



Lower section

Funicular Railway Inspection report - 2018

Job name: **FunInsp 2018**
Job number: **18011**
Client: **Cairngorm Mountain Ltd**
Engineer: [REDACTED]
Date: **July 2018**

Revision	Date	Comments
A	24/07/18	Initial information

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1. Introduction:

- 1.1. At the request of Cairngorm Mountain Ltd, the Client, the writer carried out a visual inspection of the concrete support structures to the Funicular Railway at the Cairngorm Mountain resort. The writers brief was as follows: *"To carry out a non-disruptive visual inspection of those areas of the concrete support structure that are fully exposed and safely accessible and to report on the findings"*. This report follows a similar format to that produced by this office in preceding years.
- 1.2. The scope covers the external support structure plus the track bed within the tunnel. This report specifically does not address the top or bottom station, the rails or their supports nor the running stock.
- 1.3. The purpose of this report was to comment on the integrity of the concrete components of those parts inspected, within the limitations of the brief and inspection techniques.
- 1.4. The inspections were carried out on a number of days and evenings through the Summer of 2018. The weather was generally fine.
- 1.5. The structural inspection was carried out by means of visual inspection and measurements, generally from ground level and where it was safe to do so from track level. No disruptive investigations, geotechnical investigations or materials testing were carried out, nor were any calculations carried out.
- 1.6. This report may not be relied upon by a third party for any purpose without the written consent of this practice. Furthermore, this report has been prepared and issued specifically for the benefit of the addressee and no responsibility will be extended to any third party for the whole or any part of its contents.
- 1.7. This inspection and report were carried out ahead of the 2018 repairs programme, so many of the items on the 2017 report will appear in this report as well. Many of the combined items will be addressed during 2018 summer work programme.
- 1.8. Items requiring attention are highlighted in yellow.

2. Executive summary:

2.1 The writer now has the insights from 4 years of inspections [REDACTED]

2.2 The writer feels there is a differential to be drawn between maintenance, repair of direct damage and [REDACTED]

2.2.1 A concrete structure of this age should not require [REDACTED] occasional random repairs may be reasonable [REDACTED]. The exception to this may be the plinths due to the nature of loading experienced.

2.2.2 Repair of direct damage is clearly required. Examples would include damage to the beams due to impact from snow clearing equipment.

2.2.3 [REDACTED]

2.3 All items of a "structural strength" nature have been addressed on an immediate basis and we have seen some of these. Most of the items being addressed currently, and planned for, relate to "serviceability issues", [REDACTED]

2.4 Along with a range of seemingly random defects there are a number of items that recur at numerous locations along the track. The 2015 report identified numerous defective plinths and a number of defective grout packs to the Ancon bearings, it appears that this has been brought under control with none of these items found in this report [REDACTED]

[REDACTED] Instances of mechanical damage are also recorded, but these are to be expected when working close to the beams with snow clearing equipment – care in these operations should reduce the number of instances.

2.5 This report recommends numerous repairs to improve the longevity of the structure [REDACTED]

2.6 [REDACTED] These repairs are intended to improve the longevity of the structure [REDACTED]

2.7 [REDACTED]

