# Appendix A14.2

Ground Investigation Report

# RINGSEND TO CITY CENTRE CORE BUS CORRIDOR SCHEME
# GEOTECHNICAL INTERPRETATIVE REPORT
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# 1. INTRODUCTION AND DESKTOP REVIEW

The existing site investigation information for the area has been taken from the Geological Survey of Ireland (GSi) website and the British Geological Survey (BGS) website, including the Quaternary and Bedrock Geology of Dublin and Depth of Bedrock digital maps.

The following selection of published papers has found to be of relevance to estimate the lithology and geotechnical properties:

- "Geotechnical properties of Dublin boulder clay". Authors: Long, Michael M and Menkiti, Christopher O. Sept 2007, Géotechnique 57 (7): 595-611. Published by the ICE.
- Ground Investigation Report of the National Pediatric Hospital Project, Dublin. Roughan & O'Donovan Consulting Engineers, January 2015.

## 1.1 Overview of geotechnical conditions along the Project.

Quaternary sediments cover up to 80% of the Dublin region. Quaternary thicknesses at the city area range from 5 to 20m. Maximum thicknesses are recorded along a Tertiary channel occurring on the north shore of the River Liffey valley, reaching 45m, and along a channel-like feature running along the south margin of the Dodder valley Quaternary sediments, with a thickness of 15 to 25 m.

The most commonly occurring Quaternary deposit in the area has been termed locally as the Dublin Boulder Clay. It is a glacial deposit derived from the Lower Carboniferous Limestone and it is classified by its two main members: the Black Boulder Clay (BkBC) and the Brown Boulder Clay (BrBC). The Brown Boulder Clay is less consolidated and since it overlies the Black Boulder Clay it has been interpreted as its weathered upper layer.

The Upper Brown Boulder Clay (UBrBC) is the outcome of the oxidation of the clay particles in the top 2m to 3m of the UBkBC, resulting in a change in colour from black to brown and a lower strength material. It is usually described as thick stiff to very stiff brown, slightly sandy clay, with rare silt / gravel lenses and some rootlets, particularly in the upper metre.

The Upper Black Dublin Boulder Clay (UBkBC) is a very stiff, dark grey, slightly sandy clay, with some gravel and cobbles. It is typically 4 m to 12 m thick.

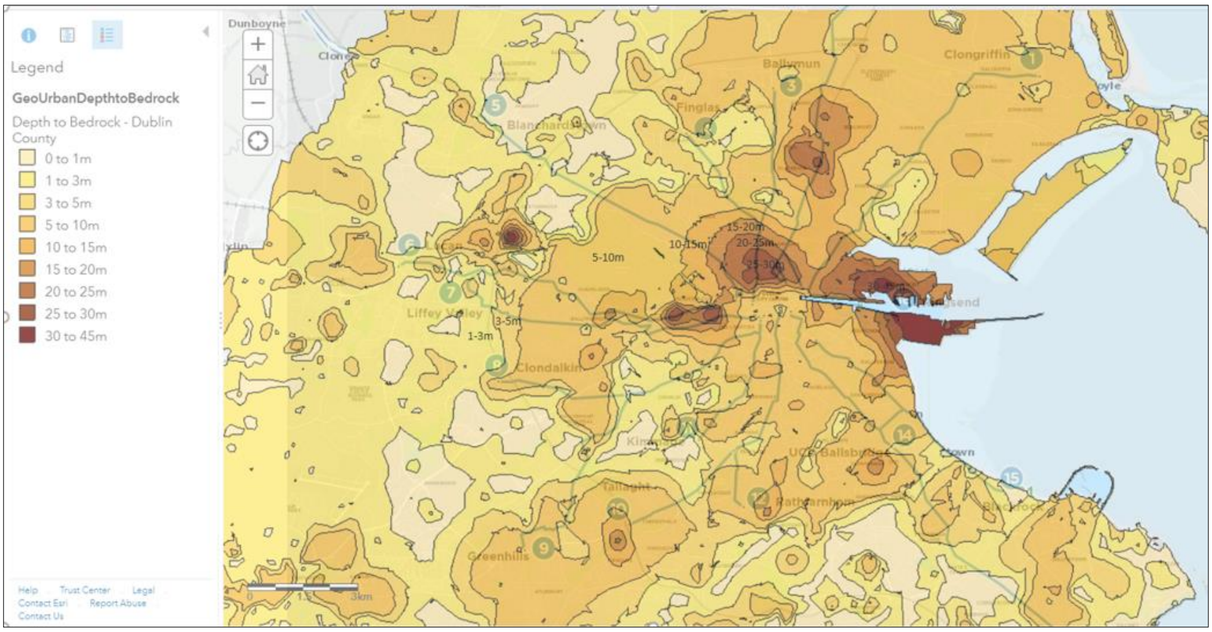
The Lower Brown Dublin Boulder Clay (LBrBC) exists as a 5 m to 9 m thick hard, brown, silty clay, with gravel, cobbles and boulders. It has previously been called the "sandy boulder clay" as it is similar to but siltier than the UBkBC above.

The Lower Black Dublin Boulder Clay (LBkBC) is a patchy layer of hard slightly sandy gravelly clay with an abundance of boulders. Its thickness does not exceed 4 m and is typically less than 2 m.

Note that not all four distinct formations of the Dublin Boulder Clay are always present. The upper two units though have been proven at all investigation sites across the city.

Bedrock close to the surface occurs mostly along the main riverbeds as well as the coastline and the higher ground areas of the Howth peninsula. The bedrock map of Ireland shows a wide variety of rock types which have originated at different periods of geological time. Underlaying the project area consists of Lower Carboniferous Limestone of the Lucan Formation (Calp), which is typically described as a dark grey to black fine grained limestone.

The following image from the Geological Survey Ireland website shows the expected depth to Bedrock.




*Depth of Bedrock from the Geological Survey Ireland website*

The water pressures correspond to hydrostatic conditions with a groundwater table about 2m below ground level.

- *Summary of Desktop Review.*

The following preliminary lithology and geotechnical properties has been assumed based on the Desktop Review:

| Layer | Depth | Thickness | Undrained shear strength, $c_u$ (kPa) |
|---|---|---|---|
| Made ground / Urban / Alluvium | 0 to 1 m | 1 | 0 |
| Upper Brown Boulder Clay, UBrBC | 1 to 3 m | 2 | 80 |
| Upper Black Boulder Clay, UBkBC | 3 to 10 m | 7 | 200 |
| Lower Brown Boulder Clay, LBrBC | 10 to 18 m | 8 | 400 |
| Lower Black Boulder Clay, LBkBC | 18 to 22 m | 4 | 600 |
| Bedrock | >22 m | N/A | >600 |

The expected depth to bedrock has been included in Section 2.

# 2. SUMMARY OF GROUND INVESTIGATION CONTRACT

At the date of this document, there are two GI contracts underway. Lot 1, which includes projects C and D , and Lot 2, which covers A and B projects.

Proposed ground investigation works aim to assess the geology of the site and determine the ground properties and conditions to enable the design of Bus Connects Core Bus Corridors. The GI provides for boreholes, trial pits, dynamic probes, standpipes/piezometer installation and monitoring, in-situ testing, geotechnical and environmental laboratory testing and preparation of a factual report, all in accordance with the "*Specification and Related Documents for Ground Investigation in Ireland*".

At the Project D schemes (Ballymun/Finglas to City Centre, Kimmage to City Centre and Ringsend to City Centre), there are 21 proposed investigation points, consisting of Cable Percussion (CP) and Rotary Core (RC) boreholes as well as few windowless dynamic samples (WS) in restricted space areas. The location of these points can be found in the form of drawings in the "*BusConnects Detailed Ground Investigation – Stage 1 – LOT 1*", February 2020.

In situ tests mainly include standard penetration tests. Laboratory tests mainly include particle size distribution, Atterberg limits, density and moisture content to identify soils and direct shear strength, triaxial CU or UU and uniaxial compression to determine the strength of the soil/rock.

For more details see the "*BusConnects Detailed Ground Investigation – Stage 1 – LOT 1*", February 2020.

For the Ringsend to City Centre Core Bus Corridor Scheme, the following investigation points have been proposed:

| Borehole Ref. | Expected Depth to Bedrock | Borehole Depth (m) – Cable Percussion | Borehole Depth (m) – Rotary Core |
|---|---|---|---|
| R16-CP01 | 10-15m | 15 | - |
| R16-CP02 | 10-15m | 15 | - |
| R16-CP03 | 15-20m | 15 | - |
| R16-CP04 | 15-20m | 15 | - |

# 3. SUMMARY OF FACTUAL REPORT

The following factual report was issued as part of the Lot 1 GI:

- Detailed Stage 1 Lot 1 Route 16. June 2021

Completed investigation points are as summarised below:

| Structure | Borehole Ref. | Expected Depth to Bedrock | Borehole Depth (m) – Cable Percussion | Borehole Depth (m) – Rotary Core | Notes |
|---|---|---|---|---|---|
| Ringsend 01 | R16-CP01 | 10-15m | 5.0 | - | |
| | R16-CP02 | 10-15m | 9.1 | - | |
| Ringsend 03 | R16-CP03 | 15-20m | 12.3 | - | |
| | R16-CP04 | 15-20m | 13.5 | - | |

The GI works undertaken comprise 4 No. Cable Percussion Boreholes to a maximum depth of 13.5m BGL; 22 SPT tests at 1 metre intervals alternating with disturbed samples and 6 GWL recordings.

13 disturbed samples were taken at each change of soil consistency or between SPT tests and 4 undisturbed samples (UT100) where ground conditions permit. Geotechnical testing consisting of 13 moisture content, 2 Atterberg limits, 2 Bulk Density and 9 Particle Size Distribution. Soil strength testing consisted of 4 Vane tests and 4 Shear Box.

Environmental & Chemical testing consisted of 19 Suite E samples and 1 pH and organic matter content test.

# 4. OVERVIEW OF SOIL CLASSIFICATION

## 4.1 Made ground

Made Ground deposits were encountered beneath the Topsoil/Surfacing and were present to depths of between 2.50m and 5.30m BGL.

Made ground deposits were described generally as either brown, sandy gravelly Clay with cobbles or greyish brown clayey gravely Sand with occasional cobbles and contained occasional fragments of concrete, plastic, red brick and wood.

Note that a culvert was encountered in borehole R16-CP02 between 3.0 and 5.3m, which was noted as a void on the log.

The Particle Size Distribution tests confirm that generally the Made ground deposits are well-graded graded with percentages of sands between 22% and 53% and percentages of gravels between 31% and 69%.

PH and total organic carbon (TOC) were determined at R16-CP04 at 0.5m depth. Organic matter content (OMC) was estimated from TOC. PH, TOC and OMC values were 9.3, 1.6% w/w C and 2.8% w/w respectively.

Asbestos was detected at 0.5m depth at borehole R16-CP03.

## 4.2 Cohesive deposits

Cohesive deposits were encountered beneath the Made Ground or interbedded with Granular Deposits and were described typically as grey slightly sandy silty CLAY.

The strength of the cohesive deposits was typically very soft till depths of 11.7mBGL.

Cohesive deposits found to be a CLAY of high plasticity, with a plasticity index ranging between 29% and 31%.

Particle Size Distribution tests confirm generally well-graded deposits with percentages of sands and gravels ranging between 11% and 15% and 2% and 5%, respectively.

## 4.3 Granular deposits

Granular deposits were encountered interbedded with cohesive deposits in the majority of holes and were typically described as either greyish sandy sub rounded to rounded fine to coarse GRAVEL with occasional cobbles or gravelly fine to coarse SAND.

Based on the SPT N values the deposits vary from loose to dense.

Particle Size Distribution tests confirm generally well-graded deposits with percentages of sands and gravels ranging between 18% and 58% and 33% and 69%, respectively.

# 5. SUMMARY OF GROUND INVESTIGATION INTERPRETATIVE REPORT

For RingsenD to City Centre CBC scheme, the following lithology and soil strength properties has been assumed based on the GI findings:

| Layer | Depth (m) | SPT | Undrained shear strength, $c_u$ (kPa) |
|---|---|---|---|
| Topsoil, Concrete | 0 to 0.5 | - | - |
| Made Ground: Brown Clay (possibly UBrBC) / Sand / Gravel | 0.5 to 6 | 6 | 40 |
| Very soft silty Grey Clay (only found in 2 out of 4 boreholes) | 6 to 12 | 3.5 | 20 |
| Gravel | Top level between 6 and 12m | 50 | 325 |

- 2 Vane tests at Made Ground Sand layer, defined as brown very sandy Gravel or brown very gravelly Sand, have shown Peak shear strength values higher than 146 KPa.

- 2 Vane tests at soft silty clay layer, shown Peak shear strength values between 11 and 13 kPa.

- 2 Shear Box tests at Made Ground Sand layer, defined as brown silty (very) gravelly Sand, shown angle of peak shearing resistant values between 34 and 44 degrees and effective cohesion values between 4 and 13 kPa.

The geological geotechnical ground profile can be found at Appendix 1.

Ground parameters from in situ and lab tests are shown in Appendix 2.

# 6. HIDROGEOLOGY

Groundwater was noted during the investigation although the exploratory holes did not remain open for sufficiently long periods of time to establish the hydrogeological regime. However, standpipes were installed to allow the equilibrium groundwater level to be determined.

Groundwater levels recorded during the GI works are summarized below:

| Date: | 20/4/21 | 16/6/21 |
|---|---|---|
| R16-CP01 | 4.46 | 4.72 |
| R16-CP02 | 5.03* | - |
| R16-CP03 | - | 2.47 |
| R16-CP04 | 3.73 | 4.40 |
| * Water depth might be unrepresentative due to culvert | | |

# 7. GEOTECHNICAL INPUT TO STRUCTURES

The following table shows the expected depth to bedrock, based on the data from the Desktop Review, as well as the depth of the encountered bedrock in the GI undertaken.

Note that most of the boreholes were terminated at a shorter length, before encountering the bedrock strata. Therefore, the expected depth to bedrock could not be confirmed.

| Structure | Permanent loads / Variable loads (KN) | Borehole Ref. | Expected Depth to Bedrock | Depth to encountered Bedrock | Depth to $N_{SPT}$ values of Refusal | Piles estimated length (m) |
|---|---|---|---|---|---|---|
| Ringsend 01 D=0.5m | 294 / 623 | R16-CP01 | 10-15m | - | 5m | 11.0 |
| | | R16-CP02 | 10-15m | - | 6m | 11.5 |
| Ringsend 02 D=0.2m | 50 | R16-CP03 | 15-20m | - | 12.5m | 11.5 |
| | | R16-CP04 | 15-20m | - | 12.5m | 12.5 |
| Ringsend 03 D=0.5m | 210 / 604 | R16-CP03 | 15-20m | - | 12.5m | 15.5 |
| | | R16-CP04 | 15-20m | - | 12.5m | 16.5 |

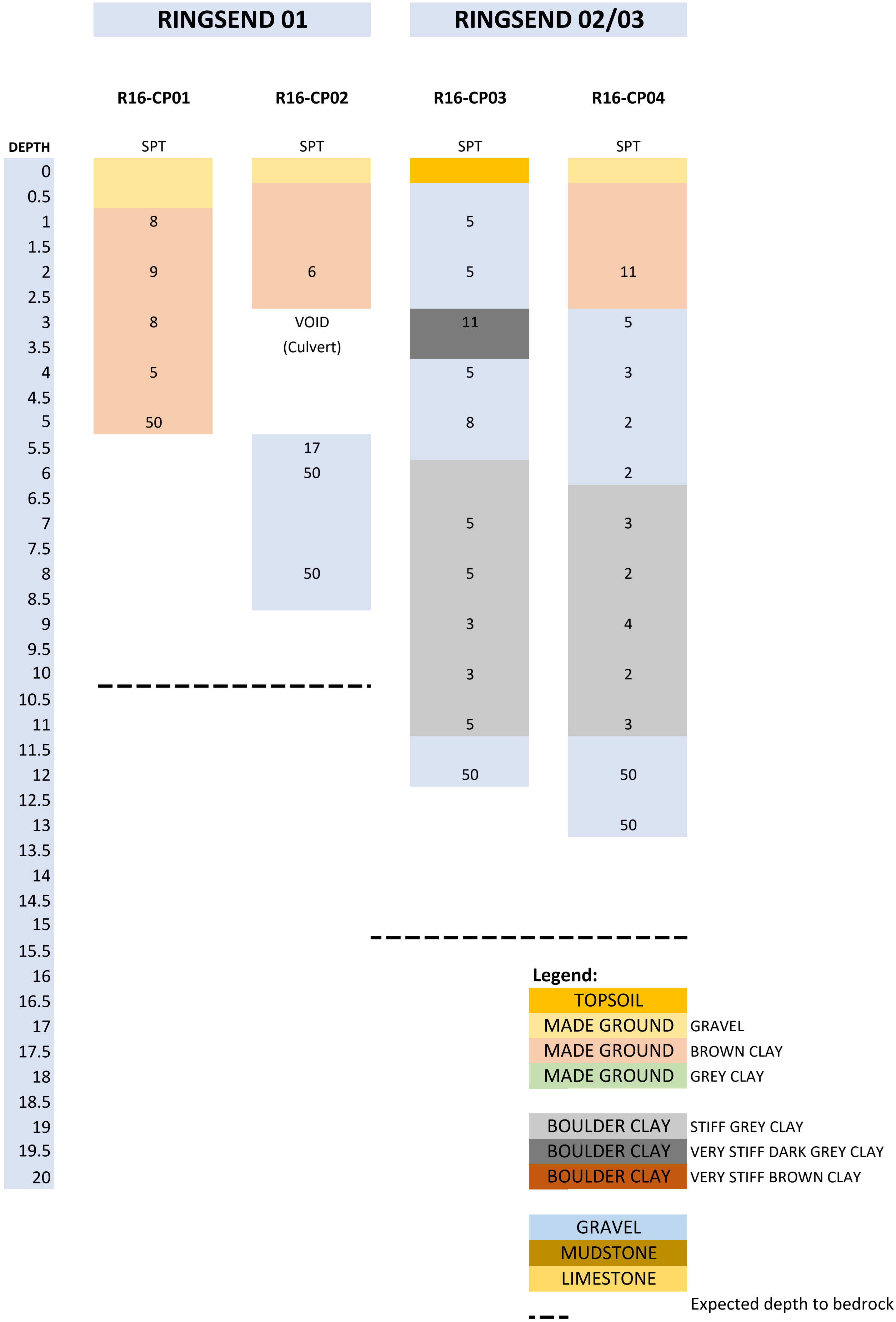
A preliminary number of the characteristic compressive resistance of piles has been obtained following the alternative procedure in accordance with the Eurocode 7 and the Irish National Annex. This procedure makes use of the ground parameters (such as the undrained shear strength, $c_u$) to estimate the shaft and base compressive resistance of piles.

