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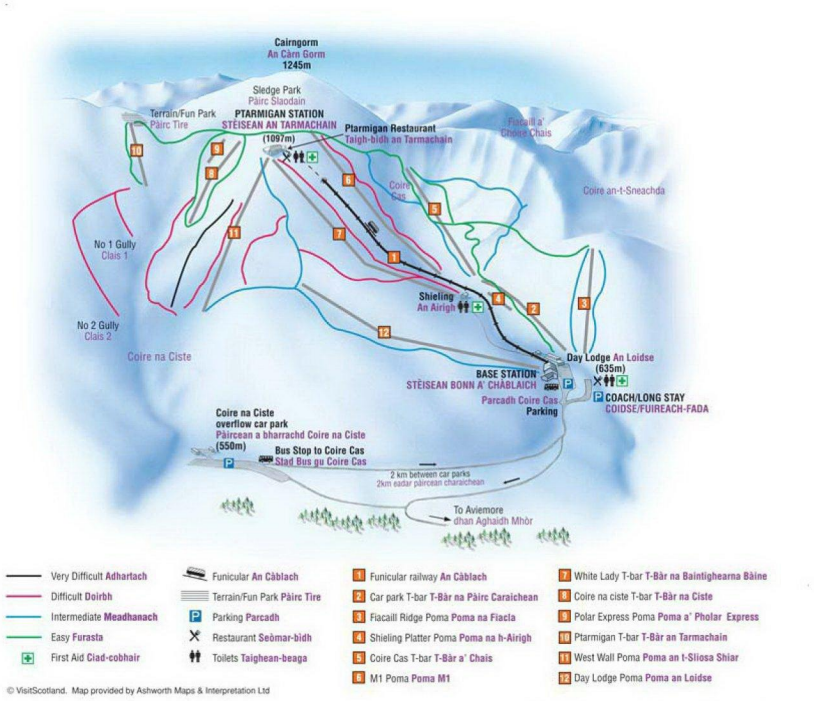


Location map for various sites

Job name: **Condition report - Funicular Railway, Cairngorm Mountain.**
Job number: **16011**
Client: **Cairngorm Mountain Ltd**
Engineer: [redacted]
Date: **December 2016**

Revision	Date	Comments
A	06/01/17	Initial information

Index:

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 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 2015.

1.2. 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.

1.3. 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.

1.4. 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.

1.5. This report specifically does not address the top or bottom station, the rails or their supports nor the running stock.

1.6. The inspections were carried out on a number of days through the Autumn of 2016. The weather was mixed and often wet.

1.7. Items requiring attention are highlighted in yellow.

2. Executive summary:

2.1 In broad terms the writer was concerned by the general condition of the Funicular Railway given its relative young age.

2.2 There are numerous items of a maintenance nature that should be undertaken, it is likely that this will be required on an annual and ongoing basis.

2.3 There are a number of more substantial repairs. This should not be a recurrent problem.

2.4 There is concern that there is a project wide problem with the beams, manifesting its self to a greater or lesser extent at different positions along the track. The problem manifests its self as excessive deflections, leading to cracking which will ultimately reduce the design life of the structure. At this stage it is not known if this is a design or a construction related problem and further detailed investigations would be required to identify the source of the problem.

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 plates

3.1.5 Insitu crosshead

3.1.6 Insitu to beam ends: Lower left
Lower right
Upper left
Upper right

3.1.7 Precast beams: Lower left
Middle left
Upper left
Lower right
Middle right
Upper right

3.1.8 Rail plinths: Left side
Right side

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. Summer 2016 work programme:

4.1 Following on from the 2015 report a number of items were addressed during the summer months of 2016 these were covered under ADAC-structures project “16010 - Funicular Railway Repairs”. Correspondence will be available on file to review this in detail if so required.

4.2 The work carried out included:

4.2.1 34 grout rail plinths were repaired.

4.2.2 7 grout rail plinths were replaced.

4.2.3 Repairs to the arrises of 3 precast concrete beams.

4.2.4 5 areas of exposed reinforcement were patch repaired.