3. Scope and references:

3.1 An inspection schedule was set up to look at the following areas:

3.1.1 Thrust blocks

3.1.2 Pier

3.1.3 Pier crosshead

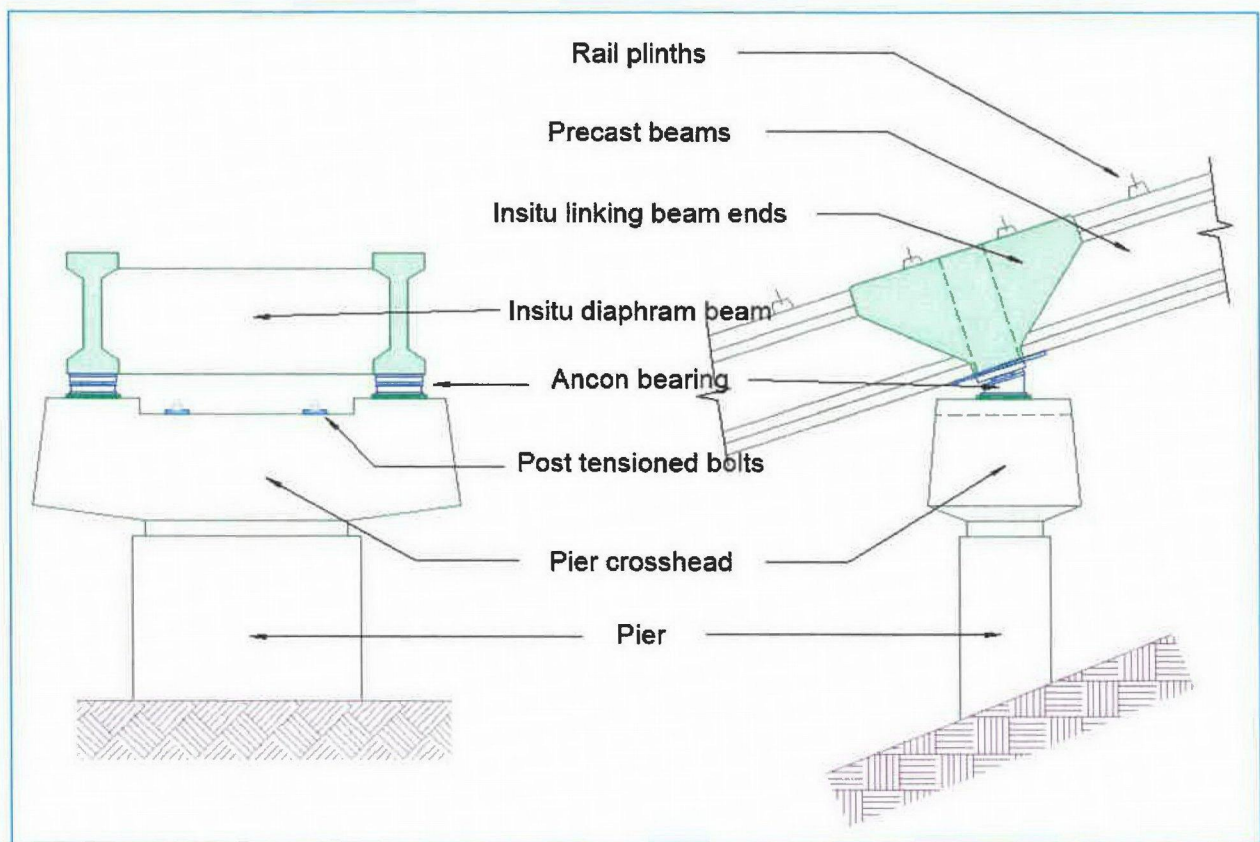
3.1.4 Ancon bearing plate grout

3.1.5 Insitu crosshead

3.1.6 Insitu to beam ends

3.1.7 Precast beams:

3.1.8 Rail plinths:



Sketch showing structural elements:

3.2 The referencing system is as follows:

3.2.1 Elevated length of railway (most of it):

- A. Upper refers to the part highest up the mountain
- B. Lower refers to the part lowest down the mountain
- C. Left refers to the left-hand side as viewed looking up the mountain
- D. Right refers to the right-hand side as viewed looking up the mountain
- E. All numbering relates to the nearest pier below that point.

3.2.2 Tunnel section:

- F. Within the tunnel the plinths sit on a continuous ground bearing slab.
- G. The tunnel is broken into lengths for referencing purposes. Each length starts at a sheave in a similar way to the pier referencing system.
- H. The numbering starts at the tunnel mouth where there is no sheave, so this point is referred to as SH00. The first sheave inside the tunnel is referenced SH01 etc.
- I. The plinths are numbered consecutively from each sheave.
- J. Left and right are as for the elevated length.

4. Funicular Railway observations:

The writer inspected the items listed in the schedule at item 3.1 of this report. It was reported that the installation had been completed in 2001, making it 17 years old.

4.1 Thrust blocks:

4.1.1 Over the approximately 1600m of elevated track outside the stations and tunnels there are a total of 7 thrust blocks, including the lower end. These are at varying spacing from approximately 250 to 300m. The general piers have slip bearings parallel to the longitudinal axis of the track so all longitudinal forces are resisted by the thrust blocks. These forces can be substantial, particularly on the steeper sections where they carry a significant portion of the gravitational load of the relevant 300m section of concrete beams.

4.1.2 Thrust blocks are located at the following piers:

Pier 0
Pier 14
Pier 29
Pier 48
Pier 65
Pier 78

4.1.3

4.1.4

4.1.5 On top of each thrust block there is a rail movement joint. This includes a large steel plate that has a grout pack underneath. There is some deterioration of this grout. The top end of at all these locations were sealed in 2017, however it is recommended that at pier 29, on the right side, the grout pack be sealed all around.

4.2 Main piers:

4.2.1 Generally these items appeared in good condition.

4.2.2 Description: Fractures of the main piers were observed at a number of locations. The available drawing show that the piers were pre-cast shells that were infilled with insitu reinforced concrete. It is therefore concluded that cracks to the shells are of no grave consequence, although they should be reviewed at each annual inspection. Ref photos [3], [4].

Location: Pier 3 vertical crack in bottom downhill face casing, repaired.
Pier 32, horizontal crack showing efflorescence near bottom downhill face.
Pier 43, horizontal crack showing efflorescence at mid height right face.
Pier 44, efflorescence showing on side faces, RHS bottom and LHS top.

