

Package / Issue:	Methodology for Assessment of Building-Induced Loads on the Albert Street Cross River Rail Cavern	Doc Ref:	B01493-IBR
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References:	PSM Technical Memorandum (Ref. PSM3700-I 102M – Assessment of Ground Loads)		

I Introduction

The CRR Albert Street Pty Ltd (ACN 660 319 693) as trustee for CRR Albert Street Trust (Albert Street Trust) has been awarded the development rights for the proposed development at 101 Albert Street in Brisbane CBD. Development of the 101 Albert Street mixed used precinct will include a commercial tower in the order of 200m tall with approximately 45 floors above ground level, along with a single level basement.

The proposed development is located adjacent to and partially above the Albert Street Cross River Rail (CRR) cavern with the top of the cavern located approximately 17m below ground. As part of the development approval process, an assessment is required to determine whether loads associated with the proposed building could adversely affect the cavern lining system.

This document presents the methodology and assessment process adopted to evaluate the effects of the proposed building on the Albert Street cavern, which has been progressively developed in collaboration with EDQ's technical advisor ARUP.

The purpose of this document is to generally describe the analytical approach, assumptions and assessment framework that will be used to quantify and compare the loading conditions. It precedes a subsequent more detailed report that will present the findings, analysis results, interpretation and conclusions arising from the assessment.

2 Assessment Objective

The primary objective of the assessment is to evaluate the magnitude of ground loads that apply to the cavern lining that result from the proposed development. Those loads will then be compared against similar loads that relate to various load cases that were nominated in the CRR Project Scope and Technical Requirements (PSTR), which the cavern lining design is based upon.

The assessment is based on the principle that the cavern lining has previously been designed to safely withstand a range of project-specific loading conditions (as defined in the PSTR), and therefore, if the stresses and ground loads generated by the proposed building are demonstrated to be less than those associated with the PSTR load cases, then the proposed development can be considered to fall within the established design envelope of the cavern.

Under these circumstances, it would then be inferred that the proposed building does not introduce loading conditions that exceed those already considered in the original cavern design and therefore does not detrimentally affect the structural integrity or serviceability of the cavern.

The assessment is not intended to reassess the structural capacity of the cavern lining. Rather, it seeks to establish whether the proposed building generates ground loading effects that remain within the range of conditions previously considered during cavern design.

3 Assessment Methodology

3.1 PSTR Load Cases

The assessment considers load cases defined in the PSTR, which are shown in Figure 1 below:

5.6.4.2 Albert Street Station

a)	Not used.	Note
b)	The CRR System shall allow for the Albert Street FOSD.	OSD-29
c)	The CRR System shall allow for retail within the Underground Station and the station precinct.	OSD-30
d)	Albert Street Station shall provision for FOSD loading of 375 kPa working load applied over part or the entire Albert Street Lot 2 site, applied between RL+4.0m and RL-8.0m, to give the most unfavourable loading conditions on the Station.	OSD-31
e)	Not used.	OSD-32
f)	Not used.	OSD-33
g)	Not used.	OSD-34
h)	Not used.	Note
i)	Albert Street Station shall allow for excavation over the entire Albert Street Lot 2 site to RL-8.0m.	OSD-46
j)	Albert Street Station shall allow for excavation over the entire Albert Street Lot 2 site (excluding the volumetric zone described in the Project Agreement Schedule G1) to RL-20.0m.	OSD-47
k)	Albert Street Station shall allow for future development loading and unloading cases as detailed in Appendix B2 Table B2-A for case 1 and Table B2-B for case 2.	OSD-48

Figure 1 – PSTR Over Station Development Load Cases

Given that the proposed development includes only a single-level basement, the excavation depth is substantially less than the excavation allowances considered within the PSTR. The reduction in overburden associated with the proposed basement excavation is significantly less than that considered in the PSTR design scenarios. Consequently, this assessment focuses primarily on loading-related load cases rather than unloading-related load cases.

The assessment presented herein focuses on the loading effects associated with the proposed development. The PSTR load cases that impose loading on the cavern and are considered in this assessment are as follows:

- **OSD-31** – 375 kPa working load applied over part or the entire Albert St Lot 2 site, applied at RL +4m.
- **OSD-31** – 375 kPa working load applied over part or the entire Albert St Lot 2 site, applied at RL -8m (applied following removal of soil/rock above RL -8m).
- **OSD-48** – 50 kPa working load applied at 1m above the cavern crown combined with a 20 kPa working load applied at ground level (RL +4m).

3.2 Proposed Building Load Case

Structural loading associated with the proposed development has been determined by the project structural engineer (HERA) and supplied to EDG for use in the assessment. These loads have been incorporated into a three-dimensional geotechnical finite element model through representation of the proposed piled foundation system.