Cu values have been derived from SPT values obtained in each borehole following the SPT-Cu relationship proposed by Stroud and Butler (1975). Calcs can be found at Appendix 3.

In Ringsend 01 and 03 0.5m diameter driven piles embedded in the Dublin boulder clay and Ringsend 02 0.2m piles, the estimated piles length that satisfies the ULS is as detailed in the table above.

# 8. APPENDICES

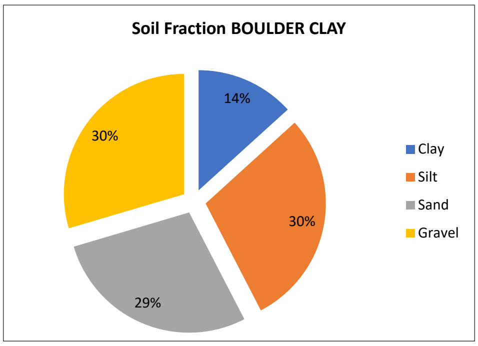
## 8.1 Geological geotechnical profile

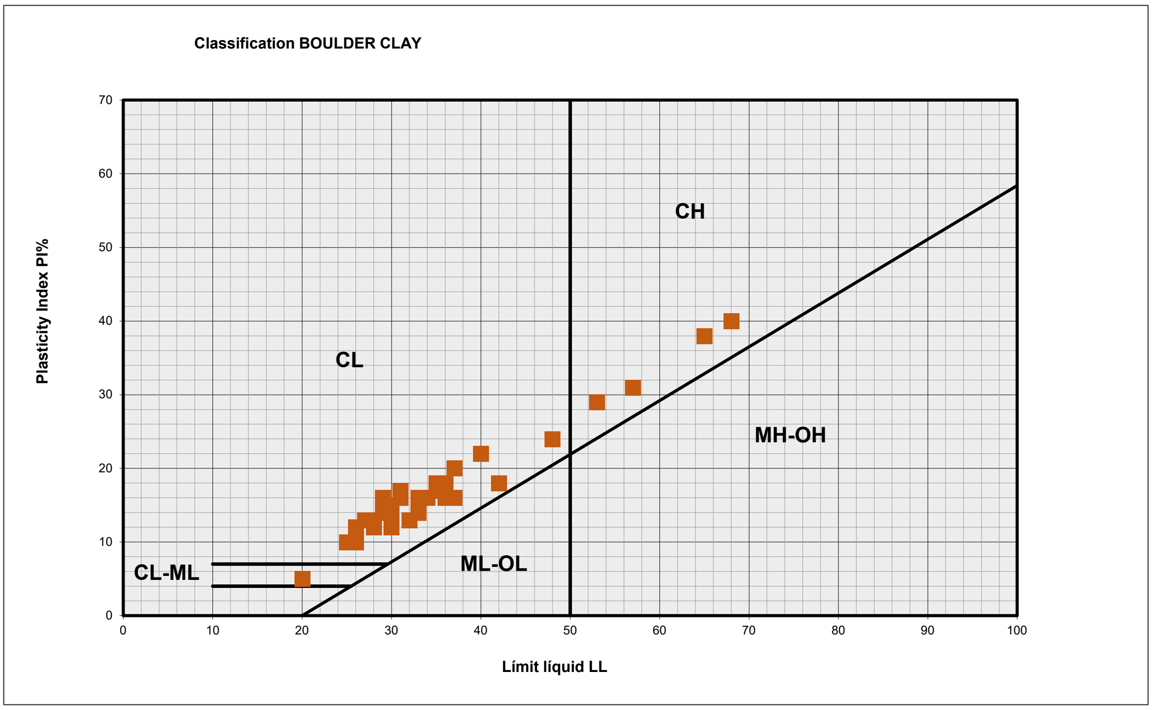

RINGSEND 01
RINGSEND 02/03
R16-CP01
R16-CP02
R16-CP03
R16-CP04
DEPTH
SPT
SPT
SPT
SPT
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
10.5
11
11.5
12
12.5
13
13.5
14
14.5
15
15.5
16
16.5
17
17.5
18
18.5
19
19.5
20
8
9
8
5
50
6
VOID
(Culvert)
17
50
50
5
5
11
5
8
5
5
3
3
5
50
11
5
3
2
2
3
2
4
2
3
50
50
Legend:
TOPSOIL
MADE GROUND
GRAVEL
MADE GROUND
BROWN CLAY
MADE GROUND
GREY CLAY
BOULDER CLAY
STIFF GREY CLAY
BOULDER CLAY
VERY STIFF DARK GREY CLAY
BOULDER CLAY
VERY STIFF BROWN CLAY
GRAVEL
MUDSTONE
LIMESTONE
Expected depth to bedrock

## 8.2 Ground parameters

**SOIL CLASSIFICATION**

| Borehole | Soil description | Sample type | Top depth (m) | Moisture Content % | Particle density $Mg/m^3$ | Bulk density $Mg/m^3$ | Liquid limit % | Plastic limit % | Plasticity Index % | Passing 0.425mm % | Classification | | Particle size distribution - Soil Fraction | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | Clay | Silt | Sand | Gravel | Cobbles | Total |
| Glasnevin BH01 | - | CB | 2.1 | 9.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH01 | Dark grey slightly sandy gravelly silty CLAY | CB | 3.6 | 10.1 | - | - | 34 | 18 | 16 | 33.1 | CL | - | 8% | 15% | 18% | 58% | 0% | 100% |
| Glasnevin BH01 | - | CB | 5.1 | 7.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH01 | Dark grey slightly sandy slightly gravelly silty CLAY | CB | 6.6 | 7.8 | - | - | - | - | - | - | - | - | 10% | 25% | 32% | 33% | 0% | 100% |
| Glasnevin BH01 | - | CB | 8.1 | 6.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH01 | Dark grey silty very sandy fine to coarse GRAVEL | C | 8.8 | 6.2 | - | - | 20 | 15 | 5 | 34 | CL-ML | - | 4% | 17% | 35% | 44% | 0% | 100% |
| Glasnevin BH01 | - | CB | 9.6 | 29.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH01 | - | CB | 11.1 | 16.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH01 | Dark grey slightly sandy gravelly silty CLAY | C | 11.9 | 11 | - | - | 36 | 18 | 18 | 55.8 | CL | - | 17% | 29% | 15% | 39% | 0% | 100% |
| Glasnevin BH01 | - | CB | 12.6 | 8.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH01 | - | CB | 14.1 | 9.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH01 | - | CB | 15.6 | 9.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH01 | Dark gery/brown slightly gravelly slightly sandy slity CLAY | C | 16.4 | 9.6 | - | - | 33 | 17 | 16 | 72.3 | CL | - | 17% | 30% | 35% | 18% | 0% | 100% |
| Glasnevin BH02A | - | CB | 2.4 | 12.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH02A | Dark grey slightly gravelly slightly sandy silty CLAY. | C | 4.7 | 8.1 | - | - | 30 | 18 | 12 | 60.6 | CL | - | 14% | 31% | 31% | 24% | 0% | 100% |
| Glasnevin BH02A | - | CB | 6.9 | 8 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH02A | Dark grey slightly sandy slightly gravelly silty CLAY | C | 10.95 | 9.3 | - | - | 36 | 19 | 17 | 57.8 | CL | - | 14% | 30% | 25% | 31% | 0% | 100% |
| Glasnevin BH02A | Dark grey slightly sandy slightly gravelly silty CLAY | C | 16.5 | 9.3 | - | - | 35 | 17 | 18 | 55.8 | CL | - | 14% | 30% | 22% | 34% | 0% | 100% |
| Glasnevin BH02A | - | CB | 17.4 | 9.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH02A | - | CB | 20.4 | 10 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH02A | Dark grey slightly sandy slightly gravelly silty CLAY | C | 22 | 9.8 | - | - | 37 | 17 | 20 | 67.1 | CL | - | 15% | 35% | 25% | 25% | 0% | 100% |
| Glasnevin BH02A | - | CB | 23.4 | 9.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| Glasnevin BH02A | Dark grey slightly gravelly slightly sandy silty CLAY | C | 25.2 | 12.3 | - | - | 40 | 18 | 22 | 78.9 | CL | - | 19% | 41% | 25% | 14% | 0% | 100% |
| Metrolink GBH01 | Greyish brown sandy gravelly silty CLAY | B | 1.2 | 12 | - | - | 33 | 19 | 14 | 69 | CL | Low Plasticity CL | 15% | 33% | 30% | 22% | 0% | 100% |
| Metrolink GBH01 | Greyish brown sandy gravelly silty CLAY | B | 2 | 12 | - | - | 32 | 19 | 13 | 63 | CL | Low Plasticity CL | 17% | 31% | 30% | 23% | 0% | 101% |
| Metrolink GBH01 | Greyish brown sandy gravelly CLAY | B | 4 | 12 | - | - | 26 | 15 | 11 | 64 | CL | Low Plasticity CL | 17% | 35% | 32% | 17% | 0% | 101% |
| Metrolink GBH01 | Greyish brown sandy gravelly CLAY | B | 6.6 | 7.7 | - | - | 26 | 15 | 11 | 62 | CL | Low Plasticity CL | 10% | 33% | 39% | 19% | 0% | 101% |
| Metrolink GBH01 | Greyish brown sandy gravelly CLAY | B | 9.4 | 19 | - | - | 27 | 14 | 13 | 44 | CL | Low Plasticity CL | 8% | 20% | 51% | 21% | 0% | 100% |
| Metrolink GBH01 | - | C | 12 | 8.1 | - | - | 26 | 16 | 10 | 57 | CL | Low Plasticity CL | 17% | 34% | 36% | 13% | 0% | 100% |
| Metrolink GBH01 | - | B | 16.6 | 7 | - | - | - | - | - | - | - | - | - | 4% | 23% | 54% | 20% | 101% |
| Metrolink GBH01 | - | B | 17.2 | 8.2 | - | - | 25 | 15 | 10 | 58 | CL | Low Plasticity CL | 17% | 35% | 36% | 13% | 0% | 101% |
| Metrolink GBH02 | Greyish brown sandy gravelly silty CLAY | B | 2 | 16 | - | - | 48 | 24 | 24 | 70 | CI | Low Plasticity CL | 14% | 33% | 30% | 23% | 0% | 100% |
| Metrolink GBH02 | Greyish brown sandy gravelly silty CLAY | B | 4 | 11 | - | - | 29 | 14 | 15 | 60 | CL | Low Plasticity CL | 16% | 34% | 30% | 20% | 0% | 100% |
| Metrolink GBH02 | Greyish brown sandy gravelly CLAY | B | 6 | 8.1 | - | - | 25 | 15 | 10 | 58 | CL | Low Plasticity CL | 13% | 34% | 32% | 21% | 0% | 100% |
| Metrolink GBH02 | Grey very gravelly very sandy CLAY | C | 9.6 | 10 | - | - | 30 | 16 | 14 | 51 | CL | Low Plasticity CL | 15% | 21% | 29% | 35% | 0% | 100% |
| Metrolink GBH02 | Greyish brown sandy gravelly CLAY | B | 14 | 10 | - | - | 30 | 15 | 15 | 72 | CL | Low Plasticity CL | - | - | - | - | - | 0% |
| Metrolink GBH02 | Greyish brown sandy gravelly CLAY | B | 16 | 10 | - | - | 28 | 15 | 13 | 63 | CL | Low Plasticity CL | 12% | 25% | 45% | 19% | 0% | 101% |
| Metrolink GBH21 | Greyish brown sandy gravelly silty CLAY | B | 1.2 | 8.5 | - | - | 26 | 15 | 11 | 50 | CL | Low Plasticity CL | 10% | 40% | 38% | 13% | 0% | 101% |
| Metrolink GBH22 | Greyish brown sandy gravelly silty CLAY | B | 1.2 | 8.7 | - | - | 26 | 14 | 12 | 46 | CL | Low Plasticity CL | 13% | 34% | 35% | 19% | 0% | 101% |
| Metrolink GBH28 | Greyish brown sandy gravelly silty CLAY | B | 1.2 | 8 | - | - | 28 | 16 | 12 | 55 | CL | Low Plasticity CL | 10% | 33% | 40% | 18% | 0% | 101% |
| R03-CP03 | Dark brown mottled grey sandy slightly gravelly CLAY | B | 2 | 17 | - | - | - | - | - | - | - | - | - | 34% | 42% | 24% | 0% | 100% |
| R03-CP03 | Brown slightly sandy slightly gravelly CLAY | B | 3 | 19 | - | - | - | - | - | - | - | - | - | 46% | 25% | 29% | 0% | 100% |
| R03-CP03 | Dark brown mottled grey slightly sandy slightly gravelly CLAY | B | 5 | 12 | 2.64 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R03-CP03 | Dark brown mottled grey slightly sandy slightly gravelly CLAY | B | 6 | 12 | - | - | 29 | 15 | 14 | 64 | CL | Low Plasticity CL | - | 49% | 31% | 20% | 0% | 100% |
| R03-CP07 | Brown slightly sandy gravelly CLAY | B | 1.5 | 23 | - | - | 35 | 18 | 17 | 43 | CI | Intermediate Plasticity CI | - | 29% | 24% | 47% | 0% | 100% |
| R03-CP07 | Brown slightly sandy gravelly CLAY | B | 3 | 16 | 2.6 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R03-CP07 | Brown mottled grey slightly sandy slightly gravelly CLAY with many cobbles. | B | 5 | 12 | - | - | 29 | 15 | 14 | 31 | CL | Low Plasticity CL | - | 24% | 14% | 27% | 35% | 100% |
| R03-CP07 | Brown slightly sandy gravelly CLAY | B | 6 | 14 | 2.7 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R03-CP08 | Brown slightly sandy slightly gravelly CLAY | B | 2.2 | 31 | 2.64 | - | 68 | 28 | 40 | 65 | CH | High Plasticity CH | 27% | 33% | 10% | 30% | 0% | 100% |
| R03-CP08 | Stiff brown slightly sandy gravelly CLAY | U | 3.5 | 9.4 | 2.62 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R03-CP08 | Brown slightly sandy very gravelly CLAY | B | 4 | 11 | - | - | 31 | 15 | 16 | 50 | CL | Low Plasticity CL | 17% | 23% | 23% | 37% | 0% | 100% |
| R03-CP14 | MADE GROUND dark grey very gravelly clayey sand of ash. | B | 2 | 38 | 2.03 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R03-CP14 | Dark grey gravelly slightly sandy CLAY with some organic material | B | 3 | 49 | - | - | 65 | 27 | 38 | 51 | CH | High Plasticity CH | 15% | 27% | 23% | 35% | 0% | 100% |
| R03-CP14 | Dark grey very gravelly very sandy CLAY. | B | 4 | 15 | 2.59 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R03-CP14 | Dark grey sandy very clayey GRAVEL | B | 5 | 10 | - | - | 29 | 13 | 16 | 36 | CL | Low Plasticity CL | 11% | 17% | 16% | 56% | 0% | 100% |
| R03-CP14 | Dark grey very gravelly very sandy CLAY. | B | 6 | 11 | 2.61 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R03-CP14 | Dark grey gravelly slightly sandy CLAY | B | 7 | 14 | - | - | 31 | 14 | 17 | 51 | CL | Low Plasticity CL | 16% | 25% | 22% | 37% | 0% | 100% |
| R03-CP14 | Dark grey very gravelly very sandy CLAY. | B | 8 | 13 | 2.6 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R03-CP14 | Brown slightly sandy gravelly CLAY | B | 9 | 13 | | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R11-CP01 | Grey brown slightly sandy slightly gravelly silty CLAY | B | 2 | 15.6 | - | - | 42 | 24 | 18 | 59 | CL | - | 13% | 32% | 24% | 31% | 0% | 100% |
| R11-CP01 | Grey brown slightly sandy slightly gravelly silty CLAY | B | 2.5 | 14.2 | - | - | - | - | - | - | - | - | - | 45% | 24% | 32% | 0% | 100% |
| R11-CP01 | Grey brown slightly sandy slightly gravelly silty CLAY | B | 4 | 15.9 | - | - | 37 | 21 | 16 | 59 | CL | - | 0% | 31% | 28% | 28% | 0% | 87% |
| R11-CP01 | Dark grey slightly gravelly slightly sandy silty CLAY | B | 5.5 | 13.5 | - | - | - | - | - | - | - | - | - | 45% | 28% | 27% | 0% | 100% |
| R11-CP01 | Dark grey slightly sandy slightly gravelly silty CLAY | B | 6 | 13.6 | - | - | 30 | 18 | 12 | 54.5 | CL | - | 13% | 27% | 26% | 34% | 0% | 100% |
| R11-CP01 | Dark grey slightly sandy slightly gravelly silty CLAY | B | 7.5 | 13.3 | - | - | 34 | 18 | 16 | 58.2 | CL | - | 14% | 30% | 28% | 28% | 0% | 100% |
| R11-CP01 | Dark grey slightly sandy slightly gravelly silty CLAY | B | 8 | 14.3 | - | - | - | - | - | - | - | - | - | 41% | 25% | 34% | 0% | 100% |
| R11-CP03 | MADE GROUND brownish grey very gravelly very sandy CLAY | B | 2 | 23 | - | - | 36 | 20 | 16 | 49 | CI | Intermediate Plasticity CI | - | - | - | - | - | 0% |
| R11-CP03 | Grey very sandy clayey GRAVEL | B | 3 | 15 | 2.67 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R11-CP03 | - | B | 4.48 | 0.3 | - | 2.71 | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R16-CP01 | Brown slightly clayey silty very sandy GRAVEL | B | 1.2 | 11 | 2.61 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R16-CP01 | Brown silty very sandy GRAVEL | B | 2 | 4.7 | - | - | - | NP | - | | - | - | - | 17% | 30% | 40% | 13% | 100% |
| R16-CP02 | Brown very gravelly SAND | B | 1 | 13 | 2.64 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R16-CP02 | Brown silty very sandy GRAVEL | B | 2 | 9.7 | - | - | - | NP | - | - | - | - | - | 6% | 25% | 69% | 0% | 100% |
| R16-CP02 | Brown & grey silty SAND | U100 | 6.5 | 19 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R16-CP02 | Brown mottled grey slightly sandy slightly gravelly CLAY with some organic material | U100 | 7.5 | 41 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R16-CP02 | Brown slightly silty very sandy GRAVEL | B | 8 | 3.5 | 2.62 | - | - | NP | - | - | - | - | - | 2% | 29% | 69% | 0% | 100% |
| R16-CP04 | Brown silty very sandy GRAVEL with many cobbles | B | 1 | - | 2.68 | - | - | - | - | - | - | - | - | 9% | 22% | 35% | 34% | 100% |
| R16-CP04 | Brown slightly clayey silty very gravelly SAND | B | 3 | - | 2.62 | - | - | - | - | - | - | - | - | 16% | 53% | 31% | 0% | 100% |
| R16-CP04 | Brown slightly clayey silty very gravelly SAND | B | 4 | 14 | 2.65 | 2.06 | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R16-CP04 | Brown silty very gravelly SAND | B | 5 | - | 2.66 | - | - | - | - | - | - | - | - | 9% | 58% | 33% | 0% | 100% |
| R16-CP04 | Brown silty gravelly SAND | B | 6 | 6.4 | 2.65 | 1.7 | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R16-CP04 | Brown & grey silty SAND | U100 | 6.5 | 19 | 2.58 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R16-CP04 | Brown mottled grey slightly sandy slightly gravelly CLAY with some organic material | B | 7 | 47 | - | - | 57 | 26 | 31 | 90 | CH | High plasticity CH | - | 84% | 11% | 5% | 0% | 100% |
| R16-CP04 | Brown mottled grey slightly sandy slightly gravelly CLAY with some organic material | U100 | 7.5 | 41 | 2.52 | - | - | - | - | - | - | - | - | - | - | - | - | 0% |
| R16-CP04 | Brown mottled grey slightly sandy slightly gravelly CLAY with some organic material | B | 8 | 46 | - | - | 53 | 24 | 29 | 93 | CH | High plasticity CH | - | 83% | 15% | 2% | 0% | 100% |
| R16-CP04 | Brownish grey silty sandy GRAVEL with cobbles | B | 12 | - | 2.69 | - | - | - | - | - | - | - | - | 5% | 18% | 67% | 10% | 100% |