Pier 45, vertical crack showing efflorescence at mid height downhill face.
Pier 46, horizontal crack showing efflorescence at mid height on downhill and left face
Pier 51, horizontal crack near bottom downhill face. Also spalling at joint on uphill face.
Pier RHS 52, small vertical crack mid height left face.
Pier RHS 53, small spall at mid height uphill face.
Pier LHS 54, spall at mid height upper left corner, plus mid height on uphill face.
Pier 69, minor spalling at top on downhill face.
Pier 72, lowest unit showing signs of frost damage and seepage through horizontal crack. Vertical crack on downhill face of lowest unit. Vertical crack on left and right face, mid height.
Pier 91, cracks with calcite bleeding on all faces.
Pier 92, right face of mid shell cracked with calcite bleed.
Pier 93, uphill face of top shell cracked.

Recommendation: There is no cause for concern at this time.

4.3 Main cross heads:

4.3.1 Generally these items appeared in good condition.

4.3.2 Description: Cracks, chips and missing chunks were seen in some cross heads.

Location: Other than pier 93, the following items were recorded in previous years:
Piers 52 and 55.
Pier 58, lower corner chipped. Crack in upstand.
Pier 63, uphill face, chip bottom middle.
Pier 75, chip on top side of top face.
Pier 81, lower face at junction with pier an old chip.
Pier 83, two minor chips.
Pier 84, W upstand cracked around base, possibly a construction joint.
Pier 87, W downhill corner breaking up.
Pier 93, see below.

Recommendation: Patch repairs are recommended to match the existing. This is not thought to be urgent.

4.3.3 Description:

Location:

Recommendation:

Crack monitoring studs have been installed and will be monitored until a feel for the situation is achieved.

4.4 Specialist Ancon bearing plate grout:

4.4.1 Generally these items appeared in good condition.

Description: In previous years a number of these items were seen in a poor condition and were repaired. No items were identified for repair this year.

Location: N.A.

Location: Mostly lower flanges of the precast beams where they bear on the bearing plates. Refer to appendix A for a schedule of observations.

Recommendation: Where applicable, resin inject cracks to seal against water ingress and to reduce the risk of corrosion problems. Where the block of concrete falls away as described above then the repair is to be done in mortars with stainless steel reinforcing dowels.

4.5.5 Description: Small cracks were observed running down the top flange of the precast beams and also in some of the insitu fill areas in line with the rail fixing points.

Location: This was observed particularly in the upper part of the system.

Recommendation: This should be part of a watching brief, no action is recommended at this time.

4.6 Problems with the precast beams, general.

4.6.1 As a point of reference a couple of beams are offered as in "good" condition. From pier 49 up and pier 78 up right. All beams would be expected to be of this standard.

4.6.2 General comment:

[REDACTED]

1 [REDACTED]

2 [REDACTED]

BS 8110-2 section 3 clause 3.2.4.2 states that to prevent corrosion in aggressive environments the crack width should not exceed 0.3mm. [REDACTED]

The possibility of ongoing corrosion of the reinforcing steel should be considered, together with the long-term consequences of this, should it be left uncorrected. It is recommended that measures should be taken to seal any cracks where rust-staining is apparent, so as to eliminate oxygen and water ingress.

[REDACTED]

Location: [REDACTED]

Recommendation: A detailed assessment of what has caused this cracking has not been carried out, but it seems likely that there is more than one cause. It is recommended that a capillary and

Recommendation: N.A.

4.5 Insitu concrete joints:

4.5.1 Description:

[REDACTED] The drawings show a system for mechanical coupling of the reinforcing bars to provide continuity at some locations. One of these couplers is specified as an Ancon PB32, which involves an onsite grouting operation [REDACTED] For operational reasons close quarters examination of this joint as a train passes was limited to one location, [REDACTED]

[REDACTED]

During 2018 there was an opportunity to take measurements whilst the train was fully laden with test weights. [REDACTED]

[REDACTED]

Location: [REDACTED] This was wide spread although not universal. [REDACTED]

[REDACTED]

Recommendation:

Elsewhere inject the joint with resins to prevent water ingress and consequent rusting of embedded reinforcement.

4.5.2 Description:

[REDACTED]

Ref photo [11].

Location: Above pier 9.

Recommendation: Break out the top half of this insitu and ensure reinforcement arrangement meets requirements for continuity and reform in good quality concrete, see 4.5.1 above.

4.5.3 Description:

[REDACTED]

Location: Insitu fill, between the precast beam ends generally.

Recommendation: Monitor for developing problems.

4.5.4 Description:

[REDACTED] At the time of writing some work had started to address this. The crack lines were drilled and resin injected to seal them. In most cases the described block of concrete fell away at the interface with the reinforcement – these then became local mortar repairs. It appears that this block of effectively unreinforced concrete is fracturing off at the bearings possibly due to some minor eccentricities of the bearing. In some instances the failure is seen in the top flange Ref photos [12], [13], [14].

crack sealing product be applied to one or two particularly bad beams as a trial and monitored for performance, if it proves satisfactory then it be rolled out to all problem areas.

4.6.3 Description: Mechanical damage to the main beams, presumably from snow clearing activities. The recommendations below apply to anywhere this sort of damage occurs both now and into the future.

Location: Refer to appendix B for a schedule of observations.

