APPENDIX B: STRUCTURAL ENGINEERING ADVICE

Job Number: 18021

SDA Structural Report: Lilyfield Road Bridge

20/12/2018

SDA

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EXECUTIVE SUMMARY

This Report presents a comparative structural review between the existing loadings on Lilyfield Road Bridge and the loadings associated with the proposed works for the Greenway, as documented in the McGregor Coxall landscape architecture drawings.

The proposed works alter the current arrangement of pedestrian paths, cycleway and grassed area, and add new deep soil planters, while also reducing the depth of soil throughout the grassed area.

The existing bridge is currently in need of remediation to fix deterioration of the piers, and these works are understood to be scheduled to take place in the near future.

Apart from the pier remediation, this Report shows that the proposed works represent a decrease in the loading on the bridge's structural elements versus the existing loading.

Charles Blumer MIEAust, Director
SDA Structures Pty Ltd

INTRODUCTION

Lilyfield Road Bridge (BN213 Hawthorne Canal Bridge) links the east and west sides of Hawthorne Canal at the canal's entrance into Iron Cove. It is an eight span bridge with spans between 12 and 15m, and a width of approximately 18m, and formerly carried vehicular traffic as part of Lilyfield Road. Since the opening of the City West Link in 2000, the bridge has not carried normal vehicular traffic, and now carries two footpaths and a cycleway on the north and south sides, with a grassed central area between them.

Inner West Council is seeking to incorporate the bridge into the proposed Greenway project, and as such, is seeking to confirm the adequacy of the bridge to support upgrades to the landscape architecture which will improve the bridge's functionality and amenity.

This Report provides the following structural assessment of the proposed works:

1. Visual structural assessment of bridge to identify areas of concern with regard to adequacy of structure
2. Comparative assessment of Existing versus Proposed loadings in order to confirm the proposed design is load neutral/reduced versus the existing.

BACKGROUND INFORMATION AND RESOURCES

In the compilation of this Report, SDA Structures has had access to the following resources:

- Existing structural drawings of the bridge by Donovan H Lee and Partners (1966): Sheets 1,5,7,12,13,14,15
- VBAJV Report of April 2016 (Rev 0): Pier Assessment Report:
  Report provides a structural assessment of the piers and headstock beams, including current of current loadings versus capacities, and recommends remediation of piers due to corrosion and spalling
- Drawings for Cathodic Protection of bridge piers by Infracorr (June 2018);
  Sheets 1-5
- Proposed Landscape Architecture scheme drawings by McGregor Coxall (70% Issue):
  Drawings SD-CD-202,302

VISUAL STRUCTURAL ASSESSMENT

SDA Structures conducted an inspection of the bridge on 19/12/2018, which consisted of:

- Walkover and visual inspection of the top surface of the bridge and balustrades
- Inspection of the underside and piers from the path on the Eastern shoreline.
- Digging (including sensitive replacement of soil and turf) of hole in the soil at the ridge line of the grassed area, about halfway along the bridge in order to confirm soil depth; presence of what appeared likely to be a membrane of some sort was also confirmed at the base of the soil at bridge deck level.

<u>Results of Structural Assessment:</u>

- No noticeable signs of significant damage or deterioration to any visible bridge elements except for the piers, which, as noted in the VBAJV Report, are showing signs of significant corrosion and section loss. It is SDA's understanding that the piers are to be remediated with cathodic protection, a scheme for which is indicated on the drawings listed above

- Balustrade heights and loading capacities will need to be reviewed to suit final architectural design; higher balustrade will be needed to suit cycleway being located adjacent to balustrade; nothing was observed on site or noted within the existing structural drawings to suggest there will be any problem fixing new balustrade to the existing bridge deck structure; the changed loadings will be negligible with regard to the bridge capacity so in summary, SDA sees no structural problem associated with amending the balustrades to suit the cycleway relocation.

LOADINGS

The current and proposed loadings on the bridge are indicated on drawings Sk1-3, and in Tables 1-3.

The following assumptions and references were used in preparation of this information:

- AS5100: Bridge Loading Code
- AS3600: Concrete Code
- AS1170: Loading Code
- Unit density of concrete: 25kN/m3
- Unit density of soil: 20kN/m3
- Cycleway live loading: 2.5kPa
- Pedestrian live loading: 5kPa
- Grassed area live loading: 2.5kPa

Soil depth is critical to the comparative analysis. As per the Architectural section, it has been surveyed as being approximately 400-450mm maximum depth through most of the grassed area, with the edges dropping down to approximately 250mm (refer Photos 1-5) for approximately 1-1.5m width along the edges of the grassed area. SDA's site investigation confirmed this maximum depth of approximately 400mm at least.