Soil Fraction BOULDER CLAY
14%
30%
29%
30%
Clay
Silt
Sand
Gravel


Classification BOULDER CLAY
Plasticity Index PI%
Límit líquid LL
CH
CL
MH-OH
ML-OL
CL-ML
0
10
20
30
40
50
60
70
80
90
100

**SOIL STRENGTH**

| Test | BH | Top depth (m) | Soil | $N_{SPT}$ | Correlation factor | Cu (KPa) |
|---|---|---|---|---|---|---|
| SPT | R11-CP04 | 1 | MADE GROUND: Brown slightly sandy slightly gravelly silty CLAY. Gravel is anugular to sub rounded fine to coarse with occasional fragments of brick and concrete. | 10 | 6.5 | 65 |
| | R11-CP04 | 2 | Medium dense greyish brown sandy sub angular to rounded fine to coarse GRAVEL | 27 | | 175.5 |
| | R11-CP04 | 2.6 | Firm brownish grey slightly sandy gravelly CLAY. Gravel is angular to sub rounded fine to coarse | 50 | | 325 |
| | R11-CP01 | 1.2 | MADE GROUND: Greyish brown slightly sandy gravelly Clay with occasional sub-angular to sub-rounded cobbles, red brick and mortar fragments. | 2 | | 13 |
| | R11-CP01 | 2 | MADE GROUND: Greyish brown slightly sandy gravelly Clay with occasional sub-angular to sub-rounded cobbles, red brick and mortar fragments. | 4 | | 26 |
| | R11-CP01 | 3 | MADE GROUND: Greyish brown slightly sandy gravelly Clay with occasional sub-angular to sub-rounded cobbles, red brick and mortar fragments. | 13 | | 84.5 |
| | R11-CP01 | 4 | Very stiff brown slightly sandy slightly gravelly CLAY with occasional sand lenses. | 35 | | 227.5 |
| | R11-CP01 | 5 | Very stiff dark grey slightly sandy gravelly CLAY with rare sub-rounded cobbles. | 28 | | 182 |
| | R11-CP01 | 6 | Very stiff dark grey slightly sandy gravelly CLAY with rare sub-rounded cobbles. | 31 | | 201.5 |
| | R11-CP01 | 7 | Very stiff dark grey slightly sandy gravelly CLAY with rare sub-rounded cobbles. | 35 | | 227.5 |
| | R11-CP01 | 8 | Very stiff dark grey slightly sandy gravelly CLAY with rare sub-rounded cobbles. | 50 | | 325 |
| | R11-CP03 | 1 | MADE GROUND: Dark brown slightly sandy gravelly Clay with occasional angular to subrounded cobbles and occasional fragments of glass, metal, red brick and wood (creosote like odour) | 3 | | 19.5 |
| | R11-CP03 | 2 | MADE GROUND: Grey slightly sandy slightly gravelly Clay with occasional angular to subangular cobbles and occasional fragments of red brick and wood | 9 | | 58.5 |
| | R11-CP03 | 3 | MADE GROUND: Grey slightly sandy slightly gravelly Clay with occasional angular to subangular cobbles and occasional fragments of red brick and wood | 50 | | 325 |
| | R16-CP01 | 1.2 | MADE GROUND: Brown slightly sandy gravelly Clay with some subangular to rounded cobbles, occasional boulders and occasional fragments of red brick | 8 | | 52 |
| | R16-CP01 | 2 | MADE GROUND: Brown slightly sandy gravelly Clay with some subangular to rounded cobbles, occasional boulders and occasional fragments of red brick | 9 | | 58.5 |
| | R16-CP01 | 3 | MADE GROUND: Brown slightly sandy gravelly Clay with some subangular to rounded cobbles, occasional boulders and occasional fragments of red brick | 8 | | 52 |
| | R16-CP01 | 4 | MADE GROUND: Brown slightly sandy gravelly Clay with some subangular to rounded cobbles, occasional boulders and occasional fragments of red brick | 5 | | 32.5 |
| | R16-CP01 | 5 | MADE GROUND: Brown slightly sandy gravelly Clay with some subangular to rounded cobbles, occasional boulders and occasional fragments of red brick | 50 | | 325 |
| | R16-CP02 | 2 | MADE GROUND: Brown slightly sandy gravelly Clay with occasional angular to subrounded cobbles and occasional fragments of concrete and red brick | 6 | | 39 |
| | R16-CP02 | 5.3 | MADE GROUND: Brown sandy clayey angular to rounded fine to coarse GRAVEL with occasional fragments of red brick (driller's notes) | 17 | | 110.5 |
| | R16-CP02 | 6 | Dense grey slightly clayey very sandy subangular to rounded fine to coarse GRAVEL with some subangular to rounded cobbles | 50 | | 325 |
| | R16-CP02 | 8 | Dense grey slightly clayey very sandy subangular to rounded fine to coarse GRAVEL with some subangular to rounded cobbles | 50 | | 325 |
| | R16-CP03 | 1 | MADE GROUND: Brown silty gravelly Sand withoccasional cobbles and boulders, and occasional fragments of concrete, plastic, wood and red brick | 6 | | 39 |
| | R16-CP03 | 2 | POSSIBLE MADE GROUND: Brown slightly gravelly clayey SAND. | 5 | | 32.5 |
| | R16-CP03 | 3 | Soft dark grey slighlty sandy very gravelly CLAY with occasional sub angular to sub rounded cobbles. Gravel is subrounded to rounded fine to coarse | 11 | | 71.5 |
| | R16-CP03 | 4 | Very loose grey very sandy subangular to rounded fine to coarse GRAVEL. | 5 | | 32.5 |
| | R16-CP03 | 5 | Very loose grey very sandy subangular to rounded fine to coarse GRAVEL. | 8 | | 52 |
| | R16-CP03 | 7 | Very soft grey slightly sandy silty CLAY with occasional shell fragments and orgnic matter. | 5 | | 32.5 |
| | R16-CP03 | 8 | Very soft grey slightly sandy silty CLAY with occasional shell fragments and orgnic matter. | 5 | | 32.5 |
| | R16-CP03 | 9 | Very soft grey slightly sandy silty CLAY with occasional shell fragments and orgnic matter. | 3 | | 19.5 |
| | R16-CP03 | 10 | Very soft grey slightly sandy silty CLAY with occasional shell fragments and orgnic matter. | 3 | | 19.5 |
| | R16-CP03 | 11 | Very soft grey slightly sandy silty CLAY with occasional shell fragments and orgnic matter. | 50 | | 325 |
| | R16-CP03 | 12 | Dense grey sandy subrounded to rounded fine to coarse GRAVEL with some subangular to rounded cobbles. | 50 | | 325 |
| | R16-CP04 | 2 | MADE GROUND: Brown slightly gravelly sandy CLAY with some cobbles and occasional fragments of red brick | 11 | | 71.5 |
| | R16-CP04 | 3 | MADE GROUND: Greyish brown clayey gravelly fine to coarse SAND. Gravel is subangular to rounded fine to coarse | 5 | | 32.5 |
| | R16-CP04 | 4 | MADE GROUND: Greyish brown clayey gravelly fine to coarse SAND. Gravel is subangular to rounded fine to coarse | 3 | | 19.5 |
| | R16-CP04 | 5 | Very loose dark grey clayey gravelly fine to coarse SAND. Gravel is subrounded to rounded fine to coarse | 2 | | 13 |
| | R16-CP04 | 6 | Very loose grey very gravelly fine to coarse SAND. Gravel is subrounded to rounded fine to coarse | 2 | | 13 |
| | R16-CP04 | 7 | Very soft grey slightly sandy silty CLAY with occasional shell fragments | 3 | | 19.5 |
| | R16-CP04 | 8 | Very soft grey slightly sandy silty CLAY with occasional shell fragments | 2 | | 13 |
| | R16-CP04 | 9 | Very soft grey slightly sandy silty CLAY with occasional shell fragments | 4 | | 26 |
| | R16-CP04 | 10 | Very soft grey slightly sandy silty CLAY with occasional shell fragments | 2 | | 13 |
| | R16-CP04 | 11 | Very soft grey slightly sandy silty CLAY with occasional shell fragments | 3 | | 19.5 |
| | R16-CP04 | 12 | Dense grey slightly clayey very sandy subrounded to rounded fine to coarse GRAVEL with some subangular to rounded cobbles | 50 | | 325 |
| | R16-CP04 | 13 | Dense grey slightly clayey very sandy subrounded to rounded fine to coarse GRAVEL with some subangular to rounded cobbles | 50 | | 325 |
| | Glasnevin BH01 | 2.1 | Stiff grey sandy gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is fine to coarse subangular to subrounded | 19 | | 123.5 |
| | Glasnevin BH01 | 3.6 | Very stiff grey sandy gravelly CLAY with occasional subangular to subrounded cobbles and boulders. Gravel is fine to coarse subangular to subrounded | 41 | | 266.5 |
| | Glasnevin BH01 | 5.1 | Driller notes gravelly CLAY - Recovery consists subangular to subrounded cobbles and boulders of Limestone | 50 | | 325 |
| | Glasnevin BH01 | 6.6 | Very stiff grey slightly sandy gravelly CLAY with occasional subangular to subrounded cobbles. Gravels fine to coarse subangular to subrounded. | 50 | | 325 |
| | Glasnevin BH01 | 8.1 | Very stiff grey slightly sandy gravelly CLAY with occasional subangular to subrounded cobbles. Gravels fine to coarse subangular to subrounded. | 50 | | 325 |
| | Glasnevin BH01 | 9.6 | Very stiff grey slightly sandy gravelly CLAY with occasional subangular to subrounded cobbles. Gravels fine to coarse subangular to subrounded. | 50 | | 325 |
| | Glasnevin BH01 | 11.1 | Very stiff grey slightly sandy gravelly CLAY with occasional subangular to subrounded cobbles. Gravels fine to coarse subangular to subrounded. | 50 | | 325 |
| | Glasnevin BH01 | 14.1 | Very stiff brown grey slightly sandy gravelly CLAY with occasional subangular to subrounded cobbles. Gravels fine to coarse subangular to subrounded | 50 | | 325 |
| | Glasnevin BH01 | 15.6 | Very stiff brown grey slightly sandy gravelly CLAY with occasional subangular to subrounded cobbles. Gravels fine to coarse subangular to subrounded | 50 | | 325 |
| | Glasnevin BH01 | 17.1 | Very stiff brown grey slightly sandy gravelly CLAY with occasional subangular to subrounded cobbles. Gravels fine to coarse subangular to subrounded | 50 | | 325 |
| | Glasnevin BH02A | 2.4 | Gravelly band. Very stiff dark grey slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse. | 44 | | 286 |
| | Glasnevin BH02A | 3.9 | Gravelly band. Very stiff dark grey slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse. | 50 | | 325 |
| | Glasnevin BH02A | 5.4 | Very stiff dark grey slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse. | 50 | | 325 |
| | Glasnevin BH02A | 6.9 | Gravelly band. Very stiff dark grey slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse. | 50 | | 325 |
| | Glasnevin BH02A | 8.4 | Very stiff dark grey slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse. | 50 | | 325 |
| | Glasnevin BH02A | 9.9 | Very stiff dark grey slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse. | 50 | | 325 |
| | Glasnevin BH02A | 11.25 | Very stiff dark grey slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse. | 50 | | 325 |
| | Glasnevin BH02A | 15.9 | Very stiff dark grey slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse. | 50 | | 325 |
| | Glasnevin BH02A | 17.4 | Very stiff brown slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse | 50 | | 325 |
| | Glasnevin BH02A | 18.7 | Very stiff brown slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse | 50 | | 325 |
| | Glasnevin BH02A | 2.4 | Very stiff brown slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse | 50 | | 325 |
| | Glasnevin BH02A | 21.9 | Very stiff brown slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse | 50 | | 325 |
| | Glasnevin BH02A | 23.4 | Very stiff brown slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse | 50 | | 325 |
| | Glasnevin BH02A | 24.9 | Very stiff brown slightly sandy gravelly CLAY. Gravel subangular to subrounded fine to coarse | 50 | | 325 |
| | Glasnevin BH02A | 26.4 | Dense grey fine to coarse angular to subangular GRAVEL with some angular to subrounded cobbles. Fines may have washed out | 50 | | 325 |
| | Metrolink GBH01 | 1.2 | Sand is fine to coarse. Gravel is subangular fine to coarse of mixed lithologies. Cobbles and boulders are subrounded to subangular of mixed lithologies. | 8 | | 52 |
| | Metrolink GBH01 | 3 | Stiff becoming very stiff black slightly sandy slightly gravelly silty CLAY.Sand is fine to coarse. Gravel is subangular to subrounded fine tomedium of mixed lithologies. | 29 | | 188.5 |