Recommendations: It is recommended that where they extend to a depth exceeding 10mm that repairs are carried out to ensure the life expectancy of the structure is not compromised. .

4.6.4 Description

Location:

Recommendation:

4.6.5 Description: A repeating pattern of micro cracking was observed between the bolts through the web of the precast concrete beams at the cross bracing connections.

Location: This was wide spread, but an example can be seen at beam 4 up and illustrated in photos [15], [16].

Recommendation: None of these observations were of a scale or nature to give rise to concern.

4.6.6 Description:

Location:

Recommendation: At this stage beams 43 and 93 are not a concern.

4.7 Problems with grout plinths to the rails.

4.7.1 Refer to appendix D for a schedule relating to matters related to the plinths. This schedule includes historic observations and actions for reference. Ref photo [22], [23], [24]

4.7.2 Following on from work programmes in the preceding two years it appears that the worst of the plinth problems have been addressed and no new problems requiring repair were found this year. There are a number of items that have been recorded as requiring action but we have not found record of when these were done. These items were not seen as a problem during this year's inspection. Recommend a review of these items.

4.7.3 There are Halfen channel details cast into the upper face of the beams with protruding bolts which run up through the plinths and secure the rails on the top of the beams immediately below the plinth giving the appearance that a "pumping action" has been happening. It is not clear at this stage if the movement is of the cast in item or of the bolt in the channel. It is recommended that the torque on the securing bolts is checked and if this is

found to be fully tightened then the concrete around the channel to be injected with resin to secure it.

4.7.4 Garaventa stated that any plinths that have failed should be replaced at the earliest opportunity and that the failure of two adjacent plinths is not acceptable. It is recommended that guidance in greater detail is obtained, asking the following questions:

A. [REDACTED]

B. Can steel shims be used to create a short-term repair?

C. Do steel shims provide all the same support and restraints that the grout plinths do?

D. Can the steel shim arrangement be left in position permanently?

4.8 Miscellaneous:

4.8.1 The rock anchors that are seen protruding from the thrust blocks and their associated bearing plates have no applied corrosion protection. Discussions with the manufacturers in 2015 indicate that this is acceptable due to the type of steel used in manufacture. [REDACTED] It is assumed that these components are fully anchored within the mass of the concrete thrust block and that this is not an issue.

4.8.2 The original metal lifting eyes cast into the tops of the precast beams are exposed in many instances. These do not appear to be corroding and this is not thought to be an issue.

4.8.3 There is a partial walkway along the length of the railway for inspection and maintenance. It would appear that the components to complete the walkway are on site and lying on the ground. It would make inspection and maintenance work significantly safer and easier if this walkway was completed. Additionally there are a number of loose retaining clips on this walkway, these should be secured as they present a trip hazard. It is my recommendation that this work be carried out.

5. Recommendations general:

The writer inspected the items listed in the schedule at item 3.1 of this report. It was reported that the installation had been completed in 2001, making it 16 years old. [REDACTED]

5.1 Implementation of recommended repairs generally:

5.1.1 There are numerous repairs recommended within section 4 of this report.

5.1.2 [REDACTED]

5.1.3 It is strongly recommended that the implementation of the various repairs within the bulk of the report are carried out under the guidance and supervision of a suitably qualified Engineer.

5.2 Structural integrity:

5.2.1 [REDACTED]

5.2.2 [REDACTED]

5.2.3 [REDACTED]

5.2.4 There is no recommended action.

5.3 Structure durability:

5.3.1 [REDACTED]

5.3.2 The following actions are recommended:

- A. Check the calculations independently.
- B. Check the required reinforcement has been provided.
- C. Check cracks and deflections onsite to verify performance.
- D. [REDACTED]

Appendix A:
Schedule of fractured flanges
Ref clause 4.5.4

Beam ref	LHS/ RHS	Bottom or top end	Inside or outside	Top or bottom flange	Comment	First recorded	Injected/ repaired
1	L	T	I	T	Minor	2018	
1	R	T	O	T	Seal by injection	2018	
9	R	T	O	T	Minor	2018	
18	L	B	Both	B	Minor	2018	
18	R	B	O	B	Minor	2018	
18	L	T	I	B	Seal by injection	2016	
18	R	T	O	B	Minor	2018	
21	R	B	I	T	Seal by injection	2015	
21	L	T	Both	B	Seal by injection	2016	
21	R	T	O	B	Minor	2016	
23	L	B	I	B	Seal by injection	2016	
23	R	B	O	B	Minor	2016	
24	L	T	O	B	Minor	2018	
25	L	T			Minor	2015	
26	L	T	I	T	Minor	2018	
27	L	T	O	B	Minor	2015	
27	R	T	I	B	Seal by injection	2015	
32	R	B		T	Minor	2015	
35	R	T			Seal by injection	2017	
37	R	B	O		Seal by injection	2015	
37	L	B	I		Seal by injection	2015	
45	L	B	O		Minor	2016	
50	R	B		L	Minor	2016	
52	R	B			Seal by injection	2016	
70	L	B			Remove and repair	2017	
72	R	B		T	Minor	2015	
76	R	B			Minor	2015	
76	L	T			Minor	2015	
80	R	T			Minor	2015	
81	L	T			Minor	2015	
90	L	T		T	Minor	2017	
91	R	M			Minor	2015	
92	R	T		T	Minor	2015	

