Railway Procurement Agency

METRO NORTH
ORAL HEARING

Stage 1 Preliminary Ground Movement Assessment Report

Rev 3_ Part9

CALCULATION SHEET

JACOBS

Project Title: Dublin Metro North			Sheet No: 1
Subject:	Running Tunnel Settlement- Chainage 13630 to 14100-DCU Stop to Griffith Avenue Stop		Calc No: 6
Job No: B0307000			File: DCU Stop to Griffith Avenue Stop
Made By: PN	Date: 16/04/08	Revised By:	Date:
Checked By: DIT	Date: 18/04/08	Checked By:	Date:

DCU Stop to Griffith Avenue Stop Bored Tunnels

INTRODUCTION

The objective of this calculation is to predict ground movements induced by construction of the bored and mined tunnels between Chainage 13630 and 14100 (DCU stop to Griffith Avenue stop section). The results of this calculation will be presented as settlement contours and will be used to identify existing buildings, structures, utilities and infrastructure that lie within the zone of influence, as per the design requirements specified Technical Note 12 'Strategy for Assessing and Managing Building, Infrastructure and Utility Response to Ground Movements Generated by Underground Excavation' September 2007, Ref: B0307000-010\Geo.360\001\1.

REFERENCES

Document/Drawing Ref	Rev	Title
B0307000-010\Geo.02\001	0	Design Input Statement for Predicting Ground Movements and the Response of Buildings, Infrastructure and Utilities Generated by Underground Excavation
B0307000-010\Geo.360\001\1	0	Technical Note 12 'Strategy for Assessing and Managing Building, Infrastructure and Utility Response to Ground Movements Generated by Underground Excavation'
BMN/0000/GE(0)(3)/11	A03	Exploratory Hole Location Plan and Inferred Geological Section Sheet 11 of 14 (Oct 07)
BMN/0000/TU/0201	B01	Typical Running Tunnel Cross Section
BMN/0000/TU/0204	B01	Cross Passage - Typical Arrangement & Sections
BMN/0000/TU/0205	B01	Cross Passage Drainage Sump - Typical Arrangement & Sections - Sheet 1
BMN/0000/TU/0206	B01	Cross Passage Drainage Sump - Typical Arrangement & Sections - Sheet 2

ANALYTICAL TOOLS

The following analytical tools were used in this analysis

- TunDisp (Jacobs in-house programme): used to calculated predicted ground movement Jacobs in-house programme.
- Surfer (Ver 8): used to generate settlement contours at ground level.

Verification of ground movement predictions will be undertaken using hand calculations for specific areas along the alignment.

CALCULATION SHEET

JACOBS

Project Title: Dublin Metro North			Sheet No: 2
Subject:	Running Tunnel Settlement- Chainage 13630 to 14100-DCU Stop to Griffith Avenue Stop		Calc No: 6
Job No: B0307000			File: DCU Stop to Griffith Avenue Stop
Made By: PN	Date: 16/04/08	Revised By:	Date:
Checked By: DIT	Date: 18/04/08	Checked By:	Date:

METHODOLOGY

1. Analysis in TunDisp

Tunnel alignment coordinates (X, Y and Z) retrieved from the relevant alignment drawings have been collated at 10m increments along the alignment. The corresponding ground level and geological sequence associated with each incremental section of the proposed development has been determined from the inferred geological long sections referenced above.

All elements generating ground movement (bored and mined tunnels, including cross passages and crossover caverns) were considered together in the Tundisp analysis. The output file contains the total settlement values corresponding to the combined effect of the ground excavation elements.

2. Contouring of settlement at Ground Level

The TunDisp output files (.dat) have been converted to a .sin file and then exported to Surfer (ver 8) to generate contours maps for the discrete sections analysed. The output files were then converted from a '.sin file' to a '.grd file'. The spacing was set to 2m in both directions and a Triangulation grid with Linear Interpolation chosen.

Contours were plotted for 2mm and 5mm settlements and for every 5mm above the 5mm settlement mark.

ASSUMPTIONS

- For tunnels, hard ground parameters were utilised where there is a minimum of half tunnel diameter cover to the crown of the tunnel.
- The completed tunnel elements are considered to be watertight and therefore long-term settlement due to consolidation is considered negligible.
- The predicted area or zone of influence affected by excavation activities has been established in the ground movement analysis. For bored and mined tunnels the zone of influence is defined as 30m each side of the tunnels centreline, or the 2mm contour line whichever is greatest. For cut and cover and retained sections the zone of influence is defined as the horizontal distance from the façade of the wall to a distance equal to the height of the wall, or to the 2mm contour line whichever is greatest.

