South Road Tram Overpass Shared Path Bridge

Incident Investigation Report

Department of Planning, Transport and Infrastructure

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Contents

Appendices

Figures

1 Executive Summary

On 18 January 2017 DPTI became aware of girder dislodgement to two spans of the South Road Tram Overpass shared pedestrian and cycle path bridge (Shared Path Bridge). As a result of the incident, South Road was temporarily closed to traffic whilst stabilisation of the structure was installed. This stabilisation is a short term measure only.

In Aurecon's opinion, the incident can be attributed to the failure of the design to adequately allow for out of balance effects. This resulted in girders tilting sufficiently to render the bearing restraint system ineffective and essentially free the bearings, allowing them to "walk" out of their design position.

Once the bearings were free to move, we believe the mechanism for the movement is due to cyclic ongoing wind load effects on the anti-throw screen, coupled with a constant lateral force due to out-of-balance self-weight effects, promoting a caterpillar movement of the bearing. Lateral movement would then have occurred incrementally over a period of time, until the bearings had moved sufficiently for the girder to lose support.

All spans of the Shared Path Bridge are exhibiting signs of the effects of this phenomenon, with noticeable bearing deformation, girder rotation and cracking of the keeper walls. It is considered likely that, if unchecked, the remaining spans of the Shared Path Bridge are at risk of failure at some point in the future. However, this is not expected in the short term.

Aurecon considers that there is no cause for concern over a similar incident occurring to the girders of the adjacent Tram Bridge structure, which are separated from and act independently of the Shared Path Bridge girders.

2 Introduction

2.1 Background

On 18 January 2017 DPTI became aware of girder dislodgement to two spans of the South Road Shared Path Bridge. As a result of the incident, South Road was temporarily closed to traffic whilst stabilisation of the structure was installed. As a short term measure only, the girders have been restrained using temporary tiebacks to the piers as shown in Figure 1. Following this temporary tie arrangement South Road was reopened to traffic, however the Shared Path Bridge remains closed to pedestrians and cyclists due to the gross misalignment of the footpath sections and the hazards presented by the temporary support anchors installed in the pathway

Figure 1 Temporary stabilising tiebacks

2.2 Project Objective and Scope

DPTI has commissioned Aurecon for the following services as noted in the Statement of Requirements for the project:

1. A detailed investigation into the cause of the incident. The deliverable will be a report that will be released by the Commissioner of Highways and must therefore be appropriate for tabling in Parliament. The report will assist to inform the long term remedial solution for the shared path bridge.

2. Development of a proposal for the remediation of the shared path bridge. This will consist of high level concept designs of suitable options, documented as engineering sketches. Order of cost estimates for the various options will be calculated, by others. We will present the options in the context of relative ongoing maintenance/inspection needs, risk and also consider the impact of construction on South Road traffic.

3. Conduct an independent review of the DPTI bridge inspection processes. The deliverable for this scope item will be a report that assesses DPTI's approach to periodic bridge inspections, in the context of best industry practice.

This report summarises the findings of the investigation into the cause of the incident, and includes recommendations on appropriate actions to repair and safeguard the structure.

3 Description of the Structure and Incident

3.1 General Description of Structure

The Shared Path Bridge consists of eight spans of single 1200 mm deep precast concrete "Super T" girders with a composite reinforced concrete, cast in situ deck slab providing shared path access over South Road and adjacent infrastructure. The spans are approximately 32 m long. The Shared Path Bridge superstructure is immediately adjacent to a larger tram and station bridge structure with which it shares a common substructure, but its superstructure is structurally independent. A 3m high anti-throw screen is attached to the northern side of the Shared Path Bridge. It is noted that an extra layer of patterning on Spans 3, 4 and 5 means that the anti-throw screen will attract additional wind loading at these spans

The bridge structures are shown in Figure 2 below, with the Shared Path Bridge denoted "Tramway Park" on the right hand side. Reference is also made to Figure 7, which shows the span configuration.

