



STRUCTURAL CONDITION REPORT

190608 - CR141, Boorowa Road, NSW 2583

Contents

1	DOCUMENT SUMMARY			
2	INTRODUCTION			
3	SCOPE OF REVIEW			
4	DESCRIPTION OF BRIDGE STRUCTURE			
	4.1	Current Traffic Loading Limits	7	
5	INSPECTION AND REVIEW			
	5.1	Inspected Defects	8	
	5.2	Recommended Defect Rectification	11	
	5.3 5.3.1 5.3.2 5.3.3	Bridge Capacity and Required Capacity Loading under self-weight Loading under dual T44 trucks (each running between the central girder and edge girder) Loading under single T44 truck (running between the central girder and edge girder)	11 13 18 24	
	5.4 5.4.1	Bridge Capacity for One-Way Truck Movement Bridge loading analysis under centred T44 axle loading	31 31	
	5.5	Assessment of the available capacity vs. the required capacity	39	
	5.6 5.6.1 5.6.2 5.6.3 5.6.4 5.6.5	Potential Capacity Upgrade Strategies External Reinforcement External Post Tensioning External Steel Permanent Propping Bridge Deck Augmentation Bridge Substructure	39 40 40 40 40	
	5.7	Recommended augmentation strategy	41	
6	CONCLUSIONS			

QUALITY CONTROL REGISTER

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1 Document Summary

Project Number:

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Upper Lachlan Shire Bridge Assessment

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26.07.2019

XK Project Director:

Bossam Latti

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Final	2	14.08.2019	Ellery Marsh	Bassam Mait)

2 Introduction

At the request of Upper Lachlan Shire Council, Xavier Knight was commissioned to undertake a review of the bridge structure at CR141, Boorowa Road. The purpose of the review was to inspect the general condition of the bridge and identify items which may require replacement, repair or maintenance found during the inspection of the accessible structural elements of the bridge and to form a professional engineering opinion as to the performance of the bridge structural elements observed and to evaluate the suitability of these for their intended use.

Furthermore, Xavier Knight is commissioned to explore the possible augmentation methods and propose a conceptual method to augment the current bridge capacity allowing for higher axle loading on the bridge. An analysis of the current bridge is performed and presented, and a methodology established to increase the current bridge capacity.

All descriptions, references to conditions of the bridge current durability presented herein are a general guidance only and are given as our opinion, based on visual inspection and observations; any interested parties should not rely on them as statements or representations of fact and must satisfy themselves through non-destructive testing, sampling, etc as to the correctness, quantity, costs, etc of each of them.

The particulars set out in this report are for the exclusive use of Client and is copyright and the property of Xavier Knight Consulting Engineers. No responsibility or liability is accepted as a result of the use of this report by any other party and is not to be used for any other purpose.

3 Scope of Review

In order to form our opinion on the elements we could view, the following level of review was undertaken.

- Bridge inspection visual and photographic of accessible areas.
- Existing structural documentation
- Measurements of accessible structural elements
- Design analysis or calculations

The level of review undertaken is limited to what is recorded in the following pages of this report and was not sufficient to certify that the bridge was constructed in accordance with the original design documents or structurally adequate in accordance with the design codes at the time of construction nor present codes.

Only visual assessment of accessible areas of the extent of defects were taken and this report does no cover detailed measurement of defects and as such as-designed reinforcement layouts were unable to be verified.

This report does not cover issues such as drainage, waterproofing and asbestos.



4 Description of Bridge Structure

The current bridge structure consists of three spans of reinforced concrete girders, discontinuous between each span. The girders are interlocked and spanned with a reinforced concrete deck that varies in thickness. The two central supports are made up of reinforced concrete portal frames that are founded on pad foundation beneath. The Girders of the end-spans are framed into their respective concrete columns, forming L shaped frames. The columns are embedded within a reinforced concrete retaining wall structure. The configurations and details of the structure are illustrated in the original design document dated 1936 and are appended in Appendix A for reference. The known dimensions from the available information is giving in approximate metric form in the table below.

Structural Detail	Description
Overall Length	29.9m
Number of Spans	3
End Span 1 Length	9.60m
Middle Span 2 Length	10.70m
End Span 3 Length	9.60m
Overall Width	6.96m
Trafficable Width	6.10m
Number of Girders Per Span	3
Typical Girder Depth	0.70m (to underside of deck)
End Span Girder Width	0.36m
Middle Span Girder Width	0.43m
Typical Girder Centre-to-Centre spacing	2.45m
Typical Deck Edge Thickness	0.19m
Typical Deck Centre Thickness	0.28m
Bridge Skew	0°

4.1 CURRENT TRAFFIC LOADING LIMITS

The current traffic loading limits specified for the bridge are displayed on the approach signage shown below. The current limits are specified as follows:

- Single Axle = 7t
- Tandem Axle = 8t
- Tri-Axle = 11t



Figure 1: Current bridge loading limits



Figure 2: Overall view of bridge asset CR141

5 Inspection and Review

Mr. and Mr. Ellery Marsh, Engineers from Xavier Knight, carried out the site inspection of Asset Number CR141, MR248W Boorowa Road/Wheeo Creek on 17/07/2019.

The following is a record of the general condition of the structure and identifies items which may require replacement, repair or maintenance found during the inspection of the accessible structural elements of the building.

5.1 INSPECTED DEFECTS

During the visual inspection a number of defects were identified. The bridge structure appears to be in good overall condition, however the defects identified below will compromise the durability of the structure in the future. All the defects below are recommended to have immediate or short term planned action taken against them to prolong the lifespan of the current structure. Our recommendations for rectifying the defects are given in Section 5.2.



Figure 3: Spalled edge of bridge deck



Figure 4: Exposed reinforcement



Figure 5: Horizontal cracking indicative of Internal spalling



Figure 6: Water intrusion through failed bridge joint seals



Figure 7: Failed sealant at bridge joint

In the areas identified above where reinforcement is exposed or there is evidence of internal spalling; we recommend that immediate removal of the spalled area and repair of the corroded reinforcement followed by structural patch repair is undertaken. For this work we recommend breaking the area back locally to fully sound and void-free concrete. The area behind the steel reinforcement should be broken back where required. The reinforcement local to the area should then be treated with Nitoprime Zincrich Primer and patch repaired with Fosroc Renderoc HB25. Care should be taken to install this repair system in accordance with the manufacturer's specifications.

We also recommend that the entire bridge structure is treated with Sika Ferrogard 903. The application of this compound will provide re-alkalinity to the structural matrix and mitigate the risk of any further corrosion.

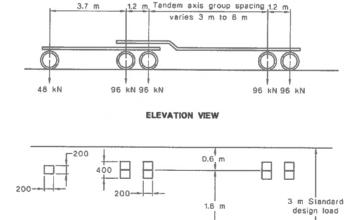
For the replacement of the bridge sealant we recommend that all the joints between the bridge decks are retrofit with the Miska Zealseal 4000C system. Advice on the installation and specification on this system should be sought directly with the manufacturer and installed strictly to their requirements.

Review of the drawings and assessment of the bridge bearings revealed an issue with the originally installed bridge; The bridge girders bear onto the supporting portal frame through two layers of tarpaper. The lack of bearing pads renders the bridge girder and its seatings subject to higher dynamic load effects and the risk of spalling due to stress concentration. Introduction of bearings under each of the girders, at their respective bearing points, is recommended.

5.3 BRIDGE CAPACITY AND REQUIRED CAPACITY

A structural analysis was performed based on the structural layout obtained from historic structural drawings. The intent of the analysis was to compare the mathematically assessed structural capacity with the modern loading requirements-for-bridges.

In this assessment we followed the directions of the RMS Corporate Circular - Bridge Technical Direction BTD2014/01; According to the stated direction, and our understanding and the Client's feedback on the road usage, we believe that the road can be classified to have lesser traffic loading than the MS1600 loading; as such the use of the T44 truck model (depicted in Figure 8 below) to Appendix A, Section A2.2.2 of the bridge loading code AS 5100.7 – 2004, in lieu of the use of the current Code specified MS1600 is justified.



PLAN VIEW

0.6 m

FIGURE A1 T44 TRUCK LOAD

Figure 8: T44 loading requirements from Section A2.2.2 AS 5100-2004

The analysis of the bridge structure has considered the loading case of a single T44 truck load, a 6-axle semitrailer at maximum regulatory mass under HML of 42.5-44.5 tonnes and a 9-axle B-double at maximum regulatory mass under GML of 62.5-63.1 tonnes. Based on our assessment the T44 loading arrangement governs the capacity checks. Every wheel arrangement below has been considered for the critical case as per the request from Upper Lachlan Shire Council:



Figure 9: T44 analysis dimensional layout

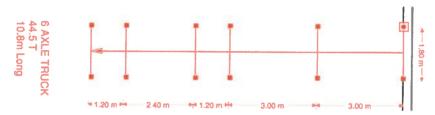


Figure 10: 6-axle semi-trailer analysis dimensional layout – arrangement 1



Figure 11: 6-axle semi-trailer analysis dimensional layout - arrangement 2

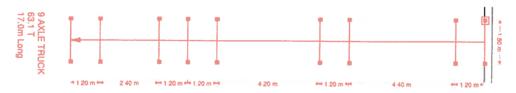


Figure 12: 9-axle B-Double analysis dimensional layout – arrangement 1

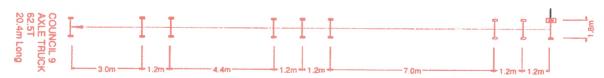


Figure 13: 9-axle B-Double analysis dimensional layout - arrangement 2

The structural analysis had to make number of assumptions due to incomplete information; the assumptions made are listed below.

