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Typical pot bearing

Ancon bearings

Job name: **Factual report on the sliding bearings to the Funicular Railway.**
Job number: **18013**
Client: **Cairngorm Mountain Ltd**
Engineer: [redacted]
Date: **August 2018**

Revision	Date	Comments
A	29/08/18	Initial issue
B	05/09/18	Edits to section 5.6 and appendix A

Ancon bearings

Index:

1 Introduction:

1.1 At the request of Cairngorm Mountain Ltd, the Client, the writer carried out a visual inspection of each of the sliding bearings supporting the Funicular Railway. The writers brief was as follows: *"To carry out a non-*disruptive *visual inspection of the sliding bearings and to report of their position relative to the end of the sliding plate and to relate this to temperature".*

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, from ground level and by ladder access where required. No disruptive investigations or materials testing were carried out. Limited calculations were carried out.

1.4 The purpose of this report was to contribute to an assessment of the performance of these bearings and to the assessment of the need for any remedial actions, all within the limitations of the brief and inspection techniques.

2 Executive summary:

2.1 These investigations were initiated after bearings with limited available travel were identified giving rise to concern about conditions in cold weather.

2.2 At the outset it was expected that only a small number of bearings would be identified as requiring modification. The problems with the bearings were found to be significantly more wide spread and the breadth of problems was wider than expected.

2.3 The problems break down into categories:

- Bearings sliding off, in part or in whole, their wearing surface in cold conditions.
- The PTFE low friction pad being more heavily worn than expected at this age, in some cases worn away entirely.
- Physical damage to the transverse low friction surface.
- A range of one off defects.

3 Scope and references:

3.1 Refer to Appendix A for a sketch drawing of the bearings.

3.2 The bearings come in two types (ref p B3):

- Pot bearings, which offer no longitudinal or transverse restraint.
- Guided bearings, which offer no longitudinal restraint, but do provide restraint to transverse movement.

3.3 There are a total of 94 support locations, most with one of each type of bearing. At the passing loop there are three and four points of support. (ref p B6)

3.4 The referencing system is as follows:

- Upper refers to the part highest up the mountain
- Lower refers to the part lowest down the mountain
- Left refers to the left hand side as viewed looking up the mountain
- Right refers to the right hand side as viewed looking up the mountain
- The supports are numbered from the bottom of the mountain upwards and are in keeping with the name plates on the piers.

3.5 The observations made during the inspection were targeted at recording temperature related movement. The following observations were made:

3.5.1 General:

- Beam angle
- Beam length

3.5.2 All bearing:

- PTFE thickness
- Any physical damage
- Evidence of wear product
- Distance from pot face to end of wearing surface
- Temperature of underside of beam

4 Methodology:

4.1 Access was from ground level or from ladders where the piers were tall.

4.2 Distances and angles of beams were measured using a Leica Disto D810. This device is reported to have an accuracy of +/- 1.0mm over distance. The angular measurement was less accurate, but sufficient for the purposes of this report.

4.3 Available movement measurements were taken using a steel tape measure, it is thought these should be +/-2mm or better.

4.4 Thicknesses of PTFE bearing pads were generally estimated, but in some cases were measured using improvised “feeler gauges”. These were small items premeasured using a Vernier caliper which were slid into the gap reflecting the PTFE thickness. These were 1.0mm and 1.5mm thicknesses – these acted as a calibration to the estimates being made.

4.5 Temperatures were measured using a Fluke 64 max infrared thermometer. This instrument is reported to have an accuracy of +/- 1°C or 1% of temperature. Readings from this type of device depend on the emissivity of the material being measured. The emissivity of the concrete was calibrated by sticking a length of masking tape to the concrete surface and measuring it. This type of tape is reported to have an emissivity of 0.95 and rapidly adopts the surface temperature of the material it is stuck to. It was concluded that this concrete surface would give an acceptable level of accuracy using an emissivity of 0.95.

The recorded temperature readings were taken on the underside of the beams. For comparison some readings were taken on the face of the web under sunlight, these were found to be significantly higher.
Recorded temperatures ranged from 8.9°C to 20.8°C.

During the inspection temperature readings were taken on the web of one beam that was in direct sunlight, it was found to be 27°C on the lit face and 21°C on the shaded face. The underside of beam reading was 18°C and this is what was recorded. This indicates that the beams could achieve temperature significantly greater than the air temperature records available particular in strong sun – leading to greater longitudinal movement than calculated.

5 Observations:

5.1 Refer to Appendix B for typical photos and specific photos of bearings. Also refer to Appendix C for the inspection records.