Appendix B:
Schedule of mechanical damage to arrises
Ref clause 4.6.3

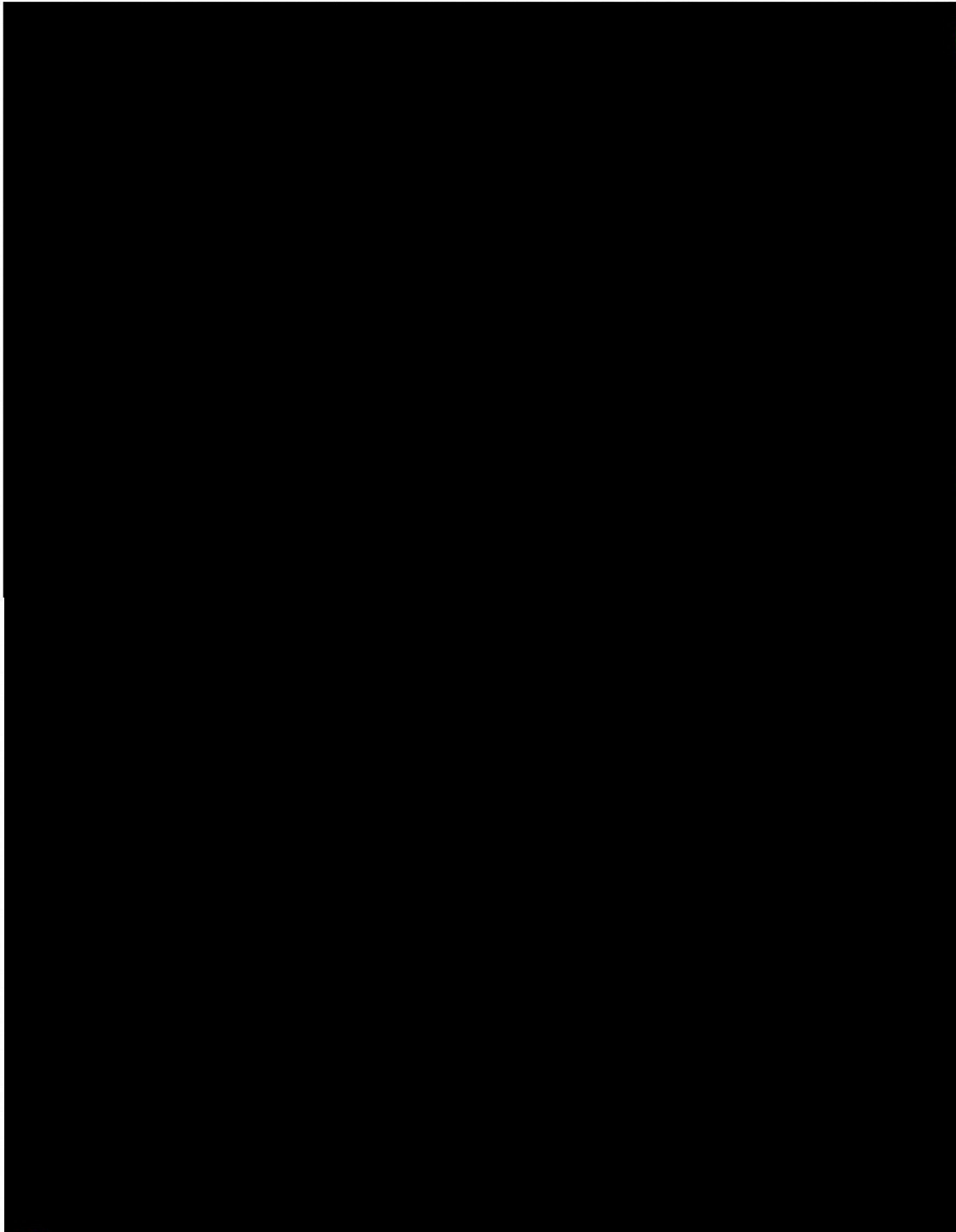
Beam ref	LHS/ RHS	Fifth location	Inside or outside	Top or bottom flange	Comment
2	L	4	I	B	OK
12	R	3	O	B	Slight damage, OK
14	R	2	O	B	Honey combing, no rust, accept for now
16	R	3	I	T	Small ding, OK
26	R	4	I	T	OK
27	L	5	O	T	2 dings, OK
31	L	3	I	B	Spalling
44	R	5	I	T	Spalling, patch repair
45	L	5	I	T	Small spall, OK
48	R	2,3,4	O	B	Various small dings
50	L	5	O	B	
50	R	3	I	B	Spalling - repair
53 LHS	L	5	I	T	Minor dings, patch repair
53 LHS	R	3,4,5	I	T	Various scrapes and dings, OK
53 RHS	L	1	I	T	Ding, repair
55	L	3	O	B	Ding, repair
56	L	5	O	T	Dings, OK
57	L	3	I	T	Dings, OK
57	L	1	O	T	Loose lump of concrete, remove and repair
62	L	3	O	T	Series of dings, OK
64	L	2,5	O	T	Ding, OK
67	R	3,5	O	T	Ding, OK
71	L	4	I	T	Ding, repair
74	L	4,5	O	T	Dings, repair
75	R	3	O	T	Scrape/ding along top, OK
87	R	2	O	T	Ding, repair
89	R	3	O	T	Ding, OK
90	R	3	O	B	Old repair cracked.
91	R	4	I	T	Ding, OK
93	L	2	I	T	Chip, OK
93	L	2,3,4	O	T	Many minor dings, OK