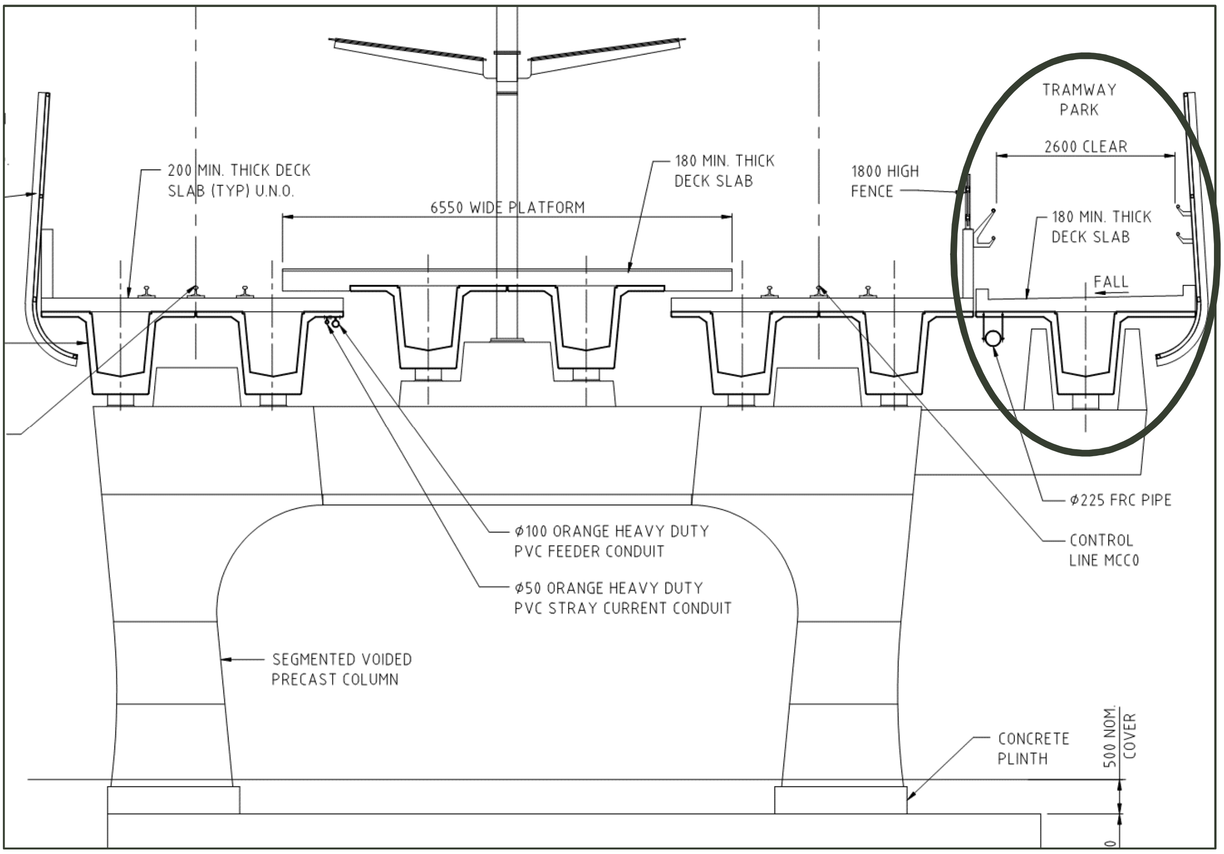


Figure 2 Typical Cross-section of the Tram Bridge and Shared Path Bridge (right side)

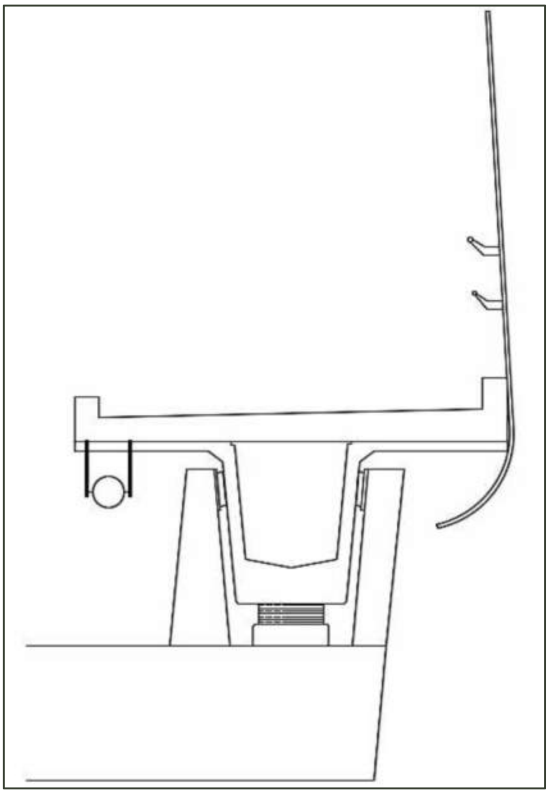


Figure 3 Girder Bearing Arrangements

The precast girder support (bearing) arrangement for the Shared Path Bridge is shown in Figure 3. Under this arrangement, each Super T girder is supported vertically by a single elastomeric bearing at each end and stabilised by the provision of side elastomeric pads fixed to extended reinforced concrete keeper walls.

3.1.1 Bearing Arrangements

The main bearings are rectangular laminated elastomeric pads, each with plan dimensions 480mm wide and 380mm long.

The bearings are either 117mm high (Part No 071505R) or 157mm high (Part No 071507R), depending on the need for the bearings to allow for longitudinal movement due to creep, shrinkage and thermal effects. Steel restraint bars, or keeper plates, are provided around the top edge of the bearing on the top attachment plate, and are intended to prevent the bearing from moving relative to the girder.

The typical arrangement for the main bearings is shown on Figure 4 below.

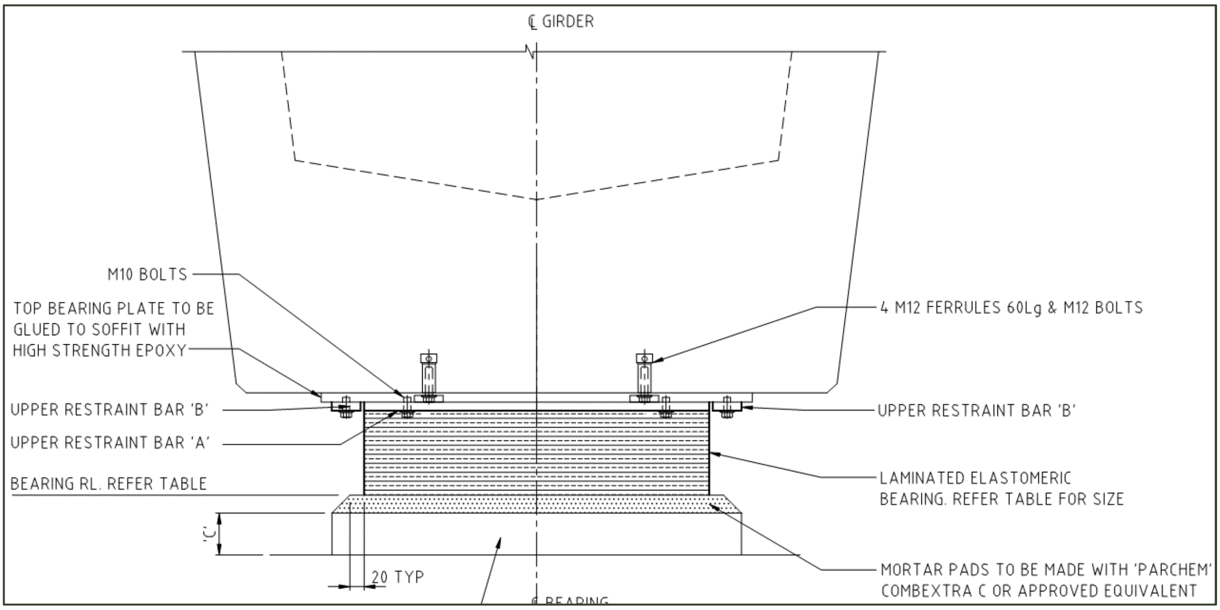
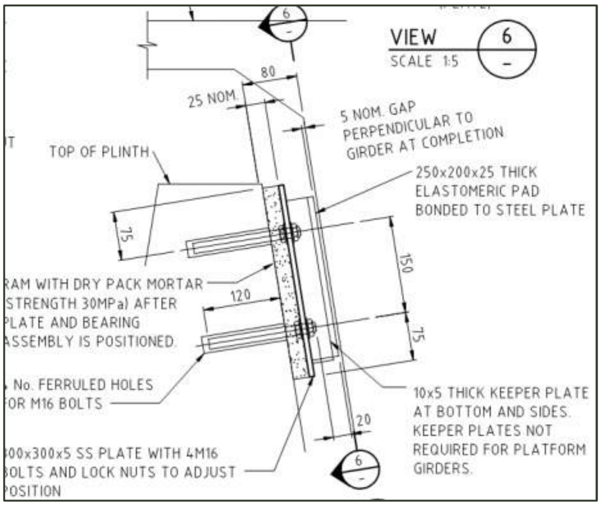