4.2.5 The grout to 4 Ancon Plates were repaired.

4.2.6 The grout to the underside of the steel beams leaving the bottom station was repaired as they landed on pier 0.

4.2.7 2 Halfen channels (that support the rail clip fixings) were injected with resin. This work item was in addition to that identified in the 2015 report.

4.3 Following concern raised about possible voids under the railway slab in the tunnel on the approach to the top station, investigations were carried out covered under ADAC-structures project “16012 - Funicular tunnel floor voids”. Correspondence will be available on file to review this in detail if so required. Here two areas of the tunnel floor were opened up, inspected and closed back in. It was concluded that there were no significant voids to be concerned about but that a watching brief should be maintained, as it is by way of these annual reports.

5. 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 15 years old. The general condition was thought to be poor for a structure of this age with wide spread minor deficiencies giving a general impression of poor quality control during the construction phase.

5.1 Thrust blocks:

5.1.1 Over the approximately 1600m of elevated track outside the stations and tunnels there are a total of 7 thrust blocks, including both ends. 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 substantiual, particularly on the steeper sections where they carry a significant portion of the gravitational load of the relevant 300m section of concrete beams.

5.1.2 Thrust blocks are located at the following piers:

Pier 0
Pier 14
Pier 29
Pier 48
Pier 65
Pier 78
Pier 94

5.1.3 Horizontal shear cracking was observed between the upstand block and the main bulk of the foundation at: Ref photo [1]

Pier 48
Pier 78

5.1.4 The top surface of the main bulk of the foundation had surface cracking that appeared to mirror the reinforcement grid below at 200mm c/c at:

Pier 65
Pier 78

5.1.5 On pier 78 where the PCC beam enters the top right side of the thrust block a large flake has spalled off. This should be repaired. Ref photo [2]

5.1.6 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, this should be closely monitored as this is a highly stressed area of the raiway.

5.2 Main piers:

5.2.1 Generally these items appeared in good condition.

5.2.2 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].

Location: Pier 3 crack in bottom casing.
Pier 46, showing efflorescence at mid height.
Pier 51, much efflorescence at joint. Also crack up face on top side.
Pier 72, lowest unit showing signs of frost damage and seepage through horizontal crack.
Pier 91, cracked with calcite bleeding on E, W & S faces.

Pier 92, W face of mid shell cracked with calcite bleed.

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

5.2.3 Description: Cracks, chips and missing chunks were seen in other piers. Ref photos [4].
Location: Piers 45, 54 and 57.
Recommendation: Patch repairs are recommended to match the existing. This is not thought to be urgent.

5.3 Main cross heads:

5.3.1 Generally these items appeared in good condition.

5.3.2 Description: Cracks, chips and missing chunks were seen in some cross heads.
Location: Piers 52 and 55 were recorded in the previous report but not this year.
Pier 58, lower corner chipped. Crack in upstand.
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.

5.3.3 Description: Crack through pier cross head, running up one face and through the PT bolts holes on the top and down the other side, this is apparent on the line of both PT bolts. This appears to be a development on the previous year, when the cracks were only recorded on the line of one bolt. Ref photos [5].

Location: Pier 93.

Recommendation: This would not be a concern in its self as the cracks are of a minor nature, but the appearance of a developing situation is of concern. It is recommended that crack monitoring is implemented immediately and that this is monitored at close intervals until a feel for the situation is achieved.

5.4 Specialist Ancon bearing plates:

5.4.1 Generally these items appeared in good condition.

5.4.2 Description: At a number of locations the insitu grout under and around these plates was seen to be deteriorating. Repairs were carried out during 2016, but further plates have been recorded this year. Ref photos [6].
Location: Pier 43, grout disintegrating – repair.
Pier 73, spalled corner on right support - repair.
Pier 89, partial fracture, accept.
Recommendation: Remove deficient grout and replace on piers so noted. Note this is a key load bearing component and required skilled operative to carry out this work. In some cases it may require temporary propping of the main beams and closing of the railway for the duration and until the grout achieves design strength.

