

**METRO NORTH
ORAL HEARING
PROOF OF EVIDENCE
Geoff Featherstone
Risk Management
Thursday 23rd April 2009**



Metro North Oral Hearing

Proof of Evidence

Risk Management

Geoffrey Featherstone

Risk Management

In response to a request made by the Inspector's technical adviser this evidence sets out details in relation to the management of risk in relation to the underground construction works.

1 Overview

RPA has adopted and developed Metro North in accordance with the 'A Code of Practice for Risk Management of Tunnel Works' prepared by The International Tunnelling Insurance Group. This is reflected in the Construction and Maintenance Requirements (contract specification) which states:

- 2.1.2 InfraCo as part of the Works shall prepare and supervise the Design such that it.....(i) is carried out in accordance with the Code of Practice for Risk Management of Tunnel Works (2006) prepared by the International Tunnelling Group, and
- 2.1.4 InfraCo shall construct the Works in accordance with.....(h) the Code of Practice for Risk Management of Tunnel Works (2006) prepared by the International Tunnelling Group.

The purpose of the Code is set out in the following:

The objective of this *Code* is to promote and secure best practice for the minimisation and management of risks associated with the design and construction of tunnels, caverns, shafts and associated underground structures including the renovation of existing underground structures, referred to hereafter as *Tunnel Works*. It sets out practice for the identification of risks, their allocation between the parties to a contract and *Contract Insurers*, and the management and control of risks through the use of *Risk Assessments* and *Risk Registers*.

RPA has extended the requirements of the Code for the whole of the Works and not just in relation to tunnel works.

RPA is fully committed to meeting the objectives of the Code.

2 Compliance Audits

As a management tool to ensure compliance, RPA periodically audits its actions against the Code and to assist in this audit a compliance matrix has been established. Appended to this evidence is a tabulation of the items within the Code against which compliance is audited. The current status of compliance with the Code has been provided to the tenderers and it is their responsibility to continue ongoing compliance with the Code. RPA will continue to audit compliance.

This transfer of information to the prospective contractors is critical to achieving the objectives of the Code and is in line with best practice.

3 Risk Register

As required by the Code, risk registers have been established that deal with both the main project risks and also in greater detail with individual components of the Works.

In addition a very substantial number of “designers’ risks assessments” for discrete areas have been prepared. The designers risk assessments have similarly been handed over to tenderers and they have been responsible through the tendering process to update them as their designs progress. These remain confidential to their tenders at this time.

4 Project Risks

The Inspector’s technical adviser has requested that some commentary be provided on the more critical areas of construction and brief discussion is provided on the following:

- the O’Connell Bridge Stop mined tunnels
- the Parnell Square Stop, and
- the section of running tunnel either side of the Parnell Square Stop

O’Connell Bridge Mined Tunnels

The issues associated with the construction of the O’Connell Bridge running platform tunnels and central concourse are clearly set out in the report entitled “*O’Connell Bridge Stop - Preliminary Geological Section and Indicative Primary Lining Design – Mined Sections*” a copy of which has been provided to the Inspector.

The Executive Summary to that report sets out the primary construction risks most of which relate to the results of additional exploratory drilling that has established that the rockhead in the area is lower than previously anticipated. The risks identified are:

- the crown pillar located in weathered rock may not be adequate
- deformations may induce larger than predicted ground movements
- there may be insufficient rock to provide a groundwater cut off
- the integrity of any grout cut off may be compromised by induced deformations

The risks in this area are shown to be fully understood and will be accounted for in the ongoing detailed designs and the likely mitigant will be a lowering of the tunnel alignment to provide increased rock cover to the tunnels. This will be within the limits of deviation provided for in the Railway Order. Excavation and ground water ingress will be controlled as appropriate by staged excavations, fissure grouting (if necessary with a grouted canopy) and the like.

The O’Connell Bridge Stop - Preliminary Geological Section and Indicative Primary Lining Design report has been provided to tenderers for the development of their detailed designs and as previously noted the detailed evaluation of tender design submissions is currently ongoing, details of which are confidential.

The Executive Summary also notes that the foundations to the O’Connell Bridge may be lower than expected. RPA has commissioned a full condition survey of the bridge

Parnell Square Stop

It is recognised that the control of excavations in the Parnell Square area will be critical given the nature of the materials to be excavated and this has been discussed in the earlier evidence of Paul Brown. A typical layout of a stop box excavation

sequence as presented by Paul is attached to this evidence and this clearly demonstrates the controlled manner in which excavation will progress.

