Stockport Interchange

PRELIMINARY INTERPRETATIVE GEOTECHNICAL REPORT

14113-WSP-SKZ-XX-RP-G-0004

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PUBLIC

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(INTERIM & DRAFT) PUBLIC

PROJECT NO. 70031899
OUR REF. NO. 14113-WSP-SKZ-XX-RP-G-0004

DATE: OCTOBER 2018

WSP
The Victoria
150-182 The Quays
Salford, Manchester
M50 3SP
Phone: +44 161 886 2400
Fax: +44 161 886 2401
WSP.com

QUALITY CONTROL

Issue/revision	First issue	Revision 1
Remarks		
Date	August 2018	
Prepared by	R. Home	
Signature		
Checked by	M. Neden	
Signature		
Authorised by	M. Neden	
Signature		
Project number	70031899	
Report number	70031899_Interchange IGR_001	
File reference	\\uk.wspgroup.com\central data\Projects\700318xx\70031899 - Stockport Interchange\02 WIP\GE Geotechnical Engineering\(09) Reporting\Interchange GDR	

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1 INTRODUCTION

1.1 AUTHORISATION

WSP has been appointed by Transport for Greater Manchester (TfGM) to provide geotechnical consultancy advice in relation to the proposed Stockport Interchange development, located in Stockport Town Centre (**Figure C.1** in **Appendix C)**.

1.2 DEVELOPMENT PROPOSALS

The new interchange will provide modern bus and coach facilities, public green spaces and allow for future integration with the Metro Link, which will run adjacent to the site along Swaine Street and crossing the River Mersey on a new bridge.

There are four main components which make up the new Interchange development; a new Bus Interchange (including North and South Concourse Buildings), a park area over the interchange supported off a podium structure, a new Gateway from Mersey Square and a Residential Building, which will occupy the south-western corner of the development.

Within the Bus Interchange, the Northern Concourse will serve the majority of the public and scheduled services with a single storey travel shop and cafe building and a two-storey public building for public amenities and staff office space. The smaller Southern Concourse will provide layover bays, coach drop off/pick up bays and driver facilities.

The podium structure over the interchange will support a public park, which will comprise extensive green spaces, seating/amenity areas and a central elliptical void, referred to as the 'Oculus'.

The new Mersey Square Gateway, located east of the Wellington Road viaduct, will provide access from Mersey Square, through an archway of the viaduct, into the Northern Concourse of the new Interchange. The Mersey Square Gateway building will be a single storey structure housing a waiting area and cycle storage. To more safely accommodate buses, it is proposed to lower the level of the road that passes beneath the viaduct by approximately 0.5m.

The residential building is a sixteen-storey tower block providing a mixture of one and two-bedroom apartments, public park level commercial units and parking space and plant/service areas at Interchange level.

A Link Bridge is proposed from the new interchange through to the adjacent Exchange Square Development and Stockport Railway Station.

Development proposals are presented in **Appendix B** and a site location plan is presented as **Figure C.1** in **Appendix C**.

1.3 OBJECTIVES

The main objective of this report is to provide design advice for the construction of the foundations, floor slabs, and external works.

Due to various scheme changes, additional investigations have been specified to support detailed design. At the time of writing, these works had not been undertaken and the recommendations made within this report should be treated as preliminary.

1.4 GEOTECHNICAL CATEGORY

It is considered that the structures will fall within Geotechnical Category 2 as defined in BS EN 1997-1:2004 (BSI, 2014). These are structures and foundations with no exceptional risk of difficult ground or loading conditions.

A geotechnical risk register is presented in **Appendix D**.