5.5 Insitu concrete joint:

5.5.1 Description: The construction drawings made available for the insitu area are stamped “preliminary” so there is uncertainty as to the veracity of these. 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, this would be susceptible to poor quality control. For operational reasons close quarters examination of this

joint as a train passes was limited to one location, pier 56. Here the crack was clearly seen opening then closing again, by an estimated 1mm, as the train passed. The concern here is that the coupler may have failed leading to a redistribution of stress to the midspan of the beams. Correspondence with A F Crudens, Consultant Civil and Structural Engineers for the scheme, confirm that the beams were designed to have sufficient strength as a simply supported beam, but that continuity reinforcement was added to restrict deflections. If this coupler has failed then greater than desirable deflections would be expected and this would compromise the durability of the structure. This appears to be happening. Ref photo [7], [8], [9]

Location: Opening of the joint line between the precast beams and insitu fill. This was wide spread although not universal.

Recommendation: Refer to section 6.

5.5.2 Description: Cracking within the insitu fill, between the precast beam ends. This generally appeared as vertical cracks, often with considerable calcite bleed, sometimes white, elsewhere stained brown. Ref photos [10], [11].

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

Recommendation: An assessment of the significance should be made as part of the review being made in 5.5.3.

5.5.3 Description: There is significant spalling damage to the insitu at location 58 L/B.

Recommendation: Carry out patch repair.

5.5.4 Description: Fracturing of the flange ends of the precast beams, usually the bottom flange. This would suggest that the beams are not bearing evenly on the bearing plates, leading to local overstress and local failure. It is thought likely that this local failure will lead to a redistribution of stress that would re-center the load. Ref photos [12], [13], [14].

Location: Lower flanges of the precast beams where they bear on the bearing plates. Specifically recorded at:

18 – L/T
21 - R/B and L/T and R/T
23 – L/B and R/B
25 - L/T
27 - L/T and R/T
32 - R/B (top flange)
37 - R/B outer and L/B inner (ref pic [??])
45 – L/B outer
50 – R/B lower
52 – R/B nasty
72 - R/B (top)
76 - R/B and L/T
80 - R/T
81 - L/T
91 – R/M and L/T (top)
92 - R/T (top)

Recommendation: Exploratory repairs should be carried out to a number of these areas, then rolled out to all such defects. This work should be carefully planned and an assessment of structural stability made before removing any concrete in these areas.

5.5.5 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.

5.5.6 Description: At various locations efflourescence or lime weeping are observed. This varies from minor white staining to significant build up of carboniferous material. Given the volume of material at some locations this gives rise to some concern over loss of material from within the relevant joints.

Location: Wide spread throughout the project, but most significantly at the Insitu / precast beam joint.

Recommendation: Research the significance of this effect on deterioration of the structural elements behind them.

5.6 Problems with the precast beams, general.

5.6.1 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.

5.6.2 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: Specifically recorded at:

2 – L/M.
26 – damage below plinth L13.
55 – middle beam, mid length E-face, large rust stained flake missing.
70 – L/T 2 gouges
74 – L/T major spall
75 – R/M top arrises
87 – L/M top arrises

Recommendations: It is recommended that where they extend to a depth exceeding 5mm that repairs are carried out to ensure the life expectancy of the structure is not compromised. All items listed here should be repaired, especially on beam 55.

5.6.3 Description: Some limited reinforcement exposed in the precast beams, these appear to be shear link leg tail ends.

Location: The side face of the precast beam webs. Specifically recorded at:

55 – R/B
86 – R/M
91 – L/M x 2
93 – L/T
93 – L/M x 2

Recommendation: Any exposed reinforcement should be fully exposed, assessed for ongoing capacity, cleaned and a patch repair carried out that will provide the bar with corrosion protection in the long term.

5.6.4 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.

5.6.5 Description: A number of beams showed longitudinal cracking in the top flange. Ref photo [17], [18]

Location: This issue was seen at the following locations, each occurrence was slightly different:

43 – R/B, top flange inside face, longitudinal fracture approximately 150mm.

51 – R/M, mid depth top flange, several meters long.

93 – T/L, top flange under plinths L17 & L18.

Recommendation: Carefully breakout smaller defects (beams 43 & 93) to investigate for cause of defect, then repair. Using knowledge gained carry out repair to beam 51. Note this may require temporary propping – these are significant operations.