Figure 4 Typical Girder Bearing Detail



As noted previously and shown in Figure 3, the girders of the Shared Path Bridge are designed to be restrained against lateral loads and rotation by side elastomeric bearing pads. The detail for these bearings is shown in Figure 5. It is noted that the drawings specify a 5mm nominal gap between the face of the side bearing pad and the outside face of the girder web. The actual gap that existed at the end of construction is not known.

Figure 5 Side Girder Bearing Pads (Southern Keeper Wall Shown)

3.1.2 Lateral Restraint System

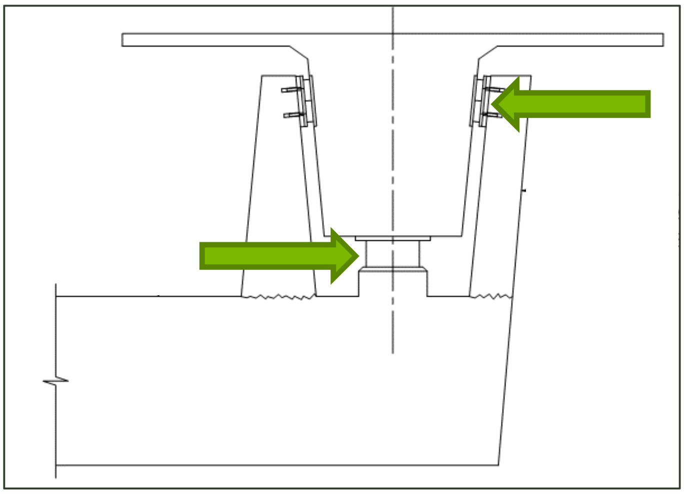


Figure 6 Couple required to resist eccentric and lateral loads

The mechanism to restrain the girders of the Shared Path Bridge against lateral/transverse actions, such as wind load, eccentric dead loads (for example the 3m high anti-throw screen on the north side of the structure only), or pedestrian loads, consists of the above-described main bearings and side elastomeric pads. A lateral load from, say, a southerly wind would act on the anti-throw screen and be resisted by a reaction “couple”, as noted in Figure 6. This couple consists of a reaction against one of the side elastomeric pads and a lateral resistance provided by the main horizontal bearing.

It is noted that wind load is a transient effect which will be applied, then released and re-applied, sometimes in the reverse direction. However, eccentric dead load effects generate a permanent reaction couple.

3.1.3 Articulation

Expansion joints have been provided in the superstructure at the Abutments and at Piers 3 and 5, thus dividing the structure into three distinct deck modules. The concrete deck slab is continuous between girders that are not separated by an expansion joint. An idealised elevation of the Shared Path Bridge showing the articulation and span arrangements is provided in Figure 7.

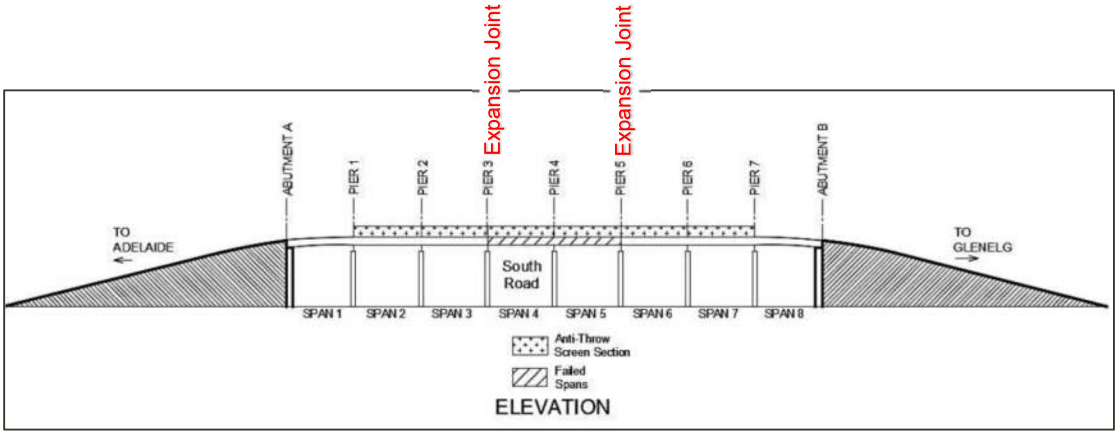


Figure 7 Span Arrangement and Articulation

3.2 The Incident

On 18 January 2017 DPTI became aware that two spans of the South Road Shared Path Bridge had tilted off their supports and that large cracks had appeared in the concrete supporting members. As a result of the incident, South Road was closed to traffic whilst temporary stabilisation of the structure was installed.

Inspection revealed that girder dislodgement occurred in Spans 4 and 5, between Piers 3 and 5 of the Shared Path Bridge which resulted from a loss of support caused by a gross transverse movement of each of the four main elastomeric bearings from beneath the girder soffit. Refer Figure 8. The two girders of Spans 4 and 5 subsequently became unstable and have tilted about their longitudinal axis. Fortunately reinforced concrete keeper walls have acted to restrain the girders, and have in fact prevented the girders from falling off the piers.

As a result of the large tilt of the girders the expansion joints at the finished surface of the shared path became misaligned above Piers 3 and 5 and failure of some connecting steel plates for the anti-throw screen occurred. In addition, cracking was observed in the pier headstocks, immediately under the outer keeper walls restraining the girders.