CALCULATION SHEET

JACOBS

Project Title: Dublin Metro North			Sheet No: 3
Subject:	Running Tunnel Settlement- Chainage 13630 to 14100-DCU Stop to Griffith Avenue Stop		Calc No: 6
Job No: B0307000			File: DCU Stop to Griffith Avenue Stop
Made By: PN	Date: 16/04/08	Revised By:	Date:
Checked By: DIT	Date: 18/04/08	Checked By:	Date:

INPUT PARAMETERS

General

The assessment parameters pertaining the geological conditions and proposed structures for the area under consideration are presented below.

Structure Type	Excavation Geology	Volume Loss (* % related to excavation depth)	Dimensions	Notes
Running tunnels (Bored)	Fluvio – Glacial Deposits	1.5%	N/A	N/A
	Glacial Till	0.6%	6.75m Dia.	Based on dimensions of TBM
	Limestone Bedrock	0.20%	N/A	N/A
Cross Passage tunnels	Fluvio – Glacial Deposits	2.25%	N/A	N/A
	Glacial Till	0.9%	5.5m Dia.	Cross Passage Entrance enlarged Sections, distance from tunnel axis to end of enlarged section = 5.5m
			4.0m Dia	Based on OD plus 0.15m overcut.
	Limestone Bedrock	0.30%	N/A	N/A
Cross Passages with Drainage Sumps	Fluvio – Glacial Deposits	2.25%	N/A	N/A
	Glacial Till	0.9%	N/A	N/A
	Limestone Bedrock	0.30%	N/A	N/A
Crossovers	Fluvio – Glacial Deposits	2.25%	N/A	N/A
	Glacial Till	0.9%	N/A	N/A
	Limestone Bedrock	0.30%	N/A	N/A

Geology	'K' Value
Fluvio – Glacial Deposits	0.3
Glacial Till	0.6
Limestone Bedrock	0.4

CALCULATION SHEET

JACOBS

Project Title: Dublin Metro North			Sheet No: 4
Subject:	Running Tunnel Settlement- Chainage 13630 to 14100-DCU Stop to Griffith Avenue Stop		Calc No: 6
Job No: B0307000			File: DCU Stop to Griffith Avenue Stop
Made By: PN	Date: 16/04/08	Revised By:	Date:
Checked By: DIT	Date: 18/04/08	Checked By:	Date:

Chainage 13630 to 13920

Area of Interest:	(315550 E, 238350 N) (315850 E, 237900 N)
Chainages:	Element 1: Northbound running tunnel 13630 to 13920m Element 2: Southbound running tunnel 13630 to 13920m Element 3: Cross Passage 303, Ch. 13814m
Tunnel Alignment Data - File Location:	P:\B0307000 Dublin Metro North\Design\Alignment\fixed final alignment\New Alignment_Complete.xls
Analysis directory (settlements):	P:\B0307000 Dublin Metro North\Design\Settlement Analysis - building Damage Assessment\Tundisp Analysis\final\pink alignment\8.Griffith to DCU (13630-13920)
TunDisp Input File:	13630_13920.inp
Geology:	Glacial Till
Running tunnels:	Diameter 6.75m VL= 0.006 (0.6%) K value at surface, K=0.6 K variable with depth , itkp =0 z, depth to plane of interest = 0m (surface settlement) No. of increments n=10 Vertical offset=0m Horizontal offset=0m
Cross passage 304:	Diameters: 5.5m, 4.0m, 5.5m VL= 0.009 (0.9%) K value at surface, K=0.6 K variable with depth , itkp =0 z, depth to plane of interest = 0m (surface settlement) No. of increments n=5,4,5 Vertical offset=0m Horizontal offset=0m

CALCULATION SHEET

JACOBS

Project Title: Dublin Metro North			Sheet No: 5
Subject:	Running Tunnel Settlement- Chainage 13630 to 14100-DCU Stop to Griffith Avenue Stop		Calc No: 6
Job No: B0307000			File: DCU Stop to Griffith Avenue Stop
Made By: PN	Date: 16/04/08	Revised By:	Date:
Checked By: DIT	Date: 18/04/08	Checked By:	Date:

Chainage 13860 to 14100

Area of Interest:	(315700 E, 238150 N) (315950 E, 237750 N)
Chainages:	Element 1: Northbound running tunnel 13860 to 14100m Element 2: Southbound running tunnel 13860 to 14100m
Tunnel Alignment Data - File Location:	P:\B0307000 Dublin Metro North\Design\Alignment\fixed final alignment\New Alignment_Complete.xls
Analysis directory (settlements):	P:\B0307000 Dublin Metro North\Design\Settlement Analysis - building Damage Assessment\Tundisp Analysis\final\pink alignment\7.Griffith to DCU (13860-14100)
TunDisp Input File:	13860_14100.inp
Geology:	Glacial Till
Running tunnels:	Diameter 6.75m VL= 0.006 (0.6%) K value at surface, K=0.6 K variable with depth , itkp =0 z, depth to plane of interest = 0m (surface settlement) No. of increments n=10 Vertical offset=0m Horizontal offset=0m