Risks associated with collapse during diaphragm wall construction are well understood as are the methods of control and will be managed by the Contractor with a detailed knowledge of the ground conditions from the extensive exploratory work carried out. Should it be however be determined by the detailed investigations / design that there is a significant risk of trench instability (this is not considered to be a significant risk) then pre-treatment of the ground will be undertaken.

Diaphragm walling in the Dublin area has already been successfully carried out in similar ground conditions (fluvio-glacial gravels that are heavily over consolidated resulting in a high density material) to those that will be experienced at Parnell Square. While these excavations were substantially shallower than the Parnell Square excavation, it was demonstrated that for these ground conditions good control of ground movements can be maintained within acceptable limits.

Groundwater ingress through the walls will be controlled by strict water-tightness criteria as described earlier and by the application of a suitable grout cut off below the diaphragm walls

Notwithstanding, it is expected that the contractor will, prior to finalising his design, further prove the conditions to be encountered.

This like any of the known risks identified will be the subject of the necessary mitigation measures that will be included in the contractor's detailed design.

Running Tunnel either side of Parnell Square

It is recognised that sections of the tunnel alignment either side of the Parnell Square Stop are not at the optimum level for tunnelling since mixed face conditions are encountered. The issue was considered in detail during the reference design phase as demonstrated by "*Technical Note 10 - Bored Running Tunnel Reference Design Report*". The relevant extract from that note is attached. Whilst the designs have moved on substantially since then the design and construction issues and risks and recommended actions noted in the extract have been considered in the ongoing design development. As such the attachment is only provided as an example of the manner in which the design has been progressed taking due recognition of the risks envisaged.

Again this Technical Note has been provided to tenderers to assist them in the continuing development of their detailed designs.

The main mitigant in dealing with mixed face conditions is the selection of the most appropriate type of tunnel boring machine and both Professor Burland and Paul Brown touched upon this in their earlier evidence and the following further information is offered.

The most effective tunnelling method for the project when considering output whilst minimising surface settlement within the mixed and soft ground areas would be through the use of either an Earth Pressure Balance (EPB) or slurry machine as these methods control face loss while retaining output. The proposed approach of the reference design was to use earth pressure balance machines for tunnelling throughout the drives but the use of slurry

machines could be equally acceptable. The Construction and Maintenance Requirements require:

“15.1.1 Closed-face tunnel boring machines shall be used. TBMs shall comply with the guidelines contained in Closed-Face Tunnelling Machines and Ground Stability produced by the BTS and ICE, published by Thomas Telford (2005)”

Tenderers have submitted their proposals as part of the tender process and are currently under evaluation, as before details will remain strictly confidential but Clause 15.1.1 will apply.

The EPB is capable of dealing effectively with both hard and soft ground and will handle the geology with the assistance of conditioning agents with relative ease. Care will be needed, as always in mechanical tunnelling, where both hard rock and soft ground feature in the face. It will be absolutely essential that pressures are maintained within the face at or around 0.3 bar above hydrostatic pressure over this zone and that accurate volume checks are continuously maintained throughout. Similarly, for a slurry machine, the slurry should be pressurised some 0.3 bar above the natural hydrostatic head to counterbalance and overcome the natural water head creating a positive footprint within the ground at the face. At no time, even at rest, should the slurry pressure be allowed to fall below the natural hydrostatic pressure thus maintaining face stability.