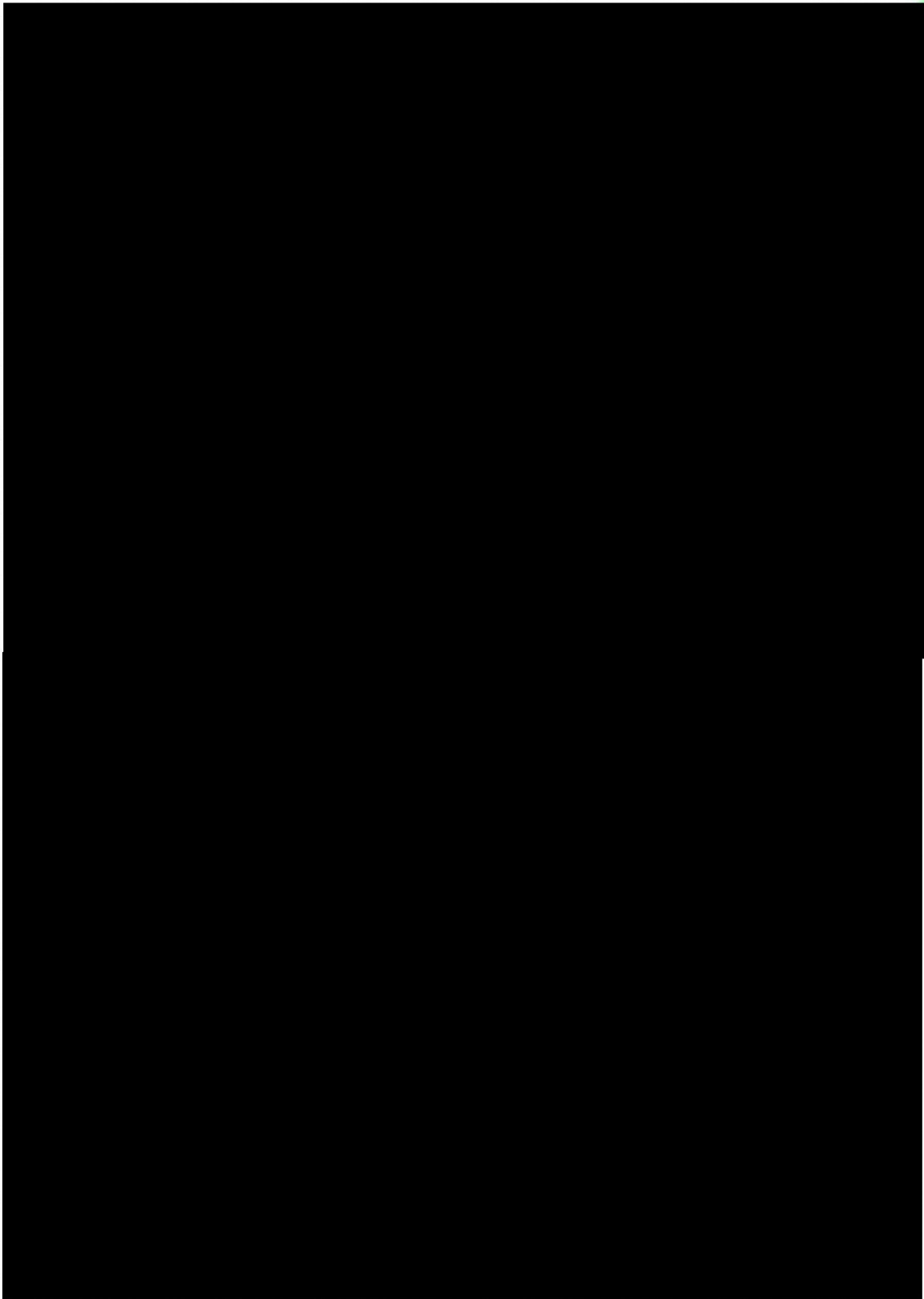
Appendix C:
Schedule of exposed reinforcement
Ref clause 4.6.4