1.5 PREVIOUS REPORTS

The following reports pertaining to the ground conditions for the site have been produced by WSP and others;

- AECOM. 2015. *Phase 1 Geotechnical and Geo-environmental Desk Study Report – Stockport Bus Station*. Ref No. 60340298/GEO/01
- AECOM. 2016. *Stockport Interchange – Ground Investigation Report*. Ref No. 60340298/GEO/02
- WSP. 2017. *Stockport Interchange – Tunnel Assessment*. Report No. 70031899_20171009_Tunnel Study
- WSP. 2018. *Stockport Interchange – Mersey Bank Survey Report*. Report No. 70031899_20180201_Bank Survey Report

These documents are referenced where required and should be read in conjunction with this report.

For a discussion of contamination and ground gas issues, reference should be made to;

- WSP. 2017. *Stockport Interchange – Pre-Stage 2 Contaminated Land Report*. Report ref: 70031899-10952

1.6 CONFIDENTIALITY STATEMENT

This report is addressed to and may be relied upon by the following:

Transport for Greater Manchester
2 Piccadilly Place
Manchester
M1 3BG

This assessment has been prepared for the sole use of the above named party. This report shall not be relied upon or transferred to any other parties without the express written authorisation of WSP. No responsibility will be accepted where this report is used in its entirety, or in part, by any other party.

Information provided by others is taken in good faith as being accurate. WSP cannot and will not accept liability for any deficiencies in third party information.

General limitations are presented in **Appendix A.**

2 GROUND INVESTIGATION

2.1 FIELDWORK

A ground investigation was undertaken by AECOM in November and December 2015, the details of which are presented in the AECOM Ground Investigation Report (GIR).

Since the AECOM investigation was undertaken, the layout of the proposed scheme has changed and WSP has proposed additional ground investigations in order to provide sufficient geotechnical data for design of the Residential Building and the Link Bridge to the Mersey Square development.

At the time of writing, these works had not been undertaken.

Table 1 presents a summary of the fieldwork undertaken in the AECOM investigation within the interchange. AECOM also undertook a series of exploratory holes for the new bridge over the River Mersey and within Mersey Square. The window sample boreholes undertaken in Mersey Square have been excluded from the assessment due to the significant distance between their location and the proposed Mersey Square Gateway building. The boreholes undertaken for the bridge have not been used in the derivation of a ground model, however the laboratory testing data has been used in the assessment of rock strength.

Exploratory hole locations are shown on drawing **Geo-PN153428-001(1)** & **Geo-PN153428-001(2)** in **Appendix C**.

Table 1 - Summary of Fieldwork

Investigation Method	No. of Positions	Depth (m BGL)*
2015 AECOM Investigation		
Window sample boreholes	10	1.70 – 5.09
Cable percussion borehole with rotary follow on	8	7.80 – 15.30
2018 Investigation		
TBC	-	-

* metres below ground level

2.2 IN-SITU TESTING

STANDARD PENETRATION TESTS

Standard Penetration Tests (SPTs) were performed within the window sample boreholes and in the cable percussion sections of the boreholes. SPTs were also undertaken sporadically within the rotary sections. The test results are presented on the exploratory hole records within the AECOM GIR and a plot of SPT *N* versus elevation is presented as **Figure C.2** in **Appendix C.**

2.3 LABORATORY TESTING

Geotechnical laboratory testing comprised:

- Moisture content
- Atterberg Limits
- Particle size distribution
- pH and water-soluble sulphate
- Soil organic matter
- Point Load Index
- Unconfined compressive strength

3 GROUND CONDITIONS & MATERIAL PROPERTIES

3.1 GROUND SUMMARY

Based on the ground investigations undertaken, a general ground summary for the site is presented in **Table 2.**