Material properties adopted for structural analysis: <u>Steel reinforcement:</u>

Yield Stress (f_y) = 230MPa

Peak Stress (f_u) = 435MPa

Peak Strain = 0.2

Structural Concrete:

Characteristic Compressive Strength (f_c) = 20MPa Concrete Density = 2350kg/m³

Based on the gross cross section dimensions, and consideration of the flexural tensile strength of the concrete, the assessed cracking bending moment for the section = $\underline{230kNm}$

Beyond the cracking bending moment, the section changes into a cracked section; within the linear elastic behaviour of concrete, the properties of the cracked transformed section were evaluated based on the considerations below;

- a. The part of the concrete section below the neutral axis having no tension contribution;
- b. A creep coefficient of 2.0 under the deck's sustained self-weight (considering the bridge's age),
- c. The strain in the concrete compression fibres is linear elastic, i.e. concrete strain is below 0.001.

The evaluated section properties of the cracked transformed section are the following:

Cracked Section Neutral Axis Depth at SLS= 233mm Cracked Section's Modulus, bottom fibre = 85.27x106mm³

The results of the bending moment and shear capacities based on the reinforcement design information and the assumed material strength were the following:

Table 1: Calculated structural capacities of CR141 elements based on outlined assumptions

		CR141 bear	m location	
	End span		Centra	l span
	Edge girder	Central girder	Edge girder	Central girder
Negative bending moment resistance (kNm)	1284	1365	•	-212/10/1999/10/1999/10/19
Shear force resistance at continuous end (kN)	425	437	•	-
Mid-spaп bending moment resistance (kNm)	858	921	1135	1220
Shear force resistance at discontinuous end (kN)	389	394	596	634

Prior to any rectification/augmentation works being undertaken we recommend that these assumptions be verified through sampling and materials testing.

The Bridge deck and girders were modelled as two tiers of beams laid at right angles (grillage model), allowing for a realist load sharing between the structural members. Structural analysis was performed considering moving loads for the loading case of a single T44 truck loading on one lane and for two T44 truck simultaneously loading both lanes. The results of analysis of the two loading cases considered are depicted in the following.

5.3.1 Loading under self-weight

The self-weight loading of the bridge forms a significant portion of the overall loading of the structure and the analysis of this is shown below:



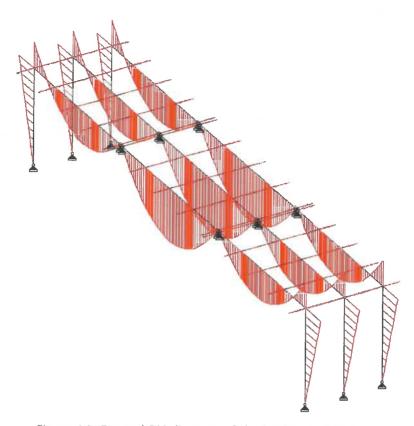


Figure 14: General BM diagram of the bridge deck 3-D

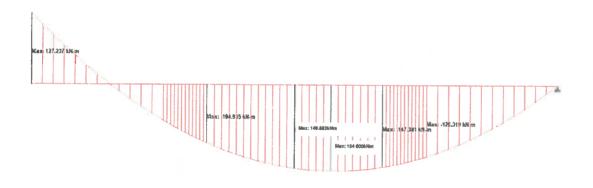
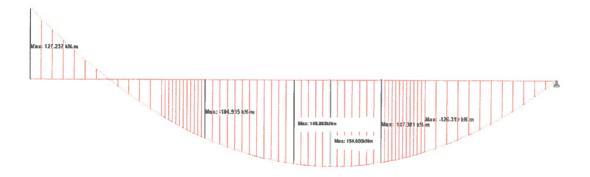


Figure 15: Bending moment & Shear Force diagrams for the edge girder of the end span



Land 1 - Show Y : Displacement Force - IM

Figure 16: Bending moment & Shear Force diagrams for the edge girder of the end span



Load 1 Sending 2 : Displacement Moment KN m

Figure 17: Bending moment & Shear Force diagrams for the central girder of the end span



Load 1 Shear Y : Displacement Force - kN

Figure 18: Bending moment & Shear Force diagrams for the central girder of the end span

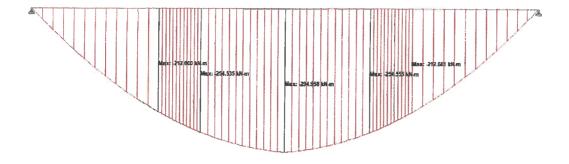


Figure 19: Bending moment & Shear Force diagrams for the edge girder of the middle span

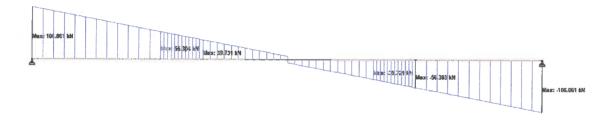


Figure 20: Bending moment & Shear Force diagrams for the edge girder of the middle span

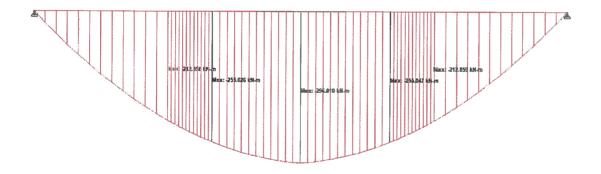
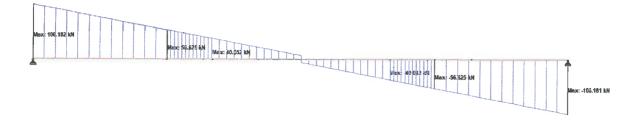
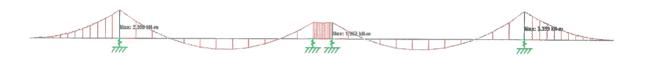


Figure 21: Bending moment & Shear Force diagrams for the central girder of the middle span



Cond 1 Shear Y : Displacement Force - kN

Figure 22: Bending moment & Shear Force diagrams for the central girder of the middle span



Moment - kN-m

Figure 23: Bending moment & Shear Force diagrams for a strip of the deck



Load 1 . Shear 1

Figure 24: Bending moment & Shear Force diagrams for a strip of the deck

5.3.2 Loading under dual T44 trucks (each running between the central girder and edge girder)

The following analysis has been completed investigating the effects of two opposing T44 truck loads on the bridge structure. The truck loads have both been positioned central to the edge and central girder. The envelope results for shear and bending moment can be seen in the figures below.

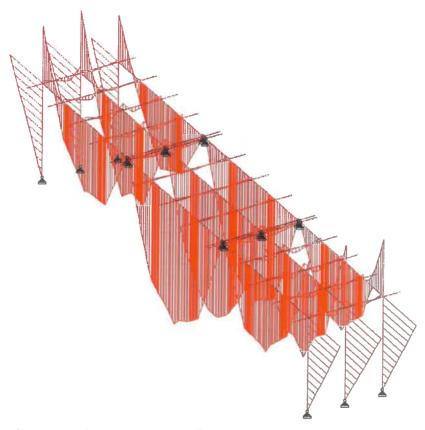


Figure 25: General maximum bending moment diagram of the bridge deck 3-D (influence line results)

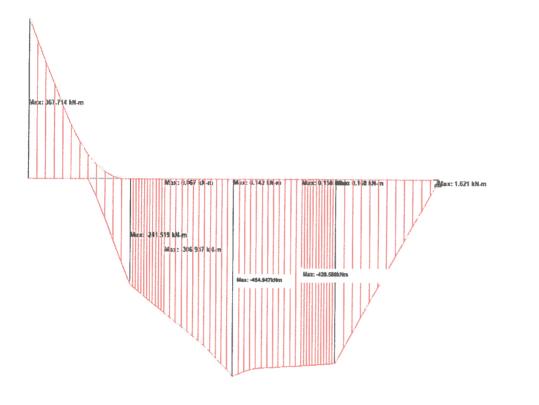


Figure 26: Maximum Bending moment diagram for the edge girder of the end span (influence line results)

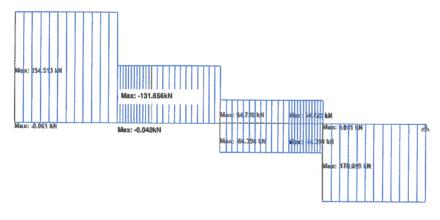
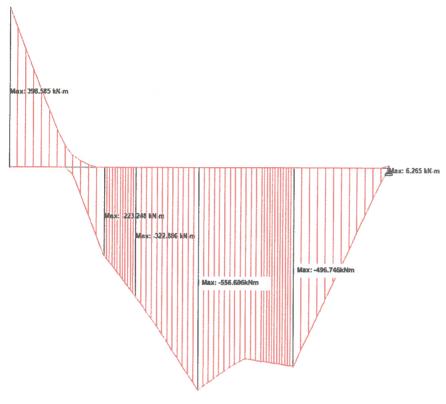
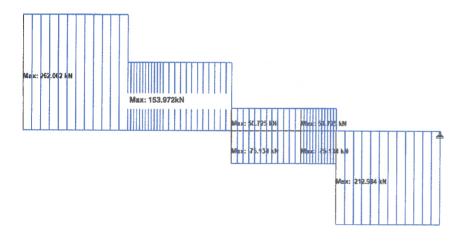