ANALYSIS

This Report presents the existing and proposed loadings onto the bridge in the form of a series of comparative loading tables, each one addressing a separate structural element: deck, headstock beams and piers.

With reference to the deck structure, the structure is consistent across the width of the bridge, and so the critical loading to be reviewed is the maximum loading rather than an average across the whole width of the bridge.

With reference to the headstock beams, the loadings onto each cantilever and the central span are reviewed separately

With reference to the piers, the North and South piers are reviewed separately.

CONCLUSIONS

As per the Tables 1-3, the reduction of the soil depth from a maximum depth of 400-450mm to 300mm throughout the grassed area provides an allowance for adding other design elements in the form of deep planter beds. These have been located strategically, over the piers, so as to not significantly increase the total loading onto the various structural elements: deck structure, headstock beams and piers.

Each structural element (deck, headstock beams, piers) is shown to have an overall decrease in loading versus the existing situation which appears to have been functioning adequately (with the exception of deterioration of the piers) for a number of years since the City West Link changed the usage of the bridge significantly.

Comparative Review of Loadings by Structural Element:

TABLE 1: Deck

*Majority of soil depth appears to be approximately 400mm (confirmed by SDA's inspection); given that all deck beam elements are the same, for the deck elements the maximum loading is the critical value rather than the average, whilst the average is more relevant for the headstock and pier elements. Note that a conservative estimate of 350dp existing soil has been assumed.

Loading Item	**Existing**		**Proposed**		**Comments**
	Description	**Loading**	**Description**	**Loading**	
DEAD LOADS					
Soil – Maximum	400-450dp*	8-9kPa	300dp	6kPa	Proposed reduced versus Existing
Soil – Average (conservative estimate)	350dp*	7kPa	300dp	6kPa	Proposed reduced versus Existing
Soil Edge Hob (North)	250dp x 150w	0.94kN/m	250dp x 150w	0.94kN/m	Proposed equal to Existing
Soil Edge Hob (South)	250dp x 150w	0.94kN/m	650dp x 400w	6.5kN/m	Fully reinforced concrete hob has ability to span from pier to pier, thus not providing additional loading onto specific deck beam element directly under it
Deep Planters over Piers	-	-	1m dp x 2.6m w soil (1m depth includes 150thk slab over existing deck, with 1m x 0.2m concrete edge walls, centred on piers	17kPa soil, 3.8kPa slab under soil, 5kN/m walls along edges	These loadings are intentionally located over the pier lines, so that the equivalent additional loading onto the deck elements is minimised (as per Sk3, due to the proposed reduction in soil depth, the proposed loading overall, including the planter beds, is actually lower than the existing).
Equivalent total uniform load over whole deck where deep planters present in proposed scheme and where only grassed area present in existing state	Grassed area only (no planters); use 400dp (conservative estimate of maximum depth)	8kPa	Equivalent total uniform load over whole 14m span (including planter plus surrounding grassed area)	7kPa (refer Sk3)	Total equivalent load (proposed) onto deck structure = 7.0kPa, which is reduced versus existing typical/maximum of 8-9kPa)

Pedestrian Walkway	75thk slab	1.9kPa	75thk slab	1.9kPa	Proposed equal to Existing
Cycleway	50thk asphalt	1.0kPa	50thk asphalt	1.0kPa	Proposed equal to Existing
LIVE LOADS					
Pedestrian Walkway		5kPa		5kPa	Proposed equal to Existing
Cycleway		2.5kPa		2.5kPa	Proposed equal to Existing
Grassed Area		2.5kPa		2.5kPa	Proposed equal to Existing
Vehicle Load	Ute or equivalent	TBC	Ute or equivalent	TBC	As per discussion at RMS on 12/12/2018 – proposed will be equal to or less than existing

TABLE 2: Headstock Beams
(Assuming 14m spacing between piers for purposes of comparison between Existing and Proposed)