CALCULATION SHEET

JACOBS

Project Title: Dublin Metro North			Sheet No: 6
Subject:	Running Tunnel Settlement- Chainage 14110 to 15780- Griffith Avenue Stop to Drumcondra Stop Station		Calc No: 6
Job No: B0307000			File: DCU Stop to Griffith Avenue Stop
Made By: PN	Date: 16/04/08	Revised By:	Date:
Checked By: DIT	Date: 17/04/08	Checked By:	Date:

OUTPUT FILE NAMES AND LOCATIONS

Chainage 13630 to 13920

Output file – tunnels:	cross2.dat
Contour plot file:	Plot1.srf
Contour file for use in CAD:	13630_13920.dxf

Chainage 13860 to 14100

Output file – tunnels:	sb07.dat
Contour plot file:	Plot1.srf
Contour file for use in CAD:	13860-14100.dxf

CALCULATION SHEET

JACOBS

Project Title: Dublin Metro North			Sheet No: 1
Subject:	Running Tunnel Settlement- Chainage 14110 to 15780- Griffith Avenue Stop to Drumcondra Stop		Calc No: 7
Job No: B0307000			File: Griffith Avenue Stop to Drumcondra Stop
Made By: PN	Date: 16/04/08	Revised By:	Date:
Checked By: DIT	Date: 17/04/08	Checked By:	Date:

Griffith Avenue to Drumcondra Stop

INTRODUCTION

The objective of this calculation is to predict ground movements induced by construction of the bored and mined tunnels between Chainage 14110 and 15780 (Griffith Avenue stop to Drumcondra stop section). The results of this calculation will be presented as settlement contours and will be used to identify existing buildings, structures, utilities and infrastructure that lie within the zone of influence, as per the design requirements specified Technical Note 12 'Strategy for Assessing and Managing Building, Infrastructure and Utility Response to Ground Movements Generated by Underground Excavation' September 2007, Ref: B0307000-010\Geo.360\001\1.

REFERENCES

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BMN/0000/GE(0)(3)/12	A03	Exploratory Hole Location Plan and Inferred Geological Section Sheet 12 of 14 (Oct 07)
BMN/0000/TU/0201	B01	Typical Running Tunnel Cross Section
BMN/0000/TU/0204	B01	Cross Passage - Typical Arrangement & Sections
BMN/0000/TU/0205	B01	Cross Passage Drainage Sump - Typical Arrangement & Sections - Sheet 1
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Verification of ground movement predictions will be undertaken using hand calculations for specific areas along the alignment.

CALCULATION SHEET

JACOBS

Project Title: Dublin Metro North			Sheet No: 2
Subject:	Running Tunnel Settlement- Chainage 14110 to 15780- Griffith Avenue Stop to Drumcondra Stop		Calc No: 7
Job No: B0307000			File: Griffith Avenue Stop to Drumcondra Stop
Made By: PN	Date: 16/04/08	Revised By:	Date:
Checked By: DIT	Date: 17/04/08	Checked By:	Date:

METHODOLOGY

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Contours were plotted for 2mm and 5mm settlements and for every 5mm above the 5mm settlement mark.

ASSUMPTIONS

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- The completed tunnel elements are considered to be watertight and therefore long-term settlement due to consolidation is considered negligible.
- The predicted area or zone of influence affected by excavation activities has been established in the ground movement analysis. For bored and mined tunnels the zone of influence is defined as 30m each side of the tunnels centreline, or the 2mm contour line whichever is greatest. For cut and cover and retained sections the zone of influence is defined as the horizontal distance from the façade of the wall to a distance equal to the height of the wall, or to the 2mm contour line whichever is greatest.

CALCULATION SHEET

JACOBS

Project Title: Dublin Metro North			Sheet No: 3
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General

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	Glacial Till	0.6%	6.75m Dia.	Based on dimensions of TBM
	Limestone Bedrock	0.20%	6.75m Dia.	Based on dimensions of TBM
Cross Passage tunnels	Fluvio – Glacial Deposits	2.25%	N/A	N/A
	Glacial Till	0.9%	5.5m Dia.	Cross Passage Entrance enlarged Sections, distance from tunnel axis to end of enlarged section = 5.5m
			4.0m Dia	Based on OD plus 0.15m overcut.
	Limestone Bedrock	0.30%	5.5m Dia.	Cross Passage Entrance enlarged Sections, distance from tunnel axis to end of enlarged section = 5.5m
			3.67m Dia	Based on equivalent circular area plus 0.15m overcut.
Cross Passages with Drainage Sumps	Fluvio – Glacial Deposits	2.25%	N/A	N/A
	Glacial Till	0.9%	N/A	N/A
	Limestone Bedrock	0.30%	N/A	N/A
Ventilation Tunnels	Fluvio – Glacial Deposits	2.25%	N/A	N/A
	Glacial Till	0.9%	N/A	N/A
	Limestone Bedrock	0.30%	Tunnel: 8.53 m Dia Adit: 4.62 m Dia	Based on equivalent circular area plus 0.15m overcut.
Crossovers	Fluvio – Glacial Deposits	2.25%	N/A	N/A
	Glacial Till	0.9%	N/A	N/A
	Limestone Bedrock	0.30%	8.87m, 10.65m, 12.38m, 14.14m	Based on OD plus 0.15m overcut.
Tunnel crossover link	Limestone Bedrock	0.30%	6.93m	Based on OD plus 0.15m overcut.