| | Metrolink GBH01 | 5 | Very stiff brownish grey sandy slightly gravelly silty CLAY. Sand is fineto coarse. Gravel is subangular fine to medium of limestone. | 50 | | 325 |
| | Metrolink GBH01 | 8 | Very stiff brownish grey sandy slightly gravelly silty CLAY. Sand is fineto coarse. Gravel is subangular fine to medium of limestone. | 50 | | 325 |
| | Metrolink GBH01 | 11 | Greyish brown slightly silty gravelly fine to coarse SAND. Gravel issubangular fine to coarse of limestone and sandstone. | 50 | | 325 |
| | Metrolink GBH01 | 14 | Grey and brown slightly sandy subangular ne to coarse GRAVEL of limestone and sandstone with low cobble content.Sand is ne to coarse. Cobbles are subangular of limestone. | 50 | | 325 |
| | Metrolink GBH02 | 1.2 | MADE GROUND: Stiff greyish brown slightly sandy slightly gravelly silty CLAY. Sand is fine to coarse. Gravel is subangular to subrounded fine to medium of mixed lithologies. | 20 | | 130 |
| | Metrolink GBH02 | 3 | Very stiff greyish black slightly sandy slightly gravelly silty CLAY. Sand is fine to coarse. Gravel is subangular to subrounded fine to medium of mixed lithologies. | 32 | | 208 |
| | Metrolink GBH02 | 5 | Firm becoming stiff brownish grey slightly sandy slightly gravelly silty CLAY. Sand is ne to coarse. Gravel is subangular ne to medium of predominantly limestone. | 50 | | 325 |
| | Metrolink GBH21 | 1.2 | Very stiff greyish black slightly gravelly sandy silty CLAY. Sand is fine to coarse. Gravel is subangular fine to medium of mixed lithologies. | 50 | | 325 |
| | Metrolink GBH21 | 1.7 | Very stiff greyish black slightly gravelly sandy silty CLAY. Sand is fine to coarse. Gravel is subangular fine to medium of mixed lithologies. | 50 | | 325 |
| | Metrolink GBH22 | 1.2 | Very stiff greyish black slightly sandy slightly gravelly silty CLAY. Sand is fine to coarse. Gravel is subrounded fine to medium of mixed lithologies. | 50 | | 325 |
| | Metrolink GBH22 | 1.8 | Very stiff greyish black slightly sandy slightly gravelly silty CLAY. Sand is fine to coarse. Gravel is subrounded fine to medium of mixed lithologies. | 50 | | 325 |
| | Metrolink GBH28 | 1.2 | Very stiff greyish black slightly gravelly sandy silty CLAY. Sand is fine to coarse. Gravel is subangular fine to medium of mixed lithologies. | 45 | | 292.5 |
| | Metrolink GBH28 | 2 | Very stiff greyish black slightly gravelly sandy silty CLAY. Sand is fine to coarse. Gravel is subangular fine to medium of mixed lithologies. | 50 | | 325 |
| | R3-CP08 | 1.2 | MADE GROUND: Brownish grey sandy clayey angular to subrounded fine to coarse Gravel with occasional fragments of ceramic, rubber and red brick | 4 | | 26 |
| | R3-CP08 | 2 | MADE GROUND: Brownish grey sandy clayey angular to subrounded fine to coarse Gravel with occasional fragments of ceramic, rubber and red brick | 5 | | 32.5 |
| | R3-CP08 | 3 | Firm brownish grey slightly sandy slightly gravelly CLAY. Gravel is subangular to subrounded fine to coarse | 11 | | 71.5 |
| | R3-CP08 | 4 | Stiff greyish brown slightly sandy gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 27 | | 175.5 |
| | R03-CP03 | 1 | MADE GROUND: Grey slightly sandy gravelly Clay with occasional angular to subangular cobbles and occasional fragments of red brick | 6 | | 39 |
| | R03-CP03 | 2 | MADE GROUND: Grey slightly sandy gravelly Clay with occasional angular to subangular cobbles and occasional fragments of red brick | 4 | | 26 |
| | R03-CP03 | 3 | Firm brown slightly sandy slightly gravelly CLAY. Gravel is subangular to subrounded fine to coarse | 12 | | 78 |
| | R03-CP03 | 4 | Very stiff grey slightly sandy slightly gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 48 | | 312 |
| | R03-CP03 | 5 | Very stiff grey slightly sandy slightly gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 50 | | 325 |
| | R03-CP07 | 2 | MADE GROUND: Greyish brown slightly sandy slightly gravelly Clay with occasional rootlets and occasional fragments of red brick | 2 | | 13 |
| | R03-CP07 | 3 | Stiff grey slightly sandy slightly gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 18 | | 117 |
| | R03-CP07 | 4 | Very stiff grey slightly sandy slightly gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 38 | | 247 |
| | R03-CP07 | 5 | Very stiff grey slightly sandy slightly gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 50 | | 325 |
| | R03-CP07 | 6 | Very stiff grey slightly sandy slightly gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 50 | | 325 |
| | R03-CP14 | 1 | MADE GROUND: Dark grey slightly sandy gravelly Clay with occasional angular to subangular cobbles and occasional fragments of brick, metal and wood | 1 | | 6.5 |
| | R03-CP14 | 2 | MADE GROUND: Dark grey slightly sandy gravelly Clay with occasional angular to subangular cobbles and occasional fragments of brick, metal and wood | 1 | | 6.5 |
| | R03-CP14 | 3 | MADE GROUND: Dark grey slightly sandy gravelly Clay with occasional angular to subangular cobbles and occasional fragments of brick, metal and wood | 21 | | 136.5 |
| | R03-CP14 | 4 | Stiff dark grey slightly sandy slightly gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 23 | | 149.5 |
| | R03-CP14 | 5 | Very stiff dark grey slightly sandy slightly gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 50 | | 325 |
| | R03-CP14 | 6 | Very stiff dark grey slightly sandy slightly gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 50 | | 325 |
| | R03-CP14 | 7 | Very stiff dark grey slightly sandy slightly gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 50 | | 325 |
| | R03-CP14 | 8 | Very stiff dark grey slightly sandy slightly gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 50 | | 325 |
| | R03-CP14 | 9 | Very stiff dark grey slightly sandy slightly gravelly CLAY with occasional subangular to subrounded cobbles. Gravel is subangular to subrounded fine to coarse | 50 | | 325 |
| | R03-RC01 | 2 | MADE GROUND: Dark grey slightly sandy gravelly Clay with red brick fragments. | 3 | | 19.5 |
| | R03-RC01 | 3.5 | MADE GROUND: Dark grey slightly sandy gravelly Clay with red brick fragments. | 2 | | 13 |
| | R03-RC01 | 5 | Stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. (Drillers notes: Boulder Clay) | 18 | | 117 |
| | R03-RC01 | 6.5 | Stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. (Drillers notes: Boulder Clay) | 21 | | 136.5 |
| | R03-RC01 | 8 | Stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. (Drillers notes: Boulder Clay) | 22 | | 143 |
| | R03-RC01 | 9.5 | Boulder Clay. Very stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. | 50 | | 325 |
| | R03-RC01 | 11 | Boulder Clay. Very stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. | 50 | | 325 |
| | R03-RC01 | 12.5 | Boulder Clay. Very stiff brown slightly sandy gravelly CLAY with occasional cobbles. | 50 | | 325 |
| | R03-RC01 | 14 | Very stiff brown slightly sandy slightly gravelly CLAY with occasional sub angular to sub rounded cobbles. | 50 | | 325 |
| | R03-RC01 | 15.5 | Very stiff brown slightly sandy slightly gravelly CLAY with occasional sub angular to sub rounded cobbles. | 50 | | 325 |
| | R03-RC01 | 17 | Very stiff brown slightly sandy slightly gravelly CLAY with occasional sub angular to sub rounded cobbles. | 50 | | 325 |
| | R03-RC01 | 18.5 | Very stiff dark brownish grey slightly sandy slightly gravelly CLAY. | 50 | | 325 |
| | R03-RC02 | 2 | MADE GROUND: Dark grey sandy gravelly Clay with occasional cobbles. | 5 | | 32.5 |
| | R03-RC02 | 3.5 | MADE GROUND: Dark grey sandy gravelly Clay with occasional cobbles. | 22 | | 143 |
| | R03-RC02 | 5 | MADE GROUND: Dark grey sandy gravelly Clay with occasional cobbles. | 28 | | 182 |
| | R03-RC02 | 6.5 | Boulder Clay. Very stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. | 50 | | 325 |
| | R03-RC02 | 8 | Boulder Clay. Very stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. | 50 | | 325 |
| | R03-RC02 | 9.5 | Boulder Clay. Very stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. | 50 | | 325 |
| | R03-RC02 | 11 | Boulder Clay. Very stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. | 50 | | 325 |
| | R03-RC02 | 12.5 | Boulder Clay. Very stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. | 50 | | 325 |
| | R03-RC02 | 14 | Boulder Clay. Very stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. | 50 | | 325 |
| | R03-RC02 | 15.5 | Boulder Clay. Very stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. | 50 | | 325 |
| | R03-RC02 | 17 | Boulder Clay. Very stiff dark grey slightly sandy gravelly CLAY with occasional cobbles. | 50 | | 325 |
| | R03-RC02 | 18.5 | MUDSTONE | 50 | | 325 |
| | R03-CP03 | 2 | MADE GROUND: Concrete fragments, red brick fragments and angular fine to coarse Gravel | 17 | | 110.5 |
| | R03-CP03 | 3.5 | MADE GROUND: Concrete fragments, red brick fragments and angular fine to coarse Gravel | 19 | | 123.5 |
| | R03-CP03 | 5 | Stiff dark grey slightly sandy gravelly CLAY with sub angular to sub rounded occasional cobbles. | 20 | | 130 |
| | R03-CP03 | 6.5 | Very stiff dark grey slightly sandy gravelly CLAY with occasional sub angular to sub rounded cobbles. | 35 | | 227.5 |
| | R03-CP03 | 8 | Very stiff dark grey slightly sandy gravelly CLAY with occasional sub angular to sub rounded cobbles. | 50 | | 325 |
| | R03-CP03 | 9.5 | Very stiff dark grey slightly sandy gravelly CLAY with occasional sub angular to sub rounded cobbles. | 50 | | 325 |
| | R03-CP03 | 11 | Very stiff dark grey slightly sandy gravelly CLAY with occasional sub angular to sub rounded cobbles. | 50 | | 325 |
| | R03-CP03 | 12.5 | Very stiff dark grey slightly sandy gravelly CLAY with occasional sub angular to sub rounded cobbles. | 50 | | 325 |
| | R03-CP03 | 14 | Very stiff dark grey slightly sandy gravelly CLAY with occasional sub angular to sub rounded cobbles. | 50 | | 325 |
| | R03-CP03 | 15.5 | Very stiff brown slightly sandy gravelly CLAY with occasional sub angular to sub rounded cobbles. | 50 | | 325 |
| | R03-CP03 | 17 | Grey slightly clayey sandy fine to coarse sub-angular to sub-rounded GRAVEL. | 50 | | 325 |

NOTE: Cu=f1·$N_{SPT}$. Correlation factor f1 according to Stroud and Butler (1975), taking a plasticity index PI=16%.

| $N_{SPT}$ Values - Average values | | | | | |
|---|---|---|---|---|---|
| Brown | Grey | Brown | Grey | Dark Grey | Greyish Black |
| 10 | 9 | 35 | 50 | 28 | 32 |
| 2 | (50) | 50 | 19 | 31 | 50 |
| 4 | 11 | 50 | 41 | 35 | 50 |
| 13 | 4 | 50 | 50 | 50 | 50 |
| 3 | 5 | 50 | 50 | 44 | 50 |
| 8 | 6 | 50 | 50 | 50 | 45 |
| 9 | 4 | 50 | 50 | 50 | 50 |
| 8 | 1 | 50 | 50 | 50 | 46.71 |
| 5 | 1 | 50 | 50 | 50 | |
| 25 | 21 | 50 | 50 | 50 | |
| 6 | 3 | 27 | 50 | 50 | |
| 6 | 2 | (12) | 11 | 50 | |
| 11 | 5 | 50 | 48 | 23 | |
| 8 | 22 | 50 | 50 | 50 | |
| 20 | 28 | 50 | 18 | 50 | |
| 2 | 8.71 | 50 | 38 | 50 | |
| 8.75 | | 50 | 50 | 50 | |
| | | 47.63 | 50 | 50 | |
| | | | 50 | 18 | |
| | | | 43.42 | 21 | |
| | | | | 22 | |
| | | | | 26 | |
| | | | | 50 | |
| | | | | 50 | |
| | | | | 50 | |
| | | | | 50 | |
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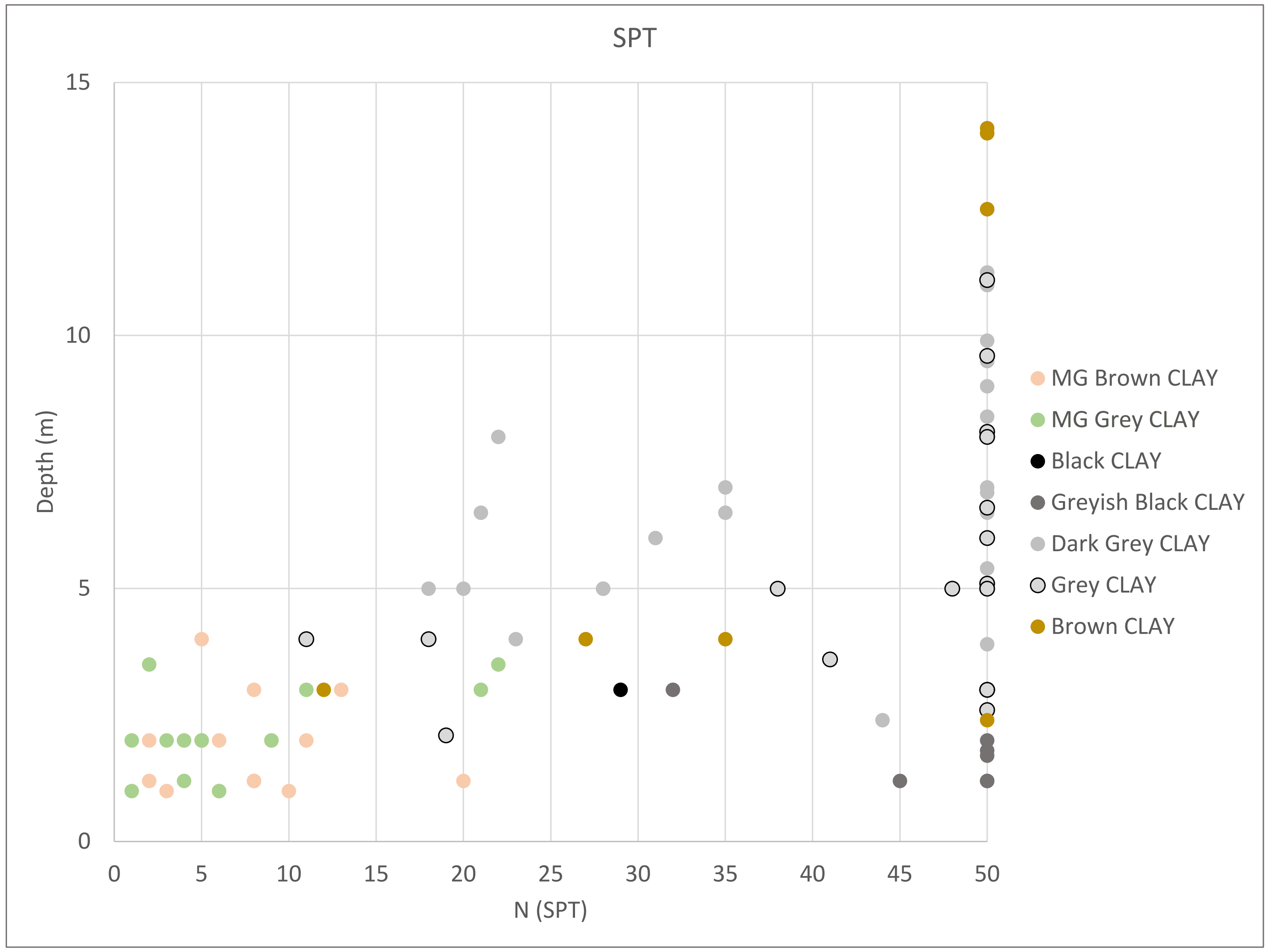
| | | | | 50 | |
| | | | | 50 | |
| | | | | 50 | |
| | | | | 50 | |
| | | | | 50 | |
| | | | | 20 | |
| | | | | 35 | |
| | | | | 50 | |
| | | | | 50 | |
| | | | | 50 | |
| | | | | 50 | |
| | | | | 50 | |
| | | | | 43.67 | |