Loading Item	Existing		Proposed		Comments
	Description	Loading	Description	Loading	
DEAD LOADS					
Soil – Maximum	400-450dp	112-126 kN/m	300dp	84kN/m	Proposed reduced versus Existing
Soil – Average (conservative estimate)	350dp	98kN/m	300dp	84kN/m	Proposed reduced versus Existing
Soil Edge Hob (North)	250dp x 150w	13.2kN	250dp x 150w	13.2kN	Not relevant to Headstock Beam capacity as load is located directly over pier below
Soil Edge Hob (South)	250dp x 150w	13.2kN	650dp x 400w	91kN	Not relevant to Headstock Beam capacity as load is located directly over pier below
Equivalent total uniform load over whole deck where deep planters present in proposed scheme and where only grassed area present in existing state	Grassed area for whole span (use soil depth of 400, which is typical thru central portion of grassed area)	112kN/m	Planter 3m wide x1m dp over beams, and grassed area 300dp elsewhere	98kN/m equivalent	Refer Sk3 for evaluation of equivalent loading – Proposed reduced versus Existing
Pedestrian Walkway	75thk slab	26.3kN/m	75thk slab	26.3kN/m	Proposed equal to Existing
Cycleway	50thk asphalt	14kN/m	50thk asphalt	14kN/m	Proposed equal to Existing
LIVE LOADS					
Pedestrian Walkway		70kN/m		70kN/m	Proposed equal to Existing
Cycleway		35kN/m		35kN/m	Proposed equal to Existing
Grassed Area		35kN/m		35kN/m	Proposed equal to Existing

Vehicle Load	Ute or equivalent	TBC	Ute or equivalent	TBC	Proposed equal to Existing

TABLE 3: Piers
Loads assume 14m spacing between piers for comparison purposes
Loads assume headstock beams have 2m cantilevers, 4.5m wide piers, 4.5m span between piers

Loading Item	Existing		Proposed		Comments
	Description	Loading (per pier)	Description	Loading (per pier)	
DEAD LOADS					
Grassed Area (use average soil depth)	350dp soil; 9.5m total width; 3.5m width goes onto North pier; 6m width goes onto South pier	858kN total; North: 316kN South: 542kN	300dp soil; 11.3m total width; 6m width goes onto North pier; 5.3m width onto South	735kN total; North: 390kN South: 345kN	North: Proposed increased versus Existing South: Proposed reduced versus Existing
Soil Edge Hob (North)	250dp x 150w	13.2kN	250dp x 150w	13.2kN	Proposed equal to Existing
Soil Edge Hob (South)	250dp x 150w	13.2kN	650dp x 400w	91kN	Proposed increased versus Existing
Equivalent total uniform load over whole deck where deep planters present in proposed scheme and where only grassed area present in existing state	Use average soil depth 350 (conservative)	North: 858kN South: 858kN	Planters 1m dp, 300dp grassed area elsewhere	North: 858kN South: 858kN	Proposed equal to Existing
Pedestrian Walkway 75thk slab	2.5m wide	North: 66 kN South: 66kN	2.5m wide	North: 66kN South: 0	North: Proposed equal to Existing South: Proposed reduced versus Existing

Cycleway 50thk asphalt	3.3m wide	North: 46kN South: 0	3.3m wide	North: 0 South: 46kN	North: Proposed reduced versus Existing South: Proposed increased versus Existing
LIVE LOADS PER PIER					
Pedestrian Walkway	2.5m wide	North: 175kN South: 175kN	2.5m wide	North: 175kN South: 0	North: Proposed equal to Existing South: Proposed reduced versus Existing
Cycleway	3.3m wide	North: 116kN South: 0	3.3m wide	North: 0 South: 116kN	North: Proposed reduced versus Existing South: Proposed increased versus Existing
Grassed Area	9.5m wide total (3.5m width goes onto North pier, 6m width goes onto South pier)	333kN total North: 210kN South: 113kN	11.3m total width; 6m width goes onto North pier; 5.3m width onto South	396kN total North: 210kN South: 186kN	North: Proposed equal to Existing South: Proposed increased versus Existing
Vehicle Load	Ute or equivalent	TBC	Ute or equivalent	TBC	Proposed equal to Existing
TOTALS PER PIER:					
DEAD		North:1299kN South: 1479kN		North: 1327kN South: 1340kN	North: Proposed increased versus Existing South: Proposed decreased versus Existing
LIVE (Crowd loading critical versus vehicle)		North: 501kN South: 288kN		North: 385kN South: 302kN	North: Proposed reduced versus Existing South: Proposed increased versus Existing
DEAD PLUS LIVE		North:1800kN South: 1767kN		North: 1712kN South: 1642kN	North and South both reduced versus Existing loadings*

*Also, according to VBAJV Report of April 2016, piers are currently loaded at approximately 35% of capacity

APPENDIX A

Loading Drawings Sk1-3

FL 3.00
FL 3.00
FL 3.00
FL 2.25
FL 2.25
FL 1.50

Ecological islands (not in scope)