Photographs of the various defects and other relevant observations are included in Section 4.

However, the photograph below best illustrates the girder dislodgement and extent of bearing movement described above.

Figure 8 Typical Bearing Movement: Pier 3

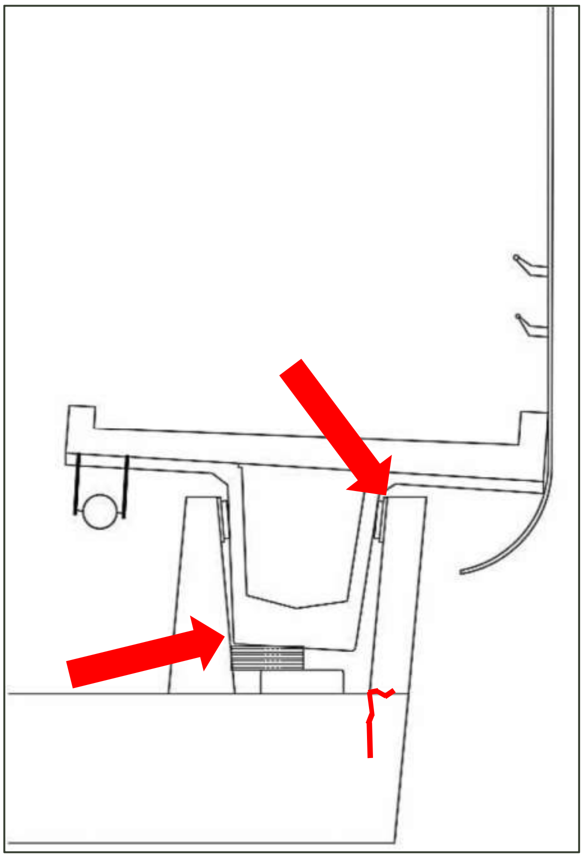


Figure 9 Girder now bearing on keeper wall

As seen in Figure 8, it is evident that the laminated elastomeric bearing has travelled under the restraint bar on the bearing attachment plate and gradually moved or “walked” to the south, until it has eventually been arrested by the adjacent keeper wall. The excessive girder tilting caused by the resultant loss of support has also resulted in the underside of the top flange of the girder bearing vertically down on the top of the outer keeper wall, essentially stabilising the girder. Cracking at the ends of the headstocks, immediately under the affected keeper walls, has been observed. This cracking is both horizontal – at the tooled construction joint between the main headstock and the keeper wall, and vertical – propagating from the inside corner of the keeper wall/headstock interface as illustrated on Figure 9.

Thus the girders of the Shared Path Bridge have attained a new equilibrium system, in a manner that was clearly not part of the original design.

4 Site Inspection

4.1 Summary

On Wednesday 1 February 2017, the bridge site inspection was attended by Aurecon staff: Harry Turner – Technical Director, and Steve Pirie – Bridge Engineer. Elevated work platforms (EWP) were used to allow inspection of various parts of the Shared Path Bridge. Visual observations, photographs and key measurements were made at all piers and at Abutment A. Abutment B was inspected from the ground. An inspection at bridge deck level was also undertaken.

All bearings and keeper walls were inspected using the EWP, with the exception of Abutment B. A spirit level was used to measure the slope of girder soffits relative to bearing shelves. Measurements of key dimensions were taken, particularly to verify the current (rotated) position of the girders and deformed shape of the bearings.

A comprehensive collection of photographs is presented as Appendix A of this report. Selected photographs, illustrating typical or salient features, are reproduced below.

It is noted that it was not part of Aurecon's scope to inspect the adjacent Tram Bridge. However, the opportunity was taken to make some observation of the bearings of this independent superstructure. A photograph of a typical Tram Bridge bearing is included in Appendix A.

4.2 Abutments

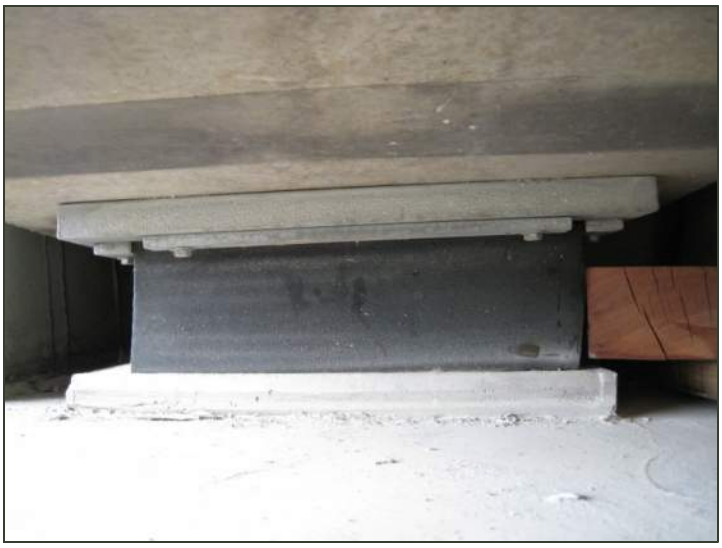


Figure 10 Bearing at Abutment A

As can be seen from the adjacent photo (Figure 10) the deformation of bearings is occurring even at the abutments. Separation of the bearing from both the beam attachment plate at its top surface and the mortar pad underneath is evident. The photo also shows the hardwood chocks that have been recently placed to restrain the bearings, following the recent girder dislodgement incident.

Observation from the ground of the Abutment B bearings, revealed a similar situation to that described above for Abutment A.

4.3 Piers 1, 2, 6 & 7

Although there is evidence of girder rotation and bearing movement, none of the bearings at Spans 1, 2, 3, 6, 7, 8 of the Shared Path Bridge have been dislodged from their keeper plates, or are in a position to dislodge in the short term.

Figure 12 Girder rotation and bearing movement evident

Figure 11 Cracking at keeper wall

Figure 12 above shows the bearing at Pier 1 west. Clear evidence of bearing deformation, uplift/separation from supported surfaces and movement of the bearing to the south is observed and is typical of the bearings at the other piers. At this location, a clear gap between the top surface of the bearing and the beam soffit can be observed.

