of a laptop computer. Software, supplied by PACE Geotechnics Ltd, is used to record the data, convert the received signals to engineering units (using the pressure and displacement transducer calibrations) and display these in real time on the laptop computer during testing to allow control of the test by the operator. Plotting these readings of displacement against pressure produces a loading curve for the material being tested. A number of mathematical analyses are applied to translate this loading curve into material strength and stiffness parameters.

The testing on this project was undertaken using a probe manufactured by In Situ S.I./PACE Geotechnics Ltd. Details of the instrument are provided below. Corrections measured for membrane stiffness (essentially resistance to inflation in air) were carried out during the testing program.

**Table 2.2.** HPD instrument details.

| Instrument | Diameter (mm) | Pressure Capacity (MPa) | Displacement Measurement          | ID & Serial No.  |
|------------|---------------|-------------------------|-----------------------------------|------------------|
| HPD        | 95            | 20                      | 6 arms at 60°<br>3 opposite pairs | HPD 04 – Eleanor |

### 2.3 HPD Testing Procedure

The boreholes were constructed using a rotary drilling rig by conventional rotary coring at nominal 146mm diameter, using water flush, to approximately 1.5m above the scheduled pressuremeter test depth. A 2 to 3m long section was then drilled using a T6-H size core barrel to provide a test pocket of nominal diameter 99.2mm. The HPD was inserted into the test pocket as soon as practicably possible using 2½ API drill rods, lowered in via the drilling rig winch.

The pressuremeter tests were carried out in a stress-controlled manner using a manually operated gas control box to pressurise the HPD at an appropriate rate for the ground conditions. During the tests a number of unload-reload loops were performed. Before carrying out the loops, a short holding period was maintained to allow reduction of creep on the ground. The loading was continued until either the ground had failed, maximum arm displacement had occurred, or if at lower pressure, expansion around the probe was uneven, such that in the opinion of the operator, continuation of the loading would result in risk of damage to the probe. Upon unloading and deflation of the membrane, the instrument was withdrawn from the tested section and recovered back to the ground surface. The boreholes were then advanced to the next specified test depth and the sequence repeated, until the testing program was completed.

## 3.0 TEST INTERPRETATION

### 3.1 Introduction

The pressure / cavity strain curve has been analysed to determine various material parameters, as appropriate, including:

|                             |             |
|-----------------------------|-------------|
| Cavity reference pressure   | $p_o$       |
| Initial shear modulus       | $G_i$       |
| Yield                       | $P_{yield}$ |
| Unload-reload shear modulus | $G_{ur}$    |
| Undrained shear strength    | $s_u$       |
| Limit Pressure              | $P_L$       |

The analysis methodologies used have followed the industry accepted practice for interpretation of pressuremeter tests (e.g., Clarke, 1996; Mair & Wood, 1987). The nature of the material tested can result in some limitations in the application and appropriateness of the interpretation methods. Any such limitations, if present, are discussed below and should be considered when selecting material parameters for engineering design purposes.

### 3.2 Description of Material Tested

An indication of the geology at the depth of each test completed is provided on the plots in Appendix A. The ground conditions encountered in the boreholes were thin layers of MADE GROUND over Glaciofluvial Sheet Deposits consisting of SAND and GRAVEL, overlying SANDSTONE bedrock of the Triassic age Chester Formation. For more detail refer to the GeoAssist Ltd report.

### 3.3 Cavity Reference Pressure

The act of drilling into undisturbed ground relieves the in situ horizontal stress, which is then effectively restored as the instrument membrane is initially pressurised. During this initial loading, a linear pressure / displacement response is anticipated as the pressure is increased and then exceeds the cavity reference pressure. With the HPD instrument, the direct correlation between the cavity reference pressure and in situ horizontal stress is problematic and should be treated with caution. This is due to the large potential for disturbance during test pocket formation and probable relaxation or stress relief of the ground following drilling of the open test pocket.

Marsland and Randolph (1977) proposed that in the vicinity of in situ horizontal stress, soil behaves elastically and therefore the initial loading curve is linear. This elastic behaviour will cease when the undrained shear strength of the soil in the cavity wall is reached, and hence the loading curve will then begin to curve away from linearity. The point at which the loading curve becomes non-linear (or the onset of yield,  $P_{\text{yield}}$ ), represents the in situ horizontal stress plus the undrained shear strength at this point:

$$P_{\text{yield}} = \sigma_{\text{ho}} + s_u.$$

The tests performed at the site were in SANDSTONE rock. However, the analysis method used to determine the undrained shear strength assumes the material is a perfectly elastic prior to failure and perfectly plastic post failure. For a rock this analysis may not be valid as the material may behave as a brittle material and fail in tension, or in triaxial compression, depending on the strength of the material and in situ stress conditions.

### 3.4 Shear Modulus

A pressuremeter test, in an elastic, perfectly plastic material, imparts a pure shear failure, hence it is normal to report shear modulus in preference to an elastic modulus. Shear modulus is determined from the initial loading curve, and from unload reload loops, performed at intervals during the test progression. The relationship used to determine shear modulus ( $G$ ) is below, where  $\epsilon_c$  is the cavity strain range:

$$G = \frac{1}{2} \frac{dp}{d\epsilon_c}$$

Haberfield and Johnson (1993) have suggested that the unload-reload modulus is the most reliable parameter from a pressuremeter test in rock. It is noted that the nature and spacing of fissures in the rock mass will affect the result. Widely spaced fissures may result in the test giving the intact modulus of the rock, rather than a mass modulus, and / or open fissures may be closed as the test progresses and give a modulus which is higher than the mass modulus.

Note is made that often in clays and sands some hysteresis is generally evident, and it is possible to determine a secant shear modulus from the reloading portion of an unload reload loop. A high degree of consistency is often possible when plotting secant shear modulus results from individual tests. This may be further extended to a series of tests in a geological formation by normalising via undrained shear strength, or in situ stress. The various plots for both initial loading shear modulus ( $G_i$ ) and the shear modulus derived from unload reload loops ( $G_{ur}$ ) are presented graphically in the test results.

Individual unload reload loops can also be analysed to determine small strain stiffness parameters. This is achieved by taking a secant modulus from the base of the loop, to the individual points on the reloading curve. Plotting the cavity strain range against modulus, gives an indication of how stiffness varies with strain. Further, a Bolton and Whittle (1999) analysis can be performed to investigate the non-linear elastic / plastic behaviour.

The secant modulus ( $G$ ) can be converted to an undrained elastic (Young's) modulus ( $E_u$ ) by use of the following relationship:

$$E_u = 2.G(1 + \nu) \quad \text{Where } \nu = \text{Poisson's ratio (assumed 0.5)}$$

Plots of calculated secant modulus values at varying shear strain % are provided within the analysis results. It is noted that any user of this analysis should satisfy themselves that it is appropriate to the material tested.

### 3.5 Strength

Undrained shear strength has been determined using Gibson and Anderson (1961) for the loading portion of the test curve. This is the generally accepted method for the determination of strength and are based on the assumption of an elastic - perfectly plastic material. The analysis of Gibson and Anderson (1961) also provides a Limit Pressure ( $P_L$ ). This is a limiting pressure defined as the pressure at which the change in volume ( $\Delta V$ ) divided by the current volume ( $V$ ) is equal to one. While this is not achieved in practice, it can be determined by extrapolation. Note is also made that the definition of  $P_L$  is different to that associated with a Ménard Limit Pressure, and the two should not be interchanged.

### 3.6 Summary of Results

Summary tables of the analysis results for each borehole location are presented in Appendix A, followed by the individual full graphical analyses for the tests completed.

## 4.0 REFERENCES

Bolton, M.D. & Whittle, R.W. (1999) A non-linear elastic/perfectly plastic analysis for plane strain undrained expansion tests. *Géotechnique*, Vol. 49, No. 1, pp. 133-141.

BS EN ISO 22476-5 (2012) Geotechnical investigation and testing - Field testing. Part 5: Flexible dilatometer test. British Standards Institution.

BS 5930 (2020) Code of practice for site investigations. British Standards Institution.

Clarke, B.G. (1996) Pressuremeters in geotechnical design. London: Blackie Academic and Professional.

Gibson, R.E. & Anderson, W.F. (1961) In situ measurement of soil properties with the pressuremeter. *Civil Engineering and Public Works Review*, Vol. 56, No. 658 May, pp. 615-618.

Haberfield, C. M. and Johnston, I.W. (1993) Factors influencing the interpretation of pressuremeter tests in soft rock, Proc. Symp. on Geotechnical Engineering of Hard Soils — Soft Rocks, Athens, Vol. 1, Balkema, Rotterdam, pp. 525-532.

Mair, R.J. & Wood, D.M. (1987) Pressuremeter testing: methods and interpretation. CIRIA Ground Engineering Report: In-situ Testing. London.

Marsland, A. & Randolph, M.F. (1977) Comparison of the results from pressuremeter tests and large in situ plate tests in London Clay. *Géotechnique*, Vol. 27, No. 2, pp. 217-243.

## APPENDIX A

### Test Data Analysis

| Description                                                          | Figure No.    |
|----------------------------------------------------------------------|---------------|
| Pressuremeter Results Summary                                        | All Boreholes |
| Pressuremeter Shear Modulus Plot & Undrained Shear Strength Plot     | Figure 1      |
| Pressuremeter In Situ Horizontal Stress, Yield & Limit Pressure Plot | Figure 2      |
| Pressuremeter Test Analysis                                          |               |
| BH1R                                                                 | T01 – T05     |
| BH4R                                                                 | T01 – T04     |

**IN SITU**  
SITE INVESTIGATION

|                    |                                  |                  |             |
|--------------------|----------------------------------|------------------|-------------|
| <b>Project</b>     | Great Jackson Street, Manchester | <b>Table No.</b> | <b>BH1R</b> |
| <b>Client</b>      | GeoAssist                        |                  |             |
| <b>Project No.</b> | P1210114                         |                  |             |

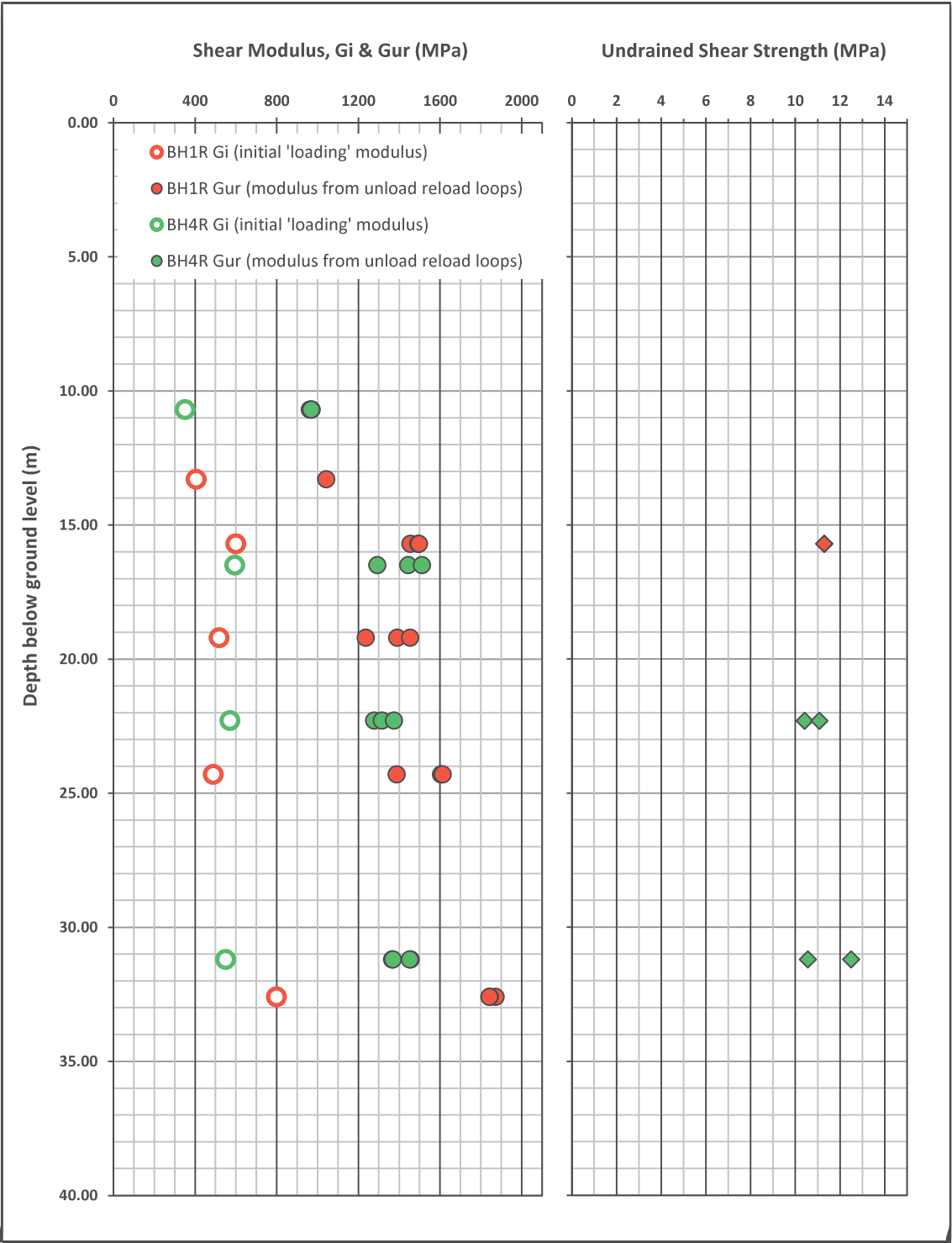
Pressuremeter Results Summary



| Test ID | Depth<br>(m) | Material description from borehole log | Max. test<br>pressure<br>(kPa) | p <sub>o</sub><br>(kPa) | Undrained strength   |                          |                | G <sub>i</sub><br>(MPa) | Loop<br>No. | G <sub>ur</sub><br>(MPa) | e <sub>c</sub><br>(%) | Non linear stiffness |       | Secant shear modulus (MPa) |      |       |        |
|---------|--------------|----------------------------------------|--------------------------------|-------------------------|----------------------|--------------------------|----------------|-------------------------|-------------|--------------------------|-----------------------|----------------------|-------|----------------------------|------|-------|--------|
|         |              |                                        |                                |                         | S <sub>u</sub> (M&R) | S <sub>u</sub> (loading) | P <sub>L</sub> |                         |             |                          |                       | α (MPa)              | β     | 1%                         | 0.1% | 0.01% | 0.001% |
| BH4R    |              |                                        |                                |                         |                      |                          |                |                         |             |                          |                       |                      |       |                            |      |       |        |
| 1       | 10.70        | SANDSTONE.                             | 15998                          | 1913                    |                      |                          |                | 351                     | 1           | 972                      | 0.063                 | 311.066              | 0.853 | 613                        | 860  | 1207  | 1694   |
|         |              |                                        |                                |                         |                      |                          |                |                         | 2           | 963                      | 0.098                 | 323.225              | 0.854 | 634                        | 889  | 1245  | 1745   |
|         |              |                                        |                                |                         |                      |                          |                |                         | 3           | 969                      | 0.137                 | 360.379              | 0.861 | 685                        | 944  | 1302  | 1795   |
| 2       | 16.50        | SANDSTONE.                             | 14764                          | 2600                    |                      |                          |                | 595                     | 1           | 1293                     | 0.053                 | 353.719              | 0.840 | 738                        | 1067 | 1541  | 2226   |
|         |              |                                        |                                |                         |                      |                          |                |                         | 2           | 1445                     | 0.060                 | 435.701              | 0.852 | 863                        | 1215 | 1711  | 2408   |
|         |              |                                        |                                |                         |                      |                          |                |                         | 3           | 1512                     | 0.083                 | 565.819              | 0.870 | 1031                       | 1392 | 1878  | 2535   |
| 3       | 22.30        | SANDSTONE.                             | 15012                          | 3234                    | 10416                | 11071                    | 57936          | 571                     | 1           | 1278                     | 0.048                 | 399.307              | 0.856 | 774                        | 1077 | 1499  | 2086   |
|         |              |                                        |                                |                         |                      |                          |                |                         | 2           | 1316                     | 0.065                 | 444.094              | 0.858 | 854                        | 1184 | 1642  | 2277   |
|         |              |                                        |                                |                         |                      |                          |                |                         | 3           | 1375                     | 0.088                 | 535.508              | 0.873 | 963                        | 1291 | 1731  | 2321   |
| 4       | 31.20        | SANDSTONE.                             | 14995                          | 3537                    | 10563                | 12500                    | 63475          | 550                     | 1           | 1366                     | 0.047                 | 570.009              | 0.881 | 984                        | 1293 | 1699  | 2232   |
|         |              |                                        |                                |                         |                      |                          |                |                         | 2           | 1369                     | 0.053                 | 450.427              | 0.859 | 860                        | 1189 | 1643  | 2271   |
|         |              |                                        |                                |                         |                      |                          |                |                         | 3           | 1456                     | 0.066                 | 657.664              | 0.897 | 1055                       | 1336 | 1692  | 2142   |
|         |              |                                        |                                |                         |                      |                          |                | 4                       | 1452        | 0.093                    | 628.810               | 0.888                | 1052  | 1361                       | 1760 | 2276  |        |