Beam ref	LHS/ RHS	Fifth location	Inside or outside	2016	2017	2018	Comment
6	R	4		ID & Rep	/	/	
8	R	5	O	/	ID	ID	
12	R	2		ID & Rep	/	/	
26	R	2		ID & Rep	/	/	
54 RHS	R	1	I	/	ID	/	
55 RHS	R	2	O	ID	ID	ID	
55 RHS	R	3,4	Soffit	/	/	ID	3 items
58	L	4	I	/	/	ID	
62	R	2	O	/	ID	ID	
66	R	3		/	ID	/	
68	R	4	O	/	ID	ID	
72	R	2	I	/	/	ID	2 items
83	R	5		ID & Rep	/	/	In situ
86	R	3	O	ID	ID	ID	
87	L	4	Soffit	/	/	/	
88	R	3	Soffit	/	/	ID	2 items honey combed holes, pos rf
91	L	3		ID	ID	/	2 items
93	L	5		ID	ID		noted minor no repair
93	L	2,3	O	ID	ID	ID	2 items
93	R	4	O	ID	/	/	

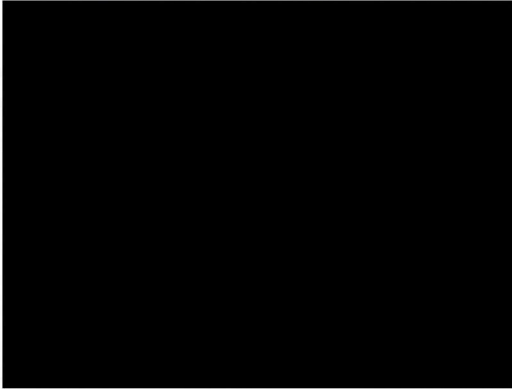
- Fifth location indicates which fifth of the beam the items was seen in. Note the fifths are generally punctuated by the steel cross bracing bolts.
- ID indicates when the problem was seen
- Rep indicates when the problem was repaired.

Appendix D:
Schedule of rail pack observations
Ref clause 4.7





Appendix E:
Photos:



Ref clause 4.1.3





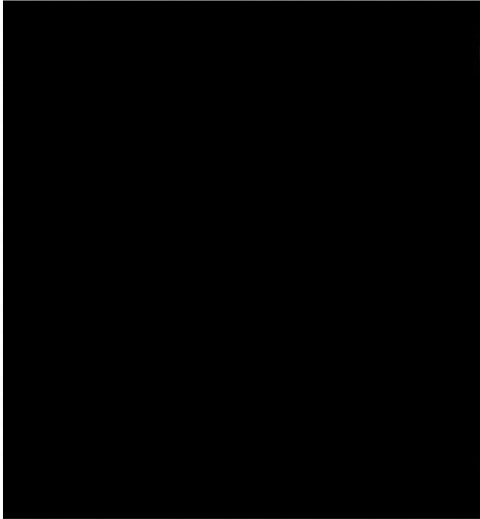
Ref clause 4.2.2

Photo [3] Main pier 91 showing cracks in shell.



Ref clause 4.2.2

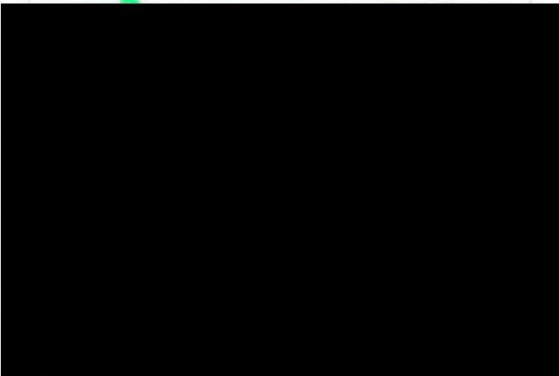
Photo [4] Significant chip out of pier shell.