Figure 27: Maximum Shear Force diagram for the edge girder of the end span (influence line results)





Lead 0 : Bending Z Moment - kiN-m Figure 28: Maximum Bending moment diagram for the central girder of the end span (influence line results)



Force - kN

Figure 29:Maximum Shear Force diagram for the central girder of the end span (influence line results)



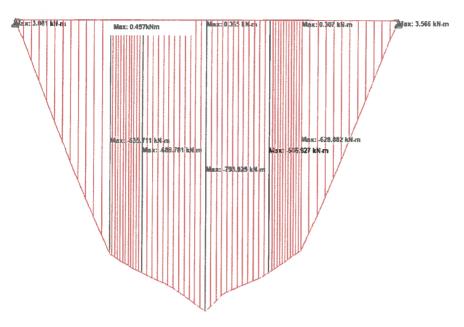


Figure 30: Maximum Bending moment diagram for the edge girder of the middle span (influence line results)

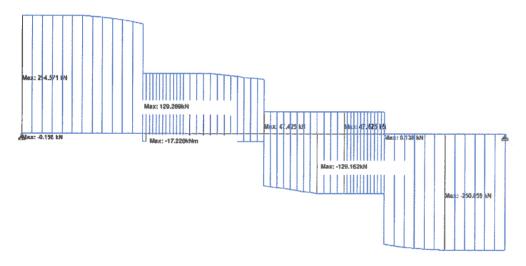


Figure 31: Maximum Shear Force diagram for the edge girder of the middle span (influence line results)

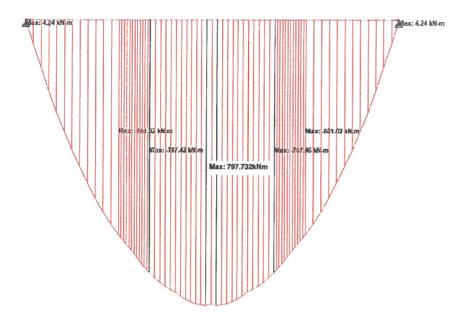


Figure 32: Maximum Bending moment diagram for the central girder of the middle span (influence line results)

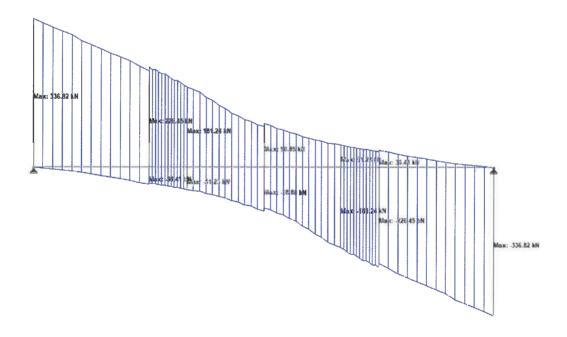


Figure 33: Maximum Shear Force diagram for the central girder of the middle span (influence line results)

Load 0 : Shear Y



Load 3 Bending 2 Moment , kill m

Figure 34: Bending moment diagram for a strip of the deck



Load 3 : Sheer Y

Figure 35: Shear Force diagram for a strip of the deck

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5.3.3 Loading under single T44 truck (running between the central girder and edge girder)

The following analysis has been completed investigating the effects of one T44 truck load on the bridge structure. The truck load has been positioned central to the edge and central girder. The envelope results for shear and bending moment can be seen in the figures below.

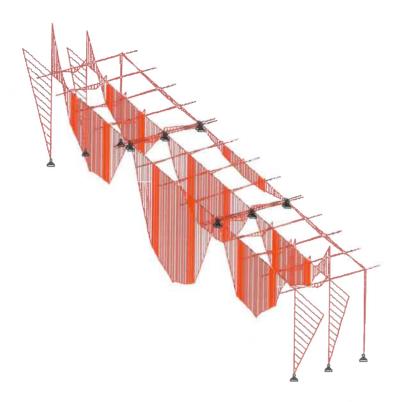
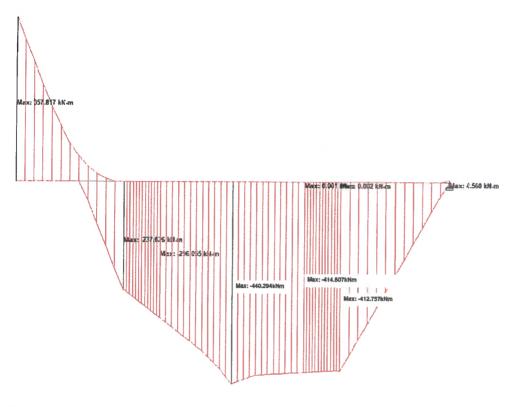


Figure 36: General maximum BM diagram of the bridge deck 3-D (influence line results)



Loed 0: Bending 2: Displacement Mornett-kN-m
Figure 37: Maximum Bending moment diagrams for the edge girder of the end span (influence line results)

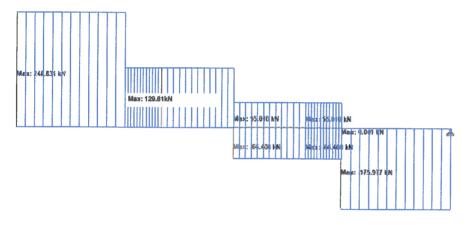


Figure 38: Maximum Shear Force diagrams for the edge girder of the end span (influence line results)

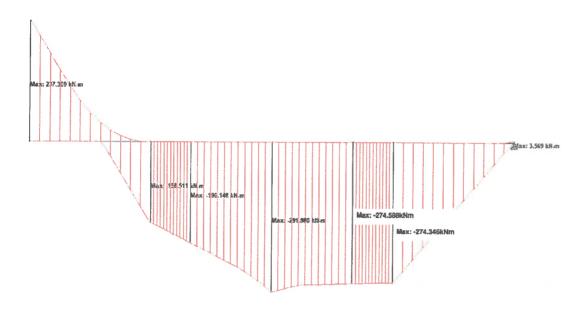


Figure 39: Maximum Bending moment diagrams for the central girder of the end span (influence line results)



Load 9 : Shear Y : Displacement Force - kN

Figure 40: Maximum Shear Force diagrams for the central girder of the end span (influence line results)

May: 12 520 hM -	
Melvis La 1917 (rith miles X; U, 1920 KW-m)	Max: 0.421 kN-m
	May: 23 Sie N.m. May: 23 141 by Max: 17.852 kN/m

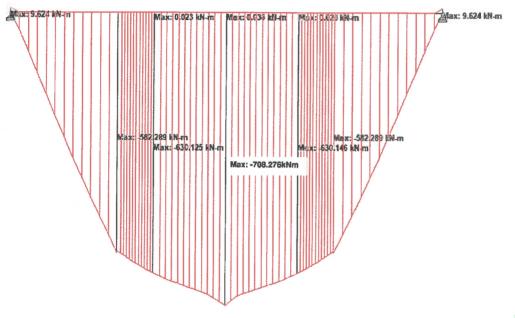
Load 9 : Bending Z : Displacement Moment - kN-m

Figure 41: Maximum Bending moment diagram for the othe∦ edge girder of the end span (influence line results)



Load 8 : Shear Y : Displacement

Figure 42: Maximum Shear Force diagram for the other edge girder of the end span (influence line results)



Load 0: Bending 2: Displacement Moment - kN-m
Figure 43: Maximum Bending moment diagram for the edge girder of the middle span (influence line results)

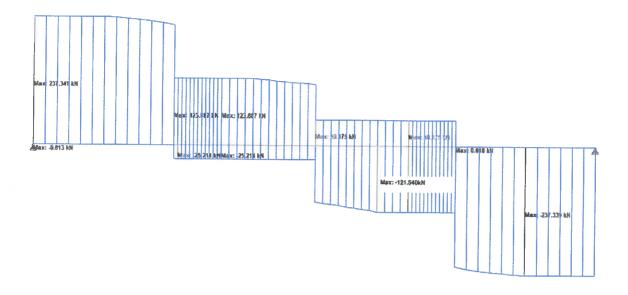


Figure 44: Maximum Shear Force diagram for the edge girder of the middle span (influence line results)

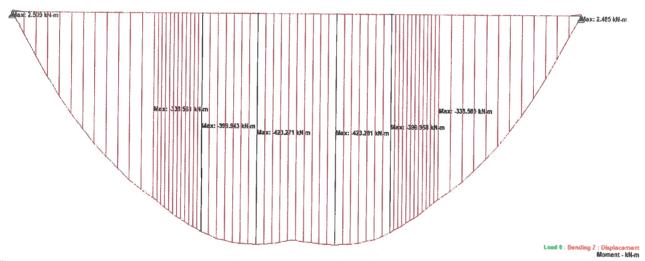
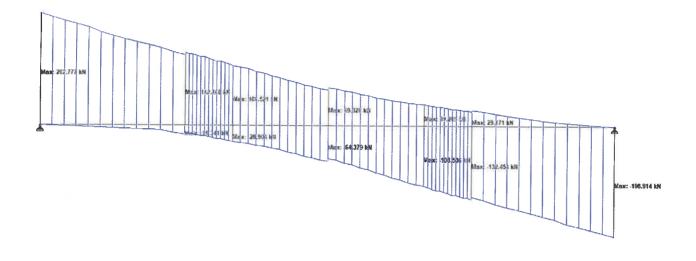