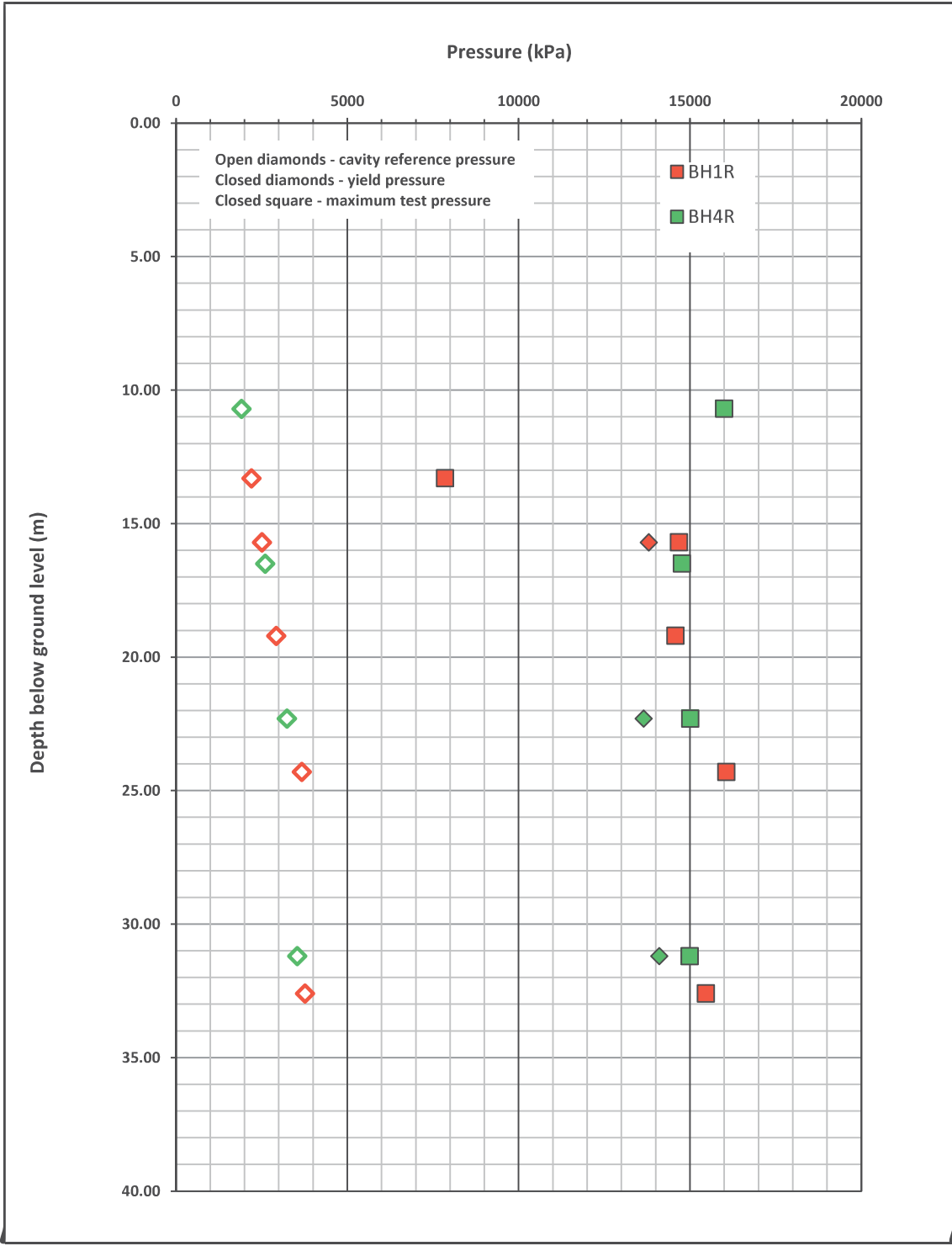
|             |                                  |           |      |
|-------------|----------------------------------|-----------|------|
| Project     | Great Jackson Street, Manchester | Table No. | BH4R |
| Client      | GeoAssist                        |           |      |
| Project No. | P1210114                         |           |      |

# Pressuremeter Shear Modulus & Undrained Shear Strength Plot



|             |                                  |            |   |
|-------------|----------------------------------|------------|---|
| Project     | Great Jackson Street, Manchester | Figure No. | 1 |
| Client      | GeoAssist                        |            |   |
| Project No. | P1210114                         |            |   |

# Pressuremeter Cavity Reference Pressure, Yield & Maximum Test Pressure Plot

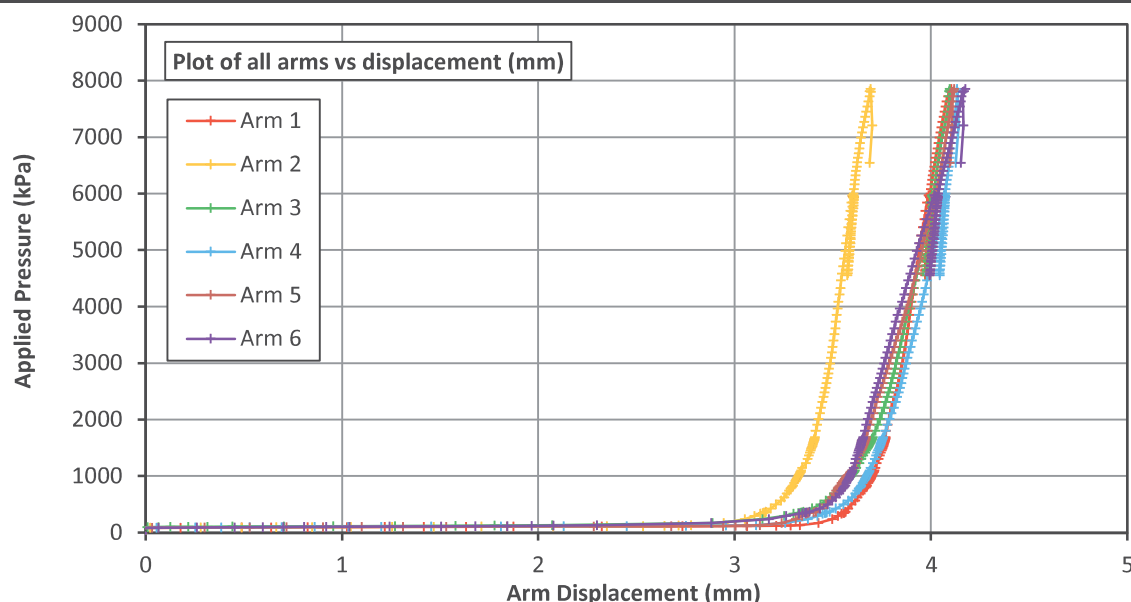


|             |                                  |            |   |
|-------------|----------------------------------|------------|---|
| Project     | Great Jackson Street, Manchester | Figure No. | 2 |
| Client      | GeoAssist                        |            |   |
| Project No. | P1210114                         |            |   |

## Pressuremeter Test Overview High Pressure Dilatometer (HPD)

**IN SITU**  
SITE INVESTIGATION

|                 |              |              |                |       |
|-----------------|--------------|--------------|----------------|-------|
| Test Date       | 20/04/2021   |              | Test No.       | 1     |
| Borehole        | BH1R         |              | Test Depth (m) | 13.30 |
| Coordinates (m) | 383353.9 (E) | 397240.7 (N) | Elevation (m)  | 32.28 |



### Material description from borehole log:

SANDSTONE.

### Test pocket conditions:

|                           |       |                           |  |
|---------------------------|-------|---------------------------|--|
| Total core recovery:      | 100 % | Test pocket depth range:  |  |
| Solid core recovery:      | 100 % | From: 12.00 m to: 10.00 m |  |
| Rock quality designation: | 68 %  | Flush: Water              |  |

### Test comment:

The test pocket was tight with arms lifting off at 3.0 to 4.0mm. The po was estimated to be at 2500kPa, with the following loading section being long and linear. The test taken to a pressure of 7856kPa, when a small leak was noted from the membrane and the test was aborted. The displacement-pressure response shown by the arms was consistent. Analysis of a single unload reload loop provides a high modulus value of 1043MPa. No yield was observed during the test.

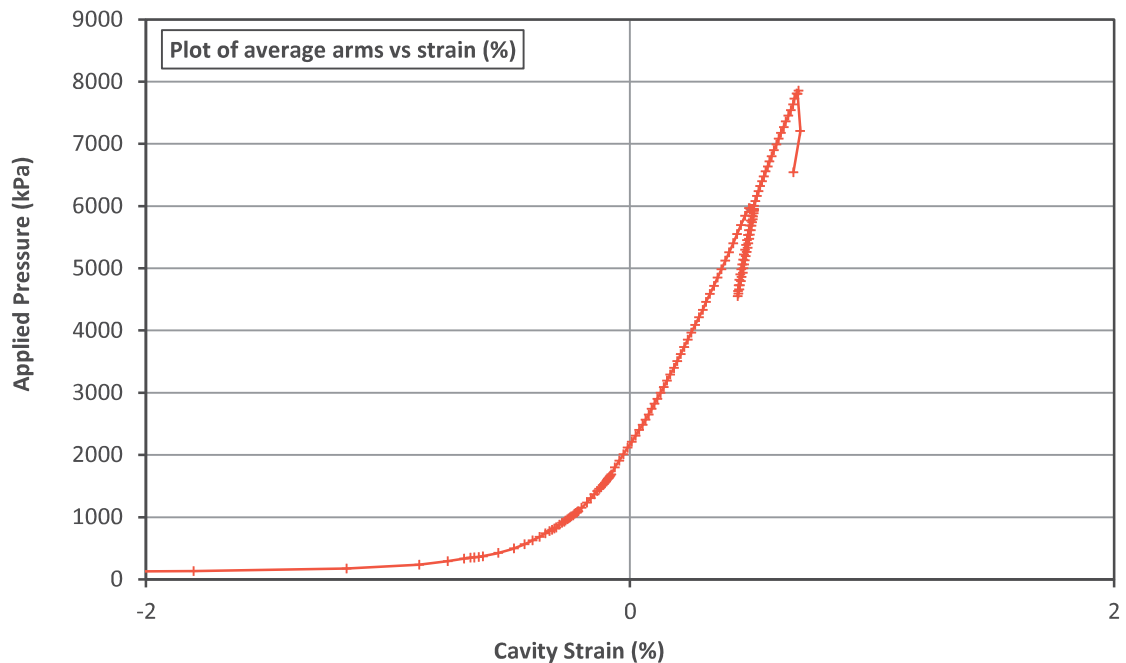
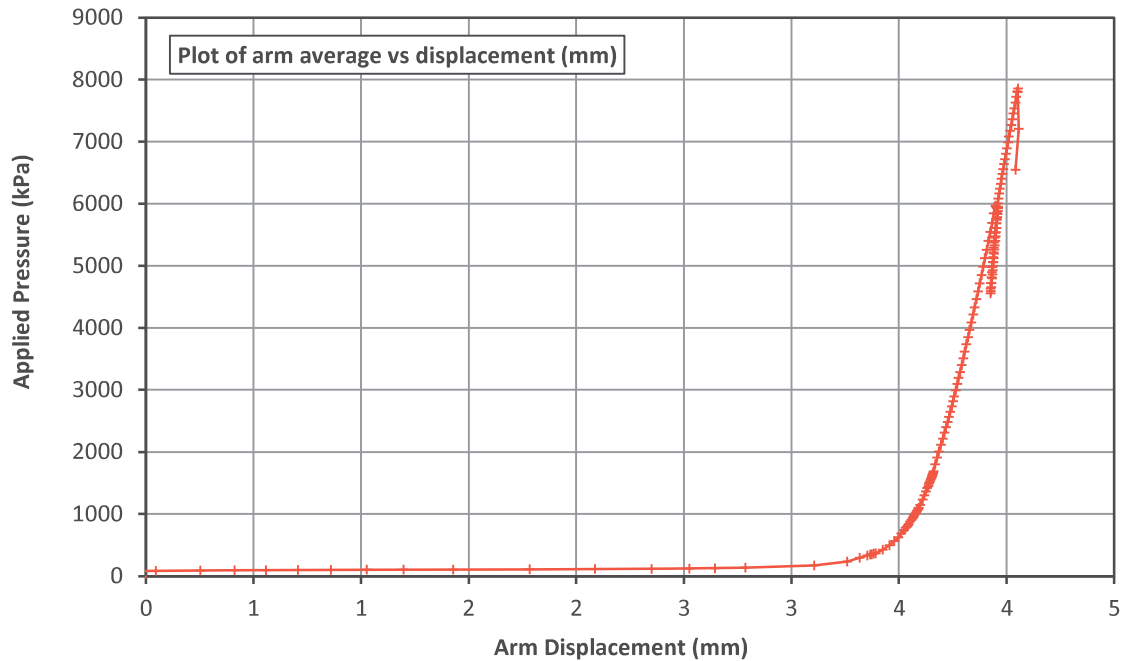
| Test details:       |               | Instrument: |         | Eleanor (HPD04) |                |        |
|---------------------|---------------|-------------|---------|-----------------|----------------|--------|
| Drilling method:    | Rotary coring |             | mV      | mV/mm           | mV             | mV/MPa |
| Casing depth:       | 12.00 m       | Arm 1:      | -2381.4 | 122.9           | TPC A: 292.3   | 102.9  |
| Water level:        | 9.50 m        | Arm 2:      | -2057.1 | 124.9           | TPC B: -2132.4 | 110.7  |
|                     |               | Arm 3:      | -2291.3 | 129.5           |                |        |
| Test time:          |               | Arm 4:      | -2122.1 | 127.4           |                |        |
| Start (probe in):   | 09:30 hrs     | Arm 5:      | -2291.1 | 132.1           |                |        |
| Finish (probe out): | 11:00 hrs     | Arm 6:      | -2147.4 | 124.1           |                |        |

|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T01 - 01 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

## Pressuremeter Test - Average Arm Plots

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 20/04/2021 | Test No.       | 1     |
| Borehole  | BH1R       | Test Depth (m) | 13.30 |

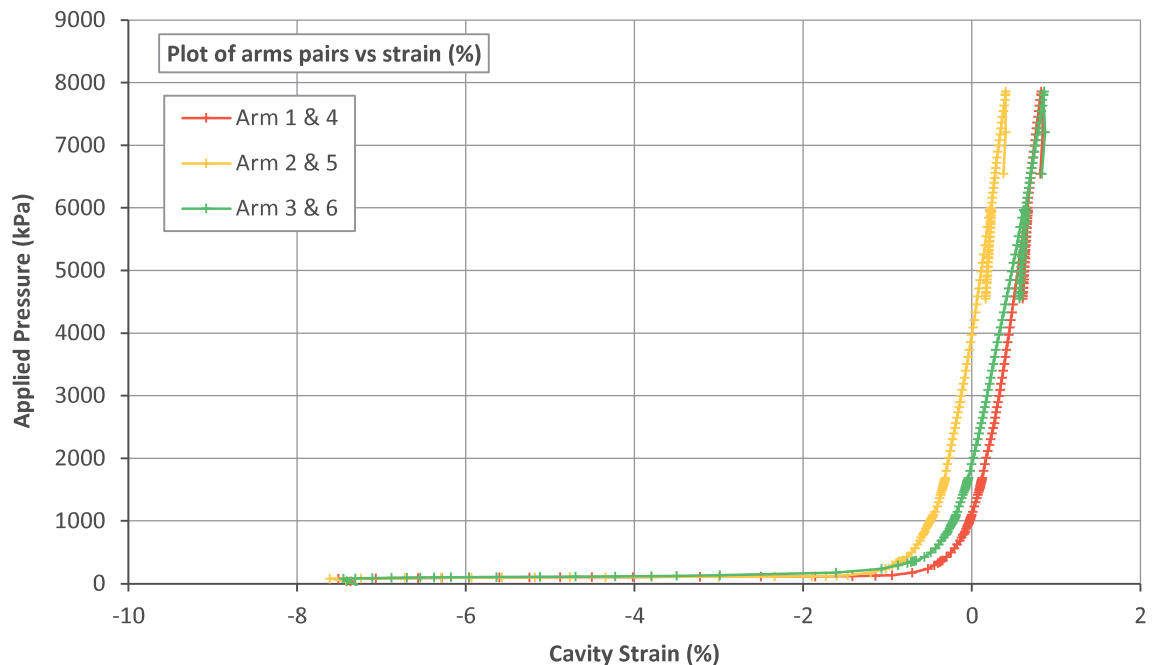
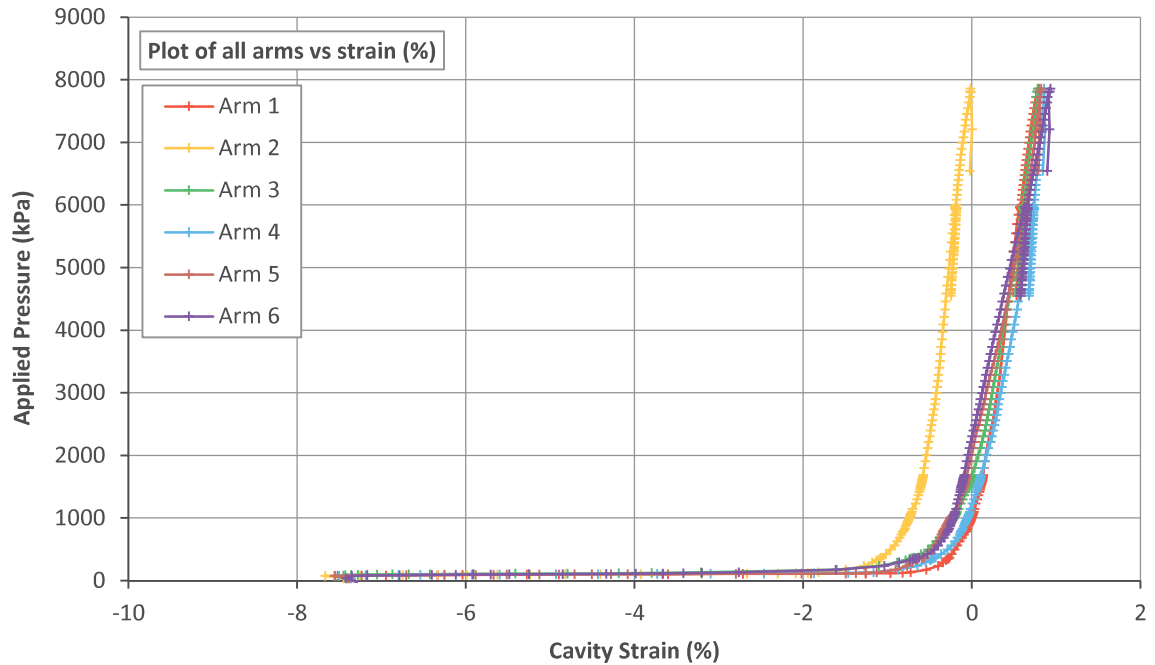


|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T01 - 02 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