Table 2 – Ground Summary

Strata	Depth to Base	Elevation of Base (mAOD)*	Thickness (m)	Comments
Concrete / Asphalt / Brick Sets	0.1 – 0.5	41.85 – 47.93	0.1 – 0.5	Absent from WS201 and WS210
Subbase	0.7 – 1.2	41.1 – 44.22	0.3 – 1.1	
Granular Made Ground	0.8 – 2.6	41.05 – 45.79	0.55 – 2.60	
Cohesive Made Ground	1.6 – 2.0	42.10 – 43.61	0.6 – 1.2	Only recorded in BH112 and WS201
Relict Topsoil	2	41.70	0.4	Only recorded in BH112
Glacial Sand & Gravel	1.6 – >5.09	38.77 – 43.62	0.6 – 3.0	Recorded in every exploratory position that penetrated the Made Ground. Bands of firm clay, between 0.4m and 1.5m thick, recorded in BH101, WS201, and WS208
Weathered Chester Formation Sandstone	>2.86 – 5.65	36.82 – <41.34	>0.41 – 1.95	
Intact Chester Formation Sandstone	7.5 – 15.3	27.41 – 34.77	>11.6	BH107 encountered a between 7.5m – 9.1m BGL.

*metres above Ordnance Datum

3.2 GROUNDWATER

Groundwater monitoring records and water strikes presented within the AECOM GIR, indicate that the main groundwater body lies within the Chester Formation Sandstone.

The groundwater table appears to decrease in elevation from approximately 39m AOD in the south of the site to approximately 36m AOD close to the River Mersey on the northern boundary.

Shallow monitoring wells indicate discontinuous groundwater bodies within the superficial deposits and Made Ground.

A contour plan showing the mean groundwater level is presented as **Dwg. 70031899_CP_003** in **Appendix C**.

3.3 GROUND CONDITIONS & MATERIAL PROPERTIES

This section discusses the ground conditions and material properties determined from the ground investigation and geotechnical laboratory testing. This section will be updated upon completion of the proposed additional ground investigation.

Where necessary, determination of geotechnical parameters has been based on cautious estimates of laboratory derived results, published correlations, and field tests, complemented with engineering judgement.

Where material parameters are assumed, derived by calculation, or taken from published sources, further details are provided as to their derivation.

MADE GROUND

Made Ground was encountered either at the surface or beneath asphalt/concrete/brick surfacing and was proven to a maximum depth of 2.6m BGL. The Made Ground generally comprised gravel subbase or an ashy gravelly sand with cobbles of brick and concrete (Granular Made Ground).

Cohesive Made Ground was encountered in BH112 and WS201 and varied between 1m and 1.2m in thickness (inclusive of a 0.4m thick layer of suspected Relict Topsoil in BH112). The Cohesive Made Ground comprised soft sandy clay with gravel of brick.

In-situ and laboratory testing from the AECOM investigation is summarised in **Table 3**.

Table 3 - Summary of In-situ & Laboratory Testing - Made Ground

<table>
<tr><th colspan="2">Parameter</th><th>No. of Tests</th><th>Min – Max</th><th>Mean</th></tr>
<tr><td colspan="5">Granular Made Ground</td></tr>
<tr><td colspan="2">SPT $N_{60}^{\dagger}$</td><td>7</td><td>4 – 79*</td><td>26</td></tr>
<tr><td colspan="2">Moisture Content (%)</td><td>2</td><td>20 & 33</td><td>27</td></tr>
<tr><td rowspan="3">Particle Size Distribution (%)</td><td>Gravel</td><td rowspan="3">2</td><td>15 & 58</td><td>36.5</td></tr>
<tr><td>Sand</td><td>38 & 61</td><td>49.5</td></tr>
<tr><td>Silt/Clay</td><td>4 & 24</td><td>14</td></tr>
<tr><td colspan="2">pH</td><td>5</td><td>8.05 – 11.98</td><td>10.82</td></tr>
<tr><td colspan="2">Water soluble sulphate SO_4 (2:1) (mg/l)</td><td>5</td><td>16.8 – 154.3</td><td>64.2</td></tr>
<tr><td colspan="5">Cohesive Made Ground</td></tr>
<tr><td colspan="2">SPT $N_{60}^{\dagger}$</td><td>2</td><td>4 & 28</td><td>16</td></tr>
<tr><td colspan="2">Moisture Content (%)</td><td>1</td><td>18</td><td>-</td></tr>
<tr><td colspan="2">pH</td><td>1</td><td>8.81</td><td>-</td></tr>
<tr><td colspan="2">Water soluble sulphate SO_4 (2:1) (mg/l)</td><td>1</td><td>13.4</td><td>-</td></tr>
<tr><td colspan="5">Relict Topsoil</td></tr>
<tr><td colspan="2">Moisture Content (%)</td><td>1</td><td>109</td><td>-</td></tr>
</table>