Figure 11 shows a horizontal crack at the construction joint between the keeper wall and the headstock at Pier 1. This crack is consistent with over-loading of the keeper wall in bending, as a result of a horizontal load being applied to the side bearing pad. This cracking is evident at the outer keeper walls of all piers.

Figure 13 Side bearing separation

Figure 13 shows a typical side bearing. At all piers, the Shared Path Bridge girders have rotated to the north, such that a clear gap is observable between the girder web and the pads fixed to the southern, or inner, keeper walls, certainly more than the 5mm design gap.

4.4 Piers 3, 4 & 5

Figure 14 Cracking to pier headstocks

Figure 15 Girder dislodgement due to excessive bearing movement

These piers support the spans where the two girders have been dislodged.

In addition to the phenomena noted above at the other piers (bearing movement/deformation and horizontal cracking) the extreme bearing movement shown in Figure 15 and the vertical cracking of the main headstock shown in Figure 14 were typically observed.

4.5 Shared Path Surface and Fence

Figure 16 Handrail misalignment

Figure 17 Deck joint damage

Inspection of the Shared Path Bridge girders from the deck surface was also undertaken. Figures 16 and 17 show the typical damage experienced at the deck joint and handrail at Piers 3 and 5.

Inspection of the anti-throw screen revealed that its gross area is approximately 45% solid. It is noted that an architectural pattern is applied to spans 3, 4 and 5 using an additional perforated plate fixed to the outside of the screen which further adds to its solid area, thus increasing the wind load on these spans compared to the rest of the structure.

The architectural mesh can be seen in Figure 18.

Figure 18 Architectural pattern on anti-throw screen

5 Assessment

5.1 Cause of Failure

The use of Super T girders, elastomeric bearings, a cast in situ deck and metal anti-throw screens is common in the industry. In most applications the Super T girders are in multiple sets, tied together with a composite cast in situ slab and inherently stable. Construction of bridges using a single line of Super T girders, and supported by a single elastomeric bearing at each end, is inherently unstable and requires particular attention.

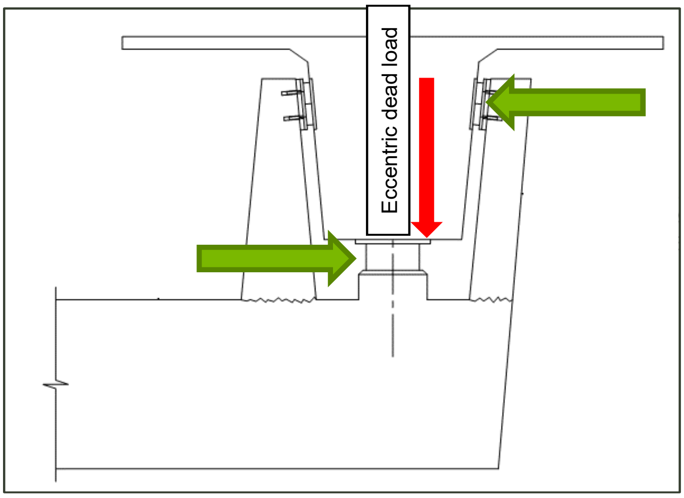


Figure 19 Couple effect for girder stability

For the Shared Path Bridge the mechanism used to stabilise the girders is noted in Section 3.1.2, and comprises a couple consisting of a reaction against one of two side elastomeric pads and a lateral resistance provided by the main horizontal bearing. The dead load reaction is not concentric on the bearing centreline, principally due to the mass of the anti-throw screen and the varying thickness of the concrete deck used to produce the transverse cross fall. It is noted that there is some ambiguity on the drawings, with some references to 1% cross fall, and other references to 2% cross fall. In our calculations we have assumed a cross fall of 1%. On this basis the eccentricity of the combined weight of the girder, deck slab and screen is estimated to be approximately 90 mm from the girder centreline. Refer Figure 19.

This produces a permanent force on the northern side bearing of around 65kN (a little over 6 tonnes). To maintain equilibrium a transverse force of around 65kN must also act on the top of the main bearing. A moderate wind load on the anti-throw screen (70 km/h wind speed) produces an additional reversible horizontal service load on the anti-throw screen (and hence on the side bearings and the main bearing), of approximately 22kN.

It is noted that any elastomeric bearing is quite flexible laterally, has a designated shear stiffness and as a result deforms significantly laterally in resisting any applied loading. We estimate that the top of the bearing (at the girder soffit) will move laterally approximately 50mm in response to the dead load out of balance alone.

As the girder is restrained from significant lateral movement by the side elastomeric pads near the top flange, any movement of the bearing at the girder soffit will cause the girder to tilt, as well as move laterally. The main bearing is not stiff enough to restrain this girder rotation, and the top of the bearing will simply accept this imposed rotation. This is illustrated graphically in Figure 20.

It is noted that due to the imposed rotation the top bearing attachment plate does not remain in full contact with the bearing and partial lift-off occurs. The effect of this is to lift the lateral restraint bar clear of the top of the bearing so it no longer restrains the bearing in place.