5.2 The inspection set out to observe the available movement across the operating temperature range before the PTFE bearings strayed beyond the limits of the bearing plate. During the inspections it became apparent that there were various other defects and damages – these were recorded, but as they are out with the original scope of this report these records may not be comprehensive.

5.3 At all locations the available movement for the specific pairs of pot and sliding bearings were similar. With ideal setting out there would be a specific temperature where the bearings would sit in the middle of the bearing plate. At the time of measuring, the available movement due to reduction in beam length (due to cooling) varied from less than zero to 135mm. The available movement was found to be erratic in many places.

5.4 The beams were generally in the order of 18m center of support to center. The beams were inclined up to 22.9° from horizontal.

5.5 The original PTFE thickness is advised as 4.5mm with 1.5mm recessed in the bearing housing ie as new there would have been 3mm of PTFE visible. The observed thickness of PTFE remaining varied from 0mm to 2mm. We were also advised that the design life was 50 years hence at 17 years old the structure is 1/3 of its way through its design life and assuming no residual thickness at end of life then we would expect to see a 2mm thickness at this point. 2mm was visible at the best locations, but generally there is less than that and much less in some locations.

PTFE thicknesses were not observed at all locations as this was not part of the original scope and at the guided bearings it is not as easy to see. Bearings with less than 1mm PTFE visible were seen at 35 (out of 196 total) locations, 4 of these were less than 0.5mm and two were completely worn away.

5.6 In addition, there were a number of damages and defects observed as follows:

5.6.1 Pier 51 guided bearing, ripped transverse slip membrane

5.6.2 Pier 61 guided bearing, ripped transverse slip membrane

5.6.3 Pier 63 pot bearing, PTFE popped out of housing

5.6.4 Pier 70 pot bearing, possible weld fracture in support bracket – note these brackets were not generally inspected for such defects and a wider specific inspection should be undertaken if these are proved to be fractures.

5.6.5 Pier 91 guided bearing, ripped transverse slip membrane

5.6.6 Pier 92 pot bearing, st/st bearing plate detached from support and partially rotated

5.6.7 Pier 94 pot bearing, seen to be rusting

5.6.8 Pier 50 guided bearing steel guide appears fractured from integral support plate ref photos on pB12 – note these plates were not generally inspected for such defects and a wider specific inspection should be undertaken if these are proved to be fractures.

6 Calculations:

6.1 Available movement:

6.1.1 The pot bearings are 90mm diameter and bear onto a 1mm thick stainless steel plate that is 285mm long, giving available temperature related movement of +/-97.5mm from an ideal position.

6.1.2 The guided bearings have two half circle bearings to carry vertical load, these are 150mm in diameter and bear onto a 1mm thick stainless steel plate that is 325mm long, giving available temperature related movement of +/-87.5mm from an ideal position.

6.1.3 The guided bearings house a bar to resist transverse movement. This bar has a seemingly fabric wrap secured with small rivets, the fabric bears transversely onto a stainless steel plate. The bar is 150mm long and the stainless steel wearing plate is 335mm long, giving available temperature related movement of +/-92.5mm from an ideal position.

6.1.4 The longitudinal movement at any bearing is related to the temperature change and length of beam from last (down hill) thrust block. Those bearings nearest the thrust blocks will only move a very little through the entire temperature range to be experienced, but the bearings furthest from the thrust blocks are up to 332m away and experience considerable movement.

6.1.5 The formula relating movement to temperature change is:

Change in length = length

x change in temperature

x coefficient of thermal expansion of concrete

The coefficient of thermal expansion of concrete has various quoted values, but here we will adopt the average figure given in the concrete design code, BS8110, part 2 1985, as 10 E-6 m/m/°C.

Using a temperature range of +25 to -11°C we have a range of +/-18°C, combined with a length of 332m gives us a maximum temperature related change in length of:

= 332,000mm x 18°C x 10 E-6 m/m/°C

= +/-60mm

6.1.6 If the bearings were optimally located this would be fine, but the bearings are not and the calculations indicate that at 15 piers the leading edge of the PTFE will stray off the stainless steel wearing plate by more than 10mm and in the worst instance it will stray over 50mm. The full set of observations and anticipated movements are presented in Appendix C.

6.2 Coefficient of friction:

6.2.1 We do not have information on the sensitivity of the structure to axial loads, but we do know that the PTFE bearings will provide a very low friction force as the beams expand and contract.

6.2.2 Available information indicates that PTFE on steel has a coefficient of static friction in the range 0.05 to 0.20 and it is thought that in this case it will be at the lower end of this range as the steel in question is polished stainless steel.