Geology	'K' Value
Fluvio – Glacial Deposits	0.3
Glacial Till	0.6
Limestone Bedrock	0.4

CALCULATION SHEET

JACOBS

Project Title: Dublin Metro North			Sheet No: 4
Subject:	Running Tunnel Settlement- Chainage 14110 to 15780- Griffith Avenue Stop to Drumcondra Stop		Calc No: 7
Job No: B0307000			File: Griffith Avenue Stop to Drumcondra Stop
Made By: PN	Date: 16/04/08	Revised By:	Date:
Checked By: DIT	Date: 17/04/08	Checked By:	Date:

Chainage 15390 to 15780

Area of Interest:	(315850 E, 236150 N) (316100 E, 236750 N)
Chainages:	Element 1: Northbound running tunnel 15390 to 15780m Element 2: Southbound running tunnel 15390 to 15780m Element 3: Cross Passage 309, Ch. 15483m
Tunnel Alignment Data - File Location:	P:\B0307000 Dublin Metro North\Design\Alignment\fixed final alignment\alignment southbound + northbound\final alignment spreadsheets\Drumcondra to DCU\New Alignment 13200-16600.xls
Analysis directory (settlements):	P:\B0307000 Dublin Metro North\Design\Settlement Analysis - building Damage Assessment\Tundisp Analysis\final\pink alignment\1.Griffith to Drumcondra (15390-15780)
TunDisp Input File:	15390_15780.inp
Geology:	Limestone
Running tunnels:	Diameter 6.75m VL= 0.002 (0.2%) K value at surface, K=0.4 K variable with depth , itkp =0 z, depth to plane of interest = 0m (surface settlement) No. of increments n=10 Vertical offset=0m Horizontal offset=0m
Cross passage 309:	Diameters: 5.5m, 3.67m, 5.5m VL= 0.003 (0.3%) K value at surface, K=0.4 K variable with depth , itkp =0 z, depth to plane of interest = 0m (surface settlement) No. of increments n=7,5,7 Vertical offset=0m Horizontal offset=0m

CALCULATION SHEET

JACOBS

Project Title: Dublin Metro North			Sheet No: 5
Subject:	Running Tunnel Settlement- Chainage 14110 to 15780- Griffith Avenue Stop to Drumcondra Stop		Calc No: 7
Job No: B0307000			File: Griffith Avenue Stop to Drumcondra Stop
Made By: PN	Date: 16/04/08	Revised By:	Date:
Checked By: DIT	Date: 17/04/08	Checked By:	Date:

Chainage 15080 to 15450

Area of Interest:	(315850 E, 236500 N) (316100 E, 237000 N)
Chainages:	Element 1: Northbound running tunnel 15080 to 15450m Element 2: Southbound running tunnel 15080 to 15450m Element 3: Cross Passage 308, Ch. 15236m
Tunnel Alignment Data - File Location:	P:\B0307000 Dublin Metro North\Design\Alignment\fixed final alignment\alignment southbound + northbound\final alignment spreadsheets\Drumcondra to DCU\New Alignment 13200-16600.xls
Analysis directory (settlements):	P:\B0307000 Dublin Metro North\Design\Settlement Analysis - building Damage Assessment\Tundisp Analysis\final\pink alignment\2.Griffith to Drumcondra (15080-15450)
TunDisp Input File:	15080_15450.inp
Geology:	Limestone
Running tunnels:	Diameter 6.75m VL= 0.002 (0.2%) K value at surface, K=0.4 K variable with depth , itkp =0 z, depth to plane of interest = 0m (surface settlement) No. of increments n=10 Vertical offset=0m Horizontal offset=0m
Cross passage 308:	Diameters: 5.5m, 3.67m, 5.5m VL= 0.003 (0.3%) K value at surface, K=0.4 K variable with depth , itkp =0 z, depth to plane of interest = 0m (surface settlement) No. of increments n=7,5,7 Vertical offset=0m Horizontal offset=0m

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