5.6.6 Description: Cracks were observed on the underside of most beams. Most were well distributed and hairline in nature. In many locations, the cracks were wider and extended up the face of the lower flange, these were up to 0.5mm wide. In some instances, there appeared to be rust staining coming out of these cracks. This gives cause for concern over the durability of the structure.

Location: Cracking to the bottom flange of the precast beams - general. Ref photos [19], [20], [21]

Recommendation: Refer to section 6.

5.6.7 Description: On the passing loop, where the middle PCC beam terminates, the end of the beam has failed and dropped off, a large chunk of concrete is to be found on the ground. This portion of concrete appears to have been unreinforced but was carrying one of the rail plinths. A temporary steel support has been installed that has been there for many years.

Location: As described above.

Recommendation: Reinstate beam end and concrete plinth, to include resin anchored reinforcement.

5.7 Problems with grout plinths to the rails.

5.7.1 These plinths were in various conditions. Most were seen to be acceptable, particularly following the Summer 2016 work programme. A number of plinths were seen to be in poor condition and should be repaired during the coming summer works programme, others should be placed on the watching brief. Ref photos [22], [23], [24]

5.7.2 During the year verbal guidance was obtained from those responsible for the rails (Garaventa) as to the significance of failed plinths. It was 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. Given that repeated instances of plinth failure are being observed, what are the criteria under which the railway should be closed pending plinth repair? (eg cracked plinth, one failed plinth, two adjacent failed plinths).

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?

5.7.3 The observations made are replicated in Appendix A. A number of items are in need of priority repair, although are still capable of carrying load and these can be left until Summer 2017.

5.8 Miscellaneous:

5.8.1 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 indicate that this is acceptable due to the type of steel used in manufacture. The bearing plates do not bear evenly and any grout under them is crumbling. It is assumed that these components are fully anchored within the mass of the concrete thrust block and that this is not an issue. Ref photos [22].

5.8.2 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.

5.8.3 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.

6. 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 15 years old. The general condition was thought to be poor for a structure of this age with wide spread minor deficiencies giving a general impression of poor quality control during the construction phase.

6.1 Implementation of recommended repairs generally:

6.1.1 There are numerous repairs recommended within section 5 of this report, of varying degrees of urgency.

6.1.2 The implementation of number of the repairs recommended within the report risk affecting the stability of the overall structure and must be addressed with careful planning and implementation.

6.1.3 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.

6.2 Structural integrity:

6.2.1 A number of observations collectively suggest that the structural integrity of the continuous concrete beams is not performing as expected.

6.2.2 Enquiries of A F Cruden's in 2016 indicated that the design had been governed by deflection calculations and that the structure was reliant on the effective continuity over the supports to achieve the recommended deflection limits.

6.2.3 Crucially A F Cruden's stated that any failure of the continuity reinforcement would not affect the structural strength of the beams as they were adequately reinforced to perform satisfactorily spanning simply between their two supporting piers.

6.2.4 There is no recommended action.

6.3 Structure durability:

6.3.1 Crack patterns seen within the span of the beams, opening joints over the supports and rust staining at a number of these locations all indicate that the recommended deflection criteria are not being met and that corrosion of the reinforcement has started. There is no evidence of extensive corrosion at this stage, but it is of concern that corrosion has initiated at this relatively young age.

6.3.2 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. If as expected the strength is adequate but the stiffness is not then it will be necessary to design and implement beam strengthening as necessary.

6.3.3 If wide spread beam strengthening is required this is likely to be very costly.

Appendix A:
Schedule of rail pack observations

This appendix includes all items listed in the 2015 report (repaired and otherwise) plus additional items identified during the 2016 inspection.
Entirely new items are highlighted in blue.
Items requiring repair action are highlighted in yellow.
Items requiring further investigation are typed in red.