| Soil | | Average $N_{SPT}$ | PI % | f1 | Cu = f1· $N_{SPT}$ (KPa) |
|---|---|---|---|---|---|
| Made ground | Brown | 8 | 16 | 6.5 | 52 |
| | Grey | 9 | 16 | 6.5 | 59 |
| Very stiff CLAY | Brown | 45 | 16 | 6.5 | 293 |
| | Grey | 45 | 16 | 6.5 | 293 |
| | Dark Grey | 45 | 17 | 6.5 | 293 |
| | Greyish Black | 45 | 16 | 6.5 | 293 |

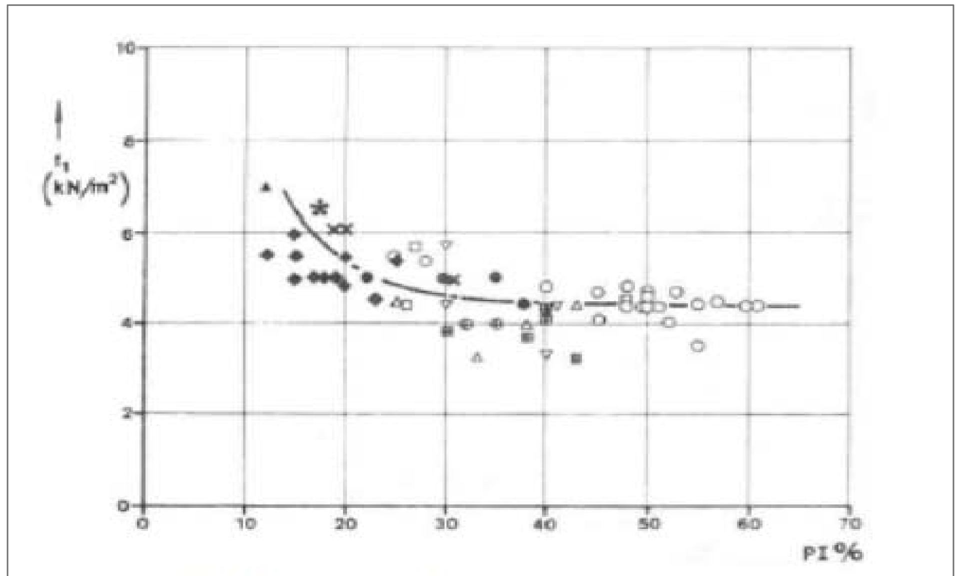



Fig.A.8.4 $f_1$ vs. PI from *Stroud and Butler*

**SOIL STRENGTH**

| Test | Borehole | Soil | Sample type | Top depth (m) | Moisture Content % | Peak shear strength KPa |
|---|---|---|---|---|---|---|
| Vane Test | R16-CP01 | Brown slightly clayey very sandy GRAVEL | B | 3.00 | - | >146 |
| | R16-CP02 | Dark brown very gravelly SAND | B | 3.00 | - | >146 |
| | R16-CP02 | Brown & grey silty SAND | U100 | 6.50 | 19.00 | 13.00 |
| | R16-CP02 | Brown mottled grey slightly sandy slightly gravelly CLAY with some organ | U100 | 7.50 | 41.00 | 11.00 |
| | R03-CP03 | Dark brown mottled grey sandy slightly gravelly CLAY | B | 2.00 | 17.00 | 19.00 |
| | R03-CP03 | Brown slightly sandy slightly gravelly CLAY | B | 3.00 | 19.00 | 20.00 |

| Test | Borehole | Soil | Sample type | Top depth (m) | Moisture Content % | Bulk density $Mg/m^3$ | Cu KPa | Load failure (deviator) kPa | Failure Mode | Strain % | Effective angle of friction (º) | Effective cohesion kPa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Triaxial CU | Glasnevin BH01 | Stiff dark grey silty very sandy fine to coarse GRAVEL | C | 8.80 | 7.70 | 2.40 | 180.30 | 360.60 | brittle | 4.29 | - | - |
| | Glasnevin BH01 | Dark grey slightly sandy gravelly silty CLAY. | C | 11.90 | 24.80 | 2.02 | 32.40 | 64.90 | plastic | 13.24 | - | - |
| | Glasnevin BH01 | Extremely stiff dark grey slightly sandy slightly gravelly silty CLAY | C | 14.65 | 8.50 | 2.35 | 682.00 | 1364.00 | plastic | 8.85 | - | - |
| | Glasnevin BH02A | Extremely stiff dark grey slightly sandy slightly gravelly silty CLAY | C | 4.70 | 8.10 | 2.39 | 516.60 | 1033.30 | brittle | 4.98 | - | - |
| | Glasnevin BH02A | Extremely stiff dark grey slightly sandy slightly gravelly silty CLAY | C | 10.95 | 9.20 | 2.32 | 475.90 | 951.80 | brittle | 4.63 | - | - |
| | Glasnevin BH02A | Extremely stiff dark grey slightly sandy slightly gravelly silty CLAY | C | 16.50 | 8.30 | 2.40 | 662.80 | 1325.50 | brittle | 5.61 | - | - |
| | Glasnevin BH02A | Extremely stiff dark grey slightly sandy slightly gravelly silty CLAY. | C | 22.00 | 9.80 | 2.32 | 670.80 | 1341.70 | brittle | 3.66 | - | - |
| | Glasnevin BH02A | Extremely stiff dark grey slightly sandy slightly gravelly silty CLAY | C | 25.20 | 8.70 | 2.25 | 503.00 | 1006.00 | brittle | 7.56 | - | - |
| | Metrolink GBH01 | Greyish brown sandy gravelly silty CLAY | - | 12.00 | 8.50 | 2.37 | 827.00 | 1654.00 | brittle | 12.50 | - | - |
| Triaxial CU with PWP | Glasnevin BH02A | Stiff dark grey slightly sandy slightly gravelly silty CLAY | - | 6.00 | 8.20 | 2.37 | - | - | - | - | 0.00 | 38.10 |
| | Glasnevin BH02A | Stiff dark brown slightly sandy slightly gravelly silty CLAY | - | 18.50 | 8.70 | 2.38 | - | - | - | - | 0.00 | 37.00 |
| | Metrolink GBH02 | Stiff brownish grey sandy gravelly silty CLAY | - | 9.60 | 10.00 | 2.26 | - | - | - | - | 27.70 | 86.49 |
| Triaxial UU | R03-CP08 | Stiff brown slightly sandy gravelly CLAY | U | 3.50 | 9.40 | 2.20 | 82.00 | 163.00 | plastic | 18.50 | - | - |

| Test | Borehole | Soil | Sample type | Top depth (m) | Moisture Content % | Bulk density $Mg/m^3$ | Peak Shear Stress KPa | Displacement at peak shear stress mm | Angle of shearing resistence | Effective cohesion KPa |
|---|---|---|---|---|---|---|---|---|---|---|
| Shear Box | R16-CP02 | Gravel | B | 7.00 | - | - | - | - | - | - |
| | R16-CP02 | Gravel | B | 9.00 | - | - | - | - | - | - |
| | R16-CP04 | Brown slightly clayey silty very gravelly SAND | B | 4.00 | 14.00 | 2.06 | 50-101-196 | 3-3-4 | 44.00 | 4.00 |
| | R16-CP04 | Brown silty gravelly SAND | B | 6.00 | 6.40 | 1.70 | 46-49-147 | 4-4-6 | 34.00 | 13.00 |
| | Metrolink BH01 | Brown gravelly sandy CLAY | B | 2.00 | 13.00 | 1.93 | 16-29-50 | 9.31-7.81-8.71 | 29.00 | 6.00 |
| | Metrolink BH01 | Gravel | B | 17.20 | 20.00 | 1.96 | 124-231-459 | 2.4-9.6-6.61 | 34.00 | 0.00 |
| | R03-CP03 | Dark brown mottled grey slightly sandy slightly gravelly CLAY | B | 5.00 | 12.00 | 2.24 | 45-79-138 | 5-5-4 | 32.00 | 15.00 |
| | R03-CP14 | Brown slightly sandy gravelly CLAY | B | 9.00 | 13.00 | 2.32 | 39-80-150 | 4.51-4.8-8.1 | 36.00 | 5.00 |

**ROCK CLASSIFICATION**

| Borehole | Top depth (m) | Soil | TCR | SCR | RQD | FI | Rock mass quality |
|---|---|---|---|---|---|---|---|
| R03-RC01 | 18.5 | Limestone | 96 | 80 | 33 | 13 | poor |
| R03-RC02 | 18.5 | Mudstone | 83 | 26 | 16 | NI | very poor |
| | 19.5 | Limestone | 83 | 26 | 16 | 8 | very poor |
| R03-RC03 | 18.5 | Mudstone | 100 | 52 | 16 | 14 | very poor |
| R11-CP01 | 8 | Limestone | 51 | 35 | 27 | 7/NI | poor |
| | 9.45 | | 100 | 74 | 23 | 14 | poor |
| | 11 | | 100 | 95 | 95 | 1 | fair |
| R11-CP03 | 4.4 | Limestone | 100 | 63 | 50 | 8 | fair |
| | 5 | | 100 | 85 | 58 | 26/6 | fair |

**ROCK STRENGTH**

| Test | Borehole | Soil | Sample type | Top depth (m) | Moisture Content % | Bulk density $Mg/m^3$ | UCS MPa | Load failure (KN) | Failure Mode |
|---|---|---|---|---|---|---|---|---|---|
| UCS | R11-CP03 | Limestone | C | 4.48 | 0.30 | 2.71 | 49.50 | 154.40 | brittle |
| | R11-CP01A | Limestone | C | 11.00 | 3.20 | 2.65 | 31.30 | 100.60 | brittle |
| | Glasnevin BH01 | Limestone | - | 20.90 | 1.80 | 2.72 | 66.20 | 500.30 | axial splitting |
| | Glasnevin BH01 | Limestone | - | 28.25 | 1.10 | 2.70 | 79.10 | 608.60 | axial splitting |
| | Glasnevin BH01 | Limestone | - | 29.60 | 0.80 | 2.65 | 82.50 | 653.40 | axial splitting |
| | Glasnevin BH01 | Limestone | - | 30.70 | 2.70 | 2.73 | 22.50 | 172.30 | axial splitting |
| | Glasnevin BH02A | Limestone | - | 32.10 | 1.70 | 2.70 | 79.90 | 640.40 | axial splitting |
| | Glasnevin BH02A | Limestone | - | 33.10 | 2.40 | 2.70 | 92.40 | 743.00 | axial splitting |
| | Glasnevin BH02A | Limestone | - | 33.90 | 2.10 | 2.68 | 66.40 | 530.10 | axial splitting |
| | Metrolink BH01 | Limestone | C | 19.75 | 0.10 | - | - | - | - |
| | Metrolink BH01 | Limestone | - | 22.50 | 1.10 | 2.64 | 39.70 | 320.80 | - |
| | Metrolink BH01 | Limestone | C | 36.30 | 0.50 | 2.68 | 26.70 | 215.80 | - |
| | Metrolink BH02 | Limestone | C | 23.00 | 0.70 | 2.73 | 39.10 | 315.40 | - |
| | Metrolink BH02 | Limestone | C | 33.40 | 0.20 | 2.70 | 43.20 | 348.30 | - |

| Test | Borehole | Soil | Sample type | Top depth (m) | Moisture Content % | Bulk density $Mg/m^3$ | PLT | Point Load index | Load failure (KN) | Failure Mode | Conversion factor | UCS MPa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Point Load Test | Glasnevin BH01 | Limestone | - | 21.20 | 0.60 | - | 1.99 | 2.72 | 19.89 | - | 14.70 | 29.25 |
| | Glasnevin BH01 | Limestone | - | 26.40 | 0.30 | - | 3.00 | 4.03 | 27.69 | - | 14.70 | 44.10 |
| | Glasnevin BH01 | Limestone | - | 28.10 | 0.60 | - | 1.42 | 1.94 | 14.22 | - | 14.70 | 20.87 |
| | Glasnevin BH01 | Limestone | - | 28.50 | 0.50 | - | 1.43 | 1.83 | 10.75 | - | 14.70 | 21.02 |
| | Glasnevin BH01 | Limestone | - | 29.50 | 0.20 | - | 2.12 | 2.90 | 21.23 | - | 14.70 | 31.16 |
| | Glasnevin BH01 | Limestone | - | 29.90 | 0.50 | - | 1.17 | 1.59 | 11.66 | - | 14.70 | 17.20 |
| | Glasnevin BH01 | Limestone | - | 30.60 | 2.70 | - | 1.14 | 1.48 | 9.01 | - | 14.70 | 16.76 |
| | Glasnevin BH01 | Limestone | - | 30.95 | 3.00 | - | 0.28 | 0.38 | 2.81 | - | 14.70 | 4.12 |
| | Glasnevin BH02A | Limestone | - | 30.80 | 2.00 | - | 1.79 | 2.42 | 17.17 | - | 14.70 | 26.31 |
| | Glasnevin BH02A | Limestone | - | 32.00 | 3.00 | - | 0.29 | 0.39 | 2.93 | - | 14.70 | 4.26 |
| | Glasnevin BH02A | Limestone | - | 33.60 | 2.60 | - | 1.18 | 1.34 | 5.22 | - | 14.70 | 17.35 |
| | Glasnevin BH02A | Limestone | - | 34.35 | 3.40 | - | 0.46 | 0.51 | 1.76 | - | 14.70 | 6.76 |
| | Glasnevin BH02A | Limestone | - | 34.60 | 1.60 | - | 2.35 | 3.25 | 24.94 | - | 14.70 | 34.55 |

| Test | Borehole | Soil | Sample type | Top depth (m) | Moisture Content % | Bulk density $Mg/m^3$ | Max Tensile Strenght MPa | BTS | Load failure (KN) | Failure Mode | Conversion factor | UCS MPa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brazil test | Glasnevin BH01 | Limestone | - | 20.75 | 1.00 | 2.63 | 3.17 | 3.17 | 95.10 | Satisfactory | 13.70 | 43.47 |
| | Glasnevin BH01 | Limestone | - | 26.20 | 1.60 | 2.68 | 7.44 | 7.44 | 116.50 | Satisfactory | 13.70 | 101.98 |
| | Glasnevin BH02A | Limestone | - | 32.90 | 2.10 | 2.62 | 5.15 | 5.15 | 83.70 | Satisfactory | 13.70 | 70.53 |

## 8.3 Characteristic compressive resistance of piles

# DESIGN COMPRESSION RESISTANCE OF PILES. TOTAL STRESSES

According to Eurocode 7 by calculation from ground parameters and Irish National Annex

*(Valid for piles spaced at 3 diameters center to center or greater)*

| | |
|---|---|
| Project | RD5862 Dublin BusConnect |
| Structure | Ringsend 01 |
| Details | Borehole R16-CP01 |

## FORMULATION

**Design compressive resistance of a pile, Rc,d:**

$$\boldsymbol{R_{c,d} = R_{s,d} + R_{b,d} \geq F_{c,d}}$$

where:

Fc,d: design value of the effects of actions (compression)

$$F_{c,d} = \frac{F_{c,k}}{\gamma_F}$$

$\gamma_F$: partial factor on actions or effects of actions

**Rs,d:** Design value of shaft resistance

$$R_{s,d} = \frac{R_{s,k}}{\gamma_s \cdot \gamma_m}$$

**Rb,d:** design value of base resistance

$$R_{b,d} = \frac{R_{b,k}}{\gamma_b \cdot \gamma_m}$$

$\gamma_s$: partial factor for shaft resistance derived from National Annex. It depends on the type of piles (driven, bored or CFA).