6.2.3 Steel on steel has a coefficient of static friction in the range 0.50 to 0.80.

6.2.4 This indicates that the axial load could be increased from a multiple of 4 times up to 10 times.

6.2.5 In the eventuality of the bearing being worn away on one side only then the increased longitudinal load would be uneven adding further to the stresses in the structure.

7 Conclusions:

7.1 The range of movement anticipated with temperature change is expected to move the beam bearings off their designed wearing plates, most winters, in 15% of cases. This is expected to accelerate the rate of wear of the PTFE pads and reduce the design life of the structure.

7.2 Two bearings were seen to have their PTFE pads completely worn away. It is expected that this will significantly increase the friction in the system and consequently lead to additional forces in the structure that were not designed for. In the absence of detailed design information it is not known how significant this is.

7.3 Most PTFE pads appear more heavily worn than would be anticipated at this stage in the structures life with 17% of the bearings having a residual thickness of PTFE that would be expected to be worn through within 15 years or less.

7.4 There are various individual defects at seven locations, these should be addressed individually, ref section 5.6.

8 Recommendations:

8.1 This report, its conclusions and recommendations are based on general engineering principals, but ADAC-structures are not bearing specialist and it recommendation that this report should be sent to the original bearing supplier and to have them review and comment on it. A dialogue has already been established with them and some of the points of reference in this report come from that source.

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8.2 Thought should be given to how this situation has arisen. For the bearings to be so badly positioned would have required very poor setting out of one of the critical elements of the project. The alternative is that some structural element has moved, most likely the piers. Only a small rotational movement of the foundations would result in the “out of position” seen. For example it is estimated that the bearings at pier 91 are some 90mm out of position, but the tower is 5900mm tall, a rotation of less than 1° would result in this problem.

It is recommended that further investigations are carried out to try and determine the accuracy of the original setting out (either anecdotally or be written records) and then to determine why there is a problem now. It is possible that the observed problems are only symptomatic of some other underlying problem.

8.3 One steel bearing support bracket was thought to be showing cracking in the face and in the weld (ref p B9). This location should be inspected by a specialist in this field and if it is found to be the case then this should be repaired and an inspection program initiated to look at the other brackets.

8.4 The writer has also been involved in annual inspections of the general concrete support structure and there are now several years worth of records. It would be a useful exercise to collate all observations along with as built information on the structure to try and identify patterns in the defects being observed.

9 Budget:

Ancon bearings

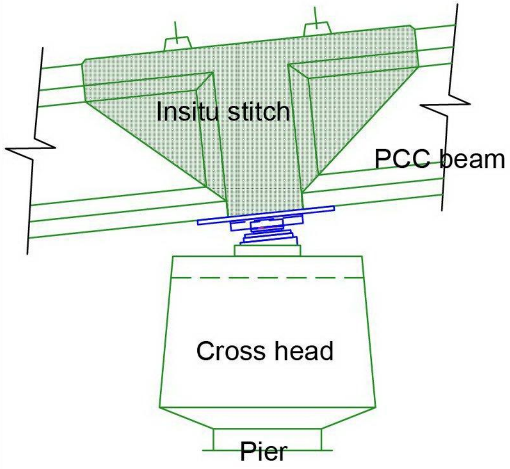
9.1 This budget is far from accurate but is intended to start to give us a feel for what we are talking about in budgetary terms.

9.2 Round figures have been discussed with CCL that indicate a new bearing would cost in the region of £1,000. If we estimate the installation of a new bearing would cost a similar amount and say that we are looking at replacing 15 pairs of bearings, ie 30 bearings at £2,000 each, hence £70,000.

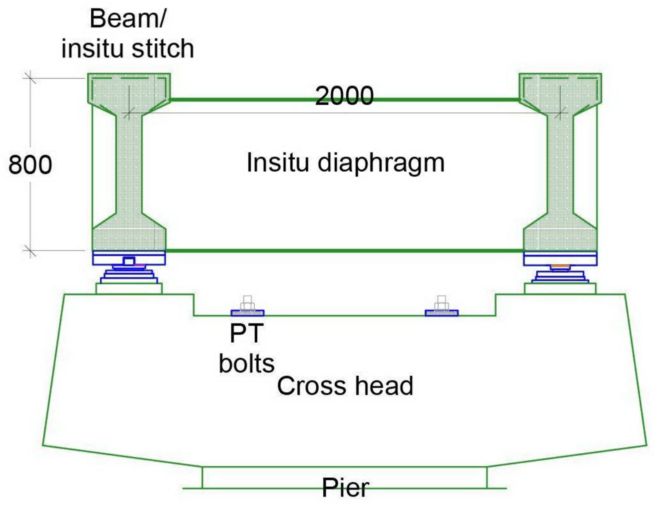
9.3 If we guestimate that a new PTFE wear pad costs £250 and would cost £750 to install and we do all those that are less than 1mm thick, that's 35 pads at £1,000 each, hence £35,000.