The pile foundations are modelled using the proposed pile diameters, toe levels and appropriate geotechnical and structural pile properties to accurately represent load transfer mechanisms between the structure and the ground. The resulting stress changes within the ground mass and their influence on the Albert Street cavern are then evaluated.

The following load combination has been considered in the analysis:

- $1.1 * (G + 0.4Q + 0.64W)$

4 Calculated Loads on Cavern

The acceptability of the proposed development will be assessed by comparing the loads induced on the cavern by the proposed building against the loads induced by the cavern design load cases described in Section 3.1.

Loading on the cavern will be evaluated using the following two measures:

- Calculated normal stresses acting on the cavern lining from the geotechnical analysis; and
- Calculated ground loads acting on the cavern lining, determined using a methodology consistent with that adopted by PSM for the original cavern lining design.

As described in PSM design documentation (Ref. PSM3700-1102M – Assessment of Ground Loads), “the following two methods were applied to assess the ground load acting on the crown of the tunnel lining:

1. Average of the vertical component of the calculated normal stress acting between the ground and permanent lining.
2. Average of the vertical component of the equivalent normal stress based on the hoop stress analogy”.

The calculated normal stresses and, ground loads (as defined above and within the PSM design documentation) will be determined for both the proposed development load case and the relevant PSTR load cases. The results will be compared to verify that the loads generated by the proposed development do not exceed those associated with the PSTR load cases and therefore remain within the loading envelope previously considered in the cavern design.

The analysis will include a series of sensitivity assessments in which key parameters are varied within credible ranges to evaluate their influence on the calculated cavern loads. The parameters considered in the sensitivity analyses are the rock mass stiffness and the ground relaxation factor (representing partial stress relief prior to installation of the lining).

The objective of the sensitivity assessment is to determine whether variation of these parameters could result in the proposed development load case generating higher cavern loads than those associated with the relevant PSTR load cases, or whether the PSTR load cases continue to govern under all reasonable parameter combinations.

Demonstrating that the PSTR load cases produce higher cavern loads across the full range of sensitivity cases would provide confidence that the proposed development remains within the loading envelope previously considered in the cavern design. This conclusion would remain valid notwithstanding that the current assessment has been undertaken using a finite element model that differs from that adopted by PSM during the original cavern design.

5 Basis for Acceptance

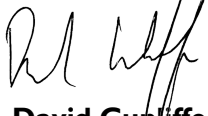
The cavern lining system was designed to accommodate the loading conditions associated with the original Cross River Rail design scenarios.

If the proposed building load case produces normal stresses and, consequently, ground loads that are lower than those associated with the governing design cases, then the proposed development does not increase loading demands beyond the established design envelope.

On this basis, it would be concluded that the proposed building does not introduce adverse loading effects that would compromise the Albert Street cavern.

The subsequent assessment report will present the detailed calculations, modelling outcomes, load comparisons and supporting evidence used to demonstrate compliance with these acceptance criteria.

For and on behalf of EDG Consulting Pty Ltd



David Cunliffe
Senior Principal

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All site conditions cannot be identified

The scope of work undertaken represents a professional assessment of the information cited to develop a basic geotechnical model of the site based on EDG's understanding of the client's risk profile. In some cases, increasing the frequency of investigations and/or sampling, or considering alternative investigation techniques may improve the interpretation, but may not identify all relevant subsurface conditions at the site.

The document presents an interpretation

Geotechnical information is an interpretation of conditions evident based on a limited number of facts established during a site investigation. Engineering logs are an interpretation of observations of samples and test results at discrete locations in the subsurface profile. A geotechnical model is an interpretation of site conditions, developed using information from discrete locations on the site and an understanding of geological processes. Interpreted conditions at and between investigation locations may be different to those inferred on the engineering logs and geotechnical model. The client must consider how variations in conditions could affect the project and seek advice to reduce risk if it is unacceptable to the client.

Conditions can change

The geotechnical information provided is based on the conditions observed at the time of the investigation. Such conditions may be time dependent and subject to external influences. Many things could influence the site conditions, including geological processes, variation in groundwater or surface water levels, other natural cycles and influence from human activities (on this site or nearby sites). Specific advice should be sought if conditions on site change from those observed at the time the report was prepared.

How to deal with different site conditions

The sub-surface conditions on the site may not be as inferred in this report. Geotechnical uncertainties can be managed throughout the project life cycle, but particularly during construction.

Knowledge of site conditions must be further developed as the ground is exposed during construction and/or operation. It is essential that the client implements the nominated design and construction requirements, including observation, interpretation and assessment of the exposed conditions during construction and operation using skilled staff familiar with the design assumptions and assumed geotechnical conditions, or engaging EDG to undertake this role on your behalf.