PROPOSED

EXISTING

Shelter / podium with storage

2+3 LD-CO-302

1 LD-CO-302

2+3 LD-CO-302

PEDESTRIAN
5kPa
LL
DL
1.9kPa
GRASSED
2.5kPa
*6kPa avge
8kPa avge
CYCLEWAY
2.5kPa
1.9kPa
1.9kPa 5kPa EXIST. PEDESTRIAN
DL LL
1.9kPa 5kPa EXIST. PEDESTRIAN
1kPa 2.5kPa EXIST. CYCLEWAY
2.5kPa EXIST. GRASSED

650dp x 400w HOB cantilevers to Pier Line

Raised planters above the piers with integrated seating

Concrete seating edge

1m Dp PLANTER
LL 2.5kPa (CONSERVATIVE - MORE LIKELY ≤1kPa)
*DL 22kPa (APPROX. AVGE INCL. WALLS)

SHELTER (LIGHTWEIGHT)
LL 2.5kPa
DL 0.5-1 kPa

Nature play

LD-CO-302

EXISTING DRIVEWAY

EXISTING DRIVEWAY

Parking for cars + trailers

* NOTE: REFER SK3 FOR EQUIVALENT UNIFORM LOAD FROM (PLANTER + SURROUNDING GRASSED AREA)

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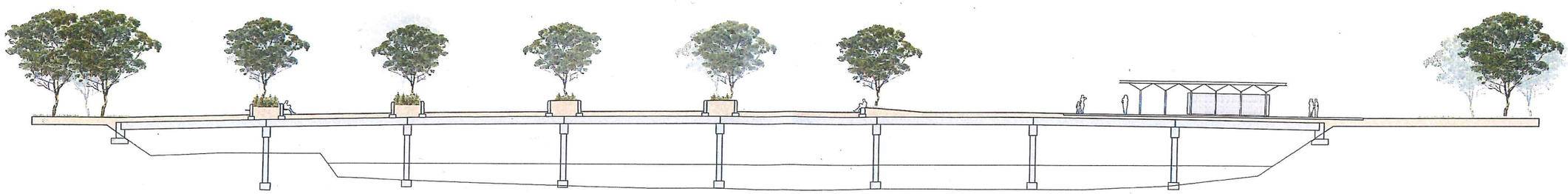
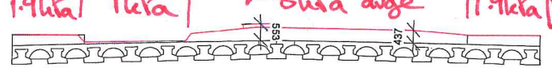
project	drawing title	engineer	project number	sketch	revision	date	Scale @ A3
Greenway Missing Links - Cooks River to Iron Cove	LOADINGS - PLAN	CB	18021	Sk1		19 Dec 2018	



1 Lilyfield Bridge - southern elevation
Scale: 1:200

5kPa | 2.5kPa | 2.5kPa | 5kPa LL
STRUCTURAL SECTION COMBINED WITH SURVEY SECTION
1.9kPa | 1kPa | 7-8kPa avge | 1.9kPa DL

EXISTING (FROM SURVEY)



5kPa
1.9kPa

2.5kPa
6kPa avge
(Planter: 2.5kPa LL
2.2kPa DL)

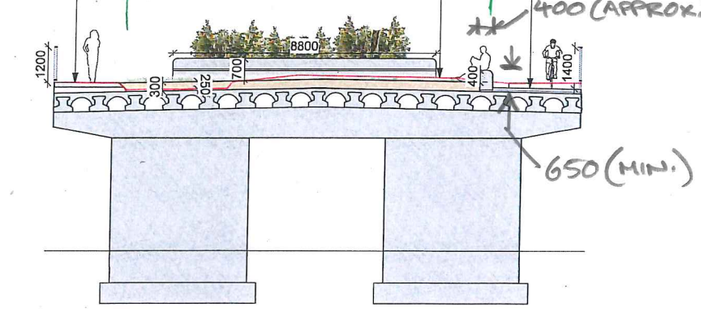
2.5kPa LL
1.9kPa DL

PROPOSED (TYPICAL)

Retain footpath at current level.
Retain existing services (gas main / electricity conduit) under footpath.

Reduce soil depth on whole bridge (from approx. 450mm to 250mm)

Remove southern footpath to facilitate cycleway.