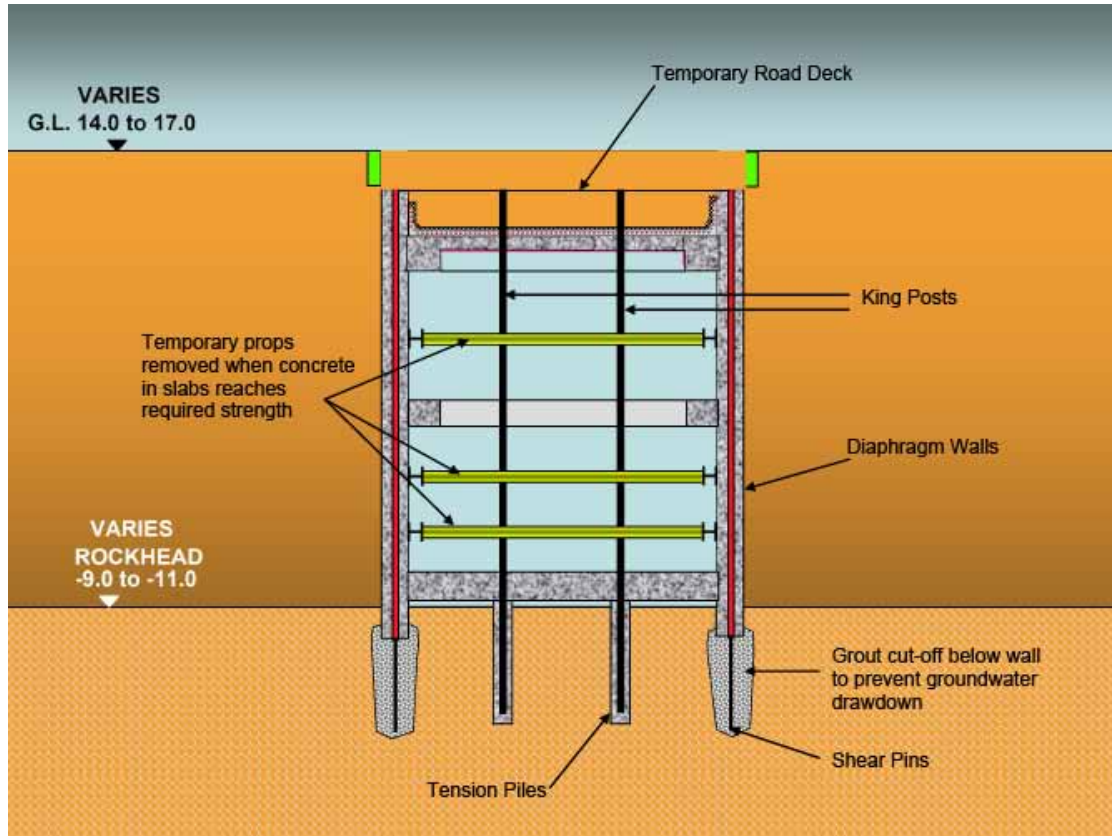
5 Summary

In response to a request made by the Inspector's technical adviser this evidence has set out details in relation to the management of risk in relation to the underground construction works.

It has demonstrated that a proper and appropriate risk management procedure is in place and that the necessary cognisance has been taken of the requirements of the *'A Code of Practice for Risk Management of Tunnel Works'* prepared by The International Tunnelling Insurance Group.

It has further demonstrated that project risks have been identified and that mitigation measures are in place and that the steady transfer of information to the tendering parties is in place.

Typical Stop Excavation



EXTRACT FROM TECHNICAL NOTE 10				
Location	Vertical Alignment	Outline Geology	Design Construction Issues and Risks	Actions/Recommendations
Mater Stop to Parnell Sq. Stop (Ch. 16469m – 17073m)	<u>Proposed Rail Level</u> Range: -5.885mOD to -12.830mOD <u>Tunnel Cover</u> Min: 15m Max: 17.17m At stops.	<p>Overlying the bedrock is a layer of Made Ground and Glacial Till with glacial sands and gravels within the till. There is a complex mix of glacial till and glacial sands and gravels (and rock) at this location and this will be better defined by the ongoing MGI. The interface with the bedrock varies between -8mOD and -12mOD.</p> <p>From Mater Stop the tunnel traverses through Glacial Till into an area of Glacial Gravels around Ch.16500 to the Stop. Bedrock is potentially encountered in the invert of the tunnel around Parnell Square Stop. Geological Long Section: August 2007. BMN-0000/GE (0)(3)-13 A01</p>	<ul style="list-style-type: none"> • The overlying buildings use changes from residential to a mix of residential, commercial and offices. Initially the tunnel is by the Mater private hospital which needs to be assessed for sensitivity to movement and vibration. The route then passes down Frederick Street North with major buildings on both sides. There are a large number of medium sized hotels. The area is in a conservation area. There is a major Findlaters 19th Century church structure before the tunnels meet Parnell Square Stop. • Glacial Gravel is likely to be hydraulically charged, 'Boreholes IGSLBH12 shows blowing sands and gravels from 10.2 to 26.4m depth (-1.2mOD to -17.4mOD) and WBH20 shows boiling sand between 12.4m and 28.6m depth (-2.4mOD and -18.6mOD). This will cause difficulties in controlling water inflow and settlement. • The tunnel drive expected to traverse through Glacial Gravels where volume loss can be expected to increase. There is a long section of mixed face tunnel drive. • TBM selection and control becomes vital. • The ground conditions are such that a fully bolted Spheroidal Graphite Lining or extremely thick concrete linings are required in this area. • Cross Passage construction in this area will require significant ground treatment plus in the area/zone where the TBM breaks into/out-off the Stop Box structure. • Risk of encountering old boreholes e.g. IGSLBH15 and WBH28. 	<ul style="list-style-type: none"> • Review of additional SI required to assess level and alignment. Consider additional investigations after main ground investigation has been reviewed. • Consider lowering or amending the alignment to move into the rock. This has to be balanced against the increased water pressure. Limit tunnel axis to about 35m below ground level. • Complete Ground Reference Conditions Report. • Select appropriate tunnelling method and TBM. • Specify use of TBM Reference Parameters Plan with guidance for correct mode. • Include advance probing and other techniques ahead of the tunnel face. • Develop areas of additional ground treatment and methodology. • Development of contingency and action plans. • Review of additional hydrogeological studies to establish extent of water changed gravels. • Recommend bored tunnel lining to be constructed using SGI. Include in Reference Design. • Relocation of cross passages depending on location of geology encountered during construction.