* extrapolated values
† corrected for hammer efficiency (assumed 60%)

Due to the variability in the Made Ground, and the limited amount of testing, no characteristic material parameters have been derived.

GLACIAL SAND & GRAVEL

Where the Made Ground was fully penetrated, Glacial Sand and Gravel was encountered to depths of between 1.6m and 4m BGL. The Glacial Sand & Gravel generally comprised loose becoming dense gravelly sand or sandy gravel with a variable cobble content. Layers of firm slightly gravelly sandy clay and firm thinly laminated sandy clay (0.4m and 1.5m thick) were encountered in BH101 and WS208. In WS201 the profile was entirely cohesive with 1.5m of clay recorded. The thicker profiles of clay in BH101 and WS201 are located in the southwest corner of the site and the thinner layer of 0.4m in WS208 is located in the northeast corner.

A contour plan showing the base elevation of the Made Ground / top elevation of the Glacial Sand & Gravel is included as **Dwg. 70031899_CP_002** in **Appendix C**.

In-situ and laboratory testing is summarised in **Table 4**.

Table 4 - Summary of In-Situ & Laboratory Testing - Glacial Sand & Gravel

Parameter		No. of Tests	Min – Max	Mean
Granular Soils				
SPT N_{60} †		40	5 – 600*	85
Moisture Content (%)		1	5	-
Particle Size Distribution (%)	Gravel	8	0 – 60	29
	Sand		37 – 86	56
	Silt/Clay		3 – 40	15
pH		5	8.82 – 9.62	9.12
Water soluble sulphate SO_4 (2:1) (mg/l)		5	17.5 – 118.1	50
Cohesive Soils				
SPT N_{60}		4	5 – 14	10
Moisture Content (%)		3	12 – 23	20
Liquid Limit (%)		1	33	-
Plastic Limit (%)			18	-
Plasticity Index (%)			15	-

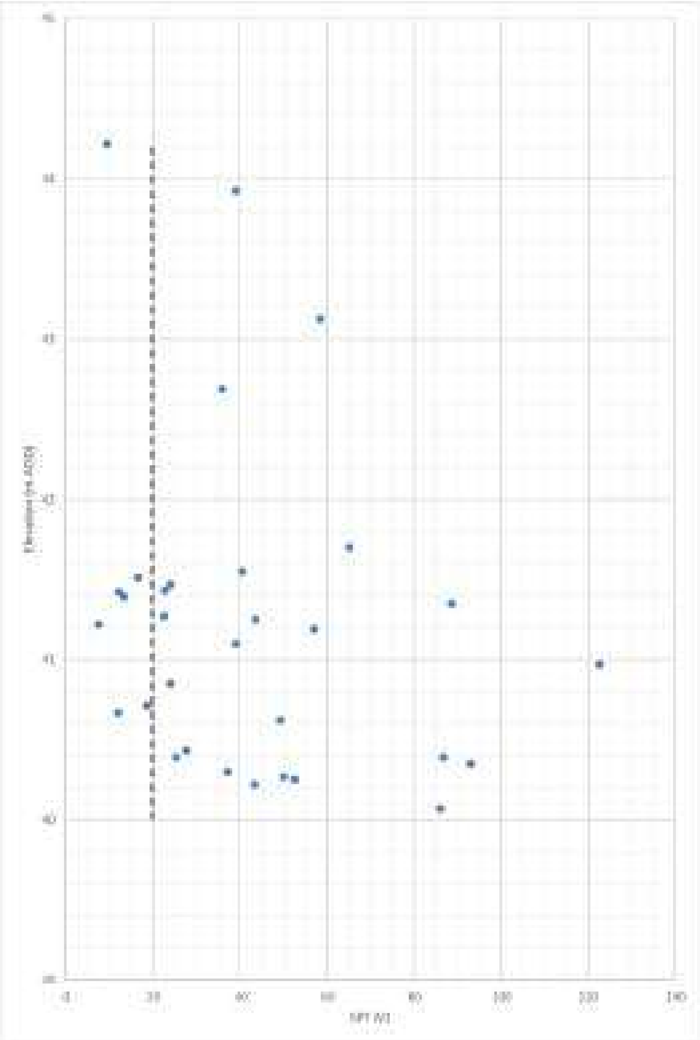
* extrapolated values
† corrected for hammer efficiency (assumed 60%)