3 Lilyfield Bridge - eastern elevation
Scale: 1:100

To be read with SDA structural specification

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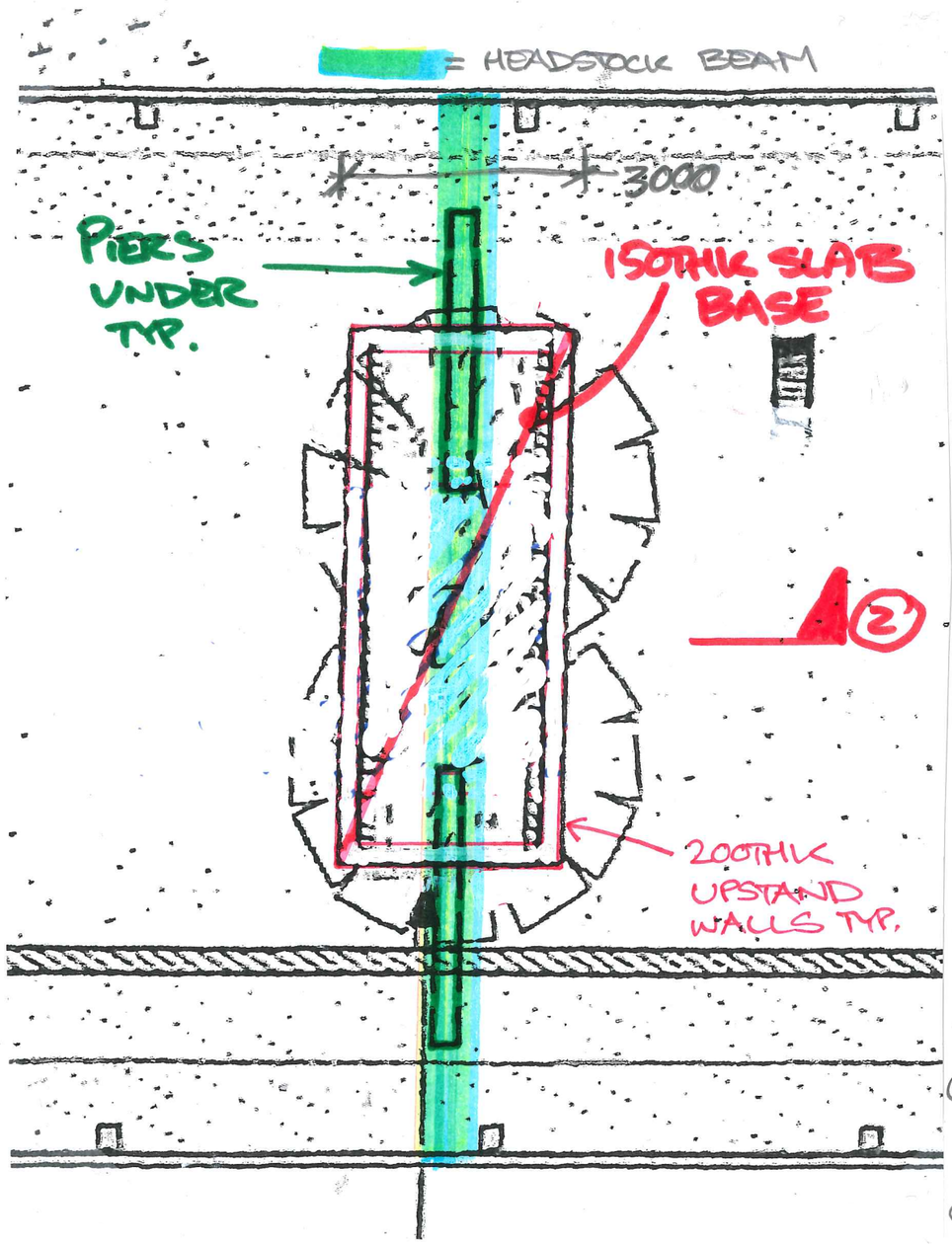
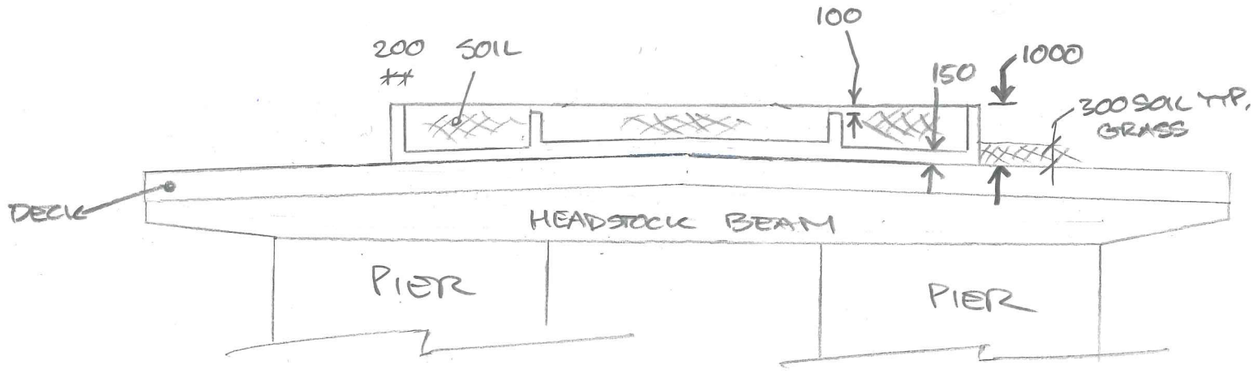
project	drawing title	engineer	project number	sketch	revision	date	Scale @ A3
Greenway Missing Links - Cooks River to Iron Cove	LOADINGS - SECTION	CB	18021	Sk2		19 Dec 2018	