Figure 45: Maximum Shear Force diagram for the central girder of the middle span (influence line results)



Force - Idi

Figure 46: Maximum Shear Force diagram for the central girder of the middle span (influence line results)



Load 9 Bending 2: Displacement Moment - NN-m

Figure 47: Maximum Bending moment diagram for the other edge girder of the middle span (influence line results)



Force - kN

Figure 48: Maximum Shear Force diagrams for the other edge girder of the middle span (influence line results)



Load 4 : Bending 7 Moment - kN-m

Figure 49: Bending moment diagram for a strip of the deck

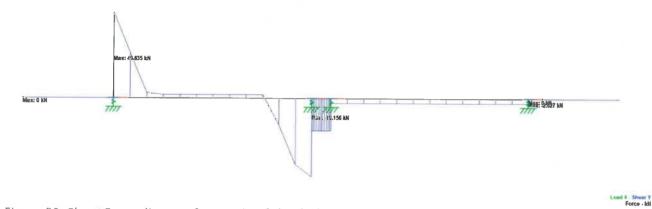


Figure 50: Shear Force diagram for a strip of the deck

Due to the large shortfall in load capacity of the bridge, both in two-way heavy vehicle traffic and one direction heavy vehicle traffic, the option for restricting the Bridge to a single access using signage, raised road markers and delineation on the bridge deck to control the heavy vehicle movement towards the centre of the bridge was discussed with the Council and considered. Analysis for a controlled one-way traffic for heavy vehicles, was performed. The following is the outcome of the bridge analysis controlled heavy vehicle movement, which is summarised in the table below.

It has also been established from this analysis that the bridge deck will require additional support beams to support the loading of a T44 truck wheel loading. The reinforcement layout, which has been taken as a typical layout from bridge asset CR141, is not sufficient to take the full weight of the T44 wheel load. This bridge deck can be augmented with the addition of beams spanning between the existing bridge girder beams to create a 2-way spanning system. The proposed layout is given in Appendix B.



Trucks over 34 tonnes cannot travel in the hatched area

Figure 51: Plan view of CR141 showing the recommended restricted area for the running of trucks over 34t

5.4.1 Bridge loading analysis under centred T44 axle loading

The following analysis has been completed investigating the effects of one T44 truck load on the bridge structure. The truck load has been positioned in the middle of the central girder. The envelope results for shear and bending moment can be seen in the figures below.

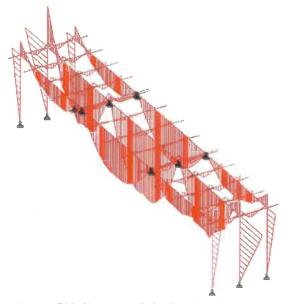
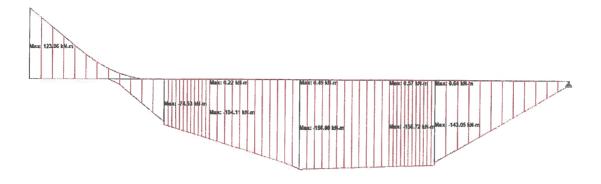


Figure 52: General maximum BM diagram of the bridge deck 3-D (influence line results)



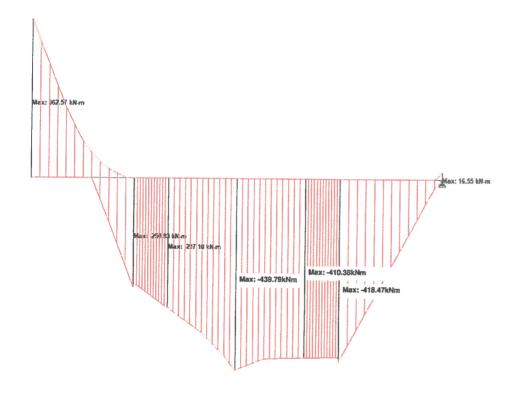
Load 8 . Bending Z

Figure 53: Maximum Bending moment diagram for the edge girder of the end span (influence line results)



Force - Idi

Figure 54: Maximum Shear Force diagram for the edge girder of the end span (influence line results)



Lead 0 : Bending Z Moment - kN-m

Figure 55: Maximum Bending moment diagram for the central girder of the end span (influence line results)

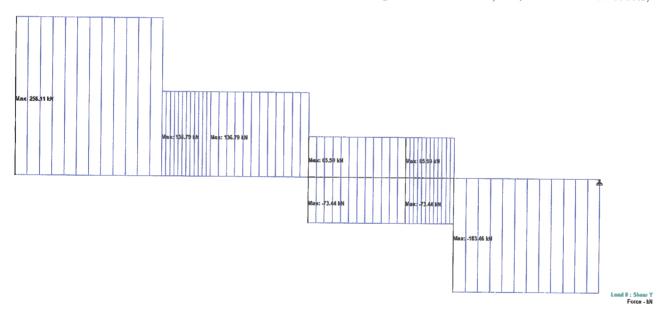
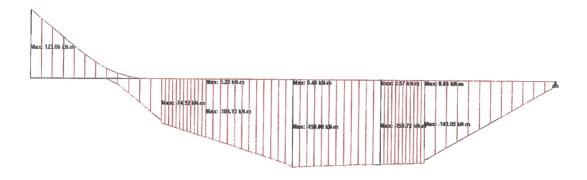


Figure 56: Maximum Shear Force diagram for the central girder of the end span (influence line results)



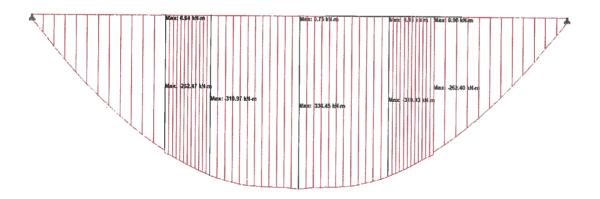
Leed 9 . Bending 2 Moment - kH-m

Figure 57: Maximum Bending moment diagram for the edge girder of the middle span (influence line results)



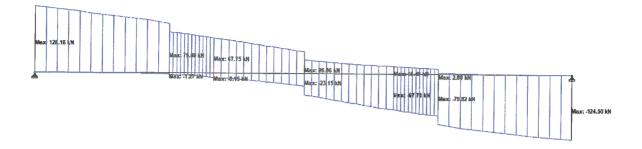
Lead 0 : Shear Y Force - kN

Figure 58: Maximum Shear Force diagram for the edge girder of the middle span (influence line results)



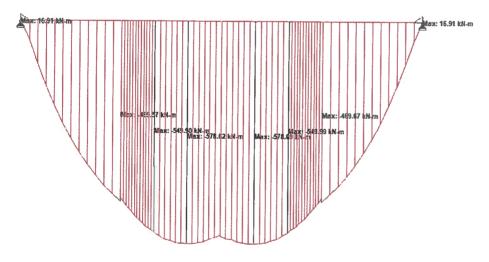
Lead 9 : Bending 2 Moment - kN-m

Figure 59: Maximum Bending moment diagram for the central girder of the middle span (influence line results)



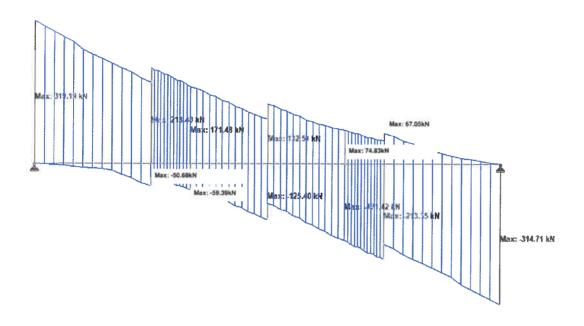
Lood B : Shear Y Force - kN

Figure 60: Maximum Shear Force diagram for the central girder of the middle span (influence line results)



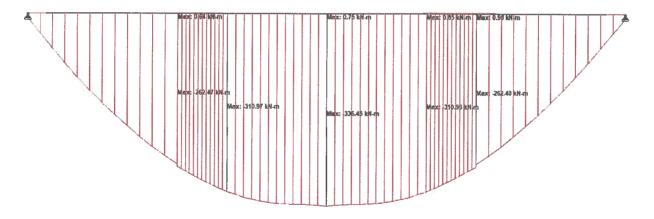
Load 6 : Bending Z Moment - kN-m

Figure 61: Maximum Bending moment diagram for the central girder of the middle span (influence line results)



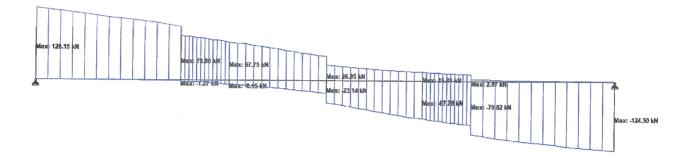
Load 0 : Shear Y Force - kN

Figure 62: Maximum Shear Force diagram for the central girder of the middle span (influence line results)



Load 0 : Bending Z Moment - kN-m

Figure 63: Maximum Bending moment diagram for the other edge girder of the middle span (influence line results)



ood 8 : Shear Y

Figure 64: Maximum Shear Force diagram for the other edge girder of the middle span (influence line results)

The bridge deck bending moment results for a strip spanning between the girder beams of the bridge, was analysed for the delineated wheel loading of a T44 truck. The results are shown in the diagrams below.