Location:	Observation:	Proposed/historic action:
02/03L	Slightly cracked	No action
03/04L	Vertical crack on inner face	No action
03/04R	Vertical crack on inner face	No action
04/19L	Vertical crack on inner face	No action
05/20L	Total disintegration	Replaced 2016
06/04L	Chip out upper face	No action
11/01L	Rotten wood inclusion	Part repaired 2016
12/01R	Corner fractured off	No action
12/08L	Upper face sheared off	No action
12/15L	Upper face sheared off	Part repaired 2016
12/16L	Upper inner corner missing	No action
13/08L	Threaded bar inclusion	No action
14/03L	Extra plinth done by CRL	Part repaired 2016
14/04R	Outer edge broken off	Part repaired 2016
14/06L	Upper face spalling	Part repaired 2016
14/14L	Upper face spalling	Part repaired 2016
14/20L	Gaps	Part repaired 2016
14/20R	Grout largely failing	Replaced 2016, but no QC sheet
15/20L	Damaged	Part repaired 2016
15/20R	Damaged	Repair
16/01L	Ref pic	Replaced 2016
16/02R	Cracked	Monitor
16/03R	Crack in plinth and flange below	Monitor
16/04R	Crack in plinth and flange below	Monitor
16/05R	Crack in flange below	Monitor
16/07R	Crack in plinth and flange below	Monitor
16/08R	Crack in plinth and flange below	Monitor
16/09R	Crack in plinth and flange below	Monitor
16/12L	Shrinkage cracks	Monitor
16/13L	Shrinkage cracks	Monitor
16/18L	Cracked.	Monitor
16/20L	Pos timber inclusion	Part repaired 2016
17/01L	Pos timber inclusion	Part repaired 2016

17/01R	Damaged	Repair
17/02L	Grout in poor condition	Monitor
17/03L	Pos timber inclusion	Replaced 2016
17/03R	Grout in poor condition	Monitor
17/04L	Poor repair	Part repaired 2016
17/04R	Plinth spalled	Monitor
17/07L	Vert crack and efflorescence	Monitor
17/12L	Vert crack and efflorescence	Monitor
17/14L	Vert crack and efflorescence	Monitor
17/15L	Vert crack and efflorescence	Monitor
18/02R	Minor crack	Monitor
18/05L	Part fractured off	Repair
18/05R	Crack	Monitor
18/06R	Crack	Monitor
18/13L	Damaged outer edge	Part repaired 2016
18/20R	Crack in flange below	Monitor
19/03L	Pos timber inclusion	Part repaired 2016
20/18R	Damaged	Part repaired 2016
22/04L	Spalled upper face	Part repaired 2016
24/01L	Disintegrating repair Noted as cracked after repair	Replaced 2016 Inspect and repair if nesc
24/06L	Poor repair	Part repaired 2016
24/08L	Poor repair	Part repaired 2016
24/20R	Outer corner damaged	FAILED - CRL to provide QC sheets for replacement.
26/13L	Old repair, pos damage Noted as split in two Beam below damaged	No action Repair Monitor
29/01R	Rail movement block upper inside corner fractured and part missing	No action
36/20L	Possible issue	No action
40/01R	Lower face, minor spalling	No action
41/01L	Missing corner	Part repaired 2016
48/04L	Upper top edge missing	No action
52/01 mid	Upper face spalled	Monitor
58/01L	Pos timber inclusion	Part repaired 2016
58/19R	Grout fractured but firm	No action
58/20L	Pos timber inclusion	Part repaired 2016
61/01R	Pos timber inclusion	Part repaired 2016
61/03L	Damaged	No action
61/12R	Damaged	Part repaired 2016
61/20L	Pos timber inclusion	Part repaired 2016
61/20R	Damaged	Part repaired 2016

62/19L	Crack in flange below	Monitor
62/20L	Top face missing	Repair
63/20R	Damaged	Part repaired 2016
64/01L	Upper face cracked	Repair
69/03R	Beam chipped	Part repaired 2016
73/01L	Horizontal crack	No action
81/01L	Fractured upper face	Part repaired 2016
90/01L	Top face flaked off	Monitor
91/08L	Flake off upper face	No action
93/07L	Flake off upper face	No action
93/17L	Chipped	No action
93/20R	Large chunk missing	Part repaired 2016
SH00/01R		Replaced 2016
SH00/02L	Fractured but stable	No action
SH00/03L	Fractured but stable	No action
SH00/04L		Part repaired 2016
SH00/05L		Part repaired 2016
SH01/03R		Part repaired 2016
SH01/04R	Lower face fractured but stable	No action
SH01/05L		FAILED - CRL to provide QC sheets for replacement.
SH01/06R	Side face fractured but stable	No action
SH01/07L		Part repaired 2016
SH01/09L	Slab cracked through, plinth OK	No action
SH01/10R		Part repaired 2016
SH01/11R	Damaged	Monitor
SH01/24R	???	Part repaired 2016
SH02/08L	Chipped but OK	No action
SH04/15L	???	Monitor
SH08/11L	Fractured, OK	No action
SH08/13	Chipped but OK	No action
SH12/14L	Cracked on MJ, OK	No action
SH15/08L	Chipped but OK	No action