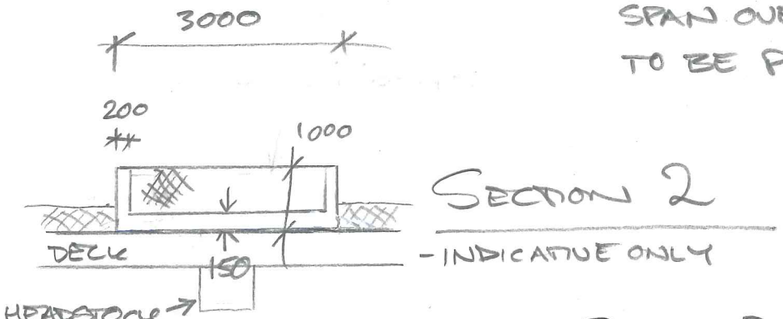
PLAN





SECTION 1

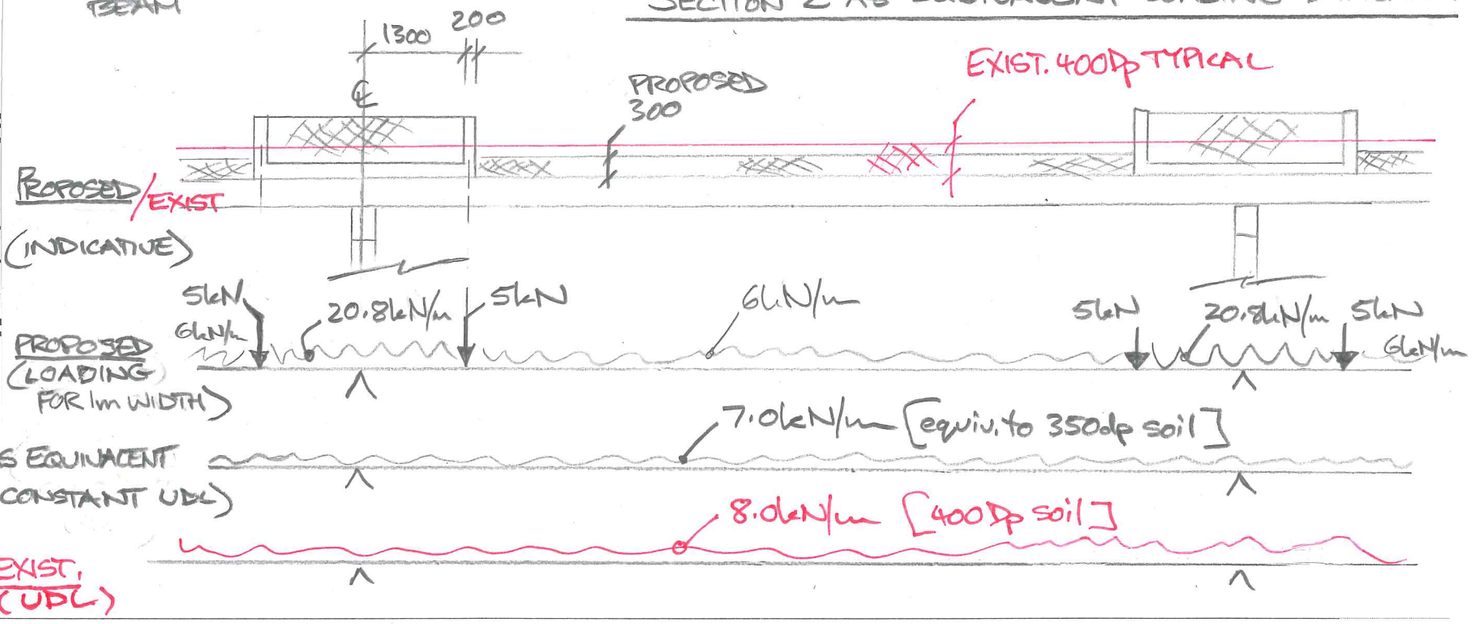
- INDICATIVE ONLY
- SOIL SUPPORTED ON SLAB, WHICH IS SUPPORTED BY 'A' BEAMS, WHICH SPAN OVER CENTRAL HEADSTOCK BEAM SPAN TO BE PICKED UP BY 'B' BEAMS



