M4 WestConnex *Structural Engineering Review*—Noise Wall Assessment Review

FOR / Structural Engineering Services

CLIENT / CPB Rizzani de Eccher

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CONTENTS

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1 BACKGROUND

CPB Contractors and Rizzani de Eccher Australia (CPBJV) are currently managing the design and construction of the Westconnex Stage 1B project in Sydney. As part of the project it is proposed to attach new noise walls to existing bridge crash barriers.

BG&E have been requested by CPBJV to carry out a desktop study to assess the ability of two existing bridges to withstand a new noise wall being attached to the traffic barrier. The subject bridges and associated noise walls are listed below and are located on the M4 Motorway in Sydney.

The noise walls consist of steel UB posts at 2.5m centres supporting a 25mm thick Acrylic panel and are being designed by SMEC Australia. The drawings and wind loads for the Noise Barriers have been supplied by SMEC Australia and the basic details are summarised in Table 1 below.

Table 1 – Noise Barriers

Bridge Name	Name	Noise Barrier Height	ULS Wind Pressure (KPa)	SLS Wind Pressure (KPa)
Silverwater Rd Overpass	NW-09B	6.0m	2.26	1.34
Bridge over Haslam's Creek	NW-11B	4.2m	2.20	1.31

It was found from the initial analysis of the bridges that the deck and parapets did not have sufficient capacity to withstand the loads from the noise barriers heights proposed above. It was therefore suggested by BG&E to reduce the Noise Wall heights such that the capacity in the deck and parapets was achieved under the ultimate load condition. The revised heights are shown below in table 2.

Table 2 – Revised Noise Barriers

Bridge Name	Name	Noise Barrier Height	ULS Wind Pressure (KPa)	SLS Wind Pressure (KPa)
Silverwater Rd Overpass	NW-09B	3.5m	2.26	1.34
Bridge over Haslam's Creek	NW-11B	3.0m	2.20	1.31

The reduced noise wall heights suggested were then reviewed by the noise wall designers and found to satisfy the minimum noise attenuation requirements for the area.

The following report describes findings based on the original noise wall heights and the revised noise wall heights reported in table 1 and 2 respectively.

The existing "Work as Executed" Drawings for the above bridges have been supplied by CPJV and are appended to this report.

2 BRIDGE DESCRIPTION

Silverwater Road Overpass Bridge is three span continuous post tensioned voided slab bridge approximately 1300 mm deep with a central "drop-in" span incorporating precast pre-tensioned I-girders. The central "drop-in" span is post tensioned to the cast in situ end spans to form a continuous three span bridge. The bridge has been designed and constructed in the early 1970's. The substructure consists of raking piers fixed into the superstructure and pinned at the foundation. The piers are founded on buried concrete buttress footings which are rock anchored to the foundation material. The abutments are supported on reinforced concrete headstocks and bored concrete piles. The span arrangement is 11,430 – 29,280 – 11,430mm. The noise wall proposed for this bridge is to be attached to the northern barrier and was originally designed to be 6.0 m high and supported by 360UB50.7 posts at 2.5 m centres. The revised noise wall height as recommended in this report is 3.5m high with posts at 2.5m centres.

Haslam's Creek Bridge is a three span continuous bridge with 1370mm deep precast pre-tensioned I-girder superstructure with a 150mm thick composite concrete deck originally designed and constructed in 1972. The superstructure was made continuous after the construction of the deck. Therefore the superstructure is only continuous for live loads and superimposed dead loads. The substructure consists of reinforced concrete blade columns supported on reinforced concrete bored piles. This bridge was widened towards the median in 1991. The span arrangement is 21,000 – 27,450 – 21,000mm. The noise wall was originally designed to be 4.2 meters high and attached to the northern barrier. The revised noise wall height as recommended in this report is 3.0m high with 250UB37 posts at 2.5m centres.