## Pressuremeter Test - Arm Displacement vs Strain (%)

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 20/04/2021 | Test No.       | 1     |
| Borehole  | BH1R       | Test Depth (m) | 13.30 |

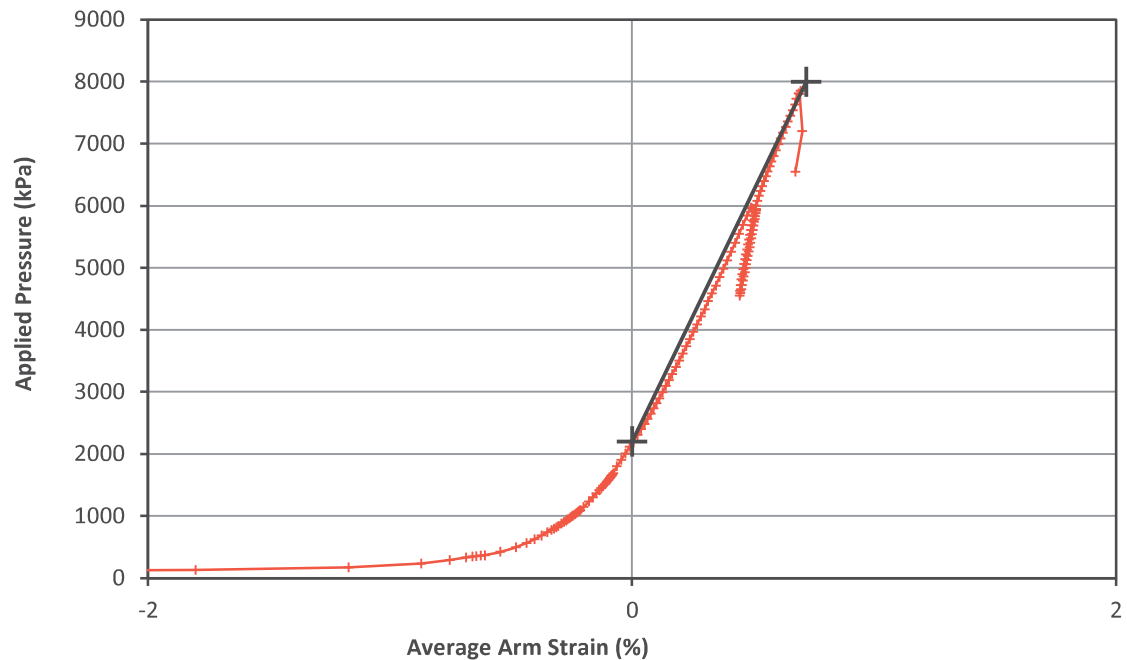


|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T01 - 03 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

## Pressuremeter Analysis - Initial Modulus & In Situ Horizontal Stress

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 20/04/2021 | Test No.       | 1     |
| Borehole  | BH1R       | Test Depth (m) | 13.30 |



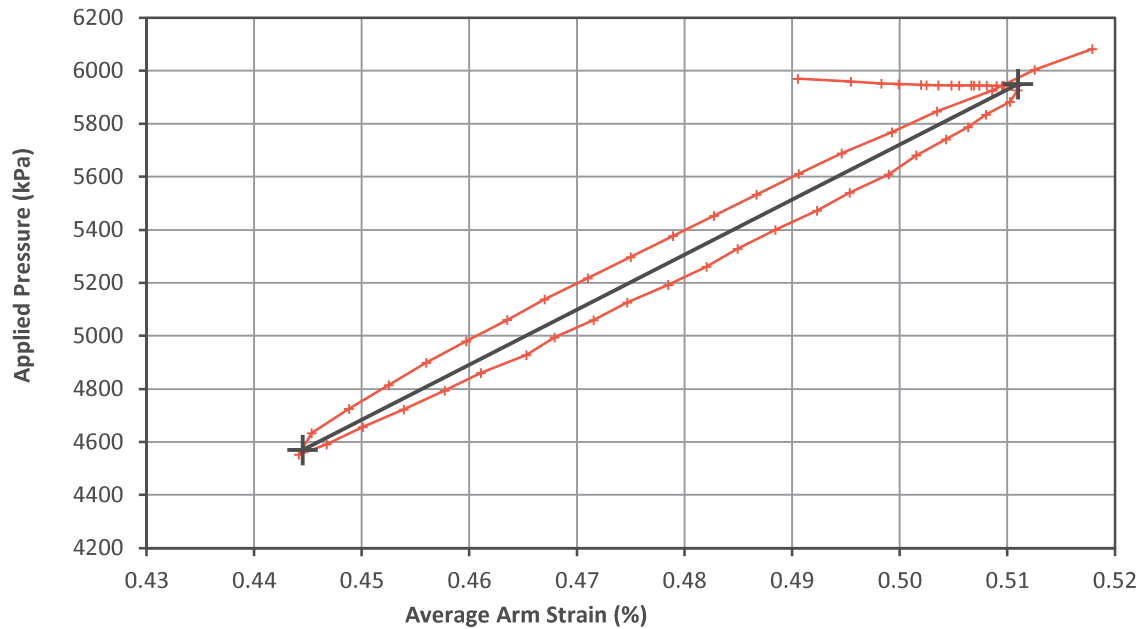
|                 |               |           |
|-----------------|---------------|-----------|
| Initial Modulus | Shear Modulus | 405.7 MPa |
|-----------------|---------------|-----------|

|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T01 - 04 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

## Pressuremeter Analysis - Unload Reload Loop

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 20/04/2021 | Test No.       | 1     |
| Borehole  | BH1R       | Test Depth (m) | 13.30 |



|               |                     |        |     |
|---------------|---------------------|--------|-----|
| <b>Loop 1</b> | Shear Modulus       | 1042.9 | MPa |
|               | Cavity Strain Range | 0.067  | %   |

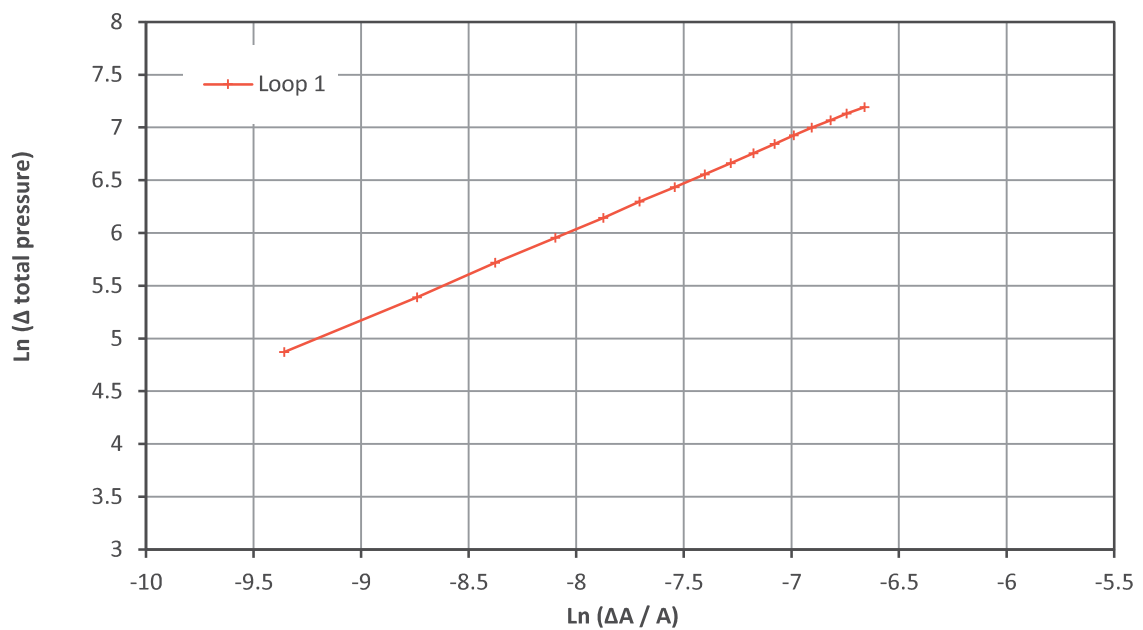
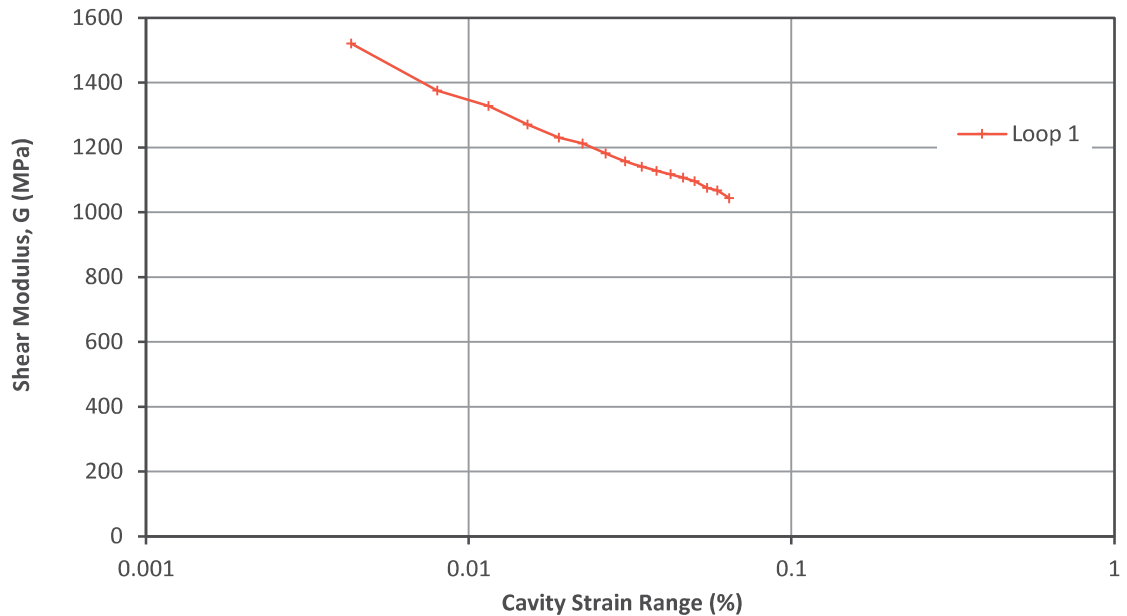
|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T01 - 05 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

## Pressuremeter Analysis

Small Strain Stiffness and Bolton & Whittle (1999)

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 20/04/2021 | Test No.       | 1     |
| Borehole  | BH1R       | Test Depth (m) | 13.30 |



| Loop 1              |                  |
|---------------------|------------------|
| Gradient( $\beta$ ) | Intercept        |
| 0.867               | 431.591<br>(MPa) |

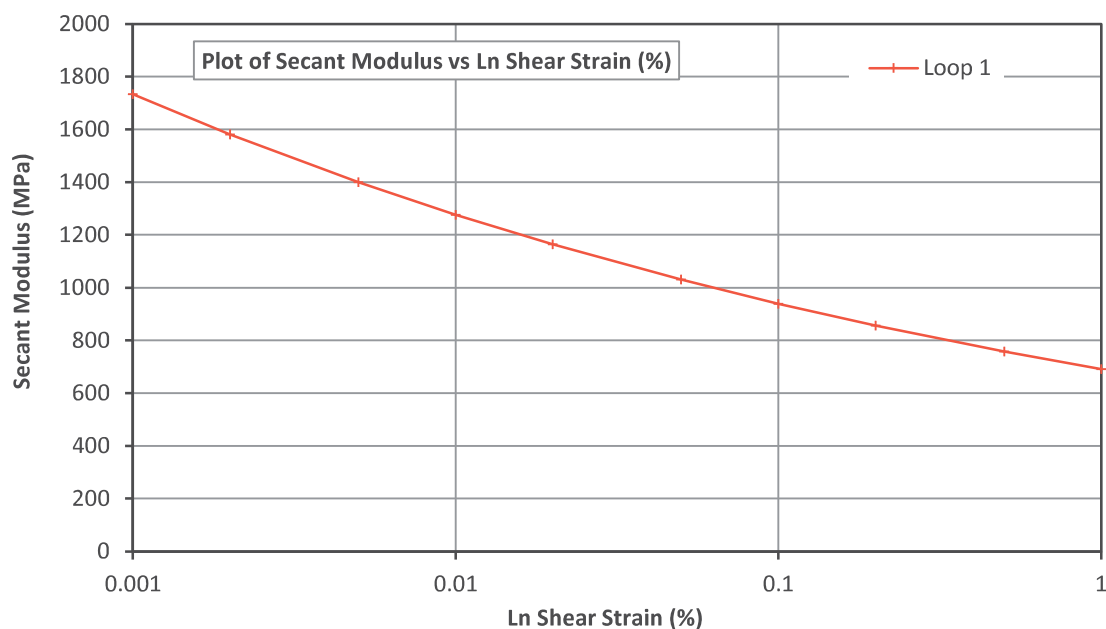
|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T01 - 06 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

## Pressuremeter Analysis

Secant Modulus - Shear Strain (%)

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 20/04/2021 | Test No.       | 1     |
| Borehole  | BH1R       | Test Depth (m) | 13.30 |



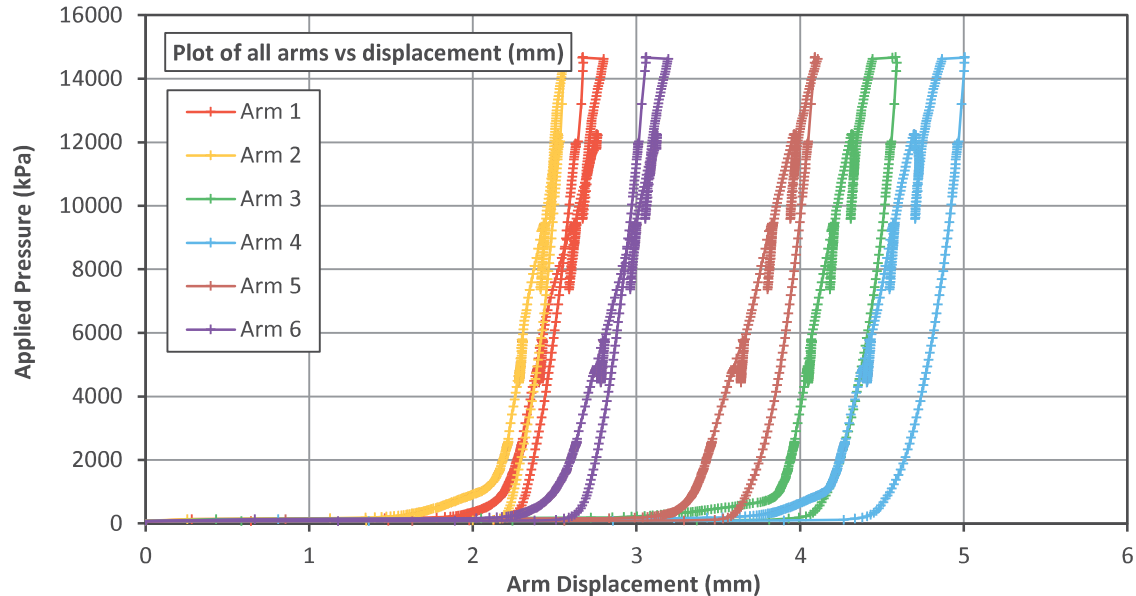
| Shear Strain  | Loop 1      |
|---------------|-------------|
| <b>0.001%</b> | <b>1734</b> |
| 0.002%        | 1581        |
| 0.005%        | 1399        |
| <b>0.010%</b> | <b>1276</b> |
| 0.020%        | 1163        |
| 0.050%        | 1030        |
| <b>0.100%</b> | <b>939</b>  |
| 0.200%        | 856         |
| 0.500%        | 758         |
| <b>1.000%</b> | <b>691</b>  |

|             |                      |            |                  |
|-------------|----------------------|------------|------------------|
| Project     | Great Jackson Street | Figure No. | BH1R<br>T01 - 07 |
| Client      | GeoAssist            |            |                  |
| Project No. | P1210114             |            |                  |

## Pressuremeter Test Overview High Pressure Dilatometer (HPD)

**IN SITU**  
SITE INVESTIGATION

|                 |              |              |                |       |
|-----------------|--------------|--------------|----------------|-------|
| Test Date       | 21/04/2021   |              | Test No.       | 2     |
| Borehole        | BH1R         |              | Test Depth (m) | 15.70 |
| Coordinates (m) | 383353.9 (E) | 397240.7 (N) | Elevation (m)  | 32.28 |



### Material description from borehole log:

SANDSTONE.

### Test pocket conditions:

|                           |      |                           |
|---------------------------|------|---------------------------|
| Total core recovery:      | 91 % | Test pocket depth range:  |
| Solid core recovery:      | 78 % | From: 14.20 m to: 16.50 m |
| Rock quality designation: | 48 % | Flush: Water              |

### Test comment:

The test pocket was tight with arms lifting off at 2.0 to 4.0mm. The  $p_0$  was estimated to be at 2506kPa, with the following loading section being long and linear. The start of material yield was interpreted at 13800kPa, with the test taken to pressure of 14683kPa, where a jump in expansion and probe movement resulted in the test being aborted. The displacement-pressure response shown by the arms was consistent, albeit with some varying expansion. Analysis of three unload reload loops provides high modulus values of 1455 to 1498MPa. Derived undrained shear strength analysis provides a value of 11.3MPa.