9.4 There may also be scaffolding cost on top plus project management fees, dependent on how you wish to deliver this.

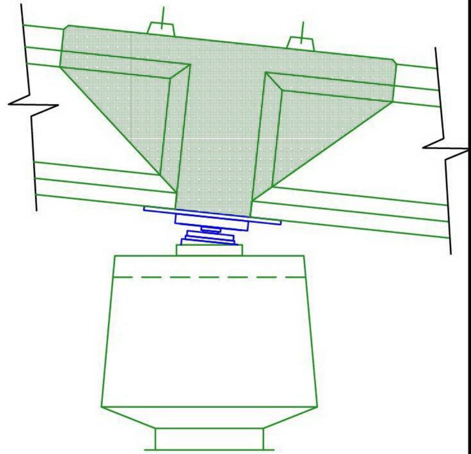
Appendix A
Typical drawn bearing details



Side view of sliding bearing:



Typical section at bearings



Side view of pot bearing:

original drawing size A4

0 10 20 30 40
scale in mm

NOTES:
- This drawing to be read in conjunction with all other Engineers drawings, notes, specifications and schedules.
- This drawing is indicative and not to be used for calculation or construction purposes.

Rev A:
- initial issue

A	05.09.18	Information	AOA
Rev.	**Date**	**Purpose**	**Chkd**

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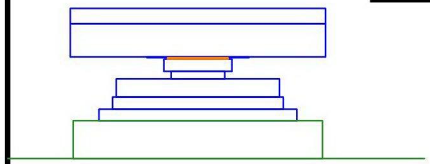
Project:
Ancon bearings report

Drawing:
Overview

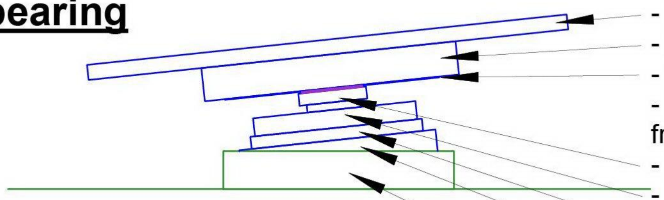
Number: 18013-100 Rev: A

Date: Sept 2018 Scale: 1:35

Pot bearing

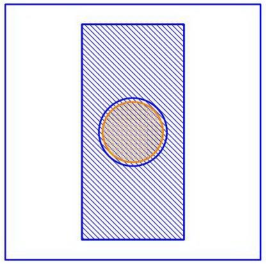


End view:



Side view:

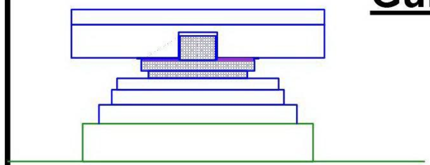
- 638x338x20 plate
- 338x338x44 plate, bolted to plate above
- 1mm tk st/st wearing flat plate 285mm long
- PTFE low friction slide, thickness showing varies from 0 - 2mm. One circles on plan.
- 90x28 round pot bearing housing, set into . . .
- 216x40 round
- 228x228x16 bolted to plate below
- 262x262xtapered (box section where angle is steeper)
- 305x330x 50 approx grout, varies



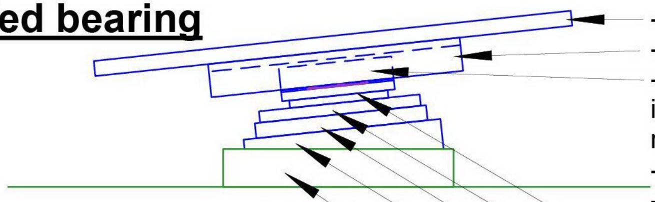
- Plan on bearing / wearing surface.
- Orange indicates PTFE pad.
- Stainless steel rectangular plate wearing
- Plan on bearing / wearing surface.
- Orange indicates PTFE pad.
- Stainless steel rectangular plate wearing surfaces, shown cross hatched, are the limit of acceptable surface contact.
- Note this plan shows ideal mid temperature position, many observed bearings were well outwith this ideal and some near the extreme of acceptable travel.