The bridge material properties shown on the drawings are summarised in Table 2 below:

Table 2 – Haslams Creek Bridge Material Properties

Bridge Element	Imperial Units	SI Units	Comment
Concrete Deck and Parapet Strength f'c	4 kip	27.576MPa	
Deck thickness	6''	152mm	
Deck Reinforcement	C#5 T & B @ 8.5''	15.8mm @ 216mm	CW60 grade Steel 400MPa
Parapet Reinforcement	Dia 4 @ 12''	12.7mm @ 305mm	Structural Grade round bar 230MPa
Cover to deck reinforcement	1.25''	31mm	
Cover to barrier reinforcement	1.5''	37.5mm	

Table 3 – Silverwater Rd Overpass Bridge Material Properties

Bridge Element	Imperial Units	SI Units	Comment
Concrete Parapet Strength f'c	4 kip	27.576MPa	
Concrete Deck strength f'c	5 kip	35 MPa	
Deck thickness	8''	203mm	
Deck Reinforcement	C#5 T & B @ 6''	15.8mm @152mm	CW60 grade Steel 400MPa
Parapet Reinforcement	Dia 4 @ 12''	12.7mm @ 305mm	Structural Grade round bar 230MPa
Cover to deck reinforcement	1.25''	31mm	
Cover to barrier reinforcement	1.5''	37.5mm	

The existing barrier for each bridge is the "Type F" profile and is approximately 730mm high and 610mm wide at the base. Additionally a steel post and rail system is attached to the top of the concrete barrier. The steel posts are spaced at approximately 2.5m. The proposed noise walls are also spaced at 2.5m to be consistent with the barrier post spacing.

The desktop structural review is limited to investigating if the bridge superstructure and barrier is suitable to withstand the loads due to the proposed noise walls only. It does not include any assessment in relation to the adequacy of the existing barrier in terms of vehicle containment and its ability to resist traffic impact loads. This is outside the scope of this report.

3 STRUCTURAL REVIEW AND DISCUSSION

The desktop structural review of the bridge superstructure and barriers for each bridge is based on the design parameters listed above. Furthermore, the review assumes the barriers are in good condition and free from any major defects.

The existing condition of the bridges decks as reported in the Level 2 Inspection reports are "Good" and "Fair" for Haslam's Creek and Silverwater Rd Bridge respectively. The parapet on Haslam's Creek Bridge has some minor spalling on the inside face north side adjacent to the abutments. The parapets on Silverwater Rd Bridge have minor vertical cracking on the inside and outside faces. On this basis, it is assumed the full ultimate capacity of the barriers can be achieved however it would be prudent to carry out any minor repairs due to spalling prior to erection of any noise walls to the bridges.

The dead loads for the noise barriers were calculated based on steel density of 7850kg/m^3 and a density of 1190kg/m^3 for 25mm thick acrylic panels. The wind loads were provided by SMEC Australia and have been used as the basis of this design review.

The post connections to the parapet shall be the responsibility of the noise wall designer and shall consist of drilled in bolts based on the typical noise wall detail shown in appendix A. The design checks carried out in this report have assumed the centroid of the HD bolt assembly securing the noise wall to the back face of the parapet is 300mm above the top surface of the deck.

The load case considered critical for the bridge deck and barrier is as follows:

- PE (Permanent Effects) + ULS Wind

This load case considers the self-weight loads of the deck, barrier and noise wall reaction loads acting on the back face of the barrier. The wind is considered in each direction perpendicular to the noise wall. The applied moment, vertical and horizontal loads applied to the back of the barrier are then distributed to the base of the barrier and edge of deck by dispersing the load at an angle of 45 degrees.

The analysis has revealed that the bridge deck and barrier have insufficient bending capacity to withstand the ULS wind loads and permanent effects due to the original noise wall heights.

The results of the analysis are summarised in Table 4 and 5, below.