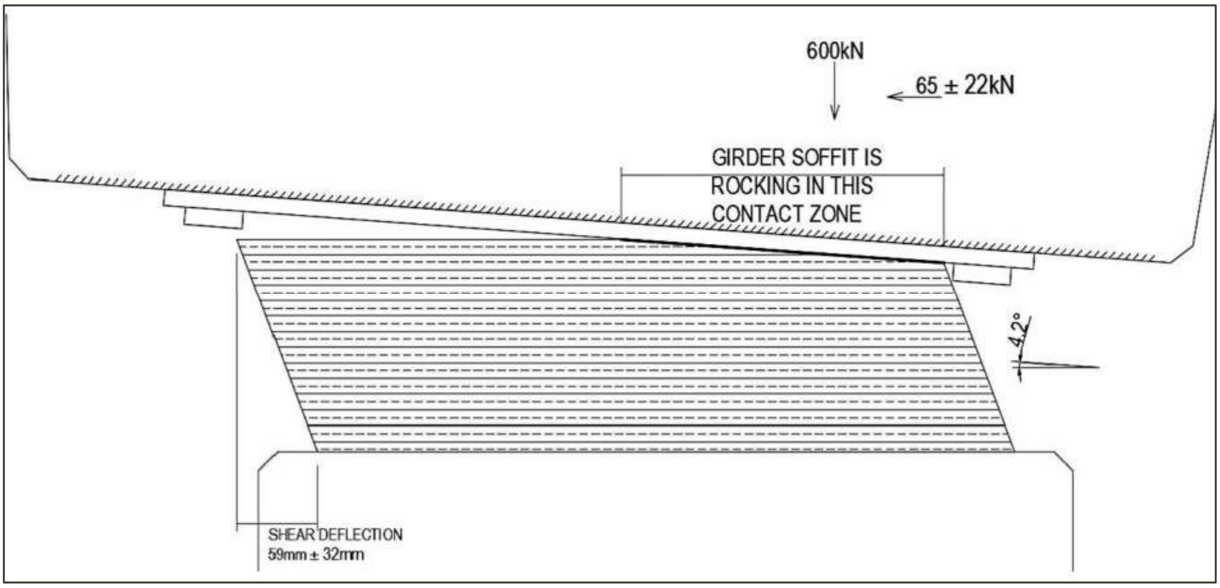


Figure 20 Effect of bearing movement on girder location and rotation

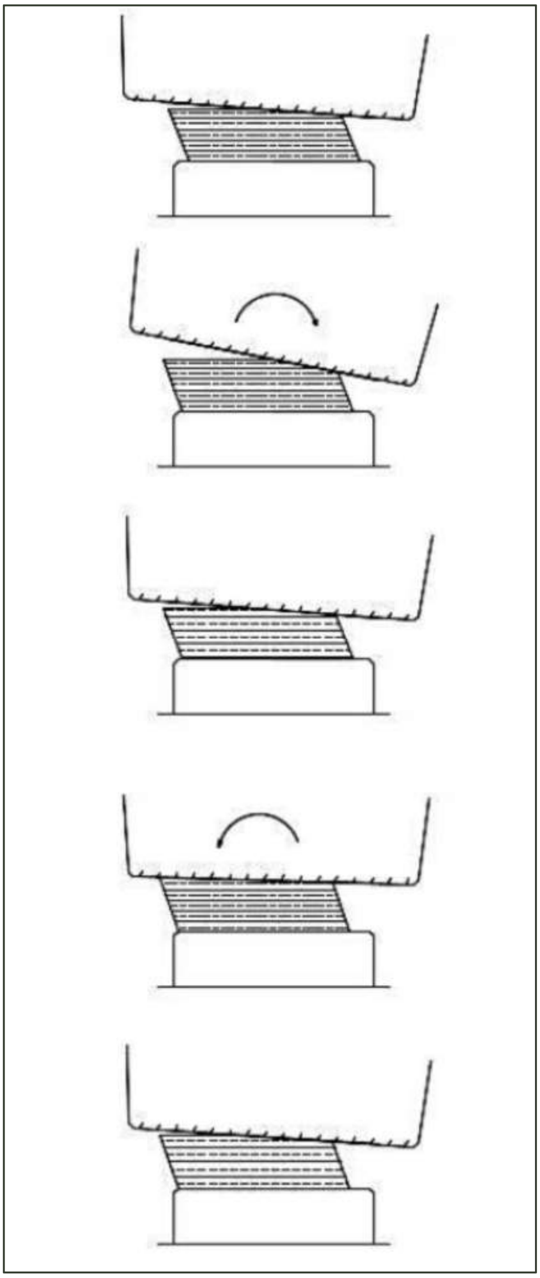
Without adequate minimum pressure on an elastomeric bearing or mechanical restraint, the bearing has a tendency to "walk" out from its installed position due to cyclic movement. The cyclic movement can result in a "caterpillar" walking action or ripple effect in the cover layer of the bearing that causes the bearing to move. Adequate minimum vertical load on the bearing normally prevents this phenomenon. AS 5100.4 requires a minimum pressure on the effective (projected) area of the bearing at zero shear deflection of 3.0 MPa and at its shear deflection limit, 2.4 MPa. The average pressure on the bearings of the shared path bridge is 3.6 MPa, but it is very non-uniform.

Various technical references address longitudinal walking of bearings due to principally longitudinal cyclic thermal movements, but we are not aware of any precedent for lateral walking of bearings.

Nevertheless we believe the mechanism in this instance is due to wind load effects on the anti-throw screen, coupled with the constant lateral force of approximately 65kN due to out-of-balance self-weight effects, promoting a caterpillar movement of the bearing.

Essentially, the effect of the transient wind load is to alter the contact zone between the girder soffit and the top of the bearing, and accordingly vary the contact pressure underneath the bearing. This rocking effect will alternately allow the front (southern part) of the bearing to move forward, then be clamped, producing a tension promoting the rear (northern part) to be pulled forward under subsequent reverse loading.

This is illustrated in Figure 21.



Stage 1: Steady state

Bearing translated, girder rotated and translated.   All constant

Constant horizontal force of 65kN to the left, through the following stages

Stage 2: Wind blows from the south

Rotation increases, top (and bottom) bearing area moves back

Front (southern end) of the bearing released, and allowed to move laterally and incrementally to the left (south)

Stage 3: Steady state

Rotation returns to steady state

Bearing clamped as per Stage 1

Bearing in tension

Stage 4: Wind blows from the north

Rotation reduces, top (and bottom) bearing area moves forward

Clamping force at the back (northern end) of the bearing reduced and pulled in tension (plus pushed from the back) and allowed to move laterally and incrementally to the left (south)

Stage 5: Steady state

Rotation returns to steady state

Bearing clamped as per Stage 1

Whole bearing has moved laterally to the left

Figure 21 Caterpillar walking mechanism

5.2 Design Standard Compliance

The design, as taken from the as-constructed drawings supplied, was assessed against compliance with the relevant Australian Bridge Design Standard, AS5100 (hereinafter referred to as the Design Standard).

Specifically, Aurecon assessed the performance of the bearings and overall restraint system for the Shared Path Bridge girders, taking into account the relevant loads acting on the structure.

5.3 Horizontal Bearings

The adequacy of the main girder bearings was assessed against the requirements of AS 5100 Part 4 – Bearings and Deck Joints. Section 12 of this standard deals with elastomeric bearings. Specifically, Aurecon assessed Design Requirements which amongst other criteria, consider allowable strains, rotations, stability and required fixings for bearings.