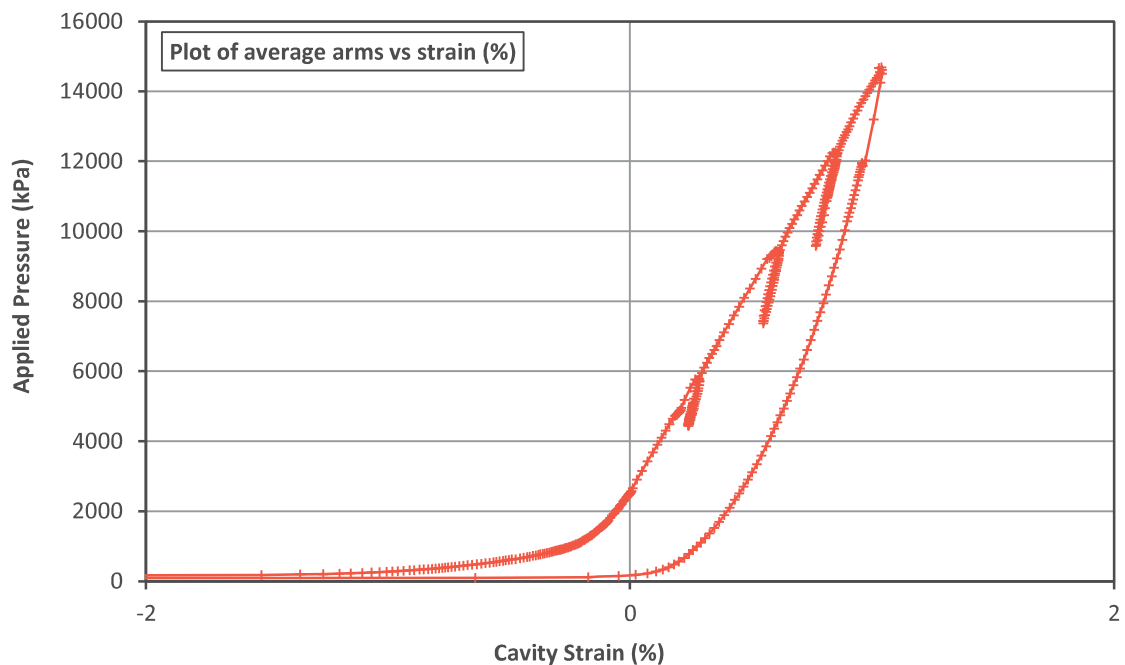
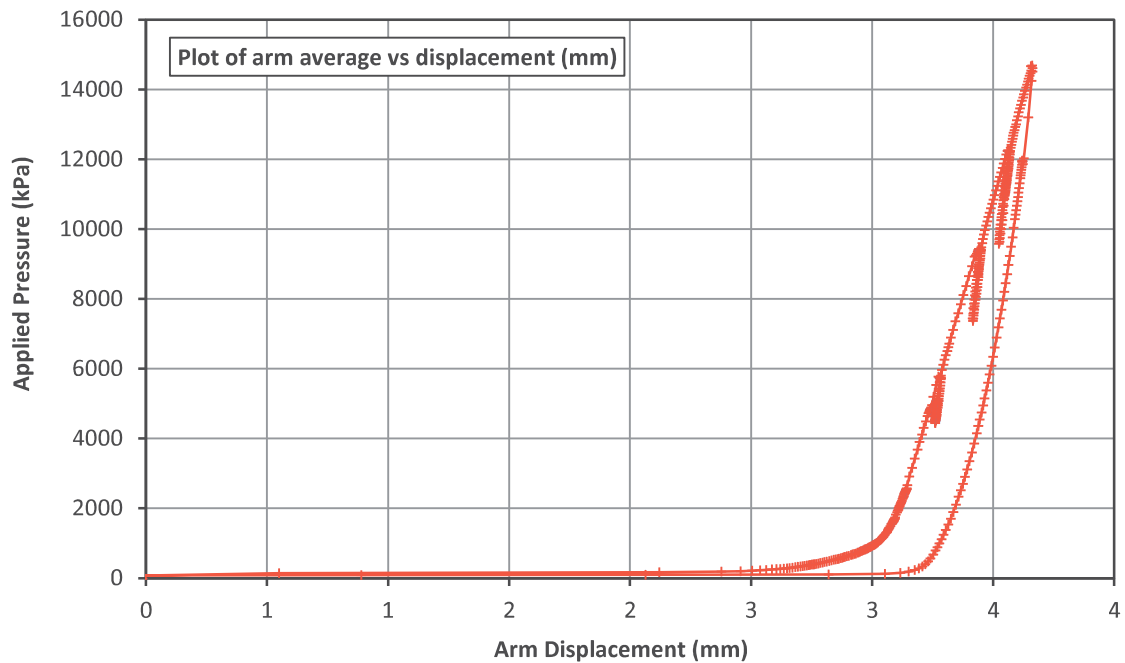
| Test details:       |               | Instrument: |         | Eleanor (HPD04) |                |        |
|---------------------|---------------|-------------|---------|-----------------|----------------|--------|
| Drilling method:    | Rotary coring |             | mV      | mV/mm           | mV             | mV/MPa |
| Casing depth:       | 14.20 m       | Arm 1:      | -2377.5 | 122.9           | TPC A: 292.9   | 102.9  |
| Water level:        | 9.50 m        | Arm 2:      | -2046.7 | 124.9           | TPC B: -2132.8 | 110.7  |
|                     |               | Arm 3:      | -2292.5 | 129.5           |                |        |
| Test time:          |               | Arm 4:      | -2121.3 | 127.4           |                |        |
| Start (probe in):   | 09:20 hrs     | Arm 5:      | -2290.7 | 132.1           |                |        |
| Finish (probe out): | 10:50 hrs     | Arm 6:      | -2137.7 | 124.1           |                |        |

|             |                      |            |                  |
|-------------|----------------------|------------|------------------|
| Project     | Great Jackson Street | Figure No. | BH1R<br>T02 - 01 |
| Client      | GeoAssist            |            |                  |
| Project No. | P1210114             |            |                  |

## Pressuremeter Test - Average Arm Plots

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 2     |
| Borehole  | BH1R       | Test Depth (m) | 15.70 |

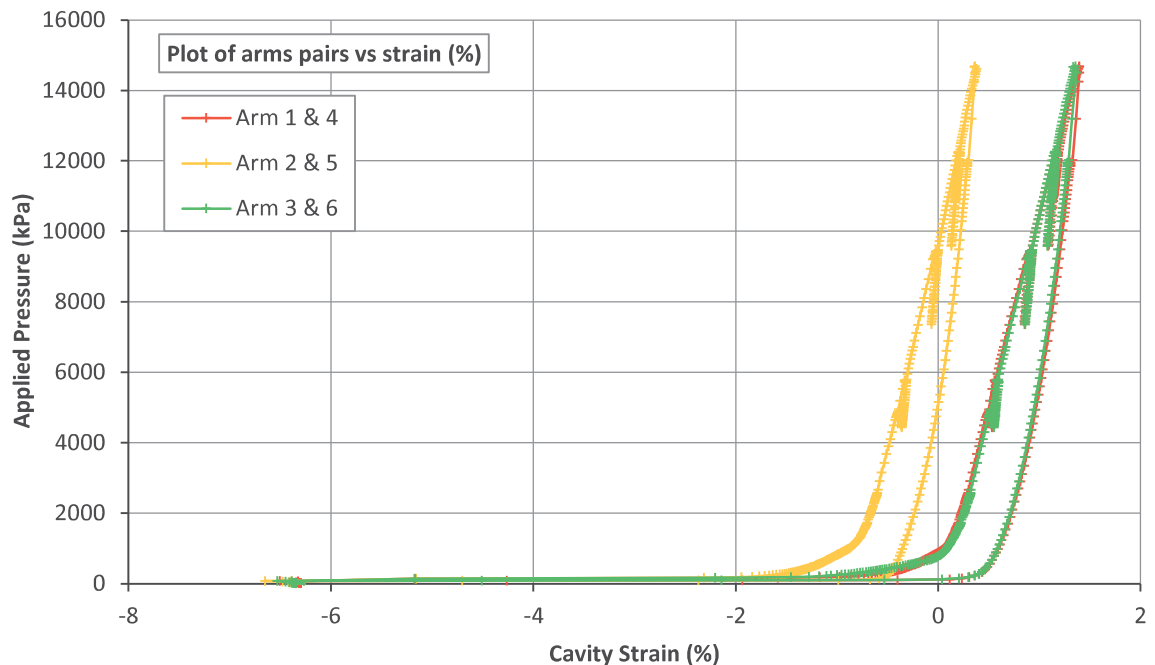
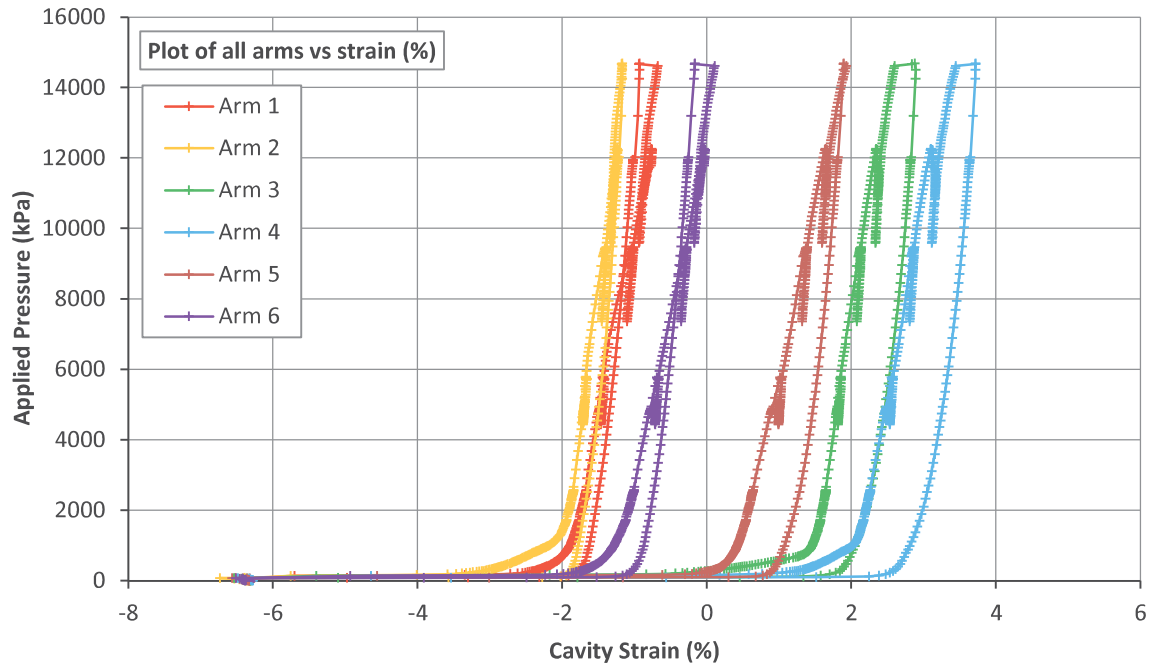


|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T02 - 02 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

## Pressuremeter Test - Arm Displacement vs Strain (%)

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 2     |
| Borehole  | BH1R       | Test Depth (m) | 15.70 |

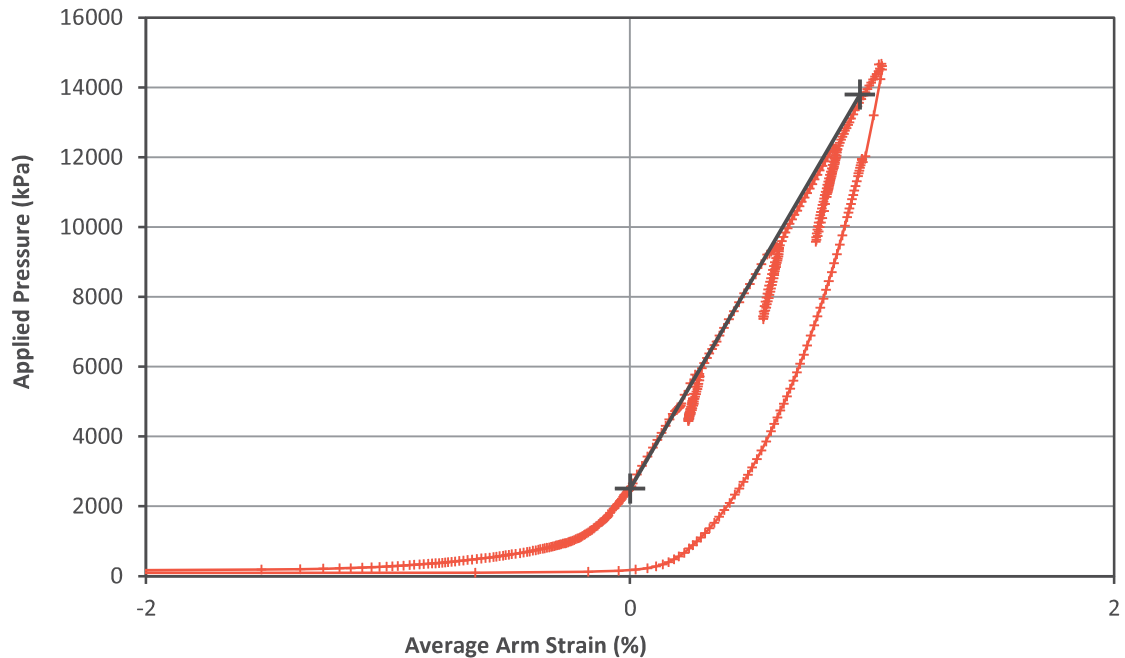


|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T02 - 03 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

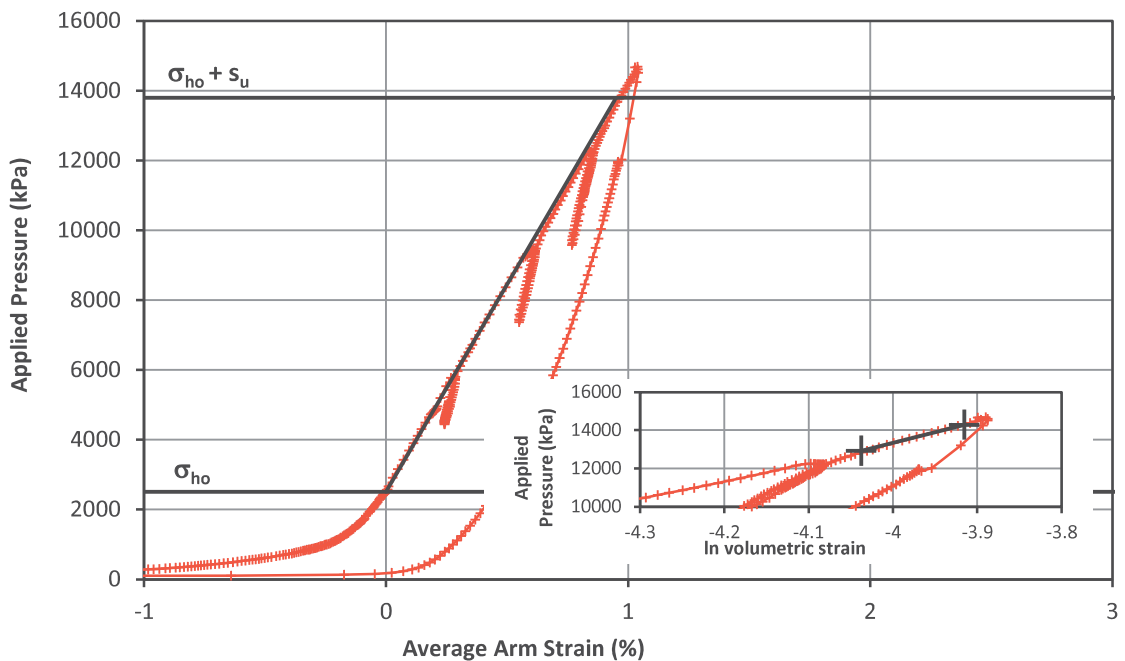
# Pressuremeter Analysis - Initial Modulus & In Situ Horizontal Stress

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 2     |
| Borehole  | BH1R       | Test Depth (m) | 15.70 |



|                        |               |           |
|------------------------|---------------|-----------|
| <b>Initial Modulus</b> | Shear Modulus | 600.1 MPa |
|------------------------|---------------|-----------|