.eed 2 : Bending : Mortent - Mt-n

Figure 65: Maximum Bending moment diagram for bridge deck strip



Load 2 : Sheer Y Force - Idi

Figure 66: Maximum Shear Force diagram for bridge deck strip

5.5 ASSESSMENT OF THE AVAILABLE CAPACITY VS. THE REQUIRED CAPACITY

Comparison between the section capacity assessment and the required bending and shear force capacity was performed considering the following load factors:

Dead Load factor = 1.2 (AS5100.7-2004 Table 7.3)

Dynamic Load factor = 1.25 (based on modal analysis of the bridge -Natural Frequency = 9-12 Hz)

Live Load Factor = 1.8 (AS5100.7-2004 Table 7.3)

The comparison of these bending moment actions against the existing bridge capacities are summarised in the table below for the following load cases:

Case 1 = 1.2*(Dead load) + 2.25*(Dual T44 loading)

Case 2 = 1.2*(Dead load) + 2.25*(Single T44 loading between central and edge girder)

Case 3 = 1.2*(Dead load) + 2.25*(Single T44 loading central about central girder

Table 2: Summary of bridge loading against current capacity

	Central Girder								
CR141	Case 1 Benting Moment (kNm)	Case 1 Rana of Capitaly Against Louding (%)	Case 2 Sending Moment :	Case I Ratio of Copiecity Against Londing (%)	Cone 2 Bentling Marriett (470m)	Case 3 Rams of Coparity Against Loading (%)			
End Span (sagging)	1438.55	64.02	841.58	109.44	1177.32	78.23			
End Span (hogging)	1049.50	130.06	686.60	198.81	968.44	140,95			
Centre Span	2150.37	56.73	1307,70	93.29	1657.40	73 61			

		Edge Girder							
CR141	Cose 1 Benalog Moment ANin	Cose I Ratio of Enpocity Against Loading that	Case 2 Bending Moment White	Case 2 Ratio of Capacity Approst Locating (N)	Case I Bending Mainent	Case 3 Ratio of Capacity Acoust Londing (N)			
End Span (sagging)	1204.55	71,23	1176.44	72.93	536,32	159.38			
End Span (hogging)	980.06	131.01	957.78	134.06	429.66	298.84			
Centre Span	2140.29	53.03	1948.93	58.24	1110.96	98.32			

5.6 POTENTIAL CAPACITY UPGRADE STRATEGIES

Xavier Knight has explored number of options to upgrade the current loading capacity of the bridge structure. The goal with these strategies is to provide a cost-efficient solution that can be installed to the bridge with minimal disruption to the existing carriageway and traffic flow. Our solutions were limited by the condition of the existing bridge structure and we endeavoured to provide a solution that would be compatible with the existing structure given its age and layout.

5.6.1 External Reinforcement

We have explored options for external reinforcement/augmentation using external steel reinforcing strips, glass fibre reinforced polymer (GFRP) and carbon fibre sheets and the possibility of using structural augmentation by wrapping of the existing structure using wraps of these materials. There are two issues identified that limit the benefit of the external reinforcement/augmentation techniques; the 1st relates to the stress level in the existing steel reinforcement and the 2nd concerns the bond strength of the existing low-strength concrete.

The analysis of the steel stress level under the action of the self-weight revealed steel stress 98MPa; as the bridge is subject to cyclic loading, the stress in the existing steel reinforcement should not exceed 65~70% of the yield stress. This limit was typically considered in the service load design of structures; accordingly, the stress in the steel reinforcement under service load should not exceed 160MPa for the 230MPa steel grade. Given the difference between the self-weight steel stress and the limiting 160MPa stress, the amount of additional strain to be subject is 0.035% strain. The limited strain limitation renders the external reinforcement less effective form of augmentation.

Although external reinforcing provides effective strength gains in structures, it is assessed that the level of stress in the reinforcing bars, under own weight, is relatively high as a percentage of the yield stress of the steel reinforcement; this will limit the benefit from the external reinforcement; this would mean the lifting and de-stressing the bridge structure to install the carbon fibre strips, or any other external reinforcement for this matter, before the bridge is re-loaded by its own weight. Given the large self-weight



of the existing bridge structure the temporary lifting of the bridge would come at a large expense that we consider to be potentially unfeasible.

In addition, this form of reinforcing / augmentation depends on the bond strength between the surface of the strengthening material and the existing concrete. With the existing concrete at such a low potential strength, age and surface condition it is likely that this bond would be compromised and lead to delamination of the post-fixed wrapping / reinforcing. This option was therefore deemed less feasible than other strategies explored.

5.6.2 External Post Tensioning

External post tensioning installation was considered as an option to upgrade the capacity of the existing bridge. The geometry of the bridge would allow for some post-installed solutions to work. External post-tensioning cables can be run from one end of a span, through the deck adjacent to the beam, profiled down to set of new cross beams constructed at the required reaction points and anchored at the opposite end of the span in the deck slab. The reaction of the profiled cables could be controlled to impose uplift reaction that opposes and equate to the self-weight bending moment; thus, achieving load capacity augmentation to the bridge girders. Assessment of the required anchorage revealed significant restrictions due to the current concrete strength, which is likely to be around only 20MPa, given the technology available at the time of installation. Post-tensioning requires sections of the concrete to be placed under high levels of stress in localised areas, which would not be suitable for this structure.

5.6.3 External Steel Permanent Propping

This is an innovative way for augmenting the bridge girders by applying upward force to the base of the girders through permanently installed steel beams parallel to the girders; the action is akin to that of External Post Tensioning discussed in 5.5.2. The application of a post-fixed structural steel members, deflected by the use of the self-weight of the bridge members, we would be able to transfer large portion of the bridge dead weight to the augmentation beams and utilise the reserve loading capacity gained to support higher truck loads on the bridge. In effect, the post installed beams will provide permanent propping to the bridge girder by pre-defined load; the technique is akin to that of profiled pre-stressing of the bridge apart from the axial force component of pre-stressing. Through this innovative approach, we can achieve a higher overall capacity of the bridge structural system. This solution aims to provide an upgrade that will be achievable to install and provide large gains in strength without the demolition of the carriageway or interrupting the bridge operation.

5.6.4 Bridge Deck Augmentation

The analysis of the effect of axle load on the bridge deck identified lack of bending capacity to resist the design forces. To address the shortage in capacity, the deck will need to be augmented by either adding monolithic structural topping to increase the depth of the deck slab, add external bottom reinforcement (bonded Carbon Fibre Strips or Steel Strips) or introduce intermediate supports to change the behaviour from one-way action to a two-way grillage action. All three augmentation techniques are viable, however, adding a monolithic topping would obstruct the use of the bridge for the period of surface preparation, casting and curing.

5.6.5 Bridge Substructure

Assessment of the bridge substructure was performed. The assessment revealed adequate capacity in the piers, abutments and foundations, as the increase in axle load values to meet the T44 Truck, although substantial for the bridge deck, produces minor increase to the total reactions. Having said that, addition of proper bearing is identified as crucial for good performance and mitigation of cracking under high non-uniform bearing stresses.

Based on the technical evaluation made, Xavier Knight recommends the use of the option discussed in 5.6.3 earlier as it provides a better stress state for the existing reinforcement and achieves the required load capacity augmentation. In addition, this option provides the possibility for introducing new bearing pads to the bridge girders without affecting the bridge profile or its approaches. We are proposing the installation of beams at underside of the existing concrete girder structure. These beams will include the installation of a new elastomeric bearing plate, which will prevent bearing failure of the existing concrete elements at the girder-support interface.

The methodology for the installation of this structural steel system is as follows:

- 1. Measure and prefabricate all augmentation elements and hot-dip galvanise to 600g/m²
- 2. Locate, core drill and install high tension rods for fixing the new brackets (total 12 no. brackets)
- 3. Install fixing to wall end brackets (post-fixing mechanical, total 12 no. brackets)
- 4. Install 310UC97 augmentation beams (2 per girder, 18 no. pieces total)
- 5. Fix pre-loading arrangement beams (frame and jack, 2 per girder) at the specified loading points, connecting the 2-310UC members at the side of the girder
- 6. Jack the frame against the girder to 120kN (2 points per girder simultaneously)
- 7. Check the deflection of the 310UC section to confirm the level of pre-loading
- 8. Lock the deflection UC sections by fixing 150UC23 near each jacking point
- 9. Release

Illustration of the assembly and the proposed method statement is appended in Appendix B, to assist explaining the method and the requirements for implementation.

The augmentation beams were assessed to be able to increase the truck load that can be by no less than 12 tonnes over and above the current capacity. however, this fail short of supporting the full T44 loading on each lane across the bridge.