Table 4 – Analysis Results – Silverwater Rd Bridge – 6.0m high Noise Wall

Design Element	Design Moment M* (DL+ ULS Wind)	Element Capacity phi Mu	Pass/Fail
ULS Moment at Base of Barrier	128 kNm	50 kNm	Fails
ULS Moment in Slab at Front face of Barrier	129 kNm	73 kNm	Fails
ULS Moment in Slab at edge of Superstructure	51.2 kNm	73 kNm	Pass

Table 5 – Analysis Results – Haslams Creek Bridge – 4.2m high Noise Wall

Design Element	Design Moment M* (DL+ ULS Wind)	Element Capacity phi Mu	Pass/Fail
ULS Moment at Base of Barrier	60.9 kNm	50 kNm	Fails
ULS Moment in Slab at Front face of Barrier	63.4 kNm	36 kNm	Fails

The analysis indicates that the barrier has insufficient strength to withstand the additional loads from the proposed noise wall. This is exacerbated by the fact that the reinforcement in the barrier is spaced at 305mm and of a lower yield strength than the reinforcement in the deck.

Following the above review, a lower height noise wall was recommended and approved for each bridge as follows:

- Haslam's Creek Bridge 3.0m high noise wall
- Silverwater Rd Bridge 3.5m high noise wall

The ensuing analysis confirms that the deck and parapets have sufficient capacity to withstand the ultimate loads due to the lower height noise walls and are summarised in the following tables 5 and 6 below.

Table 6 – Analysis Results – Silverwater Rd Bridge – 3.5m high Noise Wall

Design Element	Design Moment M* (DL+ ULS Wind)	Element Capacity phi Mu	Pass/Fail
ULS Moment at Base of Barrier	45 kNm	50 kNm	Pass
ULS Moment in Slab at Front face of Barrier	48 kNm	73 kNm	Pass
ULS Moment in Slab at edge of Superstructure	25 kNm	73 kNm	Pass

Table 7 – Analysis Results – Haslams Creek Bridge – 3.0m high Noise Wall

Design Element	Design Moment M* (DL+ ULS Wind)	Element Capacity phi Mu	Pass/Fail
ULS Moment at Base of Barrier	32 kNm	50 kNm	Pass
ULS Moment in Slab at Front face of Barrier	35 kNm	36 kNm	Pass

4 SUPERSTRUCTURE AND SUBSTRUCTURE

A brief review has been undertaken on the main superstructure and substructure elements to withstand the additional loads due to the addition of the noise wall. It is unknown what the current load rating is for these bridges. The structural design checks described in the following section have assumed T44 truck loading.

For Silverwater Rd Bridge the girder ultimate bending capacity for span 2 under the T44 loading is exceeded. Therefore an MS18 truck was used for the remainder of the analysis which was the appropriate live load for bridges designed in the early 1970's. Using this load it was found that the girders had just sufficient capacity in ultimate bending without considering the additional loads due to the 6.0m noise wall.

4.1 Haslam's Creek

The additional bending due to the addition of the originally proposed 4.2m high noise wall in the edge girders was estimated to increase the bending moment by 150kNm which is a 3.25% increase in ultimate bending. This is considered an acceptable increase in bending for girders assuming the bridge is rated to T44 loading.

The pier headstock has been checked to ensure the additional Dead Load reactions due to the noise wall can be accommodated and it was found to have sufficient capacity to withstand the extra load.

An approximate check has also been undertaken to review the additional loads in the piles due to the dead load and extra vertical reactions due to wind (resisted by push-pull action). It was found that the piles receive a lower load in the piles under wind action than what would be received under ULS live load from two lanes of T44 positioned on one side of the bridge.

This high-level comparative approach suggests the loads on the bridge due to the wind and additional self-weight would not govern the superstructure and foundation design. Furthermore, the recommended barrier height is 3.5m high and the above analysis was based on the original height of 4.2m. The 3.5m high noise wall would only provide a further 2.4% increase in the ultimate bending moment to the edge girder and hence it is recommended that the superstructure and substructure can absorb the additional loads due to the 3.5m high noise wall.

4.2 Silverwater Rd Overpass

The central span of this bridge consists of precast pre-tensioned I girders which are made continuous with an additional post tensioned duct. The two end spans are cast in situ post tensioned voided slab decks which are cast integral with raking piers thus forming a stiff frame structure. Due to complex nature of the superstructure, a spacegass model was prepared to analyse the deck and determine the distribution of live loads. It was found that the superstructure edge girders and inner girders both have sufficient capacity to withstand the loads due to the additional weight of the originally proposed 6.0m high noise wall and the recommended 3.5m high noise wall.