GRANULAR SOILS

Shear Strength

A correlation between peak effective angle of internal friction, φ'_{peak} and SPT *N1* (corrected for hammer efficiency) has been shown by Stroud (1989). **Figure 1** presents a plot of SPT *N1* versus elevation and, based on this, a representative SPT $N1_{60}$ of 20 is considered appropriate, corresponding to a φ'_{peak} of 33°.

Figure 1 – SPT *N1$_{60}$* vs Elevation – Glacial Sand & Gravel



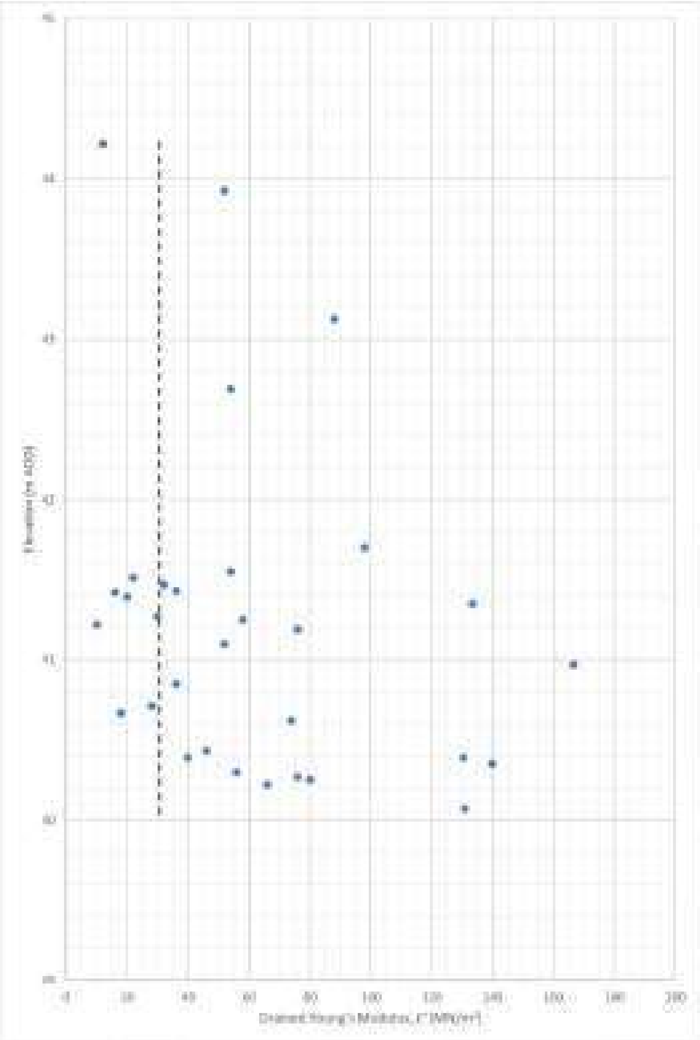
Stiffness

The drained Young's Modulus, *E'* has been determined using the relationship:

$E'(MN/m^2) = 2N_{60}$ (Clayton, 1995)

Values determined using this relationship are presented on **Figure 2** and, based on this, a drained Young's Modulus of 30MN/m^2 is considered appropriate.