Plan view:

Guided bearing

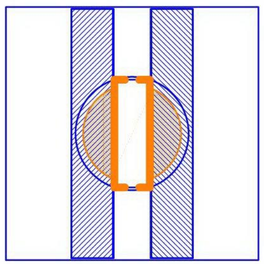


End view:



Side view:

- 635x335x20 plate
- 335x335x44 plate with slot, bolted to plate above
- transverse guide with slip membrane riveted on, integral with 150x20 round bearing plate below and running in slot
- 1mm tk st/st wearing L-shaped plates 330mm long
- PTFE low friction slide, thickness showing varies from 0 - 2mm. Two half circles on plan.
- 150x20 round bearing housing, set into . . .
- 214x15 round
- 228x228x20 bolted to plate below
- 262x262xtapered (box section where angle is steeper)
- 305x330x 50 approx grout, varies



- Plan on bearing / wearing surfaces.
- Orange indicates PTFE pads and slip membrane on guide.
- Two of stainless steel "L-shaped" wearing surfaces, shown cross hatched, are the limit of acceptable surface contact.
- Note this plan shows ideal mid temperature position, many observed bearings were well outwith this ideal and some near the extreme of acceptable travel.

Plan view:

original drawing size **A4**

0 10 20 30 40

scale in mm

NOTES:
- This drawing to be read in conjunction with all other Engineers drawings, notes, specifications and schedules.
- This drawing is indicative and not to be used for calculation or construction purposes.

Rev A:
- initial issue

Rev.	Date	Purpose	Chkd
A	05.09.18	Information	AOA

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Project:

Ancon bearings report

Drawing:

Details of bearings

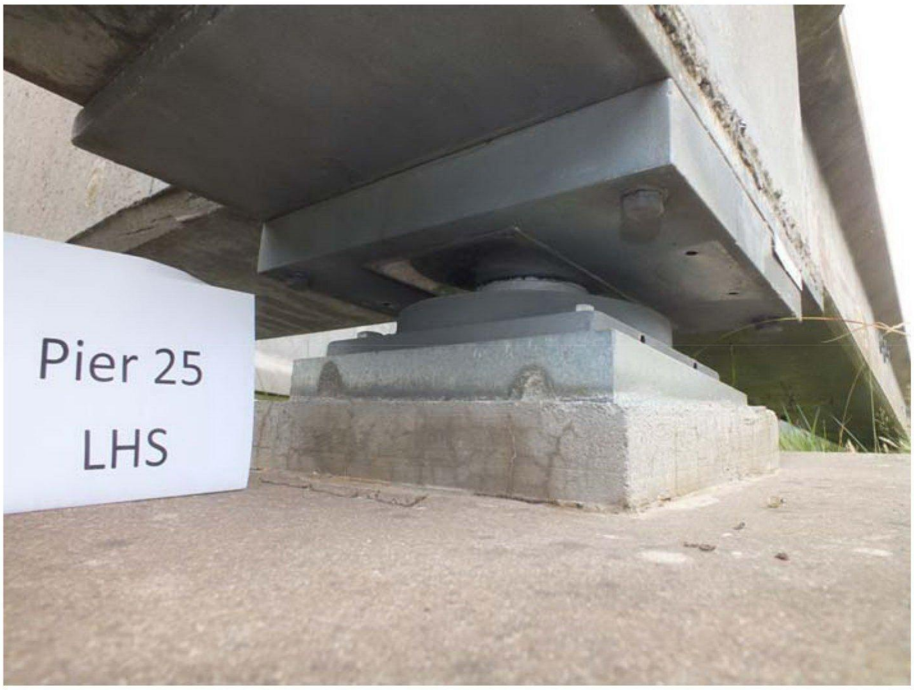
Number: 18013-101 Rev: A

Sept 2018 Scale: 1:10

Appendix B

Photographs

	Photo P23 LHS2 Manufacturers name plate
	Photo P23 LHS3 Assumed performance plate.

	Photo P25 LHS Bearing at pier 25, LHS typical. Typical pot bearing – low profile.
	Photo P25 RHS Bearing at pier 25, RHS typical. Typical guided bearing – low profile.

<table>
<tr><td>
</td><td>Photo P43 LHS

Bearing at pier 43, LHS typical.

Typical pot bearing – tall profile.</td></tr>
<tr><td>
</td><td>Photo P43 RHS

Bearing at pier 43, RHS typical.

Typical guided bearing – tall profile.</td></tr>
</table>

	Photo P37 LHS Bearing at pier 37, LHS Near end of wearing plate. Note PTFE appears in good order.
	Photo P37 LHS Bearing at pier 37, RHS. Near end of travel

	Photo P52 VIEW Typical pier elevation
	Photo P52 VIEW Typical three beam pier (there are two of these)
	Photo P53 VIEW Typical 4 beam, two pier arrangement. (there are three of these)

	Photo P42 LHS Bearing at pier 42, LHS Note bolts appear loose.
	Photo P61 RHS Bearing at pier 61, RHS. Transverse slip material ripped.