$\gamma_b$: partial factor for base resistance derived from National Annex. It depends on the type of piles (driven, bored or CFA).

$\gamma_m$: model factor

**Rs,k:** characteristic shaft resistance

$$R_{s,k} = \sum_i A_{s,i} \cdot q_{si,k} = \alpha \cdot c_u \cdot A_{si,k}$$

**Rb,k:** characteristic base resistance

$$R_{b,k} = A_b \cdot q_{b,k} = N_c \cdot c_u \cdot A_b$$

where:

$\alpha$: adhesion factor (from 1 or higher for very soft clays to 0.2 for very stiff clays.

$c_u$: Undrained shear strength

Asi,k: area of the pile shaft (for the stratum under consideration)

Nc: bearing capacity factor (Nc=9 provided thate the pile has been driven at least to a depth of 5 diameters into the bearing stratum)

Ab,k: area of the pile base

## INPUT DATA

## SOIL

| | | |
|---|---|---|
| Ground Level | 0 | mOD |
| α | 0.4 | - |
| Nc | 9 | - |

| Lithology | Thickness | From (m) | To (m) | *Cu(kPa) |
|---|---|---|---|---|
| Made Ground Gravel | 1 | 0 | -1 | 0 |
| Made Ground Gravelly Clay | 1 | -1 | -2 | 52 |
| Made Ground Gravelly Clay | 1 | -2 | -3 | 58.5 |
| Made Ground Gravelly Clay | 1 | -3 | -4 | 52 |
| Made Ground Gravelly Clay | 1 | -4 | -5 | 32.5 |
| Made Ground Gravelly Clay | 5 | -5 | -10 | 325 |
| | 0 | | | |
| | 0 | | | |
| | 0 | | | |
| | 0 | | | |
| Limestone (Bedrock) | 10 | -10 | -20 | 600 |

## FOUNDATION

| | | |
|---|---|---|
| Foundation level | 0 | mOD |
| $\phi_{pile}$ | 0.50 | m |
| Piles length | 11.00 | m |
| As | 1.57 | $m^2/m$ |
| Ab | 0.20 | $m^2$ |

| Actions | | | |
|---|---|---|---|
| Favourable Permanent Load | $G_{k,fav}$ | 0 | kN |
| Unfavourable Permanent Load | $G_{k,unfav}$ | 294 | kN |
| Variable Load | $Q_k$ | 623 | kN |

| EC7 - DA1 C1 | | |
|---|---|---|
| **A1+M1+R1** | | |
| **Design ground properties (M)** | | |
| Undrained shear strength | $\gamma_{Cu}$ | 1.00 |
| **Design resistances (R)** | | |
| Partial factor for base resistance | $\gamma_b$ | 1.00 |
| Partial factor for shaft resistance | $\gamma_S$ | 1.00 |
| Model factor | $\gamma_m$ | 1.75 |
| **Design actions (A)** | | |
| Permanent load factor (fav) | $\gamma_G$ | 1.00 |
| Permanent load factor (unfav) | $\gamma_G$ | 1.35 |
| Variable load factor | $\gamma_Q$ | 1.50 |
| Partial factor on the effects of action | $\gamma_F$ | 1.00 |

| EC7 - DA1 C2 | | |
|---|---|---|
| **A2+M1+R4** | | |
| **Design ground properties (M)** | | |
| Undrained shear strength | $\gamma_{Cu}$ | 1.00 |
| **Design resistances (R)** | | |
| Partial factor for base resistance | $\gamma_b$ | 1.30 |
| Partial factor for shaft resistance | $\gamma_S$ | 1.30 |
| Model factor | $\gamma_m$ | 1.75 |
| **Design actions (A)** | | |
| Permanent load factor (fav) | $\gamma_G$ | 1.00 |
| Permanent load factor (unfav) | $\gamma_G$ | 1.00 |
| Variable load factor | $\gamma_Q$ | 1.30 |
| Partial factor on the effects of action | $\gamma_F$ | 1.00 |

NOTE: Set M2 is only used to calculate unfavourable design actions on piles e.g. to negative skin friction.

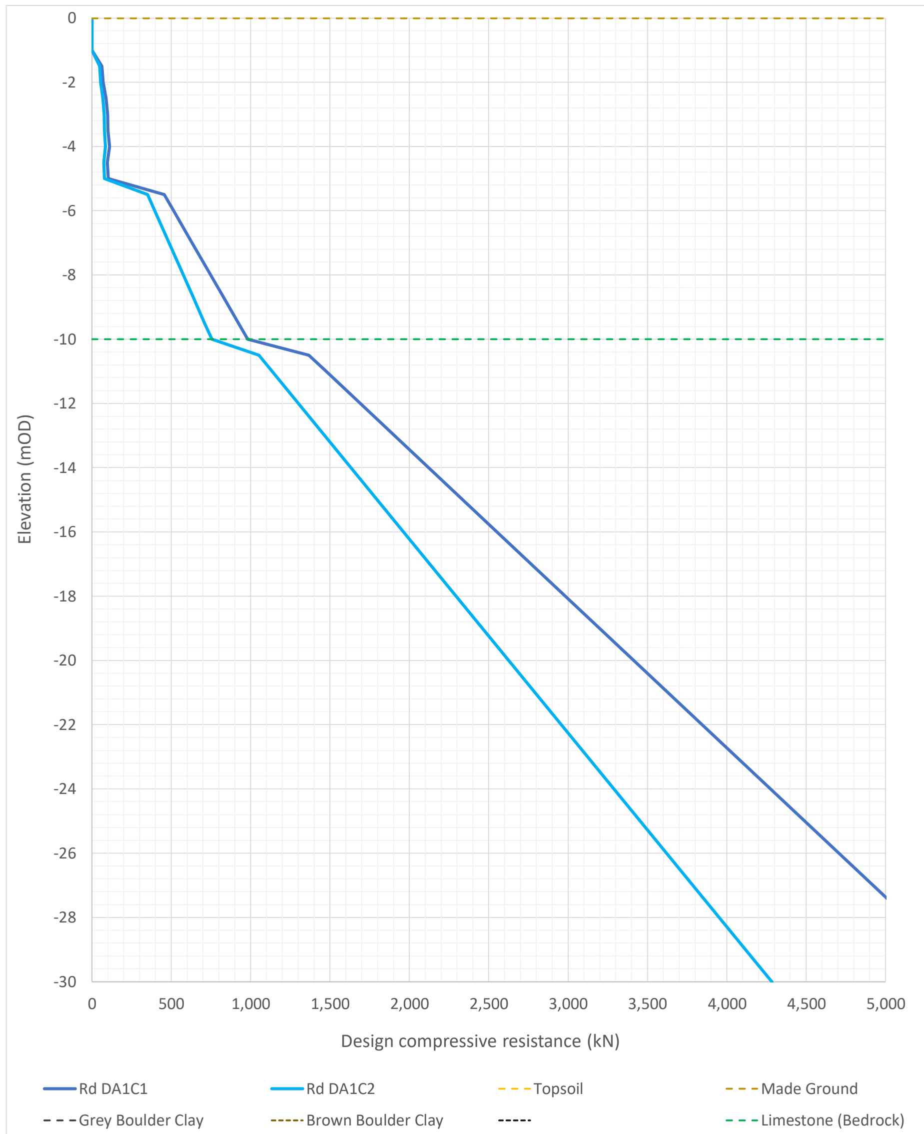
| | |
|---|---|
| Rc,d | 1475 kN |
| Fc,d | 1331 kN |

**Rc,d>Ec,d OK**

| | |
|---|---|
| Rc,d | 1134 kN |
| Fc,d | 1104 kN |

**Rc,d>Ec,d OK**

## DESIGN COMPRESSION RESISTANCE OF PILES. TOTAL STRESSES



## DESIGN COMPRESSION RESISTANCE OF PILES. TOTAL STRESSES

According to Eurocode 7 by calculation from ground parameters and Irish National Annex

*(Valid for piles spaced at 3 diameters center to center or greater)*

| | |
|---|---|
| Project | RD5862 Dublin BusConnect |
| Structure | Ringsend 01 |
| Details | Borehole R16-CP02 |

### FORMULATION

**Design compressive resistance of a pile, Rc,d:**

$$R_{c,d} = R_{s,d} + R_{b,d} \geq F_{c,d}$$

where:

Fc,d: design value of the effects of actions (compression)

$$F_{c,d} = \frac{F_{c,k}}{\gamma_F}$$

$\gamma_F$: partial factor on actions or effects of actions

Rs,d: Design value of shaft resistance

$$R_{s,d} = \frac{R_{s,k}}{\gamma_s \cdot \gamma_m}$$

Rb,d: design value of base resistance

$$R_{b,d} = \frac{R_{b,k}}{\gamma_b \cdot \gamma_m}$$

$\gamma_s$: partial factor for shaft resistance derived from National Annex. It depends on the type of piles (driven, bored or CFA).

$\gamma_b$: partial factor for base resistance derived from National Annex. It depends on the type of piles (driven, bored or CFA).

$\gamma_m$: model factor

Rs,k: characteristic shaft resistance

$$R_{s,k} = \sum_i A_{s,i} \cdot q_{si,k} = \alpha \cdot c_u \cdot A_{si,k}$$

Rb,k: characteristic base resistance

$$R_{b,k} = A_b \cdot q_{b,k} = N_c \cdot c_u \cdot A_b$$

where:

$\alpha$: adhesion factor (from 1 or higher for very soft clays to 0.2 for very stiff clays.

$c_u$: Undrained shear strength

Asi,k: area of the pile shaft (for the stratum under consideration)

Nc: bearing capacity factor (Nc=9 provided thate the pile has been driven at least to a depth of 5 diameters into the bearing stratum)

Ab,k: area of the pile base

### INPUT DATA

## SOIL

| Ground Level | 0 | mOD |
|---|---|---|
| $\alpha$ | 0.4 | - |
| Nc | 9 | - |

| Lithology | Thickness | From (m) | To (m) | *Cu(kPa) |
|---|---|---|---|---|
| Topsoil | 0.5 | 0 | -0.5 | 0 |
| Made Ground Gravelly Clay | 1.5 | -0.5 | -2 | 0 |
| Made Ground Gravelly Clay | 1 | -2 | -3 | 39 |
| Void | 2.3 | -3 | -5.3 | 0 |
| Made Ground Gravel | 0.7 | -5.3 | -6 | 110.5 |
| Gravel | 4 | -6 | -10 | 325 |
| | 0 | | | |
| | 0 | | | |
| | 0 | | | |
| | 0 | | | |
| Limestone (Bedrock) | 10 | -10 | -20 | 600 |

## FOUNDATION

| Foundation level | 0 | mOD |
|---|---|---|
| $\phi_{pile}$ | 0.50 | m |
| Piles length | 11.50 | m |
| As | 1.57 | $m^2/m$ |
| Ab | 0.20 | $m^2$ |

| Actions | | | |
|---|---|---|---|
| Favourable Permanent Load | $G_{k,fav}$ | 0 | kN |
| Unfavourable Permanent Load | $G_{k,unfav}$ | 294 | kN |
| Variable Load | $Q_k$ | 623 | kN |

| EC7 - DA1 C1 | | |
|---|---|---|
| A1+M1+R1 | | |
| **Design ground properties (M)** | | |
| Undrained shear strength | $\gamma_{Cu}$ | 1.00 |
| **Design resistances (R)** | | |
| Partial factor for base resistance | $\gamma_b$ | 1.00 |
| Partial factor for shaft resistance | $\gamma_s$ | 1.00 |
| Model factor | $\gamma_m$ | 1.75 |
| **Design actions (A)** | | |
| Permanent load factor (fav) | $\gamma_G$ | 1.00 |
| Permanent load factor (unfav) | $\gamma_G$ | 1.35 |
| Variable load factor | $\gamma_Q$ | 1.50 |
| Partial factor on the effects of action | $\gamma_F$ | 1.00 |

| EC7 - DA1 C2 | | |
|---|---|---|
| A2+M1+R4 | | |
| **Design ground properties (M)** | | |
| Undrained shear strength | $\gamma_{Cu}$ | 1.00 |
| **Design resistances (R)** | | |
| Partial factor for base resistance | $\gamma_b$ | 1.30 |
| Partial factor for shaft resistance | $\gamma_s$ | 1.30 |
| Model factor | $\gamma_m$ | 1.75 |
| **Design actions (A)** | | |
| Permanent load factor (fav) | $\gamma_G$ | 1.00 |
| Permanent load factor (unfav) | $\gamma_G$ | 1.00 |
| Variable load factor | $\gamma_Q$ | 1.30 |
| Partial factor on the effects of action | $\gamma_F$ | 1.00 |

NOTE: Set M2 is only used to calculate unfavourable design actions on piles e.g. to negative skin friction.

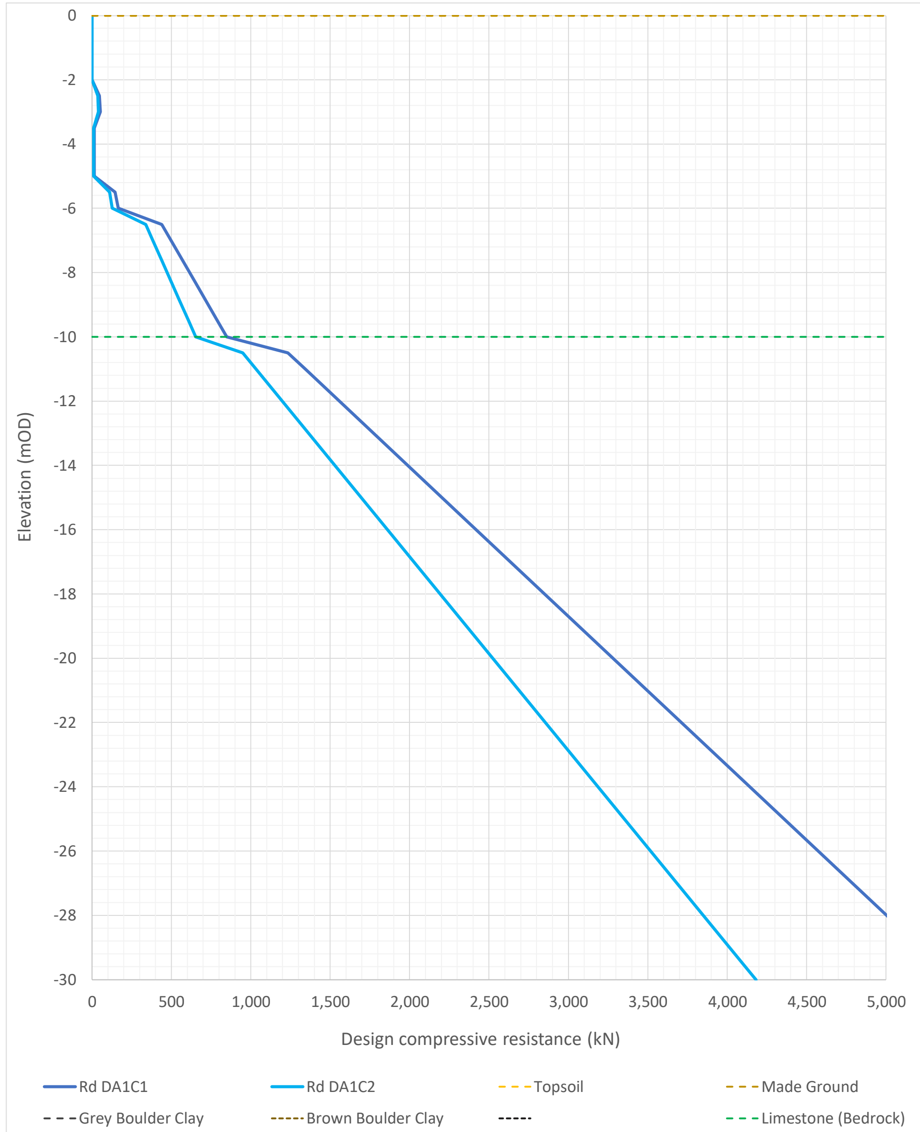
| Rc,d | 1449 kN |
|---|---|
| Fc,d | 1331 kN |

**Rc,d>Ec,d OK**

| Rc,d | 1115 kN |
|---|---|
| Fc,d | 1104 kN |

**Rc,d>Ec,d OK**

## DESIGN COMPRESSION RESISTANCE OF PILES. TOTAL STRESSES



## *DESIGN COMPRESSION RESISTANCE OF PILES. TOTAL STRESSES*

According to Eurocode 7 by calculation from ground parameters and Irish National Annex

*(Valid for piles spaced at 3 diameters center to center or greater)*

| | |
|---|---|
| Project | RD5862 Dublin BusConnect |
| Structure | Ringsend 02 |
| Details | Borehole R16-CP03 |

### FORMULATION

**Design compressive resistance of a pile, Rc,d:**

$$R_{c,d} = R_{s,d} + R_{b,d} \geq F_{c,d}$$

where:

Fc,d: design value of the effects of actions (compression)

$$F_{c,d} = \frac{F_{c,k}}{\gamma_F}$$

$\gamma_F$: partial factor on actions or effects of actions

**Rs,d:** Design value of shaft resistance

$$R_{s,d} = \frac{R_{s,k}}{\gamma_s \cdot \gamma_m}$$

**Rb,d:** design value of base resistance

$$R_{b,d} = \frac{R_{b,k}}{\gamma_b \cdot \gamma_m}$$

$\gamma_s$: partial factor for shaft resistance derived from National Annex. It depends on the type of piles (driven, bored or CFA).