The self-weight of the bridge elements defines the limit to the amount of pre-load to be applied to the augmentation beams, as the girders are used as the counterweight to achieve the intended pre-load. We have limited the preloading to 85% the dead weight of the central span and established that as the limiting factor to the extent of bridge augmentation. Should further augmentation be necessary, a solution may involve adding structural topping to the deck to increase the effective depth of the bridge girders and increase the dead weight to facilitate extra pre-loading to the augmentation beams, thus increasing the bridge loading capacity even further than the level presented. This is presented in the table below.

Table 3: Summary of bridge loading and capacities following augmentation

Central Girder - Max Bending Moment kNm]				
CR141	DL	Steel Augmentation Uplift	DL + Uplift	T44	6-Axie	9 Axle	6-Axie Councii	9-Axle Council	DL-Uplift-T44	Final Case (1.2*PL + 0.95*Uplift + 2.25*T44 Axle Load)	of assessed packy after
End	154.6 &	227.37 &	100.16 &	440.8 &	339.51 &	317 &	351.62 &	351.62 &	324.65 &	919.1 & -752.42	99.8
Span	-127.21	- 303.64	-156.29	-362.57	-251.35	-250.49	-241.93	-241.97	-262.4	919.1 @ -/32.42	
Centre Span	296.1	-418.89	-187,66	578.7	502.82	480.38	423.15	428.5	414.6 & -187.66	1210 & -120.46	99.2

Edge Girder - Max Bending Moment kNm											
CR141	DL	Steel Augmentation Uplift	DL + Uplift	T44	6-Axle	9 Axie	6-Axle council	9-Axle Council	DL+Uplift+T44	Final Case (1.2*DL + 0.95*Uplift + 2.25*T44 Axie Local)	of assessed co-sucity after at governation
End Span	154.6 & -127.24	227.37 & -303.64	100.14 & -156.26	156.8 & -123.1	117.89 & -87.97	107.56 & -84.1	120.95 & -80.27	120.95 & -84.26	48.63 & - 156.83	280.66 & -213.57	32.7
Centre Span	294.96	-418.89	-187.63	336.45	293.2	280.62	239.27	237.6	177.71 & -188.48	671.23 & - 122.34	72.9

Legend:			
+ve = Sagging BM	-ve = Hogging BM	Critical Service Combination	Critical Ultimate Combination

190608 – Structural Condition Report

6 CONCLUSIONS

The loading limitations of the existing bridge asset CR141 can be upgraded using a post-fixed solution. We expect that through the installation of a pre-loaded steel beam system the loading limits can be brought up from the existing 7t (single axle), 8t (dual axle) and 11t (tri-axle) to a comfortable 34Tonnes Total Mass Limit, considering truck loading in both lanes of the bridge carriageway. If you should wish to consider only a single-truck loading case (i.e. limiting the traffic to one direction only), the augmented bridge can receive the specified T44 loading.

The self-weight of the central span has defined the limit to the augmentation level that can be achieved by the proposed method; adding structural topping to the deck (75mm thick) can facilitate an extra 15% pre-loading to the augmentation beams and increase the deck bending capacity due to the increase in the depth of the structural elements.

Several minor repair items have also been identified as needing to be completed in addition to the upgrade works above. These items will increase the durability of the existing structure and are considered necessary to prolong the overall working life of the bridge structure. Through patch repair and corrosion protection the techniques listed herein should be applied at the earliest convenience of the Shire.

The condition of the structure reviewed during the inspection will deteriorate with time, making the observations in this report out of date. If the client doesn't act on the recommendations within 12 months then the report cannot be relied upon as an accurate record of the actual conditions of the structure. A new inspection should be undertaken prior to commissioning rectification works.

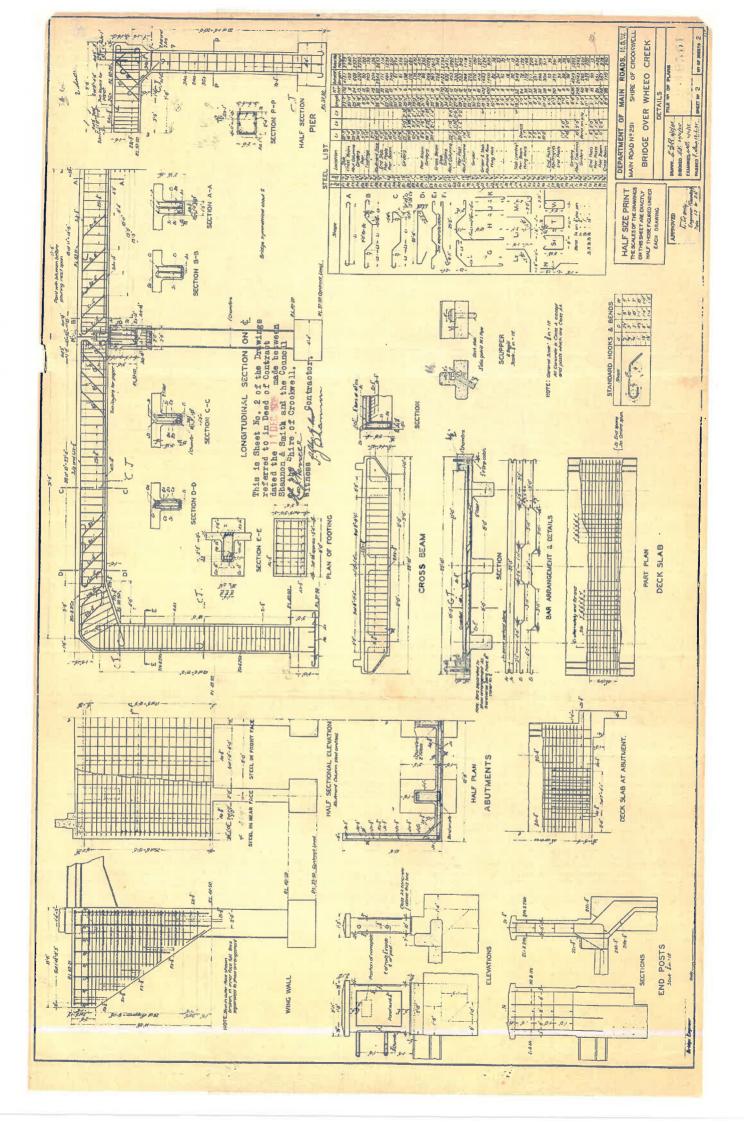
If the client does not act on the recommendations contained in this report, Xavier Knight cannot accept responsibility for any liability arising from a failure relating to the recommendations contained herein.

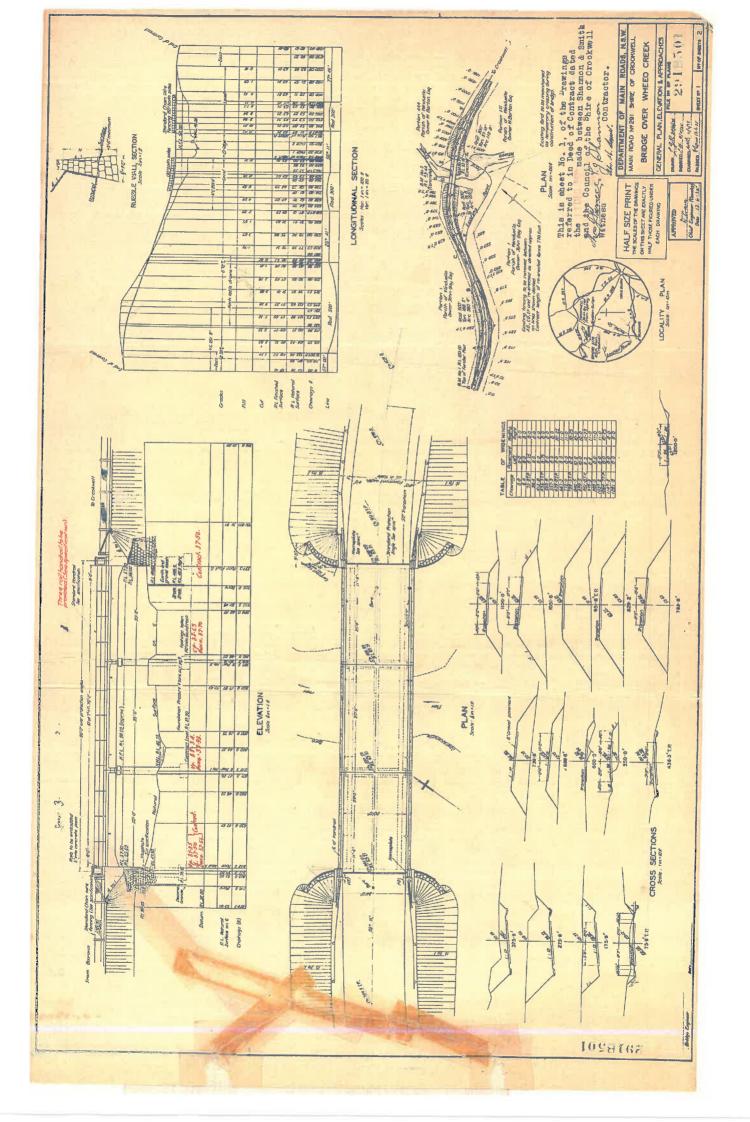
This report was completed for and on behalf of the Xavier Knight team. Kind regards,