The above analysis is based on the original design load for the bridge which an MS18 truck and on this basis, the critical girder was found to have 10% reserve capacity at the ultimate limit state with the addition of the recommended 3.5m high noise wall. The MS18 truck consists of a front axle of 36kN and two trailer axles of 144kN each which was the standard design vehicle in the early 1970's.

A simple high-level analysis of the pier footing was made to determine the additional load due to the recommended 3.5m high noise wall being attached. It was found that the foundation pressure would increase by 63kPa under DL and SLS wind which is 7.5% of the allowable bearing pressure. This increase in foundation pressure is considered acceptable.

5 CONCLUSION

The noise wall connections to the existing bridges using the original noise wall heights of 6.0m and 4.2m for Silverwater Rd and Haslam's Creek bridges respectively are not considered feasible as they impose large bending moments to the bridge deck and barrier which have insufficient capacity to support them. This was mainly due to the low bending capacity of the barrier which is reinforced with only 12mm round bar at 305mm centres. The reinforcement in the barriers are round bar structural grade which for the period of time the structures were built, have a yield strength of only 230MPa.

Subsequent to the original analysis it was recommended to reduce the noise wall heights to 3.5m and 3.0m for Silverwater Rd and Haslam's Creek bridges respectively. The analysis at these heights confirmed that the deck slab and parapet would have sufficient capacity to withstand the ultimate loads due to wind and dead load as recommended in section 1 of this report.

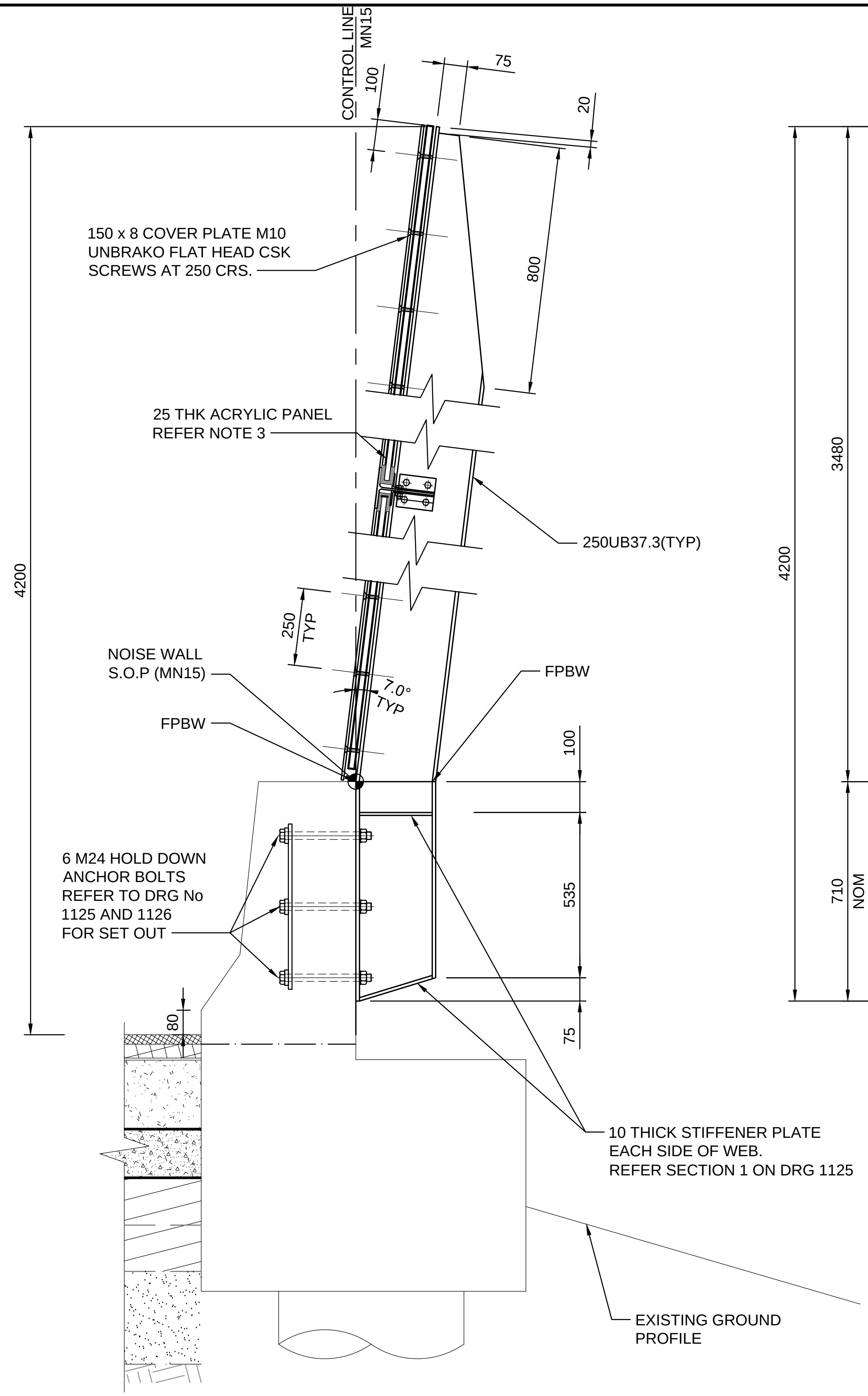
The superstructure and substructure of each bridge was also reviewed using simple high-level analysis and comparative checks. For each bridge it was generally found that there was adequate capacity to withstand the additional load imposed from the proposed noise walls. Some minor defects were documented in the Level 2 inspections reports. It would be prudent to repair these defects prior to installation of the noise walls.