Appendix B:
Photos:

Ref clause 5.1.3

Photo [1] Construction joint / shear fracturing where thrust block upstand meets main foundation.

Ref clause 5.1.5

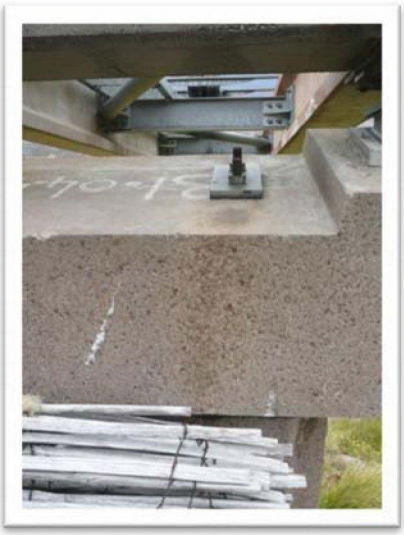
Photo [2] Large chip out of face of thrust block where PCC beam meets it.

Ref clause 5.1.2

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

Ref clause 5.1.3

Photo [4] Significant chip out of pier shell.



Ref clause 5.2.3

Photo [5] Pier 93. Crack rising up through pier crosshead and passing through bolt group. This was the only cross head where this was observed.

Ref clause 5.3.2

Photo [6] Showing deterioration of bearing plate grout.

Ref clause 5.5.1

Photo [7] Pier 56, an overview showing previous repairs carried out.

Photo [8] Pier 56 crack near top of flange unloaded.

Photo [9] Pier 56 crack near top of flange as train passes. Estimate increase in crack width = 1.0mm.

Ref clause 5.4.2

Photo [10] Pier 8, one of the poorer insitu infills. Showing joints opening between Insitu and precast plus cracking within the mass of the Insitu, both inclined and near vertical.

Photo [11] Pier 8 from above.

Ref clause 5.4.3

Photo [12] Diagonal cracks through the lower flange of the precast bead bearings.

Photo [13] Showing bottom corner fracturing away.

Photo [14] Flange fracture also seen at top of beams. This was less often.

Ref clause 5.5.4

Photo [15] Typical crack patterns around bolt groups.

Photo [16], ditto

Ref clause 5.6.5

Photo [17] Longitudinal cracking of the top flange of the PCC beams, here short.

Ref clause 5.6.5

Photo [18] Longitudinal cracking of the top flange of the PCC beams, here several meters long.

Ref clause 5.5.6

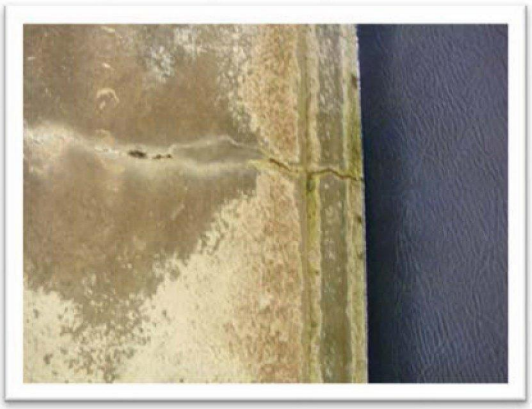


Photo [19] View of crack on typical mid-span underside of beam.

Photo [20] The above photographed crack as it appears on the side of the beam.

Photo [21] Crack at mid span of beam exhibiting rust staining.

Ref clause 5.6.1

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.