EXTRACT FROM TECHNICAL NOTE 10				
Location	Vertical Alignment	Outline Geology	Design Construction Issues and Risks	Actions/Recommendations
Parnell Sq. Stop to O'Connell Bridge Stop (Ch. 17167m - 17954m)	<u>Proposed Rail Level</u> Range: - 12.830mOD to - 24.000mOD <u>Tunnel Cover</u> Min: 17.17m Max: 21m At Stops.	Overlying the bedrock is a layer of Glacial Gravels containing deposits of Glacial Till. The Glacial Gravel is thickest at Ch.17270 (-20mOD) with the interface between the rock rising approaching of O'Connell Bridge Stop where the Gravel/Bedrock interface is located at -4mOD. From Parnell Stop the tunnel is situated in Glacial Sands and Gravels before descending into the bedrock at approximately Ch.17440m. There is an inferred fault at Ch.17400. Around this chainage mixed face conditions in the tunnel are likely. The tunnel track is 28m below ground level under the River Liffey Geological Long Sections: August 2007. BMN-0000/GE (0)(3)-13 A01 BMN-0000/GE (0)(3)-14 A01	<ul style="list-style-type: none"> • The overlying structures are mainly commercial but they also include: <ul style="list-style-type: none"> ○ Ambassador Theatre ○ Gresham Hotel, other hotels. ○ Savoy Cinema. ○ The Millennium Spire. ○ Cleary's Department Store ○ The General Post Office. ○ LUAS line and substations • Tunnel drive expected to traverses through Glacial Gravels where volume loss can be expected to increase. • Local near surface geology susceptible to consolidation from TBM vibration or general ground movement. • Glacial Gravel is likely to be hydraulically charged, 'Boreholes IGSLBH12 shows blowing sands and gravels from 10.2 to 26.4m depth (-1.2mOd to -17.4mOD) and WBH20 shows boiling sand between 12.4m and 28.6m depth (-2.4mOD and -18.6mOD) • Mixed face condition is anticipated at Ch.17440m as tunnel descends from Glacial Gravel into Bedrock. • The water inflow into the rock tunnels from the overlying River Liffey are currently uncertain as is any potential drawdown in the overlying areas. • The track separation increases to match the concourse and platform tunnel configuration. • Risk of encountering old boreholes 	<ul style="list-style-type: none"> • Review of additional SI required to assess level and alignment. Consider additional investigations after main ground investigation has been reviewed. • The main geotechnical investigation is likely to show that the mix of glacial till and glacial sands and gravels is more complex than currently shown. • Develop investigations to confirm ground water regime above tunnels. • Consider lowering or amending the alignment after additional SI. • Complete Ground Reference Conditions Report. • Select appropriate tunnelling method and TBM. • Specify use of TBM Reference Parameters Plan with guidance for correct mode. • Include advance probing and other techniques ahead of the tunnel face. • Develop areas of additional ground treatment and methodology. • Development of contingency and action plans. • Recommend bored tunnel lining to be constructed using SGI. Include in Reference Design. • Relocation of cross passages depending on location of geology encountered during construction

Railway Procurement Agency
Ghníomhaireacht um Fháil Iamróid
Parkgate Business Centre,
Parkgate Street, Dublin 8, Ireland
Phone +353 1 646 3400
Fax +353 1 646 3401
www.rpa.ie

Responsible for

LUAS METRO

Integrated
Ticketing
System

With funding and
support from

transport21
progress in motion