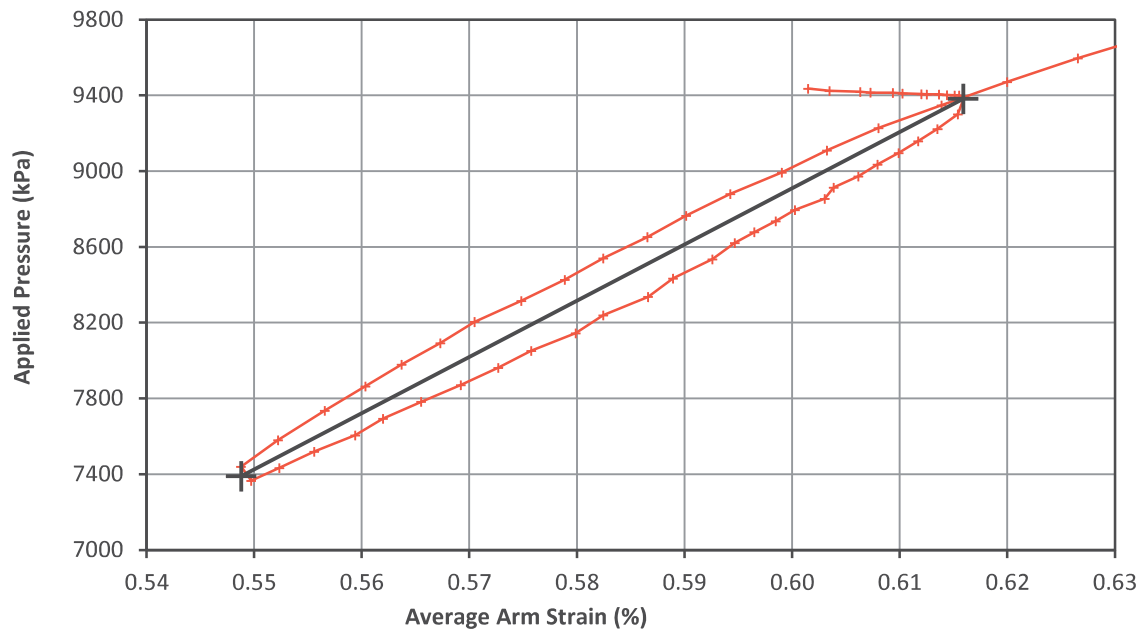
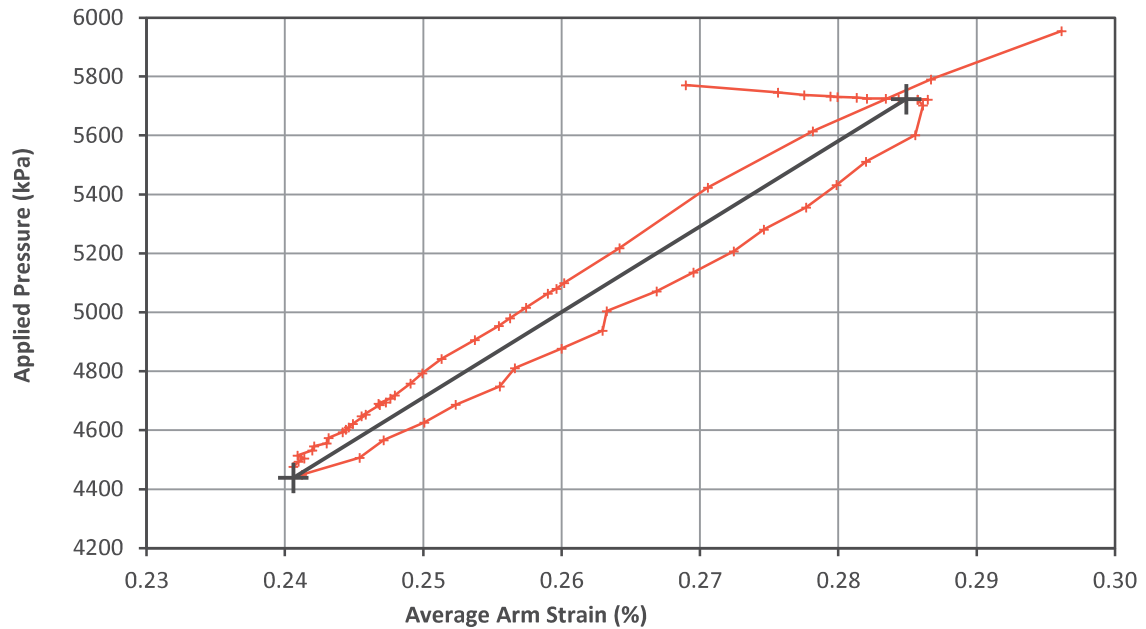
|                                |                           |           |
|--------------------------------|---------------------------|-----------|
| <b>Marsland &amp; Randolph</b> | In situ horizontal stress | 2506 kPa  |
|                                | Undrained Strength        | 11294 kPa |

|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T02 - 04 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

## Pressuremeter Analysis - Unload Reload Loop

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 2     |
| Borehole  | BH1R       | Test Depth (m) | 15.70 |

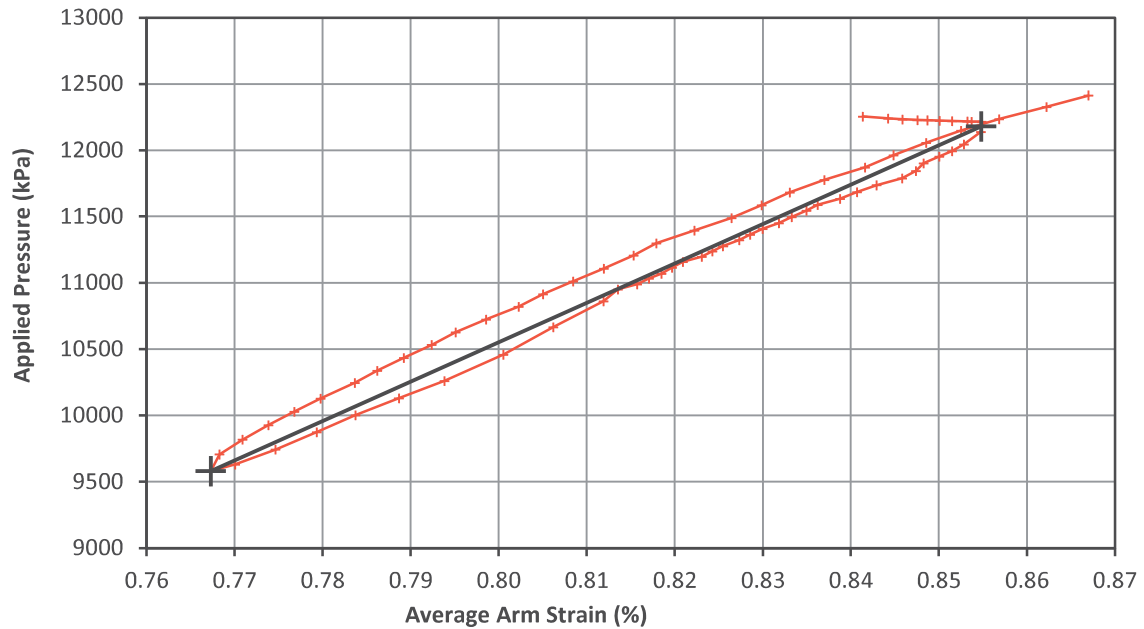


|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T02 - 05 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

## Pressuremeter Analysis - Unload Reload Loop

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 2     |
| Borehole  | BH1R       | Test Depth (m) | 15.70 |



|        |                     |        |     |
|--------|---------------------|--------|-----|
| Loop 3 | Shear Modulus       | 1497.7 | MPa |
|        | Cavity Strain Range | 0.088  | %   |

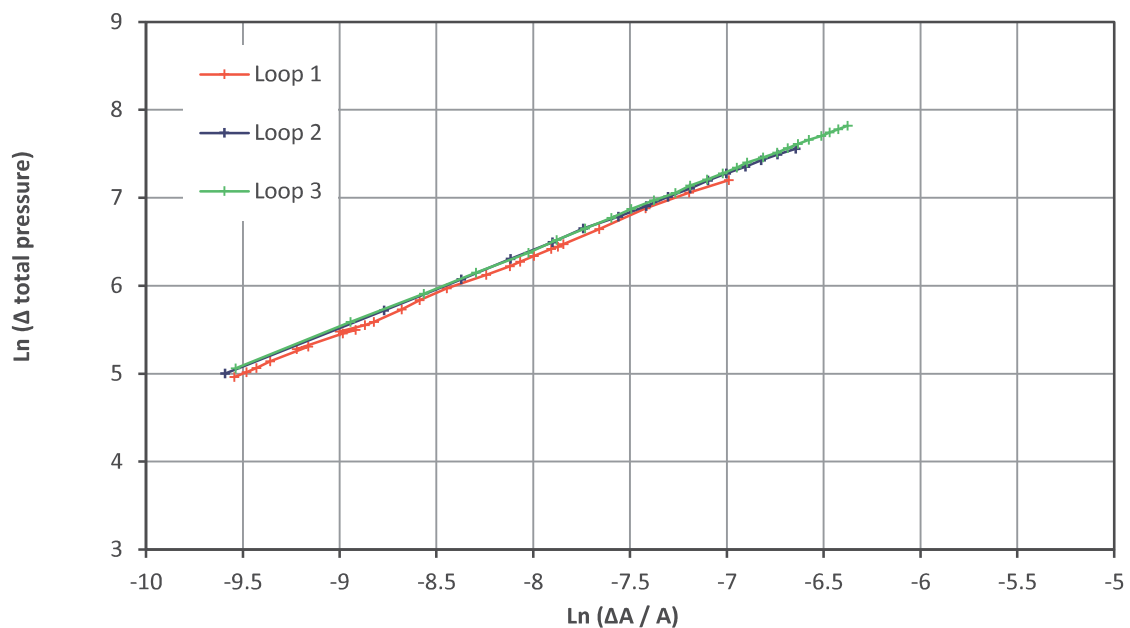
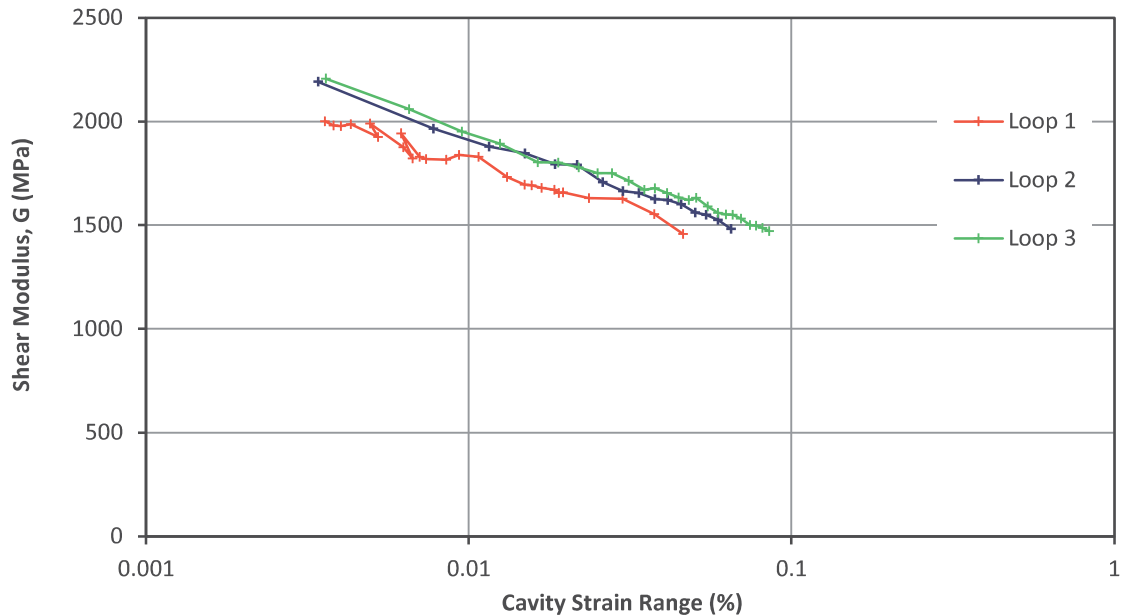
|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T02 - 06 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

# Pressuremeter Analysis

Small Strain Stiffness and Bolton & Whittle (1999)

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 2     |
| Borehole  | BH1R       | Test Depth (m) | 15.70 |



| Loop 1              |                  | Loop 2              |                  | Loop 3              |                  |
|---------------------|------------------|---------------------|------------------|---------------------|------------------|
| Gradient( $\beta$ ) | Intercept        | Gradient( $\beta$ ) | Intercept        | Gradient( $\beta$ ) | Intercept        |
| 0.886               | 673.182<br>(MPa) | 0.873               | 647.090<br>(MPa) | 0.880               | 698.872<br>(MPa) |

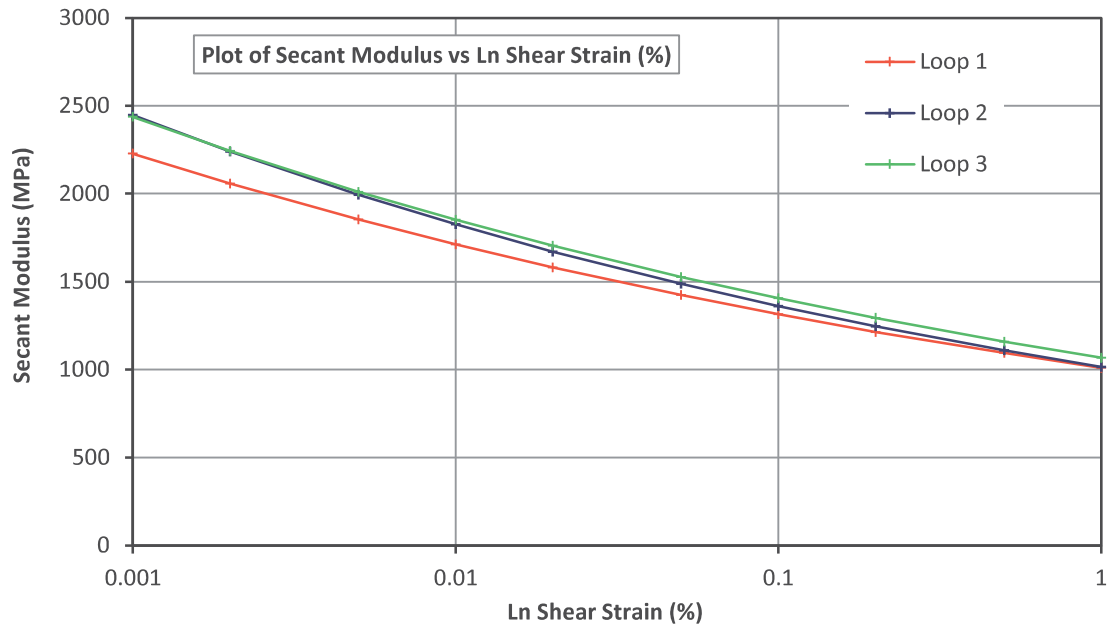
|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T02 - 08 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

## Pressuremeter Analysis

### Secant Modulus - Shear Strain (%)

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 2     |
| Borehole  | BH1R       | Test Depth (m) | 15.70 |



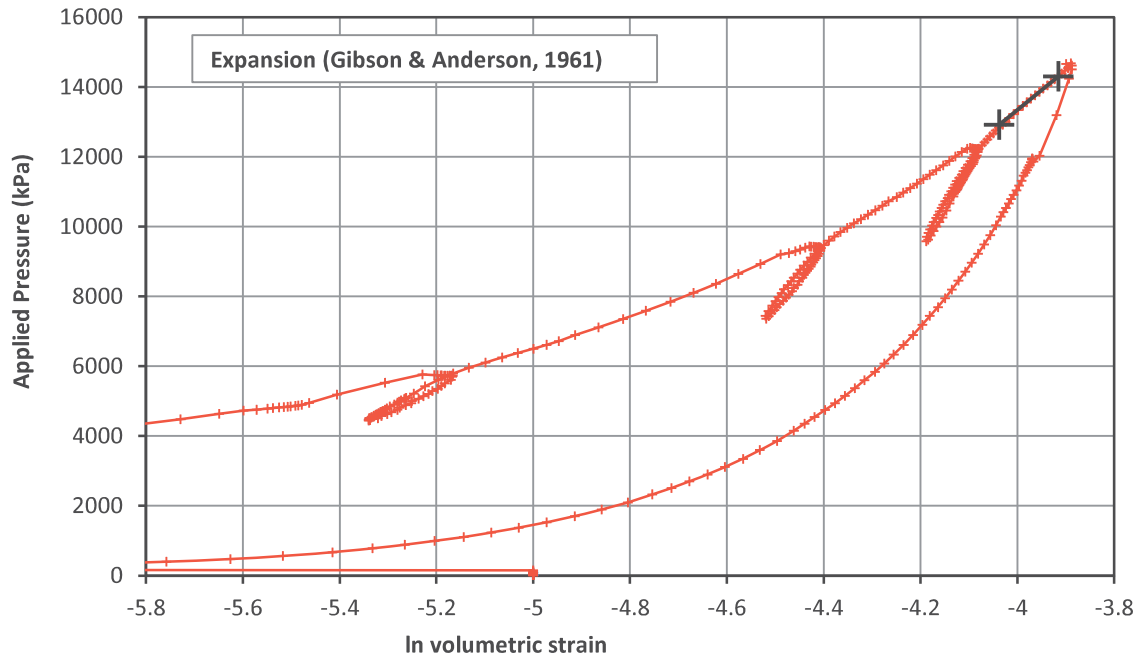
| Shear Strain  | Loop 1      | Loop 2      | Loop 3      |
|---------------|-------------|-------------|-------------|
| <b>0.001%</b> | <b>2227</b> | <b>2447</b> | <b>2438</b> |
| 0.002%        | 2057        | 2240        | 2244        |
| 0.005%        | 1852        | 1994        | 2011        |
| <b>0.010%</b> | <b>1711</b> | <b>1825</b> | <b>1851</b> |
| 0.020%        | 1581        | 1671        | 1704        |
| 0.050%        | 1423        | 1487        | 1527        |
| <b>0.100%</b> | <b>1315</b> | <b>1361</b> | <b>1405</b> |
| 0.200%        | 1214        | 1246        | 1294        |
| 0.500%        | 1093        | 1109        | 1159        |
| <b>1.000%</b> | <b>1010</b> | <b>1015</b> | <b>1067</b> |

|             |                      |            |                  |
|-------------|----------------------|------------|------------------|
| Project     | Great Jackson Street | Figure No. | BH1R<br>T02 - 09 |
| Client      | GeoAssist            |            |                  |
| Project No. | P1210114             |            |                  |

## Pressuremeter Analysis - Undrained Strength

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 2     |
| Borehole  | BH1R       | Test Depth (m) | 15.70 |



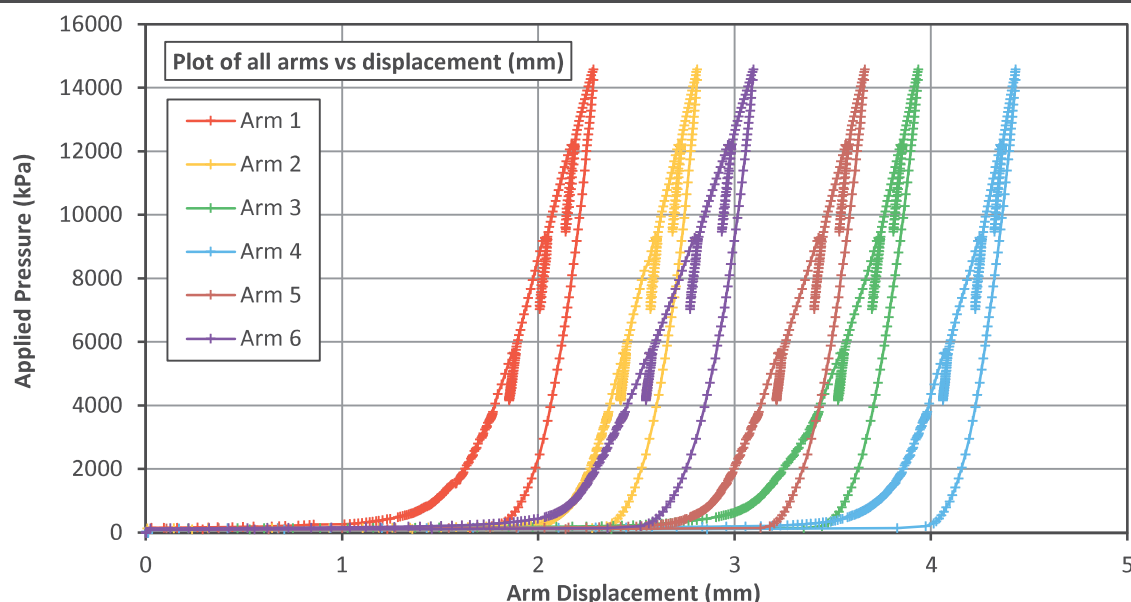
|                    |                 |       |     |
|--------------------|-----------------|-------|-----|
| Strength (loading) | Undrained Shear | 11294 | kPa |
|                    | Limit Pressure  | 58527 | kPa |

|             |                      |               |                  |
|-------------|----------------------|---------------|------------------|
| Project     | Great Jackson Street | Figure<br>No. | BH1R<br>T02 - 10 |
| Client      | GeoAssist            |               |                  |
| Project No. | P1210114             |               |                  |

## Pressuremeter Test Overview High Pressure Dilatometer (HPD)

**IN SITU**  
SITE INVESTIGATION

|                 |              |              |                |       |
|-----------------|--------------|--------------|----------------|-------|
| Test Date       | 21/04/2021   |              | Test No.       | 3     |
| Borehole        | BH1R         |              | Test Depth (m) | 19.20 |
| Coordinates (m) | 383353.9 (E) | 397240.7 (N) | Elevation (m)  | 32.28 |



### Material description from borehole log:

SANDSTONE.