Calculations undertaken by Aurecon reveal various non-compliances with AS5100.4 as follows;

AS 5100.4 Clause 12.4.2 Design Principles - Bearing Rotations

It is concluded that the bearings are not adequate for the calculated load effects. Specifically the bearings do not comply with maximum permitted lateral movements and rotations. In addition, Clause 12.4.2 (Design Principles – Bearing rotations) requires that: "The structural elements of the bridge shall be detailed with the objective that, at completion of construction, the loaded faces of the elastomeric bearing are parallel." The fact that the permanent loading acting on the girder produces a rotation about the beam's longitudinal axis, with no attempt having been made in the design to address the issue, is considered to be a non-compliance with the Design Standard.

AS 5100.4 Clause 12.6.3 Shear strain due to tangential movements and forces

This clause limits tangential distortion and minimises rolling of the edges of the bearings, or tendency of the steel plates to bend.

Requirement: $E_{sh} \leq 0.5$

This is calculated at 0.51 for both the 071505 and 071507 bearings under permanent effects only. The limit is exceeded when the effect of wind load on the anti-throw screen is included.

AS 5100.4 Clause 12.6.7 Fixing of Bearings

This clause allows fixing of bearings by friction only if the minimum vertical load is not less than the specified value. Given that the bottoms of the bearings are unrestrained by any keeper system, adherence to this requirement is appropriate and necessary for this structure.

Requirement: $N_{min} \geq 10H\text{-}2\ f_o\ A_{eff}$

Both the 157mm and 117mm thick bearings fail with approximately 135% utilisation. This precludes restraint by friction only.

In addition this clause requires a minimum pressure of 2.4 MPa on the effective (projected) area of the bearing when it is at its shear deflection limit and 3.0 MPa with no shear deflection. The average pressure on the bearings of the shared path bridge is 3.6 MPa, however in this case the contact pressure is very non-uniform with only partial contact across the surfaces of the bearing. We therefore consider that this clause is not adequately satisfied.

5.4 Side Bearings

As noted in Section 3, these elements are employed to act as a soft buffer between the webs of the girders and the keeper walls. The pads are deemed to comply with the Design Standard.

5.5 Keeper Walls

These elements are simple reinforced concrete upstands, integral with the headstocks. Their purpose is to restrain the Shared Path Bridge girders against transverse loading produced by the eccentric dead load and any applied wind load. As noted in Section 3, the combination of the two types of bearings and the keeper walls provides a “cradle” for the girders. Aurecon’s assessment of these elements concluded that the outer keeper walls of the Shared Path Bridge are significantly understrength and non-compliant with part 5 of the Design Standard which deals with concrete design. This is in effect evidenced by the horizontal cracking apparent at the base of all external keeper walls.

Our calculations indicate the strength of the keeper walls is theoretically exceeded by a wind speed of approximately 90 km/h applied perpendicular to the anti-throw screens. This is significantly less than the wind speed required to be considered by the design standard.

6 Conclusions and Recommendations

6.1 Conclusions

From the investigation of the Shared Path Bridge undertaken, Aurecon concludes that:

1. The design did not allow for the lateral movements and imposed rotations on the main bearings due to the eccentricity of the self-weight reaction to the bearing centreline (principally due to the mass of the anti-throw screen and the varying thickness of the concrete deck). This resulted in the girder tilting sufficiently to lift the lateral restraint bar clear of the top of the bearing and essentially free the bearing, allowing it to walk.
2. The cause of the bearing movement was the wind load effects on the anti-throw screen, coupled with the constant lateral force of approximately 65kN due to out of balance self-weight effects, promoting a caterpillar movement of the bearing. Lateral movement would have occurred incrementally over a period of time, until the bearings had moved sufficiently for the girder to lose support.
3. All spans of the Shared Path Bridge are exhibiting signs of this phenomenon, with noticeable bearing deformation and girder rotation. It is considered likely that, if unchecked, the remaining spans of the Shared Path Bridge are at risk of failure. It is likely that Spans 4 and 5 failed first due to their exposed position over South Road, and the slightly larger wind area of the anti-throw screens due to architectural finishes on these spans.
4. The design of the bearings supporting the Shared Path Bridge, does not meet certain requirements of the Australian Bridge Design Standard – AS5100.
5. The keeper walls that restrain the Shared Path Bridge girders against transverse loading are inadequate for the wind loads required to be considered by the Australian Bridge Design Standard – AS5100. Our calculations indicate the strength of the keeper walls is theoretically exceeded by a wind speed of approximately 90 km/h on the anti-throw screens.
6. Our inspection indicated that the remaining Shared Path Bridge girders (i.e. Spans 1, 2, 3, 6, 7 & 8) are unlikely to be dislodged in the short term.

Aurecon considers that there is no cause for concern regarding the girders of the adjacent Tram Bridge structure, which are separated from and act independently of the Shared Path Bridge girders. It is noted that the arrangement of the Tram Bridge girders and their support conditions differ from those of the Shared Path Bridge structure and are not susceptible to the phenomena detailed in this report.

6.2 Recommendations

1. The anti-throw screens should be removed from the Shared Path Bridge, in order to reduce the lateral loading on the bearing system for Spans 1, 2, 3, 6, 7 & 8. It is noted that there is no need to remove screens from the southern side of the adjacent Tram Bridge.
2. A monitoring system of all spans of the Shared Path Bridge should be set up to measure further ongoing movement, and alert the need for appropriate action.
3. A design of remediation measures should be undertaken to all spans of the Shared Path Bridge. As part of the remediation, all girders should be restored to their original design location by means of jacking. The design shall incorporate an appropriate lateral restraint system of sufficient capacity to reinstall the anti-throw screens and restore the functionality of the Shared Path Bridge structure in accordance with AS5100.
4. Repair of the damaged concrete headstocks should be undertaken, along with upgrade and replacement of failed outer keeper walls at all piers.