	Photo P63 RHS Bearing at pier 63, RHS PTFE popped out at rear.
	Photo P63 RHS Bearing at pier 63, RHS Detail of PTFE popped out at rear.

	Photo P70 LHS Bearing at pier 70 LHS Cracking in steelwork
	Photo P70 LHS Bearing at pier 70 LHS Detail of cracking in steelwork. Not particularly clear, but running along weld and also across face of steel SHS upright.

 	Photo P85 LHS Bearing at pier 85, LHS Note PTFE appears very thin, this was recorded as 1.0mm.
 	Photo P92 LHS Bearing at pier 92, LHS. Note stainless steel wearing plate's fixings have failed and this plate is unrestrained and has moved and rotated.

	Photo P91 LHS Bearing at pier 91, LHS Note pot bearing is at end of wearing plate. PTFE thickness recorded here as 0.0mm.
	Photo P91 RHS Bearing at pier 91, RHS. Note guide and bearing at edge of wearing surfaces. Also note ripped transverse slip material.in red circle.

	Photo P50 RHS Bearing at pier 50, RHS Viewed from the uphill side, cracking of guide plate. Note “bar” and disc plate are generally one piece, possibly a casting.
	Photo P50 RHS Bearing at pier 50, RHS Viewed from the downhill side, cracking of guide plate. .

Appendix C

Inspection records

Project 18013, Ancon Bearings inspection on Cairngorm Funicular Railway - August 2018

Assumed max temperature =	25	°C
Assumed min temperature =	-11	°C
Assumed coef thermal expansion =	1.00E-05	°C
assumed diaphragm thickness =	400	mm

Pier #	General		Pot bearings (LHS)				Guided bearing (RHS)				MJ's	Length from last anchorage:	Min distance to end	Max distance to end
	Beam angle	Beam length	Tk PTFE	Damage	Distance to end	Temp °C	Tk PTFE	Damage	Distance to end	Temp °C	Free gap		Calculated for the pot bearing	
00		17255	/	/	/	/	/	/	/	/		0	/	/
01	11.5	17951	~1.5	no	86	19.1	~1		85	19.9		17455	80.7	87.0
02	10.0	17851	1.5	no	95	18.6	1.5		90	19.0		35806	84.4	97.3
03	8.8	13737	1.5	no	90	20.8	<1		90	18.5		54057	72.8	92.3
04	7.5	14692	1.5	no	97	18.5	1.5		98	19.1		68194	76.9	101.4
05	6.2	17636	1.5	no	97	20.0	1.5		97	19.2		83286	71.2	101.2
06	5.9	17610	1.5	no	103	18.5	1		105	18.7		101322	73.1	109.6
07	6.1	17623		no	91	11.7		no	93	11.3		119332	63.9	106.9
08	6.1	17608		no	89	11.6		no	86	11.7		137355	58.0	107.4
09	6.0	17619		no	88	12.0		no	89	12.0		155363	52.3	108.2
10	6.1	17608	1 to 2	no	89	11.6		no	89	11.8		173382	49.8	112.2
11	6.1	17607	1 to 2	no	74	11.6		no	72	11.6		191390	30.7	99.6
12	6.0	17606		no	84	12.3		no	86	12.4		209397	35.2	110.6
13	5.8	17166		no	109	11.9		no	102	12.0		227403	56.9	138.8
14	5.3	16970		no	105	11.1		no	111	9.6	85	244969	50.9	139.1
15	5.0	17570		no	85	13.1		no	88	13.2		17170	80.9	87.0
16	4.8	17563		no	89	13.0		no	87	13.1		35140	80.6	93.2
17	5.0	17349		no	90	12.8		no	87	13.4		53103	77.4	96.5
18	5.0	17763		no	87	12.9		no	87	14.2		70852	70.1	95.6
19	4.9	17556		no	87	12.9		no	90	13.1		89015	65.7	97.8
20	5.0	17563	less	no	92	13.5		no	89	13.3		106971	65.8	104.3
21	4.6	17578	<1		105	13.4		no	95	12.5		124934	74.5	119.5
22	3.5	17605	0.5 - 2		109	13.8		no	102	13.8		142912	73.6	125.0
23	3.4	17594	1 to 2		135	15.9		no	107	16.1		160917	91.7	149.6

Project 18013, Ancon Bearings inspection on Cairngorm Funicular Railway - August 2018

Assumed max temperature =	25	°C
Assumed min temperature =	-11	°C
Assumed coef thermal expansion =	1.00E-05	°C
assumed diaphragm thickness =	400	mm