The above assessments are based on the bridge live loads being T44 for Haslam's Creek Bridge and MS18 truck for the Silverwater Rd Bridge which correspond to the original design loads for those bridges.

Based on our findings, BG&E recommend that Haslam Creek Bridge and Silverwater Rd Bridge will have sufficient capacity in the deck, parapet, superstructure and substructure elements to withstand the additional loads due to a 3.0m high and 3.5m high noise wall respectively as described in section 1 and 2 of this report.

APPENDIX A

Typical Noise Wall Section



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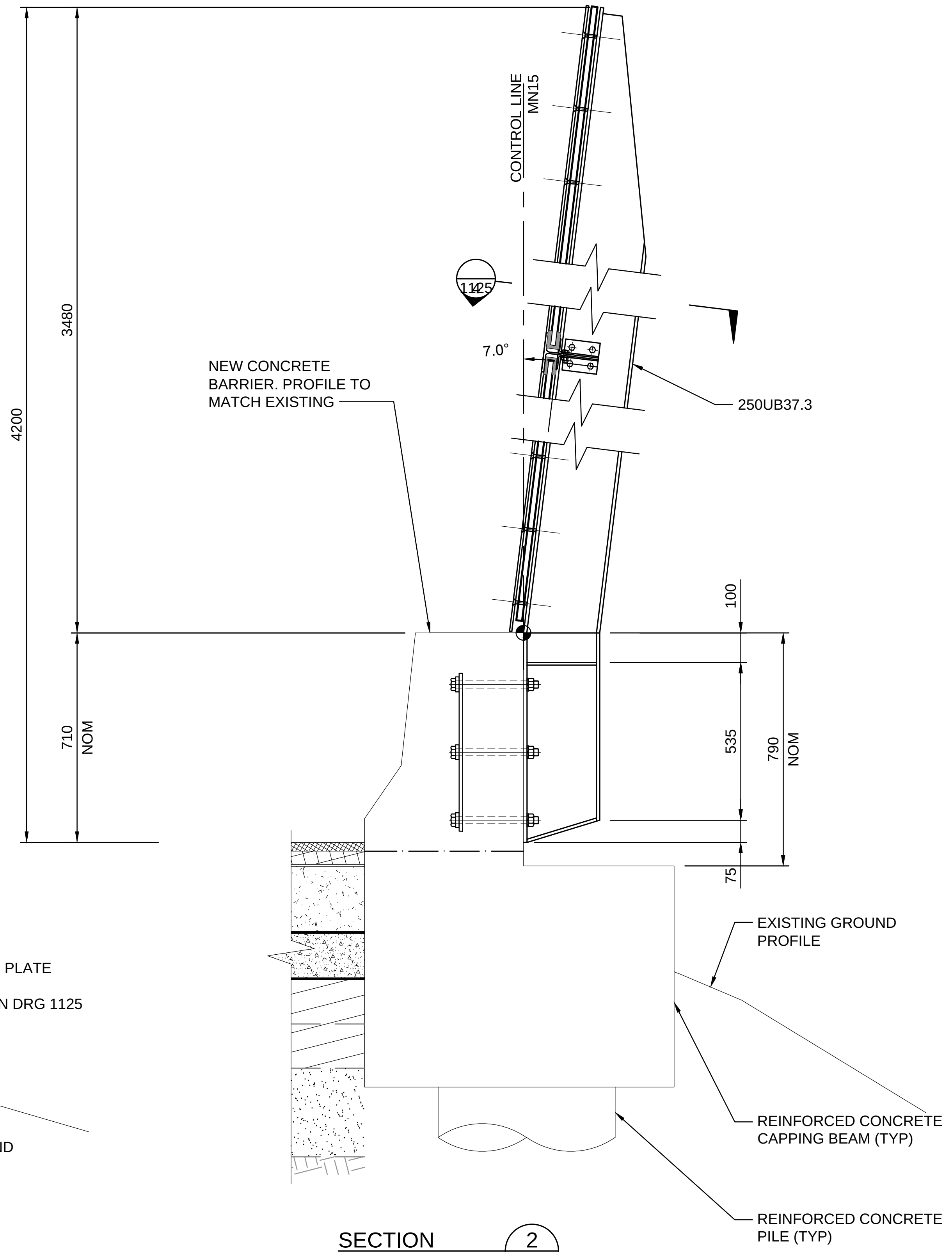

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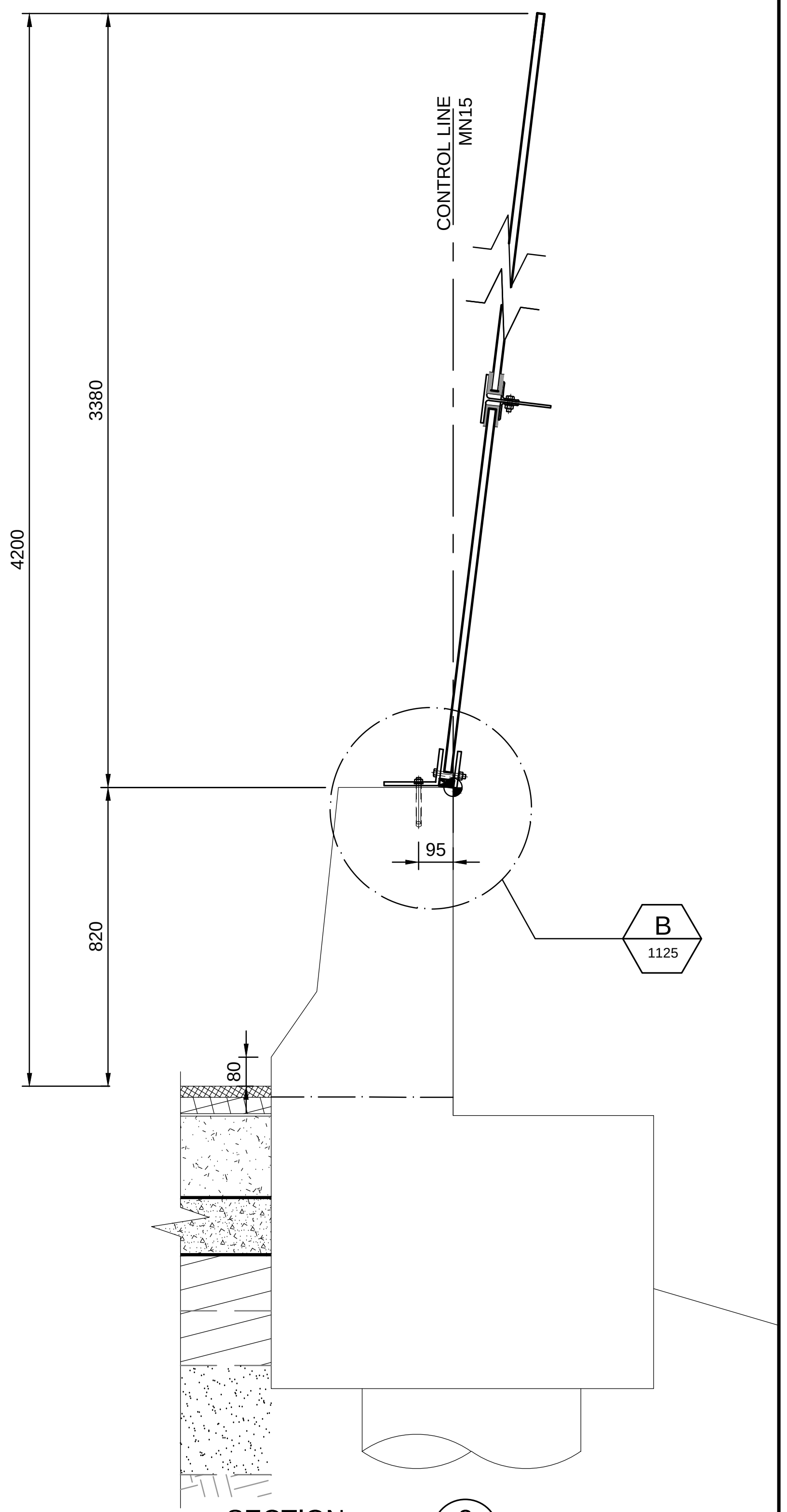