### Test pocket conditions:

|                           |      |                           |  |
|---------------------------|------|---------------------------|--|
| Total core recovery:      | 98 % | Test pocket depth range:  |  |
| Solid core recovery:      | 87 % | From: 18.10 m to: 20.40 m |  |
| Rock quality designation: | 74 % | Flush: Water              |  |

### Test comment:

The test pocket was tight and even, with arms lifting off at 1.5 to 4.0mm. The po was estimated to be at 2920kPa, with the following loading section being long and linear. No material yield was seen and the test was taken to a high pressure of 14582kPa. The displacement-pressure response shown by the arms was reasonably consistent albeit with some variation in expansion. Analysis of three unload reload loops provides modulus values of 1237 to 1455MPa.

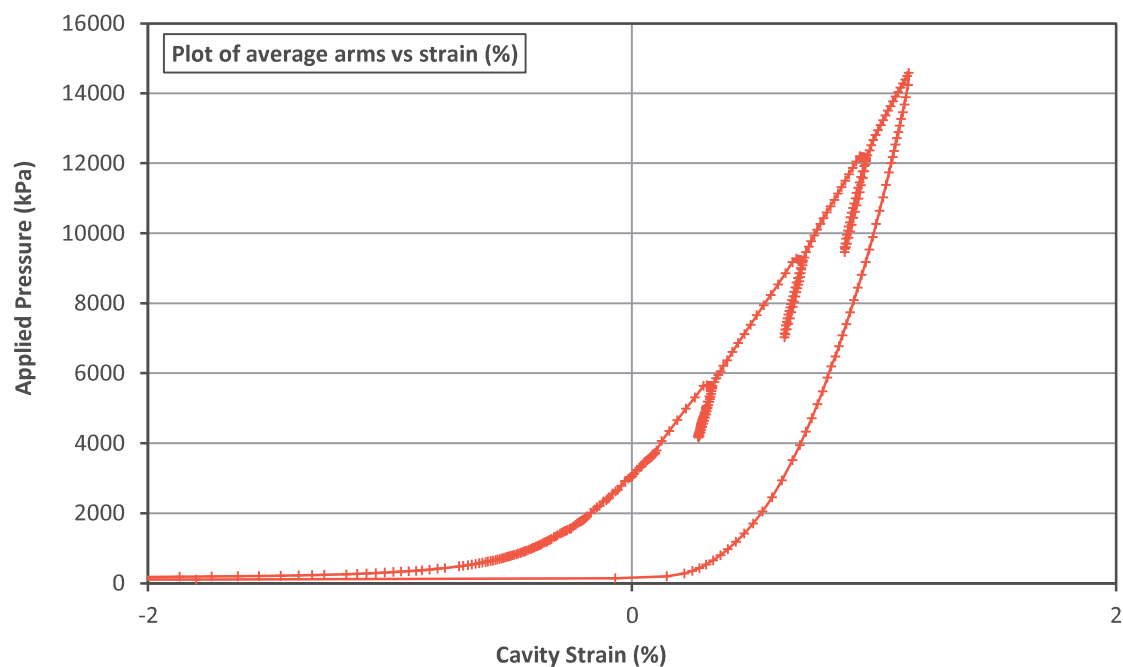
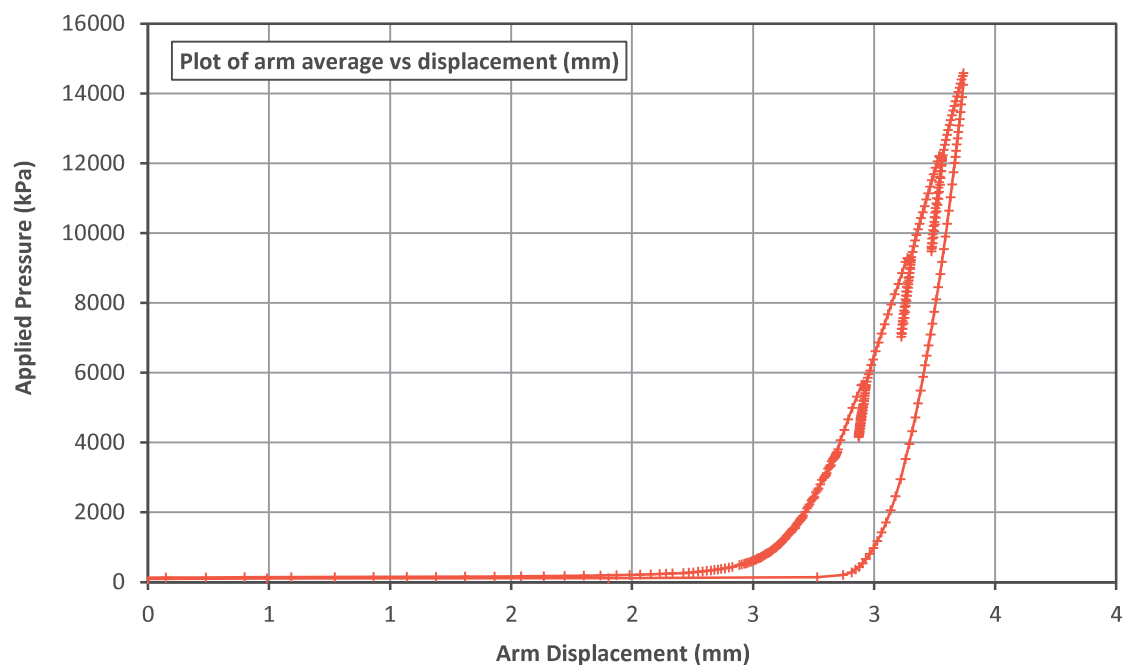
| Test details:       |               | Instrument: |         | Eleanor (HPD04) |        |         |        |
|---------------------|---------------|-------------|---------|-----------------|--------|---------|--------|
| Drilling method:    | Rotary coring |             | mV      | mV/mm           |        | mV      | mV/MPa |
| Casing depth:       | 18.10 m       | Arm 1:      | -2377.2 | 122.9           | TPC A: | 294.1   | 102.9  |
| Water level:        | 9.80 m        | Arm 2:      | -2048.0 | 124.9           | TPC B: | -2132.9 | 110.7  |
|                     |               | Arm 3:      | -2290.9 | 129.5           |        |         |        |
| Test time:          |               | Arm 4:      | -2122.3 | 127.4           |        |         |        |
| Start (probe in):   | 14:25 hrs     | Arm 5:      | -2290.4 | 132.1           |        |         |        |
| Finish (probe out): | 16:15 hrs     | Arm 6:      | -2141.9 | 124.1           |        |         |        |

|             |                                  |               |                  |
|-------------|----------------------------------|---------------|------------------|
| Project     | Great Jackson Street, Manchester | Figure<br>No. | BH1R<br>T03 - 01 |
| Client      | GeoAssist                        |               |                  |
| Project No. | P1210114                         |               |                  |

## Pressuremeter Test - Average Arm Plots

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 3     |
| Borehole  | BH1R       | Test Depth (m) | 19.20 |

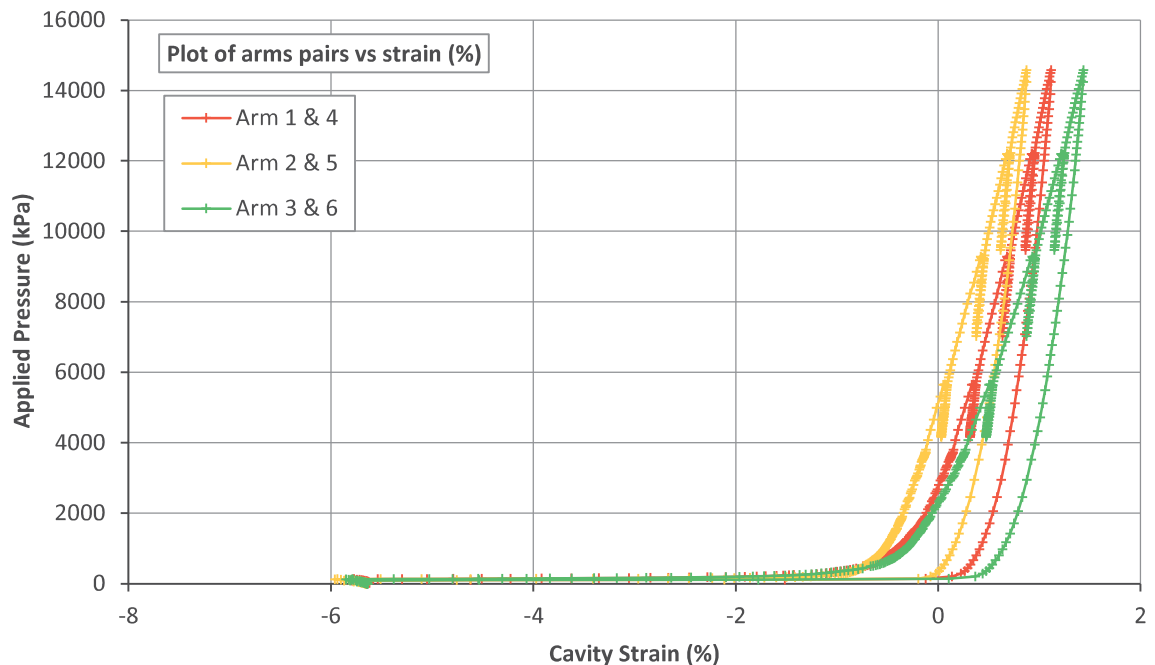
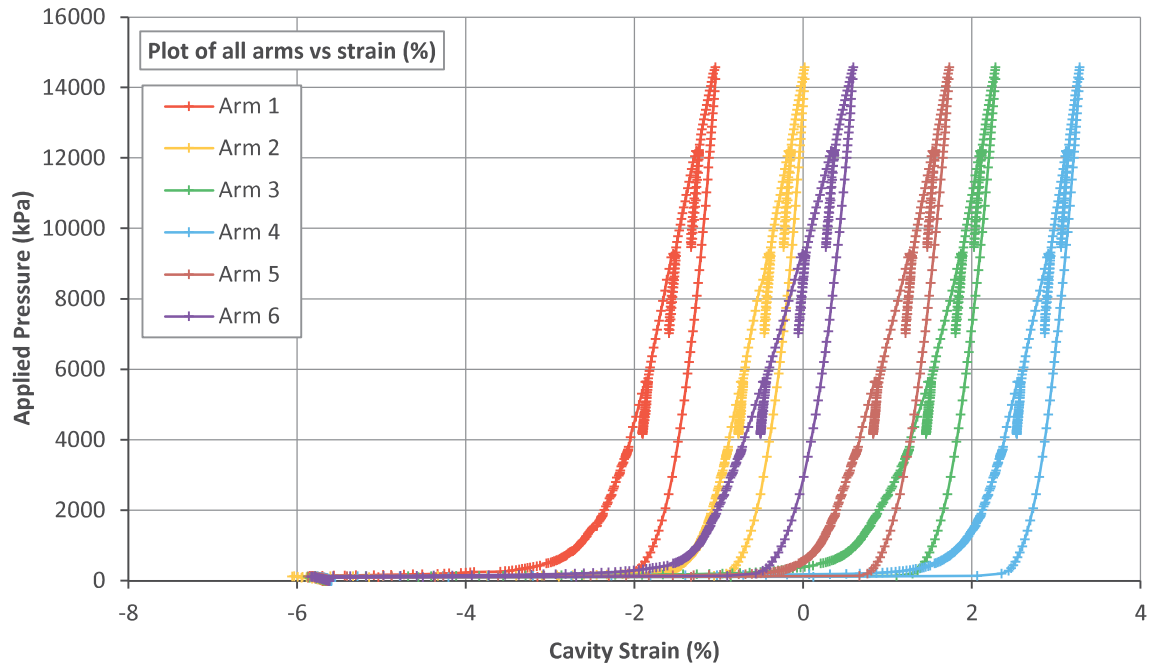


|             |                                  |               |                  |
|-------------|----------------------------------|---------------|------------------|
| Project     | Great Jackson Street, Manchester | Figure<br>No. | BH1R<br>T03 - 02 |
| Client      | GeoAssist                        |               |                  |
| Project No. | P1210114                         |               |                  |

## Pressuremeter Test - Arm Displacement vs Strain (%)

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 3     |
| Borehole  | BH1R       | Test Depth (m) | 19.20 |

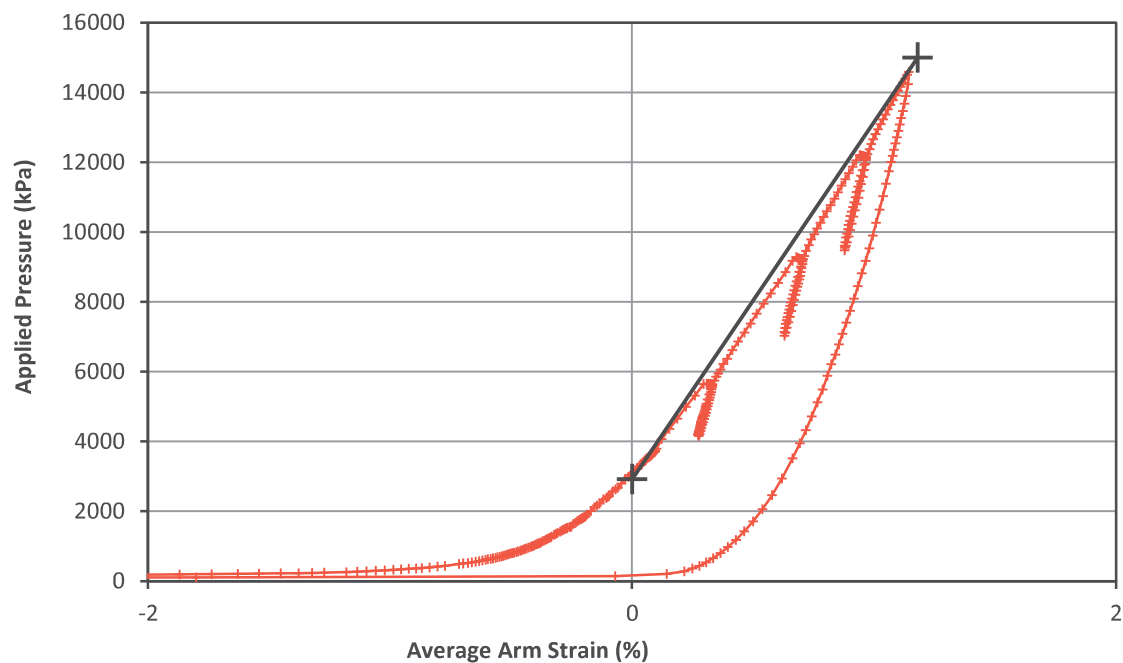


|             |                                  |               |                  |
|-------------|----------------------------------|---------------|------------------|
| Project     | Great Jackson Street, Manchester | Figure<br>No. | BH1R<br>T03 - 03 |
| Client      | GeoAssist                        |               |                  |
| Project No. | P1210114                         |               |                  |

## Pressuremeter Analysis - Initial Modulus & In Situ Horizontal Stress

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 3     |
| Borehole  | BH1R       | Test Depth (m) | 19.20 |