Ref clause 4.3.3



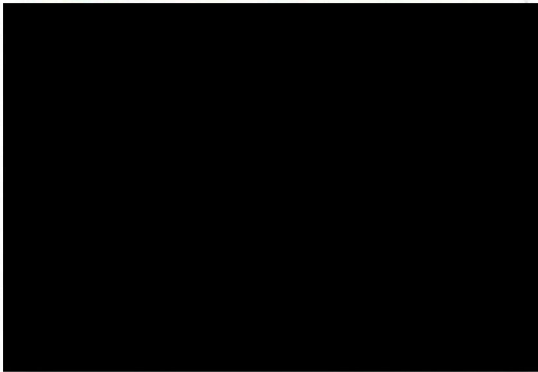
Ref clause 4.5.1



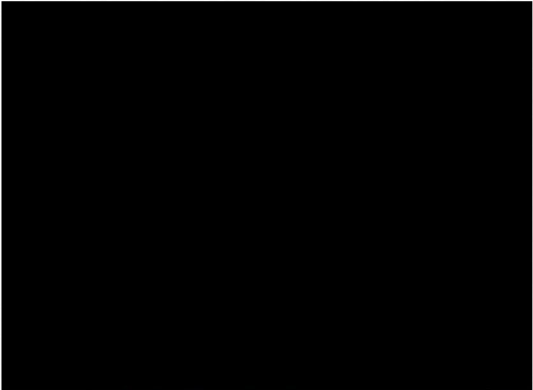
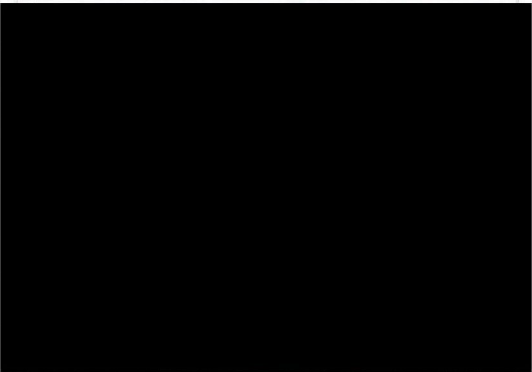
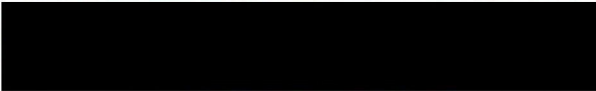
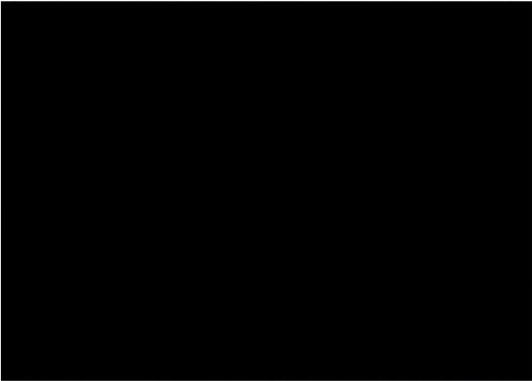
Ref clause 4.5.4



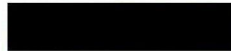
Ref clause 5.5.3

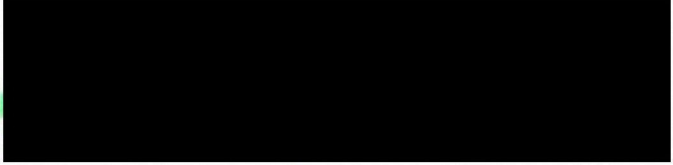


Ref clause 4.5.4

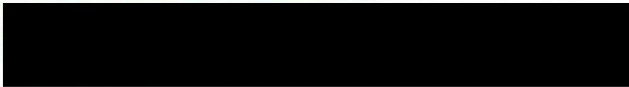
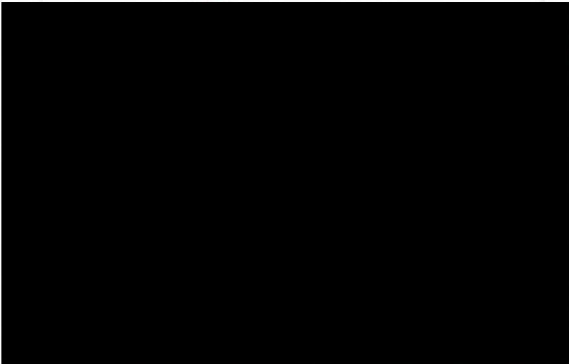
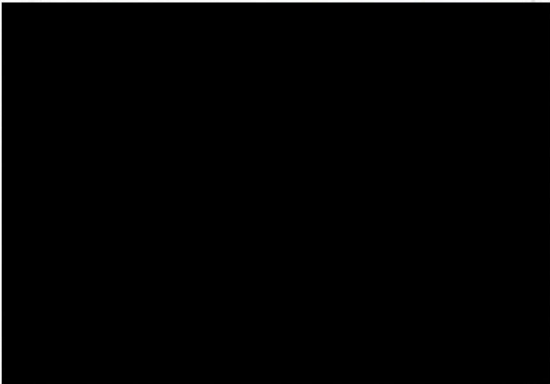
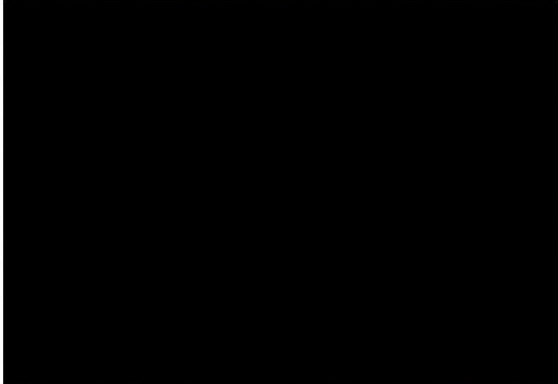


Ref clause 4.6.5





Ref clause 4.6.7



Ref clause 4.7.1



Photo [22] Typical grout plinth, exhibiting crazing, but stable



Photo [23] Typical case of a flake off one face of plinth. This regarded as stable.



Photo [24] Grout plinth showing fracture. Regarded as stable at this time.