SECTION 3
SCALE 1: 20
1120

NOTES

1. FOR GENERAL NOTES REFER TO DRG M4W-NW-002-DRG-1102
2. POSTS TO HAVE BRACE AT CENTRE OF PANEL AS REQUIRED BY PANEL MANUFACTURER WHERE POST SPACING AND WALL HEIGHT EXCEEDS DIMENSIONS OF ACRYLIC PANEL. LOCATE CENTRAL BRACE WITH REFERENCE TO URBAN DESIGNER WHERE REQUIRED
3. REQUIRED PANEL THICKNESS TO BE CONFIRMED BY MANUFACTURER PRIOR TO FABRICATION.

DRAWING FILE LOCATION \ NAME
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DESIGN LOT CODE: NW-002
PLOT DATE: 07 March 2016
TIME: 10:47:33

DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING

EXTERNAL REFERENCE FILES

X_30011657_DandC_CA3

REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No	APPROVAL
A	07.03.2016	ISSUED FOR CONSTRUCTION	207	DW

TITLE	NAME
DRAFTER	S.BROMFIELD
DRAFTING CHECK	E.SMAILES
DESIGNER	N.HAYES
DESIGN CHECK	G.WILLIAMS
DESIGN MANAGER	R.HUNTER
PROJECT MANAGER	D.WRIGHT

WESTCONNEX DESIGNER
SMEC

WESTCONNEX CONSTRUCTION JOINT VENTURE
RIZZANI DE ECCHER
LEIGHTON

SCALES AT A3 SIZE DRAWING
SCALE 1:20 0.1 0 0.1 0.2 0.3 0.4 0.5

CO-ORDINATE SYSTEM: MGA ZONE 56
HEIGHT DATUM: A.H.D.

WESTCONNEX DELIVERY AUTHORITY

WESTCONNEX - M4 WIDENING
CHURCH STREET TO HOMEBUSH BAY DRIVE
NOISE WALLS PACKAGE 2
NOISE WALL NW-11
TYPICAL SECTIONS

PLAN REGISTRATION No	ISSUE STATUS	PROJECT / DRAWING No	ISSUE
DS2015/000173	FOR CONSTRUCTION	M4W-NW-002-DRG-1123	A