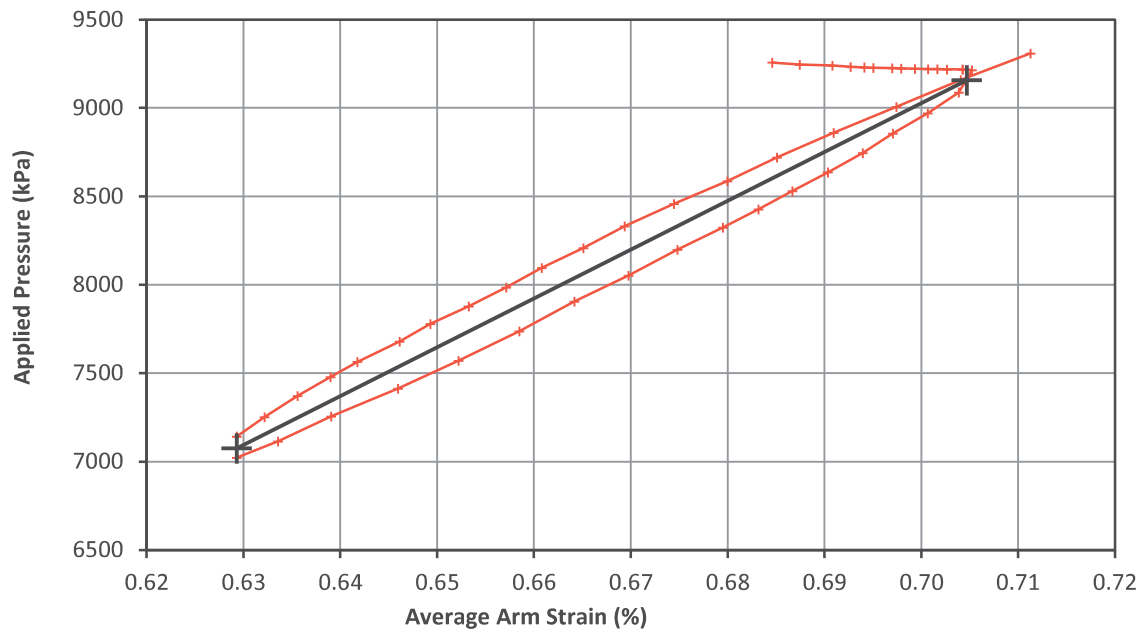
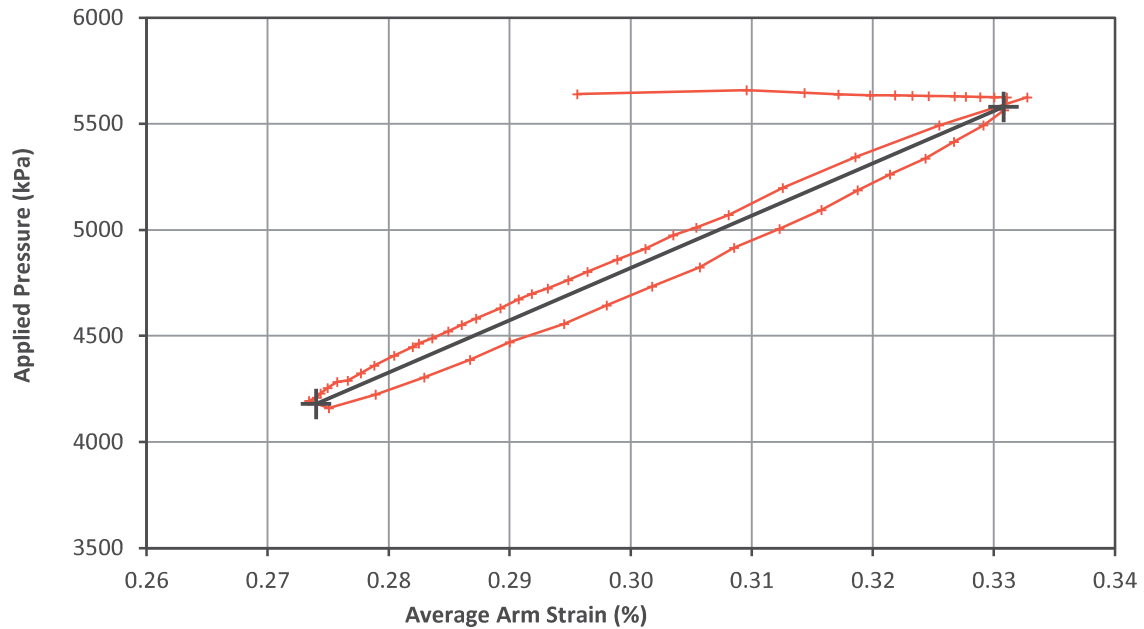
|                 |               |           |
|-----------------|---------------|-----------|
| Initial Modulus | Shear Modulus | 517.9 MPa |
|-----------------|---------------|-----------|

|             |                                  |               |                  |
|-------------|----------------------------------|---------------|------------------|
| Project     | Great Jackson Street, Manchester | Figure<br>No. | BH1R<br>T03 - 04 |
| Client      | GeoAssist                        |               |                  |
| Project No. | P1210114                         |               |                  |

## Pressuremeter Analysis - Unload Reload Loop

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 3     |
| Borehole  | BH1R       | Test Depth (m) | 19.20 |

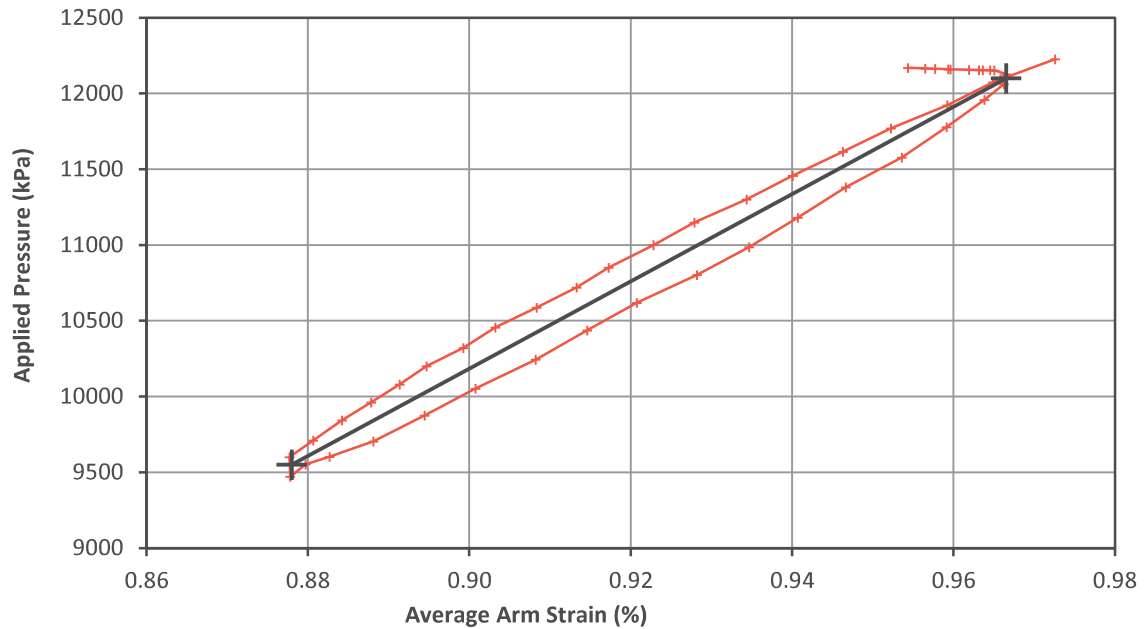


|             |                                  |               |                  |
|-------------|----------------------------------|---------------|------------------|
| Project     | Great Jackson Street, Manchester | Figure<br>No. | BH1R<br>T03 - 05 |
| Client      | GeoAssist                        |               |                  |
| Project No. | P1210114                         |               |                  |

## Pressuremeter Analysis - Unload Reload Loop

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 3     |
| Borehole  | BH1R       | Test Depth (m) | 19.20 |



|        |                     |        |     |
|--------|---------------------|--------|-----|
| Loop 3 | Shear Modulus       | 1454.6 | MPa |
|        | Cavity Strain Range | 0.089  | %   |

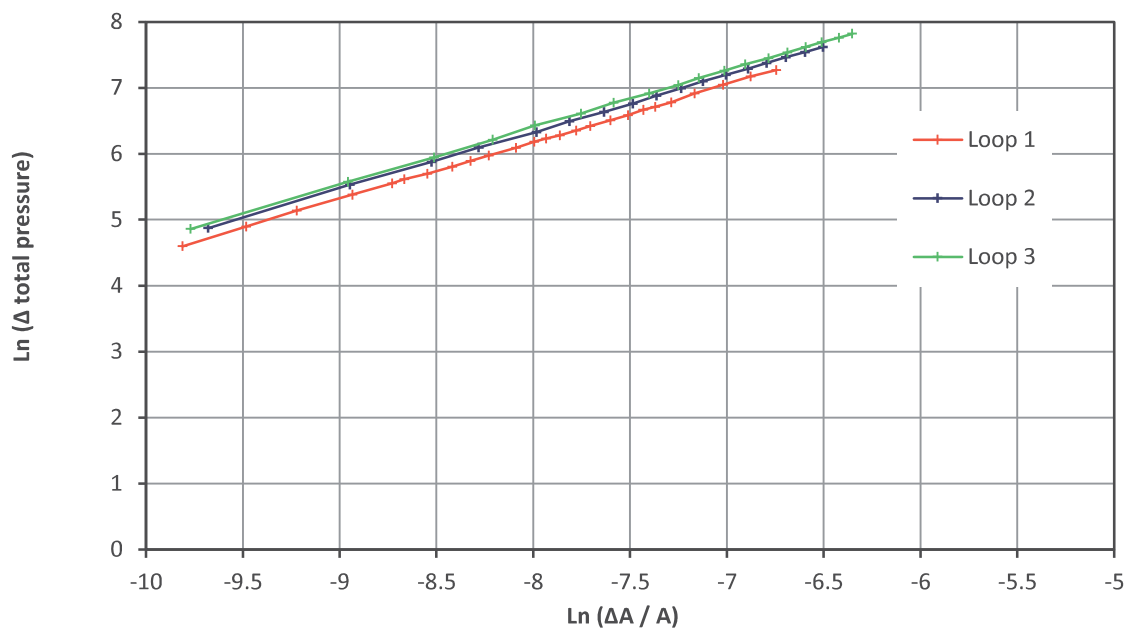
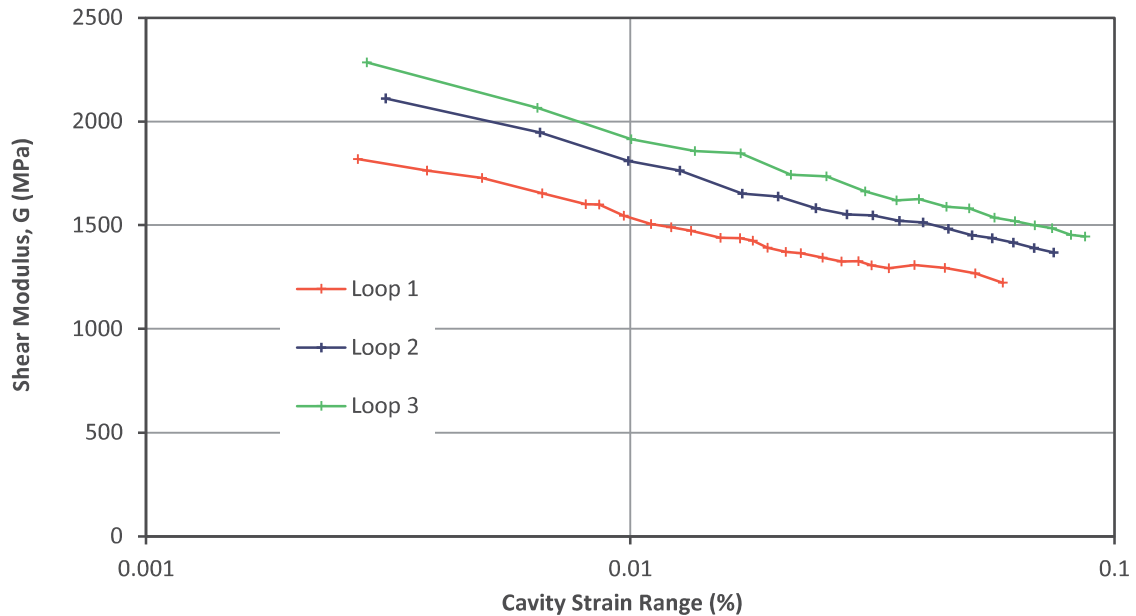
|             |                                  |               |                  |
|-------------|----------------------------------|---------------|------------------|
| Project     | Great Jackson Street, Manchester | Figure<br>No. | BH1R<br>T03 - 06 |
| Client      | GeoAssist                        |               |                  |
| Project No. | P1210114                         |               |                  |

# Pressuremeter Analysis

Small Strain Stiffness and Bolton & Whittle (1999)

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 3     |
| Borehole  | BH1R       | Test Depth (m) | 19.20 |



| Loop 1              |                  | Loop 2              |                  | Loop 3              |                  |
|---------------------|------------------|---------------------|------------------|---------------------|------------------|
| Gradient( $\beta$ ) | Intercept        | Gradient( $\beta$ ) | Intercept        | Gradient( $\beta$ ) | Intercept        |
| 0.856               | 450.457<br>(MPa) | 0.864               | 564.412<br>(MPa) | 0.866               | 615.557<br>(MPa) |

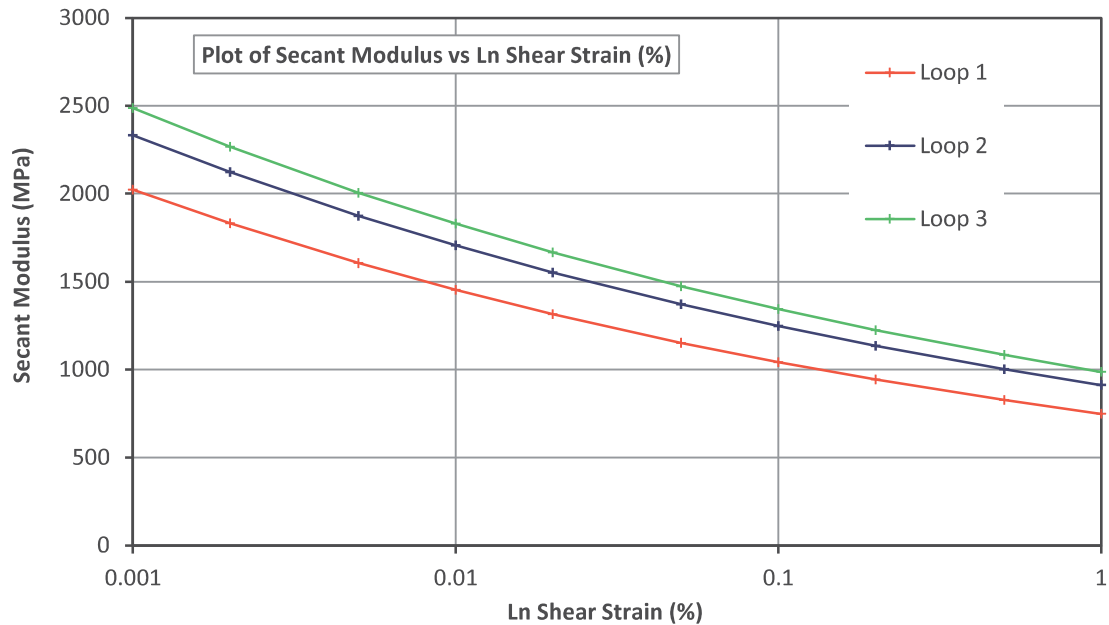
|             |                                  |               |                  |
|-------------|----------------------------------|---------------|------------------|
| Project     | Great Jackson Street, Manchester | Figure<br>No. | BH1R<br>T03 - 07 |
| Client      | GeoAssist                        |               |                  |
| Project No. | P1210114                         |               |                  |

## Pressuremeter Analysis

### Secant Modulus - Shear Strain (%)

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 21/04/2021 | Test No.       | 3     |
| Borehole  | BH1R       | Test Depth (m) | 19.20 |



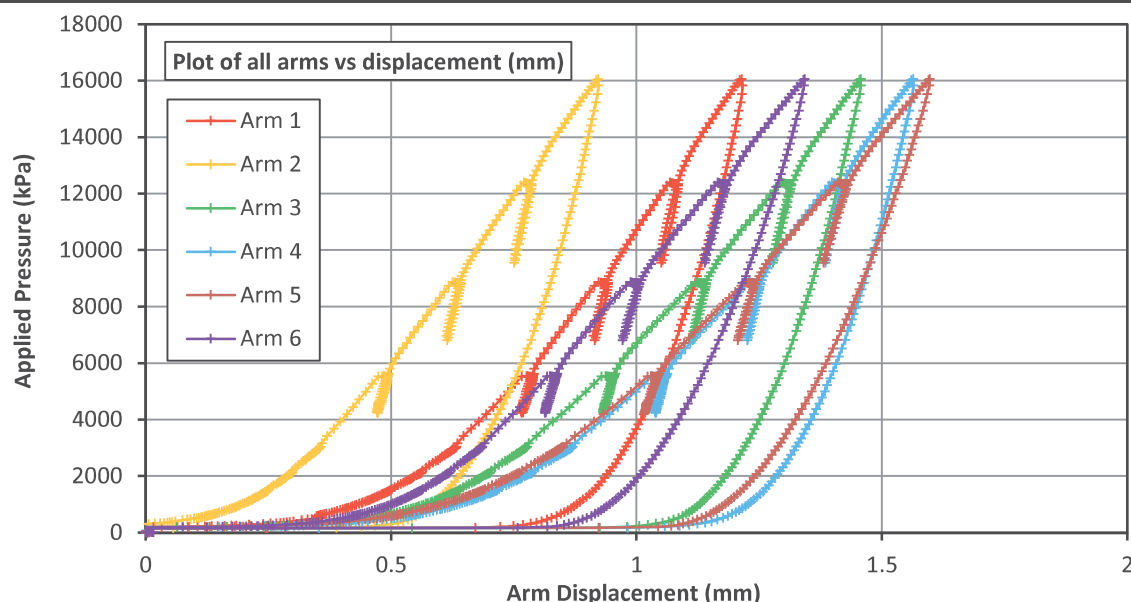
| Shear Strain  | Loop 1      | Loop 2      | Loop 3      |
|---------------|-------------|-------------|-------------|
| <b>0.001%</b> | <b>2023</b> | <b>2333</b> | <b>2488</b> |
| 0.002%        | 1831        | 2123        | 2268        |
| 0.005%        | 1605        | 1874        | 2006        |
| <b>0.010%</b> | <b>1452</b> | <b>1706</b> | <b>1828</b> |
| 0.020%        | 1314        | 1552        | 1666        |
| 0.050%        | 1152        | 1371        | 1474        |
| <b>0.100%</b> | <b>1042</b> | <b>1247</b> | <b>1344</b> |
| 0.200%        | 943         | 1135        | 1225        |
| 0.500%        | 827         | 1002        | 1083        |
| <b>1.000%</b> | <b>748</b>  | <b>912</b>  | <b>987</b>  |

|             |                                  |            |                  |
|-------------|----------------------------------|------------|------------------|
| Project     | Great Jackson Street, Manchester | Figure No. | BH1R<br>T03 - 08 |
| Client      | GeoAssist                        |            |                  |
| Project No. | P1210114                         |            |                  |

## Pressuremeter Test Overview High Pressure Dilatometer (HPD)

**IN SITU**  
SITE INVESTIGATION

|                 |              |              |                |       |
|-----------------|--------------|--------------|----------------|-------|
| Test Date       | 22/04/2021   |              | Test No.       | 4     |
| Borehole        | BH1R         |              | Test Depth (m) | 24.30 |
| Coordinates (m) | 383353.9 (E) | 397240.7 (N) | Elevation (m)  | 32.28 |



### Material description from borehole log:

SANDSTONE.