SECTION 2

- INDICATIVE ONLY

SECTION 2 AS EQUIVALENT LOADING DIAGRAM



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Thursday, 31st January 2019

Project Number: 18021

McGregor Coxall
21c Whistler Street
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Att: Alexa McAuley

Dear Alexa,

Greenway Missing Links – Constitution Road to New Canterbury Road – Preliminary Scheme for Costing

The following report sets out the design thinking behind the Structural Drawing Package: Sk10-18, in order to inform potential tendering contractors, Council, and other stakeholders such as RMS and Sydney Trains of more of the background information, other potential options considered, and pros and cons of different options. Locations of Sections 1-5 are illustrated on Sk10.

Section 1:
Tunnel Through Embankment Adjacent to Constitution Road Bridge over Light Rail

Proposed Works

- Tunnelling through the ground behind the abutment of the Sydney Trains-owned road bridge is to be designed and documented by specialist subcontractor

Structural Issues

- Works generally similar in scope to works already documented at Longport Street, with specific issues relevant to each site detailed in the GHD Report for the Sydney Light Rail Inner West Extension of 27 May 2011; Appendix H: Geotechnical Desktop Study.
- Feedback on specific complexities for each site, and especially any effects on construction methodology, cost, timeframe, permissions etc should be sought from specialist subcontractor(s) as early as possible
- It is currently assumed that the tunnelling operation will be a jacked box culvert operation as per the Longport Street works, and that in order to maximise the efficiency and economy of this operation, the Section 2 works should be constructed first in order to provide a fixed structure to jack the box culvert against.

Section 2:
Path Cutting into Embankment between Constitution Road and Old Canterbury Road

Proposed Works

- Levels of Pedestrian/Cycle path at the southern end of the Section 1 Tunnel are dictated by the tunnel needing to pass under Constitution Road, and setout is dictated by setoff from the Light Rail, and as such the path will need to be cut into the embankment for an approximately 20m extent.
- Maximum depth of the cut is approximately 2.5-3m.

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- The geology of the embankments is likely to be 0.5-1m depth of soil overlying sandstone bedrock of varying quality, largely Class III but with some Class IV rock.
- The gradient of the embankment is not clear at this time (see next point below), but appears to be in the order of 30degrees.
- Note that in this area vegetation is currently dense and survey information is incomplete; also, geotechnical information is reliant on only a few boreholes and further survey and geotechnical investigations will need to be conducted in order to provide more comprehensive and reliable guidance.

Issues Affecting Structural Scheme

- Between the path's western edge and the boundary with private property there is not only limited distance, but also a significant amount of vegetation which it is highly desirable to retain
- According to the geotechnical information within the GHD Geotechnical Desktop Study (Appendix H) of 27 May 2011, the soil layer on the embankments of the light rail corridor is potentially of low stability, with signs of previous slippage, meaning that increasing the existing gradients by means of battering is not recommended.
- Access to site restricted by nearby light rail tracks, ie (note that these issues are relevant to works within all Sections 2-5):
    - It is currently assumed that access to the light rail corridor will not be possible, and that a solution must be devised that does not require access beyond a fence line located to the west of the GST running along the western side of the corridor, near the base of the embankment
    - Access does not appear to be available from Constitution Road due to the proximity of the private property boundary, the embankment gradient and instability, and the presence of vegetation and infrastructure (power poles etc) that are preferred to be retained.
    - Access appears to only be possible via an existing rough access track running from New Canterbury Road along the private property boundary along the western side of the site and cutting down to near the base of the embankment about half way between Constitution and New Canterbury Roads. Further survey/geotechnical investigation and consultation with contractors will need to take place to confirm the viability/economy of continuing this track north as far as the southern end of Section 2, and what, if any, restrictions need to be placed on equipment relying on this access solution.
- Structure needs to found in rock beneath unstable upper soil layer and to resist horizontal loads from potential slope instability

Potential Structural Solutions:

- Battering of slope between western side of path and private property boundary is not viable due to proximity of boundary, height of cut (ie steepness of cut slope)and existing slope instability
- Stabilising of slope with shotcrete is not viable due to gradient being too steep
- Stabilising of slope with soil anchors is not viable due to proximity of boundary (construction beyond boundary is not possible).