Pier #	**General**		**Pot bearings (LHS)**				**Guided bearing (RHS)**				**MJ's**	**Length from last anchorage:**	**Min distance to end**	**Max distance to end**
	Beam angle	Beam length	Tk PTFE	Damage	Distance to end	Temp °C	Tk PTFE	Damage	Distance to end	Temp °C	Free gap		Calculated for the pot bearing	
24	4.8	17550			101	15.5		no	98	15.7		178911	53.6	118.0
25	5.3	17587			74	15.3		no	77	16.2		196861	22.2	93.1
26	5.6	17607			79	15.2		no	89	16.2		214848	22.7	100.1
27	6.1	17621			105	15.5		no	109	15.4		232855	43.3	127.1
28	6.3	17156			110	15.5		no	127	15.4		250876	43.5	133.8
29	6.8	16917			92	16.9		no	100	14.4	85	268432	17.1	113.7
30	7.3	17555			88	14.2		no	87	14.7		17117	83.7	89.8
31	7.8	17319			77	8.9			79	8.8		35072	70.0	82.6
32	8.3	17310			69	9.1			73	9.3		52791	58.4	77.4
33	8.6	17758			62	9.5			62	9.6		70501	47.5	72.9
34	9.1	17554			39	9.6			37	9.5		88659	20.7	52.7
35	9.5	17608			20	9.7			19	9.3		106613	-2.1	36.3
36	9.9	17595			15	9.7			16	9.9		124621	-10.8	34.1
37	10.3	17628	1 to 2		4	9.8			3	9.8		142616	-25.7	25.7
38	10.8	17611			15	10.0			15	9.9		160644	-18.7	39.1
39	11.2	17619			5	10.3			9	10.1		178655	-33.1	31.3
40	11.4	17589			3	10.4			5	10.5		196674	-39.1	31.7
41	11.8	17561			10	10.8			10	10.4		214663	-36.8	40.5
42	12.3	17649			18	11.0			19	11.0		232624	-33.2	50.6
43	12.6	17598			25	10.6			28	10.5		250673	-29.1	61.1
44	13.1	15031			12	10.8			5	11.1		268671	-46.6	50.2
45	13.2	16531	1 to 2		38	14.0			30	13.7		284102	-33.0	69.3
46	13.9	14045			58	10.7			54	10.5		301033	-7.3	101.0
47	14.1	16201			80	12.6			99	13.2		315478	5.5	119.1

Project 18013, Ancon Bearings inspection on Cairngorm Funicular Railway - August 2018

Assumed max temperature =	25	°C
Assumed min temperature =	-11	°C
Assumed coef thermal expansion =	1.00E-05	°C
assumed diaphragm thickness =	400	mm

Pier #	General		Pot bearings (LHS)				Guided bearing (RHS)				MJ's	Length from last anchorage:	Min distance to end	Max distance to end
	Beam angle	Beam length	Tk PTFE	Damage	Distance to end	Temp °C	Tk PTFE	Damage	Distance to end	Temp °C	Free gap		Calculated for the pot bearing	
48	14.6	12525			85	11.0			80	10.7	105	332079	11.9	131.5
49	14.9	11905			79	11.0			71	10.2		12725	76.2	80.8
50	15.3	17554	1 to 2		68	11.1			66	10.4		25030	62.5	71.5
51	15.5	17628			4	10.7		RIPPED	3	10.8		42984	-5.3	10.1
52 part	15.9	17589			25	11.7			22	11.5		61012	11.2	33.1
52 RHS pot	/	0			25	11.1		/	/	/		79001	7.5	36.0
53 RHS	16.2	17605	~1		45	12.0		little	45	11.6		79401	26.7	55.3
53 LHS	/	0			55	11.4			41	11.4		97406	33.2	68.2
54 RHS	16.7	17610			48	12.3			50	13.1		97806	25.2	60.4
54 LHS	/	0			45	12.5			45	12.1		115816	17.8	59.5
55 RHS	17.1	17629			55	12.2			49	11.7		116216	28.0	69.9
55 LHS	/	0			49	12.3			54	?		134245	17.7	66.0
56 part	17.5	17642			40	12.5			45	12.3		134645	8.4	56.8
56 RHS pot	/	0			58	11.6		/	/	/		152687	23.5	78.5
57	17.9	17603			30	13.3			33	13.0		153087	-7.2	47.9
58	18.2	17584			32	13.3			32	12.4		171090	-9.6	52.0
59	18.8	17650			52	13.7			51	12.5		189074	5.3	73.4
60	19.2	17622			30	13.8			34	12.7		207124	-21.4	53.2
61	19.7	17618			8	13.5		RIPPED	10	13.6		225146	-47.2	33.9
62	20.0	17610			55	13.1			44	13.2		243164	-3.6	83.9
63	20.1	17639		PTFE popped out	49	13.0			59	13.1		261174	-13.7	80.3
64	20.1	17657			52	13.8			60	13.4		279213	-17.2	83.3