### Test pocket conditions:

|                           |       |                           |  |
|---------------------------|-------|---------------------------|--|
| Total core recovery:      | 100 % | Test pocket depth range:  |  |
| Solid core recovery:      | 86 %  | From: 23.50 m to: 25.60 m |  |
| Rock quality designation: | 55 %  | Flush: Water              |  |

### Test comment:

The test pocket was tight and even, with arms lifting off at 0.3 to 1.0mm. The po was estimated to be at 3673kPa, with the following loading section being long and linear. No material yield was observed and the test was taken to a high pressure of 16060kPa. The displacement-pressure response shown by the arms was consistent over the small expansion range. Analysis of three unload reload loops provides modulus values of 1388 to 1613MPa.

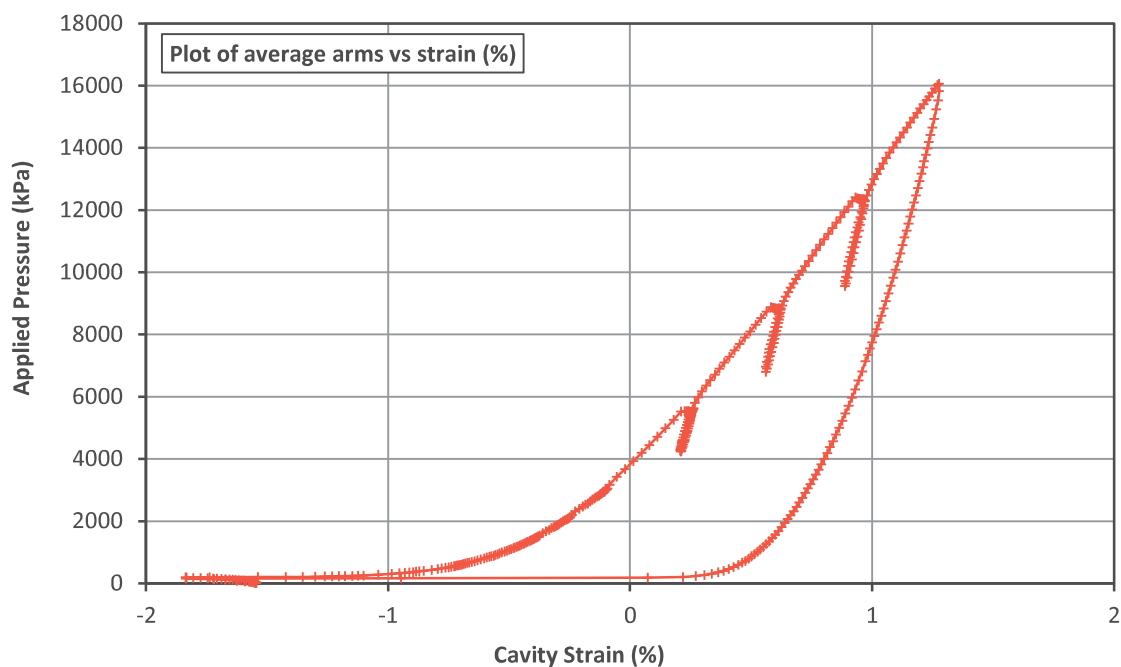
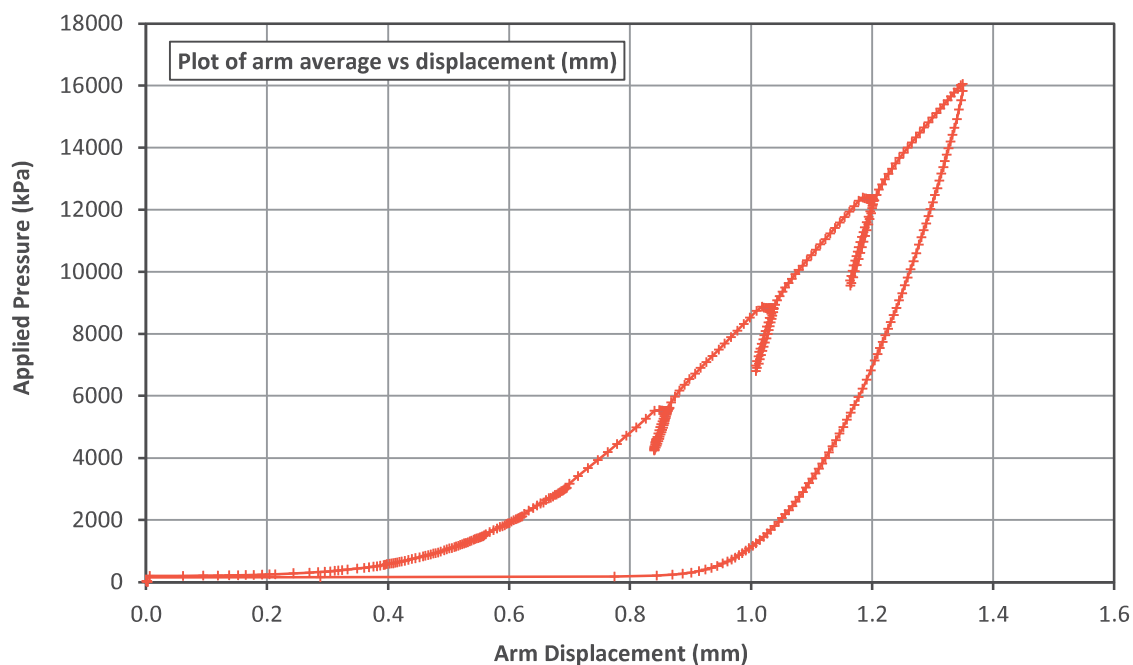
| Test details:       |               | Instrument: |         | Eleanor (HPD04) |        |         |        |
|---------------------|---------------|-------------|---------|-----------------|--------|---------|--------|
| Drilling method:    | Rotary coring |             | mV      | mV/mm           |        | mV      | mV/MPa |
| Casing depth:       | 23.20 m       | Arm 1:      | -2378.4 | 122.9           | TPC A: | 291.9   | 102.9  |
| Water level:        | 9.80 m        | Arm 2:      | -2041.7 | 124.9           | TPC B: | -2134.5 | 110.7  |
|                     |               | Arm 3:      | -2290.3 | 129.5           |        |         |        |
| Test time:          |               | Arm 4:      | -2119.9 | 127.4           |        |         |        |
| Start (probe in):   | 12:05 hrs     | Arm 5:      | -2290.6 | 132.1           |        |         |        |
| Finish (probe out): | 14:10 hrs     | Arm 6:      | -2139.9 | 124.1           |        |         |        |

|             |                                  |            |                  |
|-------------|----------------------------------|------------|------------------|
| Project     | Great Jackson Street, Manchester | Figure No. | BH1R<br>T04 - 01 |
| Client      | GeoAssist                        |            |                  |
| Project No. | P1210114                         |            |                  |

## Pressuremeter Test - Average Arm Plots

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 22/04/2021 | Test No.       | 4     |
| Borehole  | BH1R       | Test Depth (m) | 24.30 |

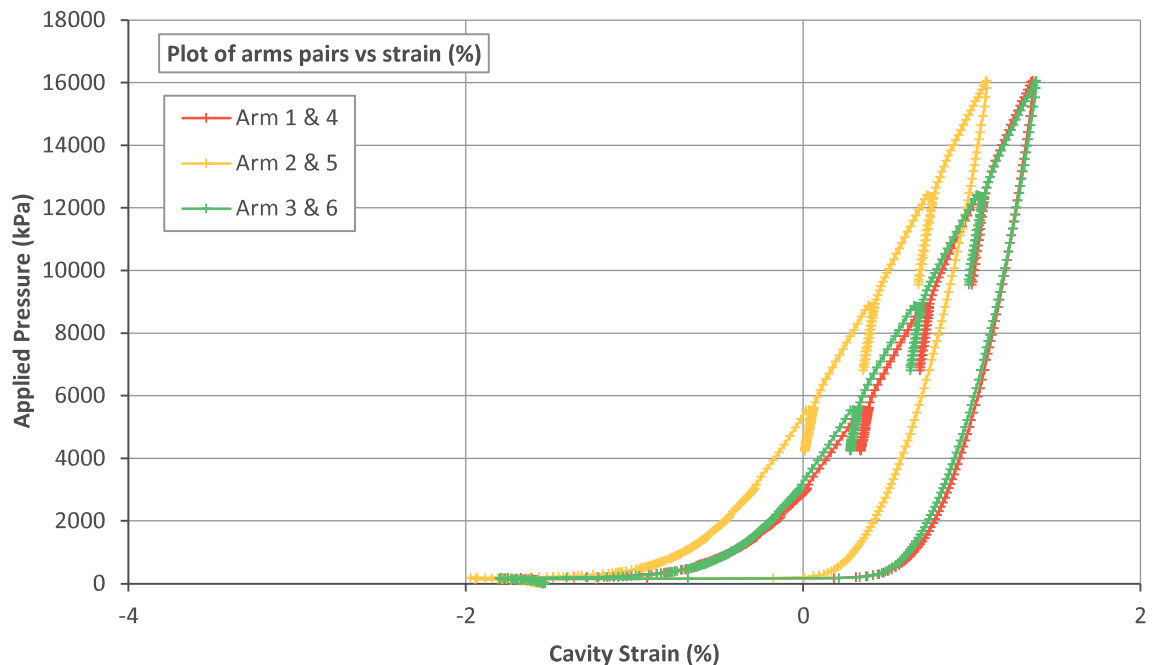
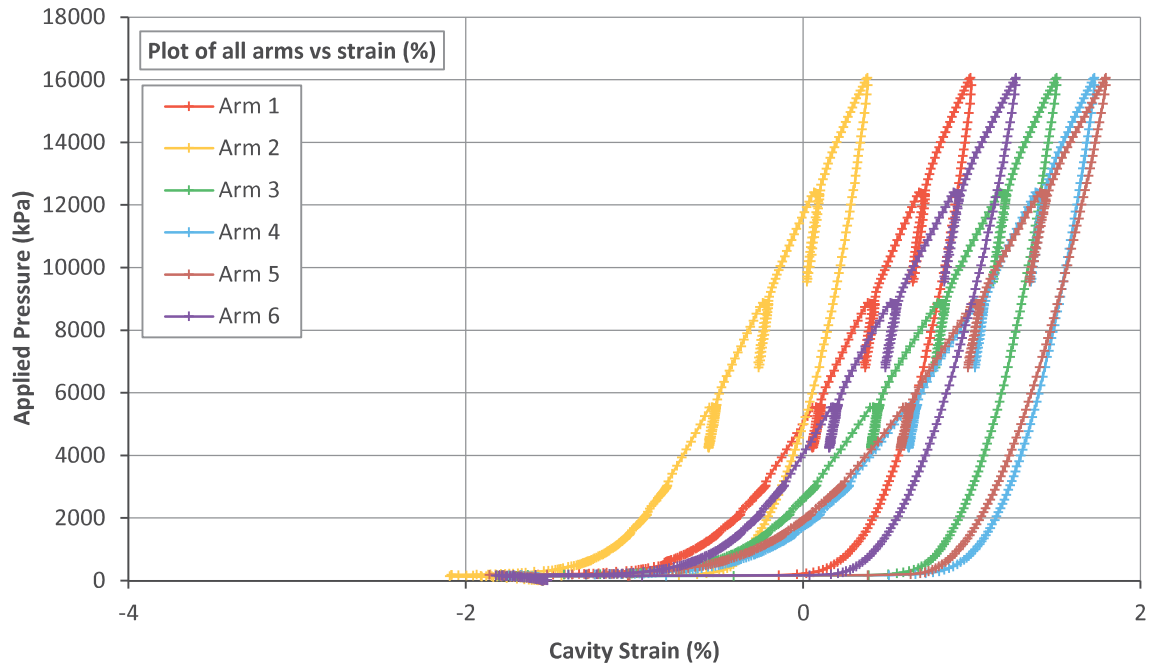


|             |                                  |               |                  |
|-------------|----------------------------------|---------------|------------------|
| Project     | Great Jackson Street, Manchester | Figure<br>No. | BH1R<br>T04 - 02 |
| Client      | GeoAssist                        |               |                  |
| Project No. | P1210114                         |               |                  |

## Pressuremeter Test - Arm Displacement vs Strain (%)

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 22/04/2021 | Test No.       | 4     |
| Borehole  | BH1R       | Test Depth (m) | 24.30 |

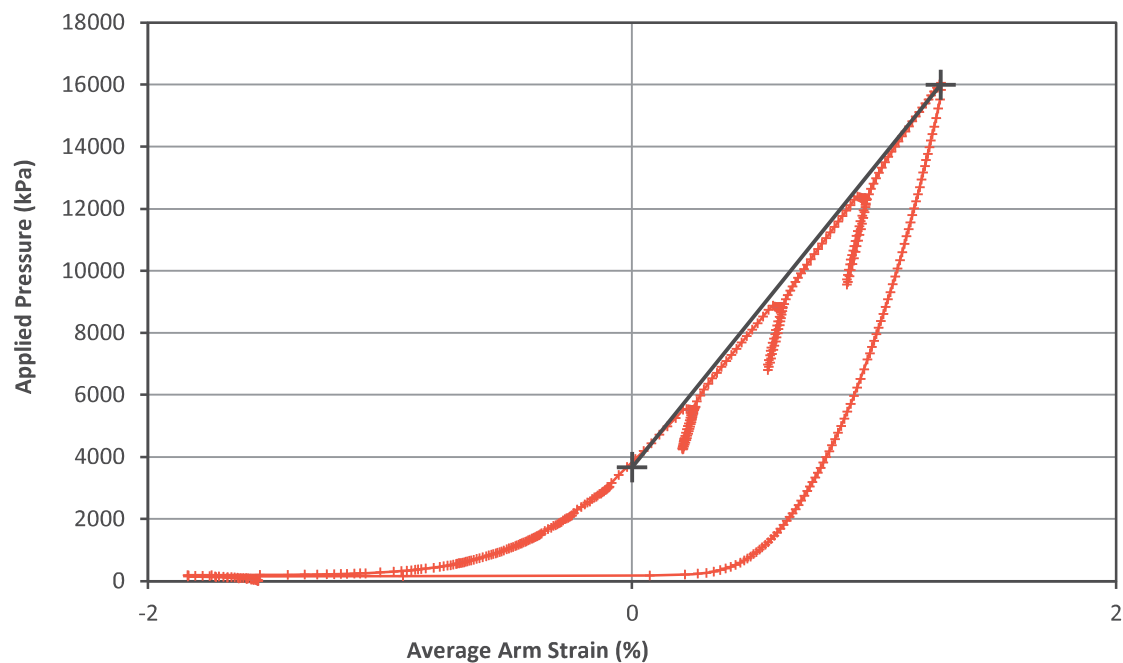


|             |                                  |               |                  |
|-------------|----------------------------------|---------------|------------------|
| Project     | Great Jackson Street, Manchester | Figure<br>No. | BH1R<br>T04 - 03 |
| Client      | GeoAssist                        |               |                  |
| Project No. | P1210114                         |               |                  |

## Pressuremeter Analysis - Initial Modulus & In Situ Horizontal Stress

**IN SITU**  
SITE INVESTIGATION

|           |            |                |       |
|-----------|------------|----------------|-------|
| Test Date | 22/04/2021 | Test No.       | 4     |
| Borehole  | BH1R       | Test Depth (m) | 24.30 |



|                 |               |           |
|-----------------|---------------|-----------|
| Initial Modulus | Shear Modulus | 489.6 MPa |
|-----------------|---------------|-----------|

|             |                                  |               |                  |
|-------------|----------------------------------|---------------|------------------|
| Project     | Great Jackson Street, Manchester | Figure<br>No. | BH1R<br>T04 - 04 |
| Client      | GeoAssist                        |               |                  |
| Project No. | P1210114                         |               |                  |