Figure 2 – Drained Young's Modulus vs Elevation – Glacial Sand & Gravel



COHESIVE SOILS

Undrained Shear Strength

The undrained shear strength, c_u has been estimated from the following relationship with SPT N_{60}:

$c_u(kN/m^2) = f_1 N_{60}$ (Clayton, 1995)

Where *f1* is a factor related to the plasticity index, which has been taken as 5 assuming a moderately conservative representative plasticity index of 25% (Stroud, 1975).

Based on this relationship and the SPTs undertaken within the Glacial Clay, an undrained shear strength of $50kN/m^2$ is considered appropriate.

Stiffness

Values of drained Young's Modulus, *E'* have been derived from the following relationship with SPT N_{60}:

$E'(MN/m^2) = 0.9N_{60}$ (Clayton, 1995)

Based on the above relationship and the results of the SPTs, a drained Young's Modulus of $8MN/m^2$ is considered appropriate.

WEATHERED CHESTER FORMATION SANDSTONE

Chester Formation Sandstone was encountered underlying the Glacial Sand and Gravel at depths between 2.45m and 4m BGL.

Rockhead level generally decreases from approximately 42m AOD at the southern extent of the site to approximately 39m AOD in the northern area. A contour plan showing rockhead elevation is presented as **Dwg. 70031899_CP_001** in **Appendix C**.

The sandstone comprised an upper weathered zone grading into intact rock. In this report the weathered zone has been related to the depth over which the sandstone was recovered as a sand or where there was very little / no core recovery. The thickness of the weathered zone varied from 0.7m in BH106 to 1.95m in BH104.

Shear Strength

The weathered sandstone was recovered as a very dense sand and, as such, these materials have been considered as a granular soil.

Based on correlations with SPT $N1_{60}$ (Stroud, 1989) a characteristic φ'_{peak} of 42° is considered appropriate.

Stiffness

Based on engineering judgement, a drained Young's Modulus, *E'* of 150MN/m^2 is considered appropriate for the Weathered Chester Formation Sandstone.

INTACT CHESTER FORMATION SANDSTONE

The intact Chester Formation Sandstone was recorded an extremely weak to weak fine to coarse grained sandstone with occasional clasts of quartzite and mudstone gravel.

One main discontinuity set, likely representing bedding, was recorded in the sandstone and was typically very closely to medium spaced and subhorizontal.

Extremely weak to weak reddish-brown mudstone was encountered in BH104 between 32.67m and 33.37m AOD.In-situ and laboratory testing for the Intact Chester Formation is summarised in **Table 5**. The values presented in Table 5 also include testing undertaken for the Bridge Pier due to the limited testing data.

Table 5 - Summary of In-Situ & Laboratory testing - Intact Chester Formation Sandstone