$\gamma_b$: partial factor for base resistance derived from National Annex. It depends on the type of piles (driven, bored or CFA).

$\gamma_m$: model factor

**Rs,k:** characteristic shaft resistance

$$R_{s,k} = \sum_i A_{s,i} \cdot q_{si,k} = \alpha \cdot c_u \cdot A_{si,k}$$

**Rb,k:** characteristic base resistance

$$R_{b,k} = A_b \cdot q_{b,k} = N_c \cdot c_u \cdot A_b$$

where:

$\alpha$: adhesion factor (from 1 or higher for very soft clays to 0.2 for very stiff clays.

$c_u$: Undrained shear strength

Asi,k: area of the pile shaft (for the stratum under consideration)

Nc: bearing capacity factor (Nc=9 provided thate the pile has been driven at least to a depth of 5 diameters into the bearing stratum)

Ab,k: area of the pile base

### INPUT DATA

## SOIL

| | | |
|---|---|---|
| Ground Level | 0 | mOD |
| α | 0.4 | - |
| Nc | 9 | - |

| Lithology | Thickness | From (m) | To (m) | *Cu(kPa) |
|---|---|---|---|---|
| Topsoil / Made Ground | 1 | 0 | -1 | 0 |
| Made Ground Sand | 1 | -1 | -2 | 39 |
| Made Ground Sand | 1 | -2 | -3 | 32.5 |
| Gravelly Clay | 1 | -3 | -4 | 71.5 |
| Gravel | 1 | -4 | -5 | 32.5 |
| Gravel | 2 | -5 | -7 | 52 |
| Soft Grey Clay | 2 | -7 | -9 | 32.5 |
| Soft Grey Clay | 2 | -9 | -11 | 19.5 |
| Gravel | 4 | -11 | -15 | 325 |
| | 0 | | | |
| Limestone (Bedrock) | 5 | -15 | -20 | 600 |

## FOUNDATION

| | | |
|---|---|---|
| Foundation level | 0 | mOD |
| $\phi_{pile}$ | 0.20 | m |
| Piles length | 11.50 | m |
| As | 0.63 | $m^2/m$ |
| Ab | 0.03 | $m^2$ |

| Actions | | | |
|---|---|---|---|
| Favourable Permanent Load | $G_{k,fav}$ | 0 | kN |
| Unfavourable Permanent Load | $G_{k,unfav}$ | 0 | kN |
| Variable Load | $Q_k$ | 50 | kN |

| EC7 - DA1 C1 | | |
|---|---|---|
| **A1+M1+R1** | | |
| **Design ground properties (M)** | | |
| Undrained shear strength | $\gamma_{Cu}$ | 1.00 |
| **Design resistances (R)** | | |
| Partial factor for base resistance | $\gamma_b$ | 1.00 |
| Partial factor for shaft resistance | $\gamma_s$ | 1.00 |
| Model factor | $\gamma_m$ | 1.75 |
| **Design actions (A)** | | |
| Permanent load factor (fav) | $\gamma_G$ | 1.00 |
| Permanent load factor (unfav) | $\gamma_G$ | 1.35 |
| Variable load factor | $\gamma_Q$ | 1.50 |
| Partial factor on the effects of action | $\gamma_F$ | 1.00 |

| | |
|---|---|
| Rc,d | 131 kN |
| Fc,d | 75 kN |

**Rc,d>Ec,d OK**

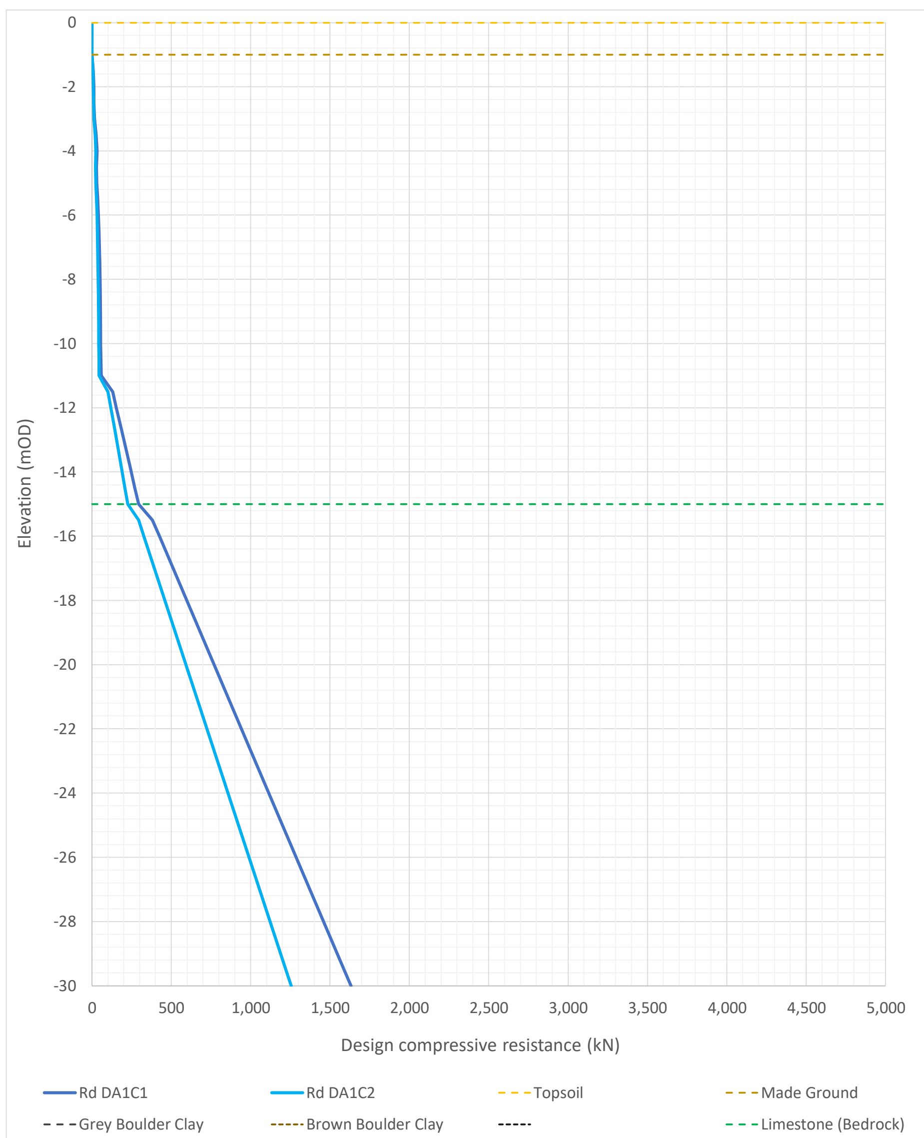
| EC7 - DA1 C2 | | |
|---|---|---|
| **A2+M1+R4** | | |
| **Design ground properties (M)** | | |
| Undrained shear strength | $\gamma_{Cu}$ | 1.00 |
| **Design resistances (R)** | | |
| Partial factor for base resistance | $\gamma_b$ | 1.30 |
| Partial factor for shaft resistance | $\gamma_s$ | 1.30 |
| Model factor | $\gamma_m$ | 1.75 |
| **Design actions (A)** | | |
| Permanent load factor (fav) | $\gamma_G$ | 1.00 |
| Permanent load factor (unfav) | $\gamma_G$ | 1.00 |
| Variable load factor | $\gamma_Q$ | 1.30 |
| Partial factor on the effects of action | $\gamma_F$ | 1.00 |

NOTE: Set M2 is only used to calculate unfavourable design actions on piles e.g. to negative skin friction.

| | |
|---|---|
| Rc,d | 101 kN |
| Fc,d | 65 kN |

**Rc,d>Ec,d OK**

## DESIGN COMPRESSION RESISTANCE OF PILES. TOTAL STRESSES



# DESIGN COMPRESSION RESISTANCE OF PILES. TOTAL STRESSES

According to Eurocode 7 by calculation from ground parameters and Irish National Annex

*(Valid for piles spaced at 3 diameters center to center or greater)*

| | |
|---|---|
| Project | **RD5862 Dublin BusConnect** |
| Structure | **Ringsend 02** |
| Details | **Borehole R16-CP03** |

## FORMULATION

**Design compressive resistance of a pile, Rc,d:**

$$R_{c,d} = R_{s,d} + R_{b,d} \geq F_{c,d}$$

where:

Fc,d: design value of the effects of actions (compression)

$$F_{c,d} = \frac{F_{c,k}}{\gamma_F}$$

$\gamma_F$: partial factor on actions or effects of actions

**Rs,d:** Design value of shaft resistance

$$R_{s,d} = \frac{R_{s,k}}{\gamma_s \cdot \gamma_m}$$

**Rb,d:** design value of base resistance

$$R_{b,d} = \frac{R_{b,k}}{\gamma_b \cdot \gamma_m}$$

$\gamma_s$: partial factor for shaft resistance derived from National Annex. It depends on the type of piles (driven, bored or CFA).

$\gamma_b$: partial factor for base resistance derived from National Annex. It depends on the type of piles (driven, bored or CFA).

$\gamma_m$: model factor

**Rs,k:** characteristic shaft resistance

$$R_{s,k} = \sum_i A_{s,i} \cdot q_{si,k} = \alpha \cdot c_u \cdot A_{si,k}$$

**Rb,k:** characteristic base resistance

$$R_{b,k} = A_b \cdot q_{b,k} = N_c \cdot c_u \cdot A_b$$

where:

$\alpha$: adhesion factor (from 1 or higher for very soft clays to 0.2 for very stiff clays.

$c_u$: Undrained shear strength

Asi,k: area of the pile shaft (for the stratum under consideration)

Nc: bearing capacity factor (Nc=9 provided thate the pile has been driven at least to a depth of 5 diameters into the bearing stratum)

Ab,k: area of the pile base

## INPUT DATA

### SOIL

| | | |
|---|---|---|
| Ground Level | 0 | mOD |
| $\alpha$ | 0.4 | - |
| Nc | 9 | - |

| Lithology | Thickness | From (m) | To (m) | *Cu(kPa) |
|---|---|---|---|---|
| Topsoil / Made Ground | 2 | 0 | -2 | 0 |
| Made Ground Gravelly Clay | 1 | -2 | -3 | 71.5 |
| Made Ground Sand | 1 | -3 | -4 | 32.5 |
| Sand | 1 | -4 | -5 | 19.5 |
| Sand | 2 | -5 | -7 | 13 |
| Soft Grey Clay | 2 | -7 | -9 | 13 |
| Soft Grey Clay | 1 | -9 | -10 | 26 |
| Soft Grey Clay | 1 | -10 | -11 | 13 |
| Soft Grey Clay | 1 | -11 | -12 | 19.5 |
| Gravel | 3 | -12 | -15 | 325 |
| Limestone (Bedrock) | 5 | -15 | -20 | 600 |

### FOUNDATION

| | | |
|---|---|---|
| Foundation level | 0 | mOD |
| $\phi_{pile}$ | 0.20 | m |
| Piles length | 12.50 | m |
| As | 0.63 | $m^2/m$ |
| Ab | 0.03 | $m^2$ |

| Actions | | | |
|---|---|---|---|
| Favourable Permanent Load | $G_{k,fav}$ | 0 | kN |
| Unfavourable Permanent Load | $G_{k,unfav}$ | 0 | kN |
| Variable Load | $Q_k$ | 50 | kN |

| EC7 - DA1 C1 | | |
|---|---|---|
| **A1+M1+R1** | | |
| **Design ground properties (M)** | | |
| Undrained shear strength | $\gamma_{Cu}$ | 1.00 |
| **Design resistances (R)** | | |
| Partial factor for base resistance | $\gamma_b$ | 1.00 |
| Partial factor for shaft resistance | $\gamma_s$ | 1.00 |
| Model factor | $\gamma_m$ | 1.75 |
| **Design actions (A)** | | |
| Permanent load factor (fav) | $\gamma_G$ | 1.00 |
| Permanent load factor (unfav) | $\gamma_G$ | 1.35 |
| Variable load factor | $\gamma_Q$ | 1.50 |
| Partial factor on the effects of action | $\gamma_F$ | 1.00 |

| EC7 - DA1 C2 | | |
|---|---|---|
| **A2+M1+R4** | | |
| **Design ground properties (M)** | | |
| Undrained shear strength | $\gamma_{Cu}$ | 1.00 |
| **Design resistances (R)** | | |
| Partial factor for base resistance | $\gamma_b$ | 1.30 |
| Partial factor for shaft resistance | $\gamma_s$ | 1.30 |
| Model factor | $\gamma_m$ | 1.75 |
| **Design actions (A)** | | |
| Permanent load factor (fav) | $\gamma_G$ | 1.00 |
| Permanent load factor (unfav) | $\gamma_G$ | 1.00 |
| Variable load factor | $\gamma_Q$ | 1.30 |
| Partial factor on the effects of action | $\gamma_F$ | 1.00 |

NOTE: Set M2 is only used to calculate unfavourable design actions on piles e.g. to negative skin friction.