Recommended Structural Solution:

- Contiguous pile wall is considered to be the only viable solution to retain the slope, with a slab on ground for the path, and details are presented in the Structural Drawing Package.

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Section 3:
Elevated Pathway Between Section 2 and Old Canterbury Road

Proposed Works

- Pedestrian/Cycle path to run along the embankment between the light rail tracks at the bottom and private land at the top, extending from the southern end of the Section 2 works to New Canterbury Road.

Issues Affecting Structural Scheme

- Access Restrictions
    - Refer to Section 2 above
- Height of pathway above bedrock
    - Pathway up to approximately 5m above bedrock level
- Uncertainty regarding levels and geotechnical information
- Maximising efficiency and cost of construction methodology/sequencing as well as cost and functional and aesthetic concerns related to the completed physical design solution

Proposed Structural Solution:

Steel frame structure above ground, with two columns near but inset from edges at 5m spacing, with bracing members as required to suit height, founded on rock (refer details in Structural Package); design similar to existing design for Central Links project

- Foundations proposed as piles through soil to rock where soil present
    - Piles socketed into rock to resist soil lateral forces
- Alternatively, steel columns fix direct to rock
    - Eliminates need for concreting, piling rig, but
    - Steelwork below ground in final condition so needs bituminous paint coating and more difficult/expensive maintenance checks than above-ground steelwork
- Steel columns fix direct to rock where no soil present
- Above-ground steelwork for frames, bracing and deck beams and joists, and FRP decking to be installed progressively using previously installed, already braced structure and crane/cherry-picker to provide access.
- Similarity to other Council project gives opportunities for review and shared knowledge and efficiencies across projects

Other Solutions Considered (Refer Drawing SKE01):

(i) Single central row of columns – columns as concrete (450mm diameter), embedment into rock TBC once more complete geotechnical information available but assume approximately 1.5m; piles would be poured to just above rock level to permit socket for base fixity, and then an above-ground formed column poured with reinforcement lapped into it from below; steelwork for deck structure similar to full steelwork scheme.

Pros:

- More elegant structure, with large cantilevers and less visual 'clutter' underneath deck
- Less maintenance for concrete than steelwork over project lifespan

Cons:

- Socketing of piles into rock is to a significantly greater depth than for steel two-column solution, in order to ensure rigidity of bases; this would potentially mean greater piling rig size and trickier access requirements
- 2 stages of concrete pouring: first the piles within the rock, then the above-ground columns

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- Construction methodology for pouring concrete columns 5m tall would require scaffolding and significant lateral restraint
- Construction methodology in two-column solution allows for access along 2-3m+wide track between columns (dimension can be adjusted to suit equipment dimensions if necessary); central support potentially doesn't leave enough space downslope between column and fence to light rail, and vegetation clearance will potentially need to be increased if track is upslope of column.

(ii) Reinforced block walls running down slope at 5m spacing, with joist and deck structure as per steelwork scheme

Pros:

- Less steel members and connections
- Blockwork has less maintenance over lifespan of project

Cons:

- Building of walls up to 5m above the ground will require scaffolding for safe work platforms, that would need to be dismantled each time and moved to the next bay
- Greater overall weight of structure used versus steelwork structure
- Three trades working on site simultaneously in the same space: blockwork laying, concrete filling and steelwork in a progressive installation, bay by bay.

Section 4:
Elevated Pathway Under New Canterbury Road Bridge

Proposed Works

- Walkway as per Section 3, with the added consideration of restricted access into cross-sectional triangular space between road bridge pier and sloping ground under the western end of the bridge

Issues Affecting Structural Scheme

- Access Restrictions
  - Refer to Section 2 above for general restrictions
  - Access also potentially available from existing walkway at southern end of Section 5
- Slope appears to be all exposed sandstone, with better strength rock lower down the slope and some weaker surface rock present higher up the slope
- Tight geometry limits the size of potential equipment, especially that of equipment used to bore/dig into rock for foundations

Proposed Structural Solution

- As per Section 3, southern end, where rock becomes exposed
- Levelling/excavation of rock likely to need to be done with hand equipment such as jackhammers, due to geometrical restrictions under bridge

Section 5:
Elevated Pathway South of New Canterbury Road Bridge

Proposed Works and Structural Solution

- Walkway as per southern end of Section 3, where rock becomes exposed

Yours sincerely,

Charles Blumer MIEAust, Director
SDA Structures Pty Ltd