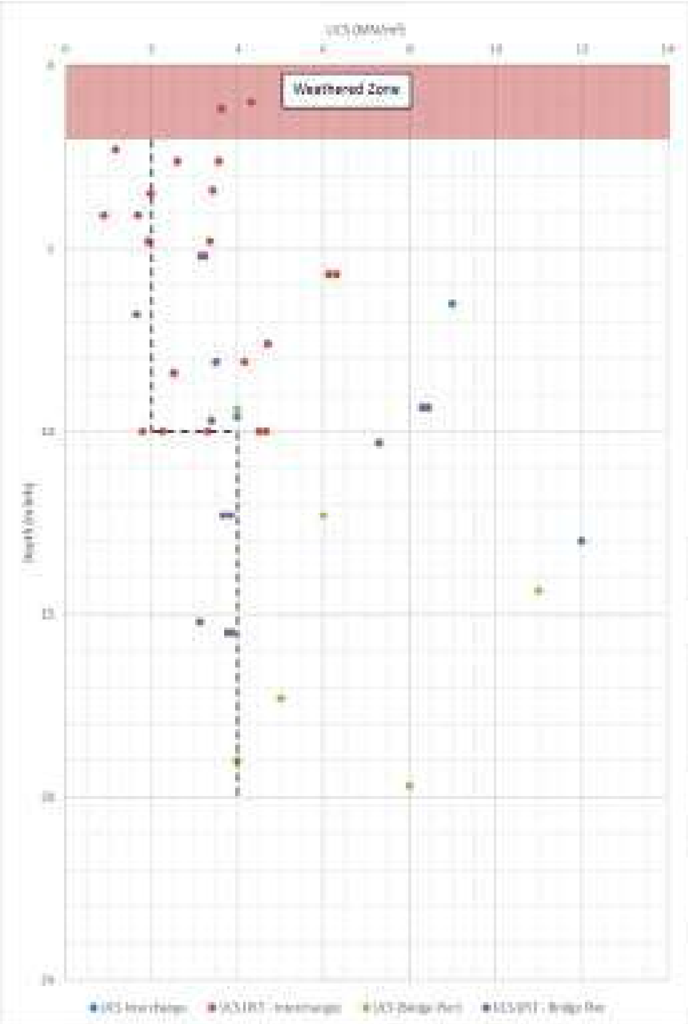
Parameter	No. of Tests	Min – Max	Mean
SPT N_{60}	20	236 – 750*	477
Moisture Content (%)	41	5.6 – 16.7	11.3
Axial Point Load Index, I_{S50} (MN/m^2)	34	0.03 – 0.281	0.12
Unconfined Compressive Strength (MN/m^2)	9	4 – 12	7

* extrapolated values

Unconfined Compressive Strength

Figure 3 presents a plot of unconfined compressive strength (UCS) versus depth below rockhead level (m brh) for the Chester Formation Sandstone, which includes values from direct testing and values estimated from point load testing. Conversion of the point load index I_{S50} to an equivalent UCS is achieved through the application of a correction factor, *K*. This is derived by correlating with direct UCS tests at equivalent depths. A *K* value of 30 has been adopted for the site.

Figure 3 – UCS vs Depth Below Rockhead – Intact Chester Formation Sandstone



Based on **Figure 3**, a UCS of 2MN/m^2 is considered appropriate for the Intact Chester Formation Sandstone between 2m and 10m brh. Below 10m brh the UCS increases to 4MN/m^2.

Stiffness

The mass modulus of the rock (E_m) can be assessed based on the UCS using the following relationship developed by Rowe and Armitage (1987) and presented in CIRIA 181 (Gannon et al, 1990):

$$E_m = 275 * \sqrt{UCS}$$

Based on the characteristic UCS values given in the previous section, the relationship suggests the following profile of Young's Modulus:

E' = 390MN/m^2 between 2m and 10m brh

E' = 550MN/m^2 below 10m brh

3.4 SUMMARY OF PRELIMINARY CHARACTERISTIC PARAMETERS

Table 6 summarises the characteristic parameters, based on the current investigation data.