Appendix A
Site Photographs

Abutment A

Abutment A Bearing Elevation

Abutment A Bearing Rotation

Pier 1 East

P1 East Elevation

P1 East Rotation

P1 East Wall Cracking

Pier 1 West

P1 West Elevation

P1 West Bearing Rotation

P1 West Wall Cracking

Pier 2 East

P2 East Elevation

P2 East Side Bearing

P2 East Wall Cracking

Pier 2 West

P2 West Elevation

P2 West Side Bearing

P2 West Wall Cracking

Pier 3 East

P3 East Bearing Rotation

P3 East Side Bearing

P3 East Wall Cracking

P3 East Wall Cracking

Pier 3 West

P3 West Elevation

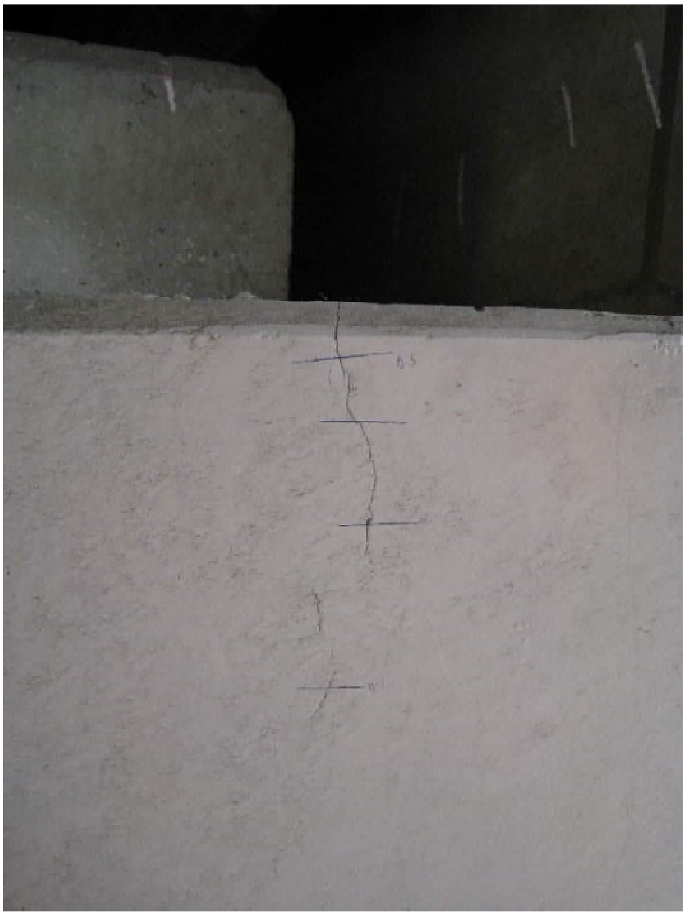
P3 West Wall Cracking

P3 West Wall Cracking

P3 West Wall Cracking

Pier 4 East

P4 East Elevation



P4 East Pier Cracking

P4 East Side Bearing

P4 East Side Bearing Separation

P4 East Wall Cracking

P4 East Wall Cracking

Pier 4 West

P4 West Elevation

P4 West Side Bearing Separation

P4 West Wall Cracking

Pier 5 East

P5 East Elevation

P5 East Side Bearing

P5 East Wall Cracking

P5 East Wall Crack inside Face

Pier 5 West

P5 West Bearing Rotation

P5 West Wall Cracking

P5 West Side Bearing

P5 West Headstock Cracks

Pier 6 East

P6 East Elevation

P6 East Side Bearing

P6 East Wall Cracking

P6 East Wall Cracking

Pier 6 West

P6 West Elevation

P6 West Bearing Rotation

P6 West Side Bearing

P6 West Wall Cracking

Pier 7 East

P7 East Bearing Rotation

P7 East Side Bearing

Pier 7 West

P7 West Bearing Displacement

P7 West Side Bearing Separation

P7 West Wall Cracking

Abutment B West

Abutment B West

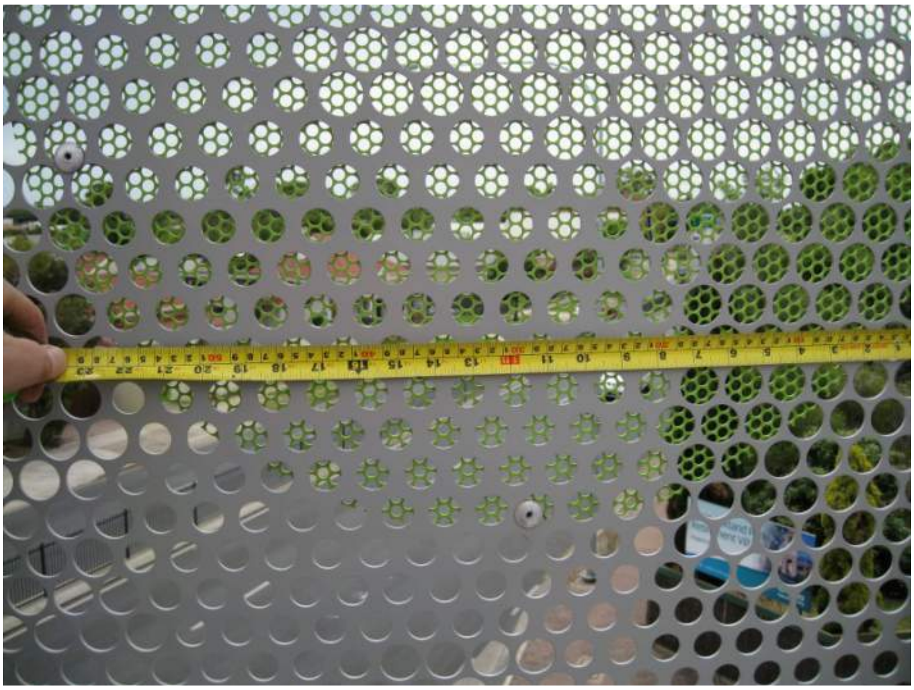
Footpath and Fencing

Temporary Tie Anchors Typical

Tram Parkway Throw Screen

Joint Damage Typical

Handrail Misalignment



Throw Screen Detail

Tram Bridge Bearing (Typical)

Pier 2 West Bearing 9 on Tram Bridge

This photograph does not depict any part of the Shared Path Bridge and is included for comparison purposes only.

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