Structural Engineer
BE(Civil)(Hons)







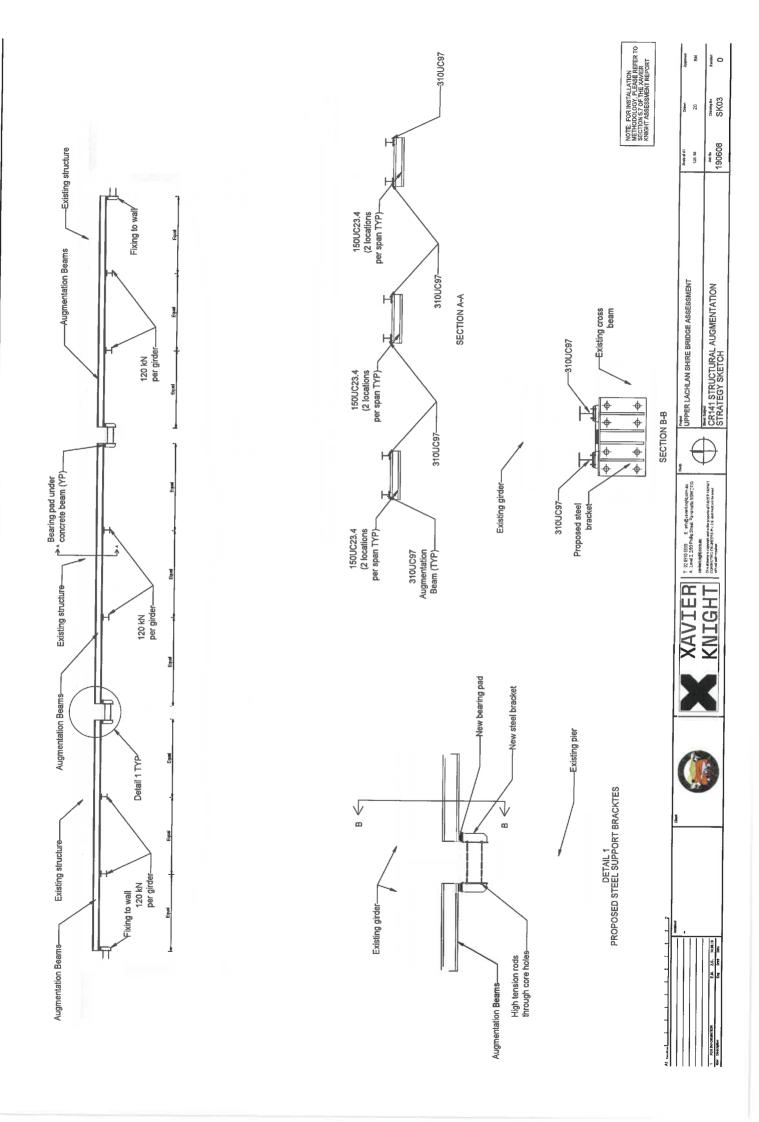






APPENDIX B: Structural Augmentation Strategy Sketche











National Heavy Vehicle Regulator Common Heavy Freight Vehicle Configurations

1. COMM	ON RIGID TRUCKS - GENERAL ACCESS	Description	Maximum Length (metres)	Mass under GML (tannes)	Mass under CML (formes)	Maximum Régulatury Maris under HML (tons
(a)		2 Axle Rigid Truck	≤ 12.5	15.0	CML does not apply	(e
(b)	an va	3 Axle Rigid Truck	≤ 12.5	22.5	23.0	•
(c)	W. 1	4 Axle Rigid Truck	≤ 12.5	26.0	27.0	
[d]		4 Axle Twinsteer Rigid Truck	≤ 12.5	26.5	27.0	-
e)	100 20 th	5 Axle Twinsteer Rigid Truck	≤ 12.5	30.0	31.0	-
LEOMM	ON SEMITRAILER COMBINATIONS - GENERAL ACC	ss			-	
a)	10 10 10	3 Axde Semitrailer	≤ 19.0	24.0		*
b)	(0 10 10	4 Axle Semitrailer	≤ 19.0	31.5	32.0	32.0
(c)	10 20 20	5 Axle Semitrailer	≤ 19.0	35.0	36.0	37.5
d}	W 19 09	5 Axle Semitrailer	≤ 19.0	39.0	40.0	40.0
e)	Wall Street	6 Axle Semitrailer	≤ 19.0	42.5	43.5	45.5
, сомм	ON RIGID TRUCK AND TRAILER COMBINATIONS (G.	noral access when complying with presc	ribed mass and dimension requirem	ants)		
a)	40 90 90 90	2 Axle Truck and 2 Axle Dog Trailer	≤ 19.0	30.0		2
ь)	60 00 110	2 Axle Truck and 2 Axle Pig Trailer	≤ 19.0	30.0	CML does not apply	•
c)	10 15 10 10	3 Axle Truck and 2 Axle Dog Trailer	≤ 19.0	40.5	41.0	•
d)	60 165 150	3 Axle Truck and 2 Axle Pig Trailer	≤ 19.0	37.5	CML does not apply	•
e)	10 10 10 10 10 10 10 10 10 10 10 10 10 1	3 Axle Truck and 3 Axle Dog Trailer	≤ 19.0	42.5	43.5	
f)	60	3 Axle Truck and 3 Axle Pig Trailer	≤ 19.0	40.5	CML does not apply	-
g)	5 80 88 W	3 Axle Truck and 4 Axle Dog Trailer	≤ 19.0	42.5	43.5	
h)	100 00 000 000 000 000 000 000 000 000	4 Axle Truck and 3 Axle Dog Trailer	≤ 19.0	42.5	43.5	-
i)	00 00 00 00	4 Axle Truck and 4 Axle Dog Trailer	≤ 19.0	42.5	43.5	
сомм	ON B-DOUBLE COMBINATIONS - CLASS 2	the state of the s	The second second	-		
o)		7 Axle B-double	≤ 19.0	55.5	57.0	57.0
b}	6 D 18 200 18	8 Axle B-double	≤ 26.0	59.0	61.0	62.5
c)	10 10 10 10 10 10 10 10 10 10 10 10 10 1	8 Axle B-double	≤ 26.0	59.0	61.0	62.5
d)	AOI 16.5 20.0 25.0	9 Axle B-double	≤ 26.0	62.5	64.5	68.0
. COMM	ON TYPE I ROAD TRAINS - CLASS 2		and the second			District on the last
a)	00 00 00 00 00 103 103 103	9 Axle A-double	≤ 36.5	72.0	74.0	74.0
b)	62 16 209 15 200	11 Axle A-double	≤ 36.5	79.0	81.0	85.0
c)	00 165 200 200 200	12 Axle A-double	≤ 36.5	82.5	84.5	90.5
d)	50 16.2 220 200 200 50 16.2 220 200 200	12 Axle Modular 8-triple	≤ 35.0	82.5	84.5	90.5
»)	50 Hz 200 200 200	12 Axle B-triple	≤ 36.5	82.5	84.5	90.5
f}		14 Axle AB-triple	≤ 36.5	99.0	101.0	107.5
9}	at the same of the same of	15 Axle AB-triple	≤ 36.5	102.5	104.5	113.0
h)	eth Milk 2001 200 2001 200	11 Axle Rigid Truck and 2 Dog Trailers	≤ 36.5	88.5	90.5	91.0
	ON TYPE 2 ROAD TRAINS - CLASS 2	Trodo tagle fractional 2 2003 francis		00.5	70.3	71.0
a) 👹	1 50 500 50 500 60 500 165 200 165 200 165 209	16 Axle A-triple	≤ 53.5	115.5	117.5	124.5
) 5	16.8 200 200 200 200 200 200 200 200 200 20	18 Axle A-triple	≤ 53.5	122.5	124.5	135.5
6.01	of the latest the latest to th	15 Axle A8-triple	≤ 44.0 - Classified by the NHVR	102.5	104.5	113.0
i)		13 Axle Rigid Truck and 2 Dog Trailers	as Type 1 when L ≤ 36.5m ≤ 47.5 - Classified by the NHVR	95.5		102.0
	10 45 45 20 45 20	17 Axle BAB-Quod	as Type 1 when L ≤ 36.5m			
6.0t	H.Si 20th 20th H.Si 20th 20th		≤ 53.5			130.0
10	200 200 200 200 200 200 200 200 200 200	18 Axle BAB-Quad	≤ 53,5	122.5	124.5	135.5
) <u>sell</u>	50 808 50 850 800 800 44 9 200 95 200 200 200	17 Axle ABB-Quad	≤ 53.5	119.0	121.0	130.0
d will	16.5t 20.0t 20.0t 20.0t 20.0t	18 Axle ABB-Quad	≤ 53.5	122.5	124,5	135.5





Zealseal™ 4000 System

For Bridge & Road Applications.

(For carpark, public space and architectural applications see Miska ZealSeal™ 2000 data sheet).

The Miska Zealseal™ System provides a waterproof, trafficable seal utilizing Zealcrete LV[™] epoxy elastomeric concrete as the armor nosing to support the Zealseal™ expansion foam.