Table 6 - Summary of Preliminary Characteristic Parameters

Parameter	Characteristic Value	Justification
Granular Made Ground		
Bulk Unit Weight, γ_b (kN/m^2)	17	Loose gravel – BS 8002 (BSI, 2015)
Drained Young's Modulus, E' (MN/m^2)	5	Assumed value based on engineering judgement
Glacial Sand & Gravel - Granular		
Bulk Unit Weight, γ_b (kN/m^2)	18	Medium dense to dense sand/gravel – BS 8002 (BSI, 2015)
Peak effective angle of internal friction, φ'_{peak} (°)	33	SPT $N1_{60}$ relationship (Stroud, 1989)
Drained Young's Modulus, E' (MN/m^2)	30	Figure 2
Glacial Sand & Gravel - Cohesive-		
Bulk Unit Weight, γ_b (kN/m^2)	18	Medium strength clay - BS 8002 (BSI, 2015)
Undrained Shear Strength, c_u (kN/m^2)	50	SPT N_{60} relationship (Clayton, 1995)
Drained Young's Modulus, E' (MN/m^2)	8	SPT N_{60} relationship (Clayton, 1995)
Weathered Chester Formation Sandstone		
Bulk Unit Weight, γ_b (kN/m^2)	20	Very dense sand – BS 8002 (BSI, 2015)
Peak effective angle of internal friction, φ'_{peak} (°)	42	SPT $N1_{60}$ testing (Stroud, 1989)
Drained Young's Modulus, E' (MN/m^2)	150	Engineering judgement
Intact Chester Formation Sandstone		
Bulk Unit Weight, γ_b (kN/m^2)	21	Engineering judgement
UCS, σ_c (MN/m^2)	2MN/m^2 between 2m and 10m brh 4MN/m^2 below 10m brh	Figure 3
Stiffness, E' (MN/m^2)	390MN/m^2 between 2m and 10m brh 550MN/m^2 below 10m brh	UCS relationship – CIRIA 181 (Gannon et al, 1990)

4 GEOTECHNICAL & ENGINEERING ASSESSMENT

4.1 DEVELOPMENT PROPOSALS

As discussed in **Section 1.2**, there are four main components which make up the new Interchange development; a new Bus Interchange (including North and South Concourse Buildings), a park area over the interchange supported off a podium structure, a new Gateway from Mersey Square and a sixteen-storey Residential Building, which will occupy the south-western corner of the development.

The new Mersey Square Gateway building, located east of the Wellington Bridge, will be a single storey structure. To more safely accommodate buses, it is proposed to lower the level of the road that passes beneath the Wellington Road viaduct by approximately 0.5m.

A Link Bridge is proposed from the new interchange through to the adjacent Exchange Square Development and Stockport Railway Station.

Development proposals are presented in **Appendix B**.

The column design loads within the Residential Building range from 9000-14000kN and the Interchange and Podium from 3500-7000kN. Structural loads for the Northern and Southern Concourse buildings and the Mersey Square Gateway building are currently not finalised, but are anticipated to be relatively low.

4.2 EARTHWORKS & RETAINING STRUCTURES

At the time of writing, finished levels had not been finalised, but it understood that below the Northern Concourse finished level may be in the region of 42.65mAOD under the Northern Concourse, rising to approximately 42.85mOD under the Southern Concourse and the Residential Building.

The existing topography decreases from approximately 45.5m AOD on the southern boundary to approximately 42.5m AOD in the northern area of the site and these levels suggest that up to approximately 3m of cut will be required under the Southern Concourse and Residential Building.

Significant filling is not anticipated under the Northern Concourse and therefore, there would seem to little scope for the reuse of cut soils on the site.

There will be a requirement for retaining structures on the southern, western and eastern boundaries but, at the time of writing, the extent and form of these had not been determined.

4.3 FOUNDATIONS

Given the structural loads and the underlying ground conditions, it is not considered feasible to support the Residential Building and the Podium on pads or raft foundations and the use of piled foundations is considered appropriate. Piled foundations are also likely to be required for the Link Bridge. The use of rock socketed, continuous flight auger (CFA) or rotary bored piles are likely to be the most suitable piling techniques.

The single storey retail structure on the Northern Concourse is likely to be a lightly loaded, steel frame structure and it is anticipated that it will be designed to sit on the ground floor slab. The two-storey building on the Northern Concourse will be more heavily loaded, but it is anticipated that, given the likely level of Glacial Sand and Gravel (41.5m – 42.5m AOD), traditional spread foundations (pads or strips) may be appropriate (see below).

Further ground investigation is proposed for the Mersey Square Gateway building and this report will be updated once the investigation is completed. However, at this stage and given the likely structural form, a semi-raft type foundation may be suitable.