Project 18013, Ancon Bearings inspection on Cairngorm Funicular Railway - August 2018

Assumed max temperature =	25	°C
Assumed min temperature =	-11	°C
Assumed coef thermal expansion =	1.00E-05	°C
assumed diaphragm thickness =	400	mm

Pier #	General		Pot bearings (LHS)				Guided bearing (RHS)				MJ's	Length from last anchorage:	Min distance to end	Max distance to end
	Beam angle	Beam length	Tk PTFE	Damage	Distance to end	Temp °C	Tk PTFE	Damage	Distance to end	Temp °C	Free gap		Calculated for the pot bearing	
65	18.8	16675			69	13.2			76	13.0	140	297270	-2.9	104.1
66	18.8	17557	2.0mm		88	12.7	~1.0		92	12.4		16875	84.0	90.1
67	19.2	17577	~1.5		74	13.0	~1.0		79	12.6		34832	65.6	78.2
68	19.7	17567	1.5		90	15.5	1.0mm		92	15.6		52809	76.0	95.0
69	20.0	17595	1.5		85	14.9	1.5		85	15.4		70776	66.7	92.1
70	20.4	17582	1.5	pos fractured steel!	92	15.4	1.5		106	15.5		88771	68.6	100.5
71	20.7	17574	~1.5		83	14.6	~1.5		82	15.0		106753	55.7	94.1
72	21.2	17604	~1.5	no	65	13.8	1.0		55	14.1		124727	34.1	79.0
73	21.3	17582	1.0	no	90	14.6	1.0		93	14.8		142731	53.5	104.8
74	21.7	17588	<1.0	no	85	13.3	1.0		87	13.7		160713	45.9	103.8
75	21.9	17594	1.0	no	81	14.1	0.5		80	14.1		178701	36.1	100.5
76	22.5	17575	1.0	no	92	13.5	1.0		80	13.8		196695	43.8	114.6
77	22.7	17543	1.0	no	81	13.5	1.0		76	13.3		214670	28.4	105.7
78	22.9	16625	1.5	no	91	13.5	1.0		89	14.2	74	232613	34.0	117.8
79	21.7	17510	2.0	no	85	13.5	1.5		89	13.5		16825	80.9	86.9
80	20.5	17571	1.5	no	82	13.2	1.5		79	13.4		34735	73.6	86.1
81	19.2	17616	1.5	no	86	13.3	1.5		86	13.4		52706	73.2	92.2
82	18.3	17543	1.5	no	82	12.5	1.5		79	12.8		70722	65.4	90.8
83	18.3	17552	1.5	no	67	12.9	1.5		69	13.6		88665	45.8	77.7
84	18.2	17546	1.5	no	90	12.7	1.0mm		89	12.5		106617	64.7	103.1
85	18.3	17520	1.0mm	no	80	12.3	1.5		86	12.4		124563	51.0	95.8
86	18.2	17538	1.5	no	90	12.1	1.0mm		89	12.1		142483	57.1	108.4

Project 18013, Ancon Bearings inspection on Cairngorm Funicular Railway - August 2018

Assumed max temperature =	25	°C
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Assumed coef thermal expansion =	1.00E-05	°C
assumed diaphragm thickness =	400	mm

Pier #	General		Pot bearings (LHS)				Guided bearing (RHS)				MJ's	Length from last anchorage:	Min distance to end	Max distance to end
	Beam angle	Beam length	Tk PTFE	Damage	Distance to end	Temp °C	Tk PTFE	Damage	Distance to end	Temp °C	Free gap		Calculated for the pot bearing	
87	18.2	17535	1.5	no	90	12.1	1.0mm		88	12.0		160421	52.9	110.7
88	18.6	17526	1.0mm	no	93	11.3	1.0mm		93	11.8		178356	53.2	117.4
89	18.7	17534	1.0mm		85	11.7	1.5		90	11.6		196282	40.4	111.1
90	18.5	17517	1.0mm	no	61	11.2	1.0mm		64	11.4		214216	13.4	90.6
91	17.4	17588	<0.0		-2	10.7	0.0	Ripped	1	10.6		232133	-52.4	31.2
92	16.3	17603	1.0mm	st/st plate loose and rotated!	65	10.5	<1.5		56	10.4		250121	11.2	101.3
93	14.9	17681	1.0mm		94	10.3	1.5mm		86	10.3		268124	36.9	133.4
94	/	/	1.5mm	some rust	135	10.0	Not accessible					286205	74.9	177.9