System Applications

Asphalt on Concrete Deck Installations

- Concrete Rebate Installations

- Steel Armor Nosing and Cold Applied Sealant with Backer Rod Retrofits

Zealseal™ 4000 A Zealseal™ 4000 C

Zealseal™ 4000 R

Key Advantages

- Zealseal $^{\mbox{\scriptsize TM}}$ has a minimum controlled depth of 50mm giving a guaranteed bond line that is not subject to the diligence of the installer.
- Zealseal™ has a operating system which is active across the full depth and width of the seal as opposed to the varying depths in some sealant systems.
- Zealseal™ has a homogeneous uniform structure and maintains its shape irrespective of the width or its position in the movement range.
- Zealseal™ is nitrogen blown and therefore is chemically inert providing higher heat resistance and UV stability than EVA chemically formed products.

Zealseal™

ZealsealTM is a nitrogen blown, closed cell, cross linked polyethylene material which conforms to ASTM D-1056, Type 2 Class B, Grade 3 specifications. It is a preformed, low density, resilient material that is UV stabilized. Manufactured in such a way that it is free of toxins, non reactive and chemically inert. Zealseal™ is also compatible with other construction materials and combined with its resistance to abrasion, oxidation and most chemicals, is ideal as a waterproof, expansion joint material

Key Features

- Capacity for 60% compression (percentages based on initial seal width selection)
- Capacity for 100% horizontal and vertical shear
- Whilst Zealseal has a capacity for 30% tension, this "must not" be used in movement calculations when selecting sizing for Road and Bridge applications. It is recommended that this capacity be kept for a safety factor should a movement calculation exceed the expected +movement.
- · Does not support flame and is self extinguishing
- Large temperature operating range with no thermal shrinkage.
- Manufactured in such a way that it is free of toxins, non reactive and chemically inert.
- Weather and UV resistant
- On site welding of joins, intersections, upturns and different seal sizes. (A monolithic waterproof system)
- Quick and easy installation
- •Enhanced bond line design increases bond strength to all surfaces. Supplied with approximate 3mm x 3mm bond surface grooves @ 10mm centres.
- Bonded using Zealbond[™]. (See overleaf for details)
- Cleanup with Zealcleaner



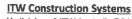








Pictured: Gateway Motorway Brisbane



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Zealseal™ 4000 System

For Bridge & Road Applications.

(For carpark, public space and architectural applications see Miska Zealseal™ 2000 data sheet).



Zealseal™ Sizing

(For Road & Bridge applications)

The table across is a guide to the sizing and recommended movement ranges. For full details on selecting the correct Zealseal™ size, refer to the Miska data sheet:

"Zealseal Guide to Sizing"



Seal	Seal Width	Seal Height	Nominal Gap Size mm	Minimum Gap mm	Maximum Gap mm
ZS25	25	50	19	10	25
ZS30	30	50	23	12	30
ZS35	35	50	26	14	35
ZS40	40	50	30	16	40
ZS45	45	50	34	18	45
ZS50	50	50	38	20	50
ZS55	_ 55	50	41	22	55
ZS60	60	75	45	24	60
ZS65	65	75	49	26	65
ZS70	70	75	52	28	70
ZS75	75	75	56	30	75
ZS80	80	75	60	32	80
ZS85	85	75	64	34	85

Zealcrete LV™

Zealcrete LV[™] is a Fast Setting, , moisture insensitive, 100% solid, low viscosity two-component Epoxy elastomeric concrete. Zealcrete LV[™] is designed as an expansion joint header and high impact nosing for Bridge and Roads applications. Zealcrete LV[™] is designed to preserve and protect concrete decks and substructures by absorbing impact, preventing water absorbsion and ingress of chemicals and eliminating spalled edges on joint lines.

Note: New Concrete must cure for 10 Days prior to Installing Zealcrete™ LV.

Key Features

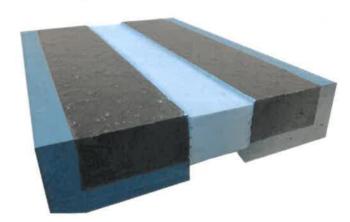
- Low viscosity for ease of mixing
- Moisture insensitive
- Fast setting, Gel time 15-20 minutes
- Excellent load bearing characteristics
- Excellent thermal shock resistance
- Waterproof and Chemical Resistant
- High abrasion resistance
- Excellent adhesion to various substrates
- Resistant to UV and ozone exposure
- Resistant to freeze-thaw changes

Zealbond™

Zealbond[™] is a 100% solids, moisture insensitive, two component, modified epoxy adhesive designed for bonding Zealseal[™] to construction materials including Zealcrete LV[™] concrete, steel, wood and other construction materials. Zealbond[™] meets ASTM C-881, Type 1 & 11, Grade 2, Class B & C.

ZealcleanerTM

Zealcleaner™ is a Zero-VOC Clean up solvent designed to be an industrial grade cleaner that is environmentally friendly. Zealcleaner™ is a low viscosity, water soluble cleaner and degreaser that is an alternative to flammable cleaners and solvents. It will dissolve and aid clean up of most uncured epoxies, urethanes, paints, and other difficult to remove substances. The low evaporation rate allows the product to remain on the surface rather than flashing off into the air, minimizing the required amount for the job. *use white cotton rags.



Zealband



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Zealseal™ 4000A Asphalt on Concrete Deck Installation

Sizing for Asphalt on concrete deck application

When the Zealcrete™ LV elastomeric concrete nosing "sits on" the concrete Decking or when the upper surface of the Zealcrete™ is above the upper surface of the concrete decking the nosing aspect ratio, width: depth, must be taken into consideration. Although the top surface of the nosing will be level with the top surface of the asphalt after the installation, the depth of the asphalt and therefore the level of support behind the nosing is a factor that must be considered when sizing the material for the particular project.



Pictured: Gateway Motorway Brisbane

Zealcrete™ LV Sizing Guides

Asphalt Depth at minimum of 50mm

In cases where the asphalt is at a depth of 50mm or less, Miska recommends that the depth of the Zealcrete™ nosing should be maintained at 50mm and the minimum width should be maintained at 150mm wide.

Zealcrete™ sizing at minimum = 50mm Deep x 150mm Wide

ASPHALT Zealcrete LVTM 150 CONCRETE DECK

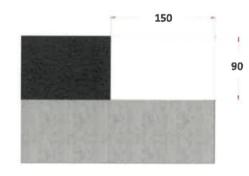
Asphalt Depth > 50mm up to 90mm

In cases where the asphalt is at a depth > 50mm and \leq 90mm the Width of the ZealcreteTM nosing should be maintained at 150mm.

Zealcrete™ sizing = 90mm Deep x 150mm Wide

Asphalt Depth ≥ 90mm

In cases where the asphalt is at a depth ≥ 90mm Deep then an Aspect Ratio (Depth: Width) of **0.6** should be maintained at all times.



Example Sizing Chart: Aspect Ratio - 0.6 = (e.g. 75mm/0.6 = 125mm)

Asphalt Depth mm	Nosing Depth mm	Nosing Width mm	Volume of Zealcrete per meter (Litres) Both sides of Block Out
90	90	150	27.0
100	100	170	33.4
125	125	210	52.5
150	150	250	75.0

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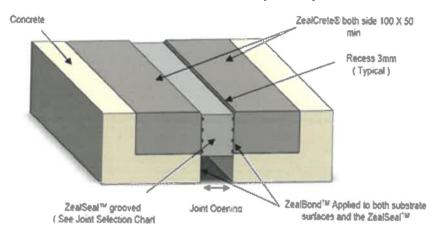


Zealseal™ 4000C Concrete Blockout Installion

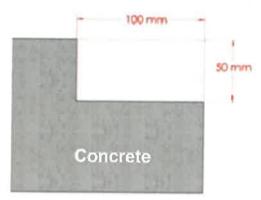
Sizing for Concrete Blockout Installations

When the Zealcrete[™] Nosing is fully supported by concrete on both sides of the rebate, with height of the concrete being level with the trafficable surface of the road Miska recommends an aspect ratio (width: height) of 0.5 be maintained.

Minimum blockout size = 50mm Deep x 100mm wide per side. (An Aspect ratio of 0.5 must be retained) 50mm/0.5 = 100mm







Concrete Blockout, Zealcrete LV will be supported by concrete on both sides of the blockout

Zealseal™ 4000R Retrofit Installations

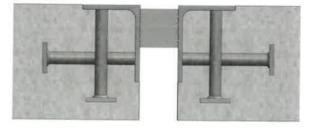
Retrofit Applications

- Retrofit Existing Steel Armour Nosing Joint Systems
- Retrofit Existing Cold Applied Sealant with Backer Rod Joint Systems

The Zealseal™ seal itself is ideally suited to the repair of existing Steel Armour or Cold Applied Sealant Joint Systems where the armour is structurally sound but the existing seal is leaking causing joint failure and degradation bridge bearings and support structure. Zealseal™ is well suited as a direct replacement for Compression Seals, Water Stops and existing Cold Applied sealant and Backer Rod Systems. The Zealbond™ bonder is formulated to bond the Zealseal™ to Concrete, Steel, Elastomeric Concrete and many other types of substrates given the correct preparation.

General-

Repair procedures of existing Steel or Elastomeric Concrete armoured joint systems consists of removal of joint seal between armour edges, sandblasting the armour, priming the armour, and installing new Zealseal™ joint seals.





Pictured: William Jolly Bridge Brisbane (Oct 2010)

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