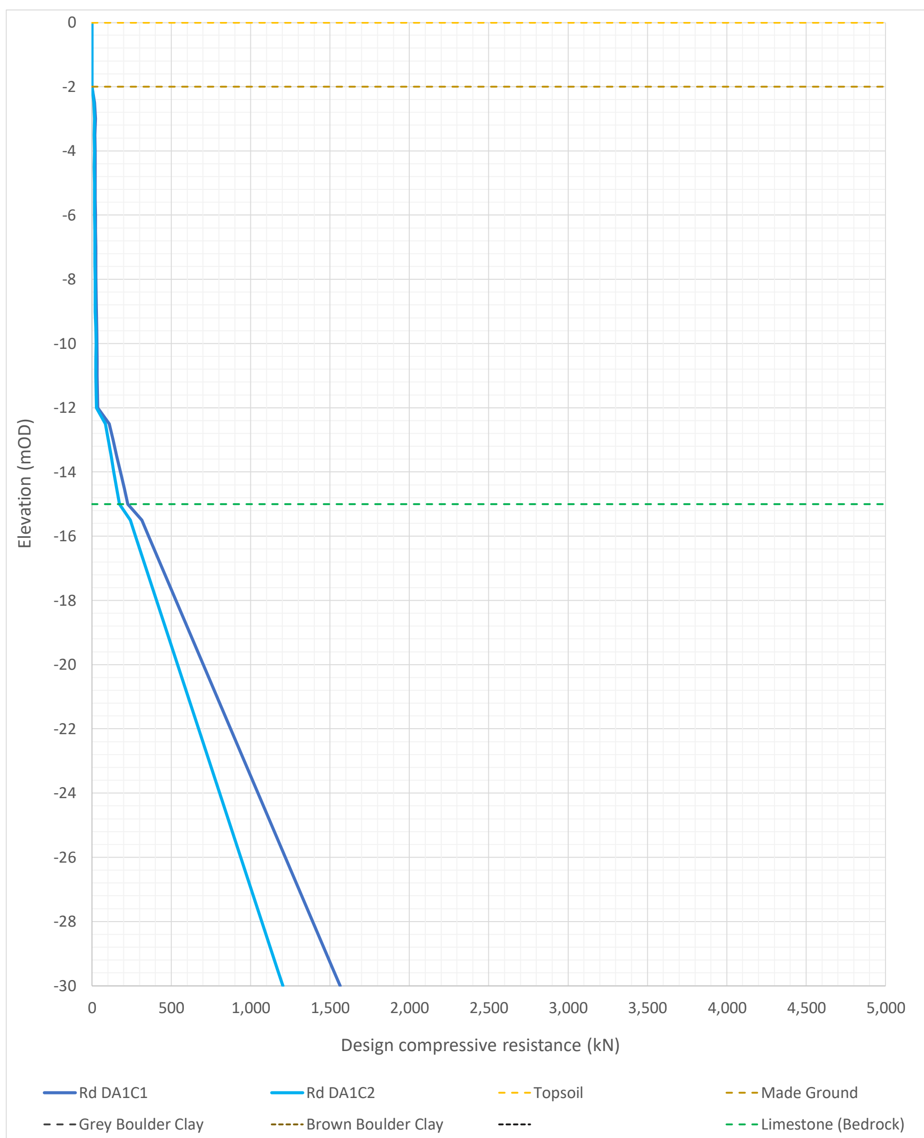
| | |
|---|---|
| Rc,d | 109 kN |
| Fc,d | 75 kN |

**Rc,d>Ec,d OK**

| | |
|---|---|
| Rc,d | 84 kN |
| Fc,d | 65 kN |

**Rc,d>Ec,d OK**

## DESIGN COMPRESSION RESISTANCE OF PILES. TOTAL STRESSES



## *DESIGN COMPRESSION RESISTANCE OF PILES. TOTAL STRESSES*

According to Eurocode 7 by calculation from ground parameters and Irish National Annex

*(Valid for piles spaced at 3 diameters center to center or greater)*

| | |
|---|---|
| Project | RD5862 Dublin BusConnect |
| Structure | Ringsend 03 |
| Details | Borehole R16-CP03 |

### FORMULATION

**Design compressive resistance of a pile, Rc,d:**

$$R_{c,d} = R_{s,d} + R_{b,d} \geq F_{c,d}$$

where:

Fc,d: design value of the effects of actions (compression)

$$F_{c,d} = \frac{F_{c,k}}{\gamma_F}$$

$\gamma_F$: partial factor on actions or effects of actions

**Rs,d:** Design value of shaft resistance

$$R_{s,d} = \frac{R_{s,k}}{\gamma_s \cdot \gamma_m}$$

**Rb,d:** design value of base resistance

$$R_{b,d} = \frac{R_{b,k}}{\gamma_b \cdot \gamma_m}$$

$\gamma_s$: partial factor for shaft resistance derived from National Annex. It depends on the type of piles (driven, bored or CFA).

$\gamma_b$: partial factor for base resistance derived from National Annex. It depends on the type of piles (driven, bored or CFA).

$\gamma_m$: model factor

**Rs,k:** characteristic shaft resistance

$$R_{s,k} = \sum_i A_{s,i} \cdot q_{si,k} = \alpha \cdot c_u \cdot A_{si,k}$$

**Rb,k:** characteristic base resistance

$$R_{b,k} = A_b \cdot q_{b,k} = N_c \cdot c_u \cdot A_b$$

where:

$\alpha$: adhesion factor (from 1 or higher for very soft clays to 0.2 for very stiff clays.

$c_u$: Undrained shear strength

Asi,k: area of the pile shaft (for the stratum under consideration)

Nc: bearing capacity factor (Nc=9 provided thate the pile has been driven at least to a depth of 5 diameters into the bearing stratum)

Ab,k: area of the pile base

### INPUT DATA

## SOIL

| | | |
|---|---|---|
| Ground Level | 0 | mOD |
| α | 0.4 | - |
| Nc | 9 | - |

| Lithology | Thickness | From (m) | To (m) | *Cu(kPa) |
|---|---|---|---|---|
| Topsoil / Made Ground | 1 | 0 | -1 | 0 |
| Made Ground Sand | 1 | -1 | -2 | 39 |
| Made Ground Sand | 1 | -2 | -3 | 32.5 |
| Gravelly Clay | 1 | -3 | -4 | 71.5 |
| Gravel | 1 | -4 | -5 | 32.5 |
| Gravel | 2 | -5 | -7 | 52 |
| Soft Grey Clay | 2 | -7 | -9 | 32.5 |
| Soft Grey Clay | 2 | -9 | -11 | 19.5 |
| Gravel | 4 | -11 | -15 | 325 |
| | 0 | | | |
| Limestone (Bedrock) | 5 | -15 | -20 | 600 |

## FOUNDATION

| | | |
|---|---|---|
| Foundation level | 0 | mOD |
| $\phi_{pile}$ | 0.50 | m |
| Piles length | 15.50 | m |
| As | 1.57 | $m^2/m$ |
| Ab | 0.20 | $m^2$ |

| Actions | | | |
|---|---|---|---|
| Favourable Permanent Load | $G_{k,fav}$ | 0 | kN |
| Unfavourable Permanent Load | $G_{k,unfav}$ | 210 | kN |
| Variable Load | $Q_k$ | 604 | kN |

| EC7 - DA1 C1 | | |
|---|---|---|
| **A1+M1+R1** | | |
| **Design ground properties (M)** | | |
| Undrained shear strength | $\gamma_{Cu}$ | 1.00 |
| **Design resistances (R)** | | |
| Partial factor for base resistance | $\gamma_b$ | 1.00 |
| Partial factor for shaft resistance | $\gamma_s$ | 1.00 |
| Model factor | $\gamma_m$ | 1.75 |
| **Design actions (A)** | | |
| Permanent load factor (fav) | $\gamma_G$ | 1.00 |
| Permanent load factor (unfav) | $\gamma_G$ | 1.35 |
| Variable load factor | $\gamma_Q$ | 1.50 |
| Partial factor on the effects of action | $\gamma_F$ | 1.00 |

| | |
|---|---|
| Rc,d | 1318 kN |
| Fc,d | 1190 kN |

**Rc,d>Ec,d OK**

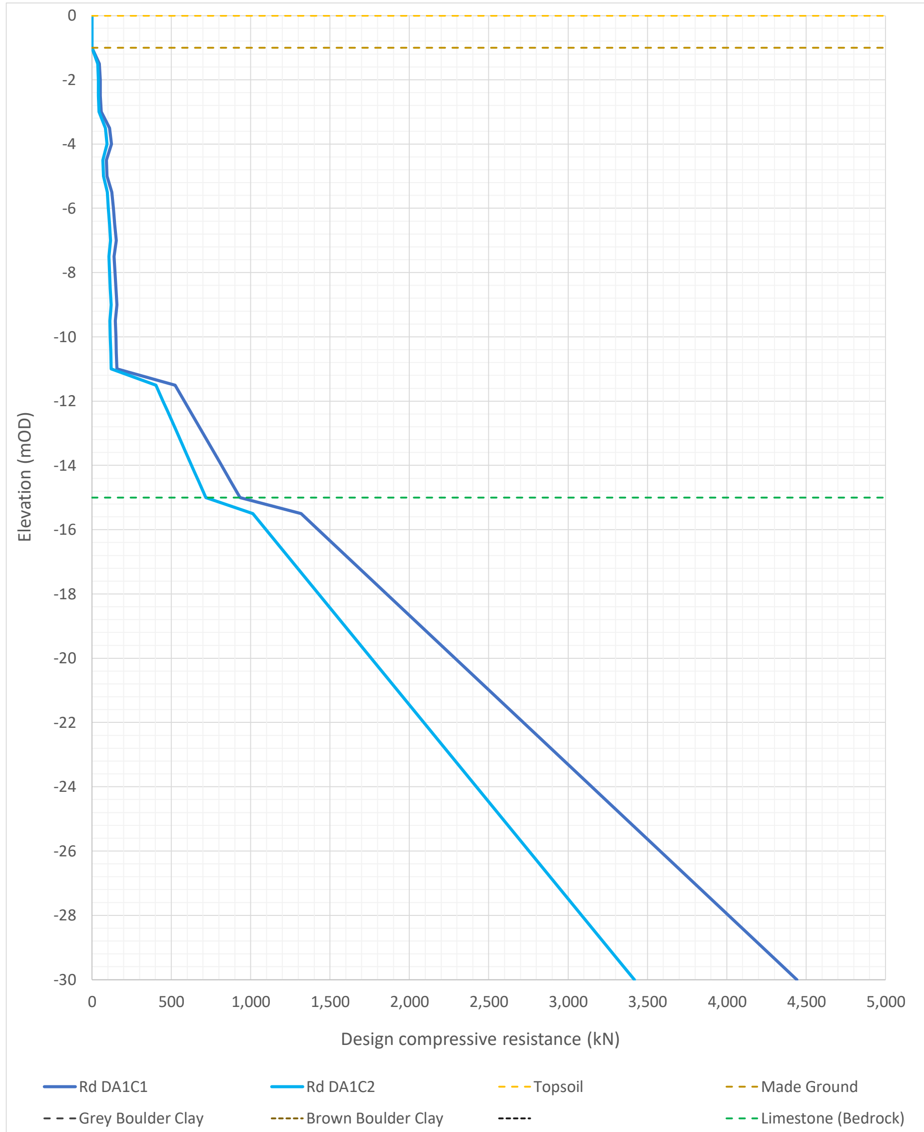
| EC7 - DA1 C2 | | |
|---|---|---|
| **A2+M1+R4** | | |
| **Design ground properties (M)** | | |
| Undrained shear strength | $\gamma_{Cu}$ | 1.00 |
| **Design resistances (R)** | | |
| Partial factor for base resistance | $\gamma_b$ | 1.30 |
| Partial factor for shaft resistance | $\gamma_s$ | 1.30 |
| Model factor | $\gamma_m$ | 1.75 |
| **Design actions (A)** | | |
| Permanent load factor (fav) | $\gamma_G$ | 1.00 |
| Permanent load factor (unfav) | $\gamma_G$ | 1.00 |
| Variable load factor | $\gamma_Q$ | 1.30 |
| Partial factor on the effects of action | $\gamma_F$ | 1.00 |

NOTE: Set M2 is only used to calculate unfavourable design actions on piles e.g. to negative skin friction.

| | |
|---|---|
| Rc,d | 1014 kN |
| Fc,d | 995 kN |

**Rc,d>Ec,d OK**

## DESIGN COMPRESSION RESISTANCE OF PILES. TOTAL STRESSES



## *DESIGN COMPRESSION RESISTANCE OF PILES. TOTAL STRESSES*

According to Eurocode 7 by calculation from ground parameters and Irish National Annex

*(Valid for piles spaced at 3 diameters center to center or greater)*

| | |
|---|---|
| Project | RD5862 Dublin BusConnect |
| Structure | Ringsend 03 |
| Details | Borehole R16-CP03 |

### FORMULATION

**Design compressive resistance of a pile, Rc,d:**

$$R_{c,d} = R_{s,d} + R_{b,d} \geq F_{c,d}$$

where:

Fc,d: design value of the effects of actions (compression)

$$F_{c,d} = \frac{F_{c,k}}{\gamma_F}$$

$\gamma_F$: partial factor on actions or effects of actions

Rs,d: Design value of shaft resistance

$$R_{s,d} = \frac{R_{s,k}}{\gamma_s \cdot \gamma_m}$$

Rb,d: design value of base resistance

$$R_{b,d} = \frac{R_{b,k}}{\gamma_b \cdot \gamma_m}$$

$\gamma_s$: partial factor for shaft resistance derived from National Annex. It depends on the type of piles (driven, bored or CFA).

$\gamma_b$: partial factor for base resistance derived from National Annex. It depends on the type of piles (driven, bored or CFA).

$\gamma_m$: model factor

Rs,k: characteristic shaft resistance

$$R_{s,k} = \sum_i A_{s,i} \cdot q_{si,k} = \alpha \cdot c_u \cdot A_{si,k}$$

Rb,k: characteristic base resistance

$$R_{b,k} = A_b \cdot q_{b,k} = N_c \cdot c_u \cdot A_b$$

where:

$\alpha$: adhesion factor (from 1 or higher for very soft clays to 0.2 for very stiff clays.

$c_u$: Undrained shear strength

Asi,k: area of the pile shaft (for the stratum under consideration)

Nc: bearing capacity factor (Nc=9 provided thate the pile has been driven at least to a depth of 5 diameters into the bearing stratum)

Ab,k: area of the pile base

### INPUT DATA

## SOIL

| Ground Level | 0 | mOD |
|---|---|---|
| $\alpha$ | 0.4 | - |
| Nc | 9 | - |

| Lithology | Thickness | From (m) | To (m) | *Cu(kPa) |
|---|---|---|---|---|
| Topsoil / Made Ground | 2 | 0 | -2 | 0 |
| Made Ground Gravelly Clay | 1 | -2 | -3 | 71.5 |
| Made Ground Sand | 1 | -3 | -4 | 32.5 |
| Sand | 1 | -4 | -5 | 19.5 |
| Sand | 2 | -5 | -7 | 13 |
| Soft Grey Clay | 2 | -7 | -9 | 13 |
| Soft Grey Clay | 1 | -9 | -10 | 26 |
| Soft Grey Clay | 1 | -10 | -11 | 13 |
| Soft Grey Clay | 1 | -11 | -12 | 19.5 |
| Gravel | 3 | -12 | -15 | 325 |
| Limestone (Bedrock) | 5 | -15 | -20 | 600 |

## FOUNDATION

| Foundation level | 0 | mOD |
|---|---|---|
| $\phi_{pile}$ | 0.50 | m |
| Piles length | 16.50 | m |
| As | 1.57 | $m^2/m$ |
| Ab | 0.20 | $m^2$ |

| Actions | | | |
|---|---|---|---|
| Favourable Permanent Load | $G_{k,fav}$ | 0 | kN |
| Unfavourable Permanent Load | $G_{k,unfav}$ | 210 | kN |
| Variable Load | $Q_k$ | 604 | kN |

| EC7 - DA1 C1 | | |
|---|---|---|
| A1+M1+R1 | | |
| **Design ground properties (M)** | | |
| Undrained shear strength | $\gamma_{Cu}$ | 1.00 |
| **Design resistances (R)** | | |
| Partial factor for base resistance | $\gamma_b$ | 1.00 |
| Partial factor for shaft resistance | $\gamma_s$ | 1.00 |
| Model factor | $\gamma_m$ | 1.75 |
| **Design actions (A)** | | |
| Permanent load factor (fav) | $\gamma_G$ | 1.00 |
| Permanent load factor (unfav) | $\gamma_G$ | 1.35 |
| Variable load factor | $\gamma_Q$ | 1.50 |
| Partial factor on the effects of action | $\gamma_F$ | 1.00 |

| EC7 - DA1 C2 | | |
|---|---|---|
| A2+M1+R4 | | |
| **Design ground properties (M)** | | |
| Undrained shear strength | $\gamma_{Cu}$ | 1.00 |
| **Design resistances (R)** | | |
| Partial factor for base resistance | $\gamma_b$ | 1.30 |
| Partial factor for shaft resistance | $\gamma_s$ | 1.30 |
| Model factor | $\gamma_m$ | 1.75 |
| **Design actions (A)** | | |
| Permanent load factor (fav) | $\gamma_G$ | 1.00 |
| Permanent load factor (unfav) | $\gamma_G$ | 1.00 |
| Variable load factor | $\gamma_Q$ | 1.30 |
| Partial factor on the effects of action | $\gamma_F$ | 1.00 |

NOTE: Set M2 is only used to calculate unfavourable design actions on piles e.g. to negative skin friction.

| Rc,d | 1363 kN |
|---|---|
| Fc,d | 1190 kN |

**Rc,d>Ec,d OK**

| Rc,d | 1049 kN |
|---|---|
| Fc,d | 995 kN |

**Rc,d>Ec,d OK**

## DESIGN COMPRESSION RESISTANCE OF PILES. TOTAL STRESSES