HIE’s decision to close the Cairn Gorm funicular again (3)

Description

(A) The steel strengthening brackets

This picture shows the three different types of bracket used in the strengthening works.

I have labelled these:-

Type 1. The bracket in the foreground (used in the central section of the “I” beam

Type 2. The brackets around the insitu block either side of the number 23

Type 3. The brackets around the scarf joint, more clearly seen on the right of the next picture.

As far as I can determine from surveys taken in January and February 2023 the following number of brackets have been added to the funicular structure:

Type 1… no. 917;

Type 2… no. 179;

Type 3… no. 333.

Total … no 1429.

TYPE 1.

126 of the 188 “I” beams have no type 1 brackets. All the other beams, just less than 1/3rd, have at least 7 brackets, while some at the passing loop half way along the railway have as many as 25!!! Why? The ADAC Structures reports mentioned poor quality control in the manufacture of the “I” beams but if that was the explanation why are just over 2/3rds of the “I” beams apparently ok?

Between piers 51 to 57, the passing loop, there are 19 beams and 355 brackets, an average of over 18 per “I” beam and 38% of the total number fitted. That’s not poor quality control, it is proof that there is a significant structural issue with the passing loop which has not being acknowledged in any report I have seen.

Compare this picture of the “I” beams at the passing loop (note the 4 bolt pattern) pre-repair work, courtesy of LECS UK who approved the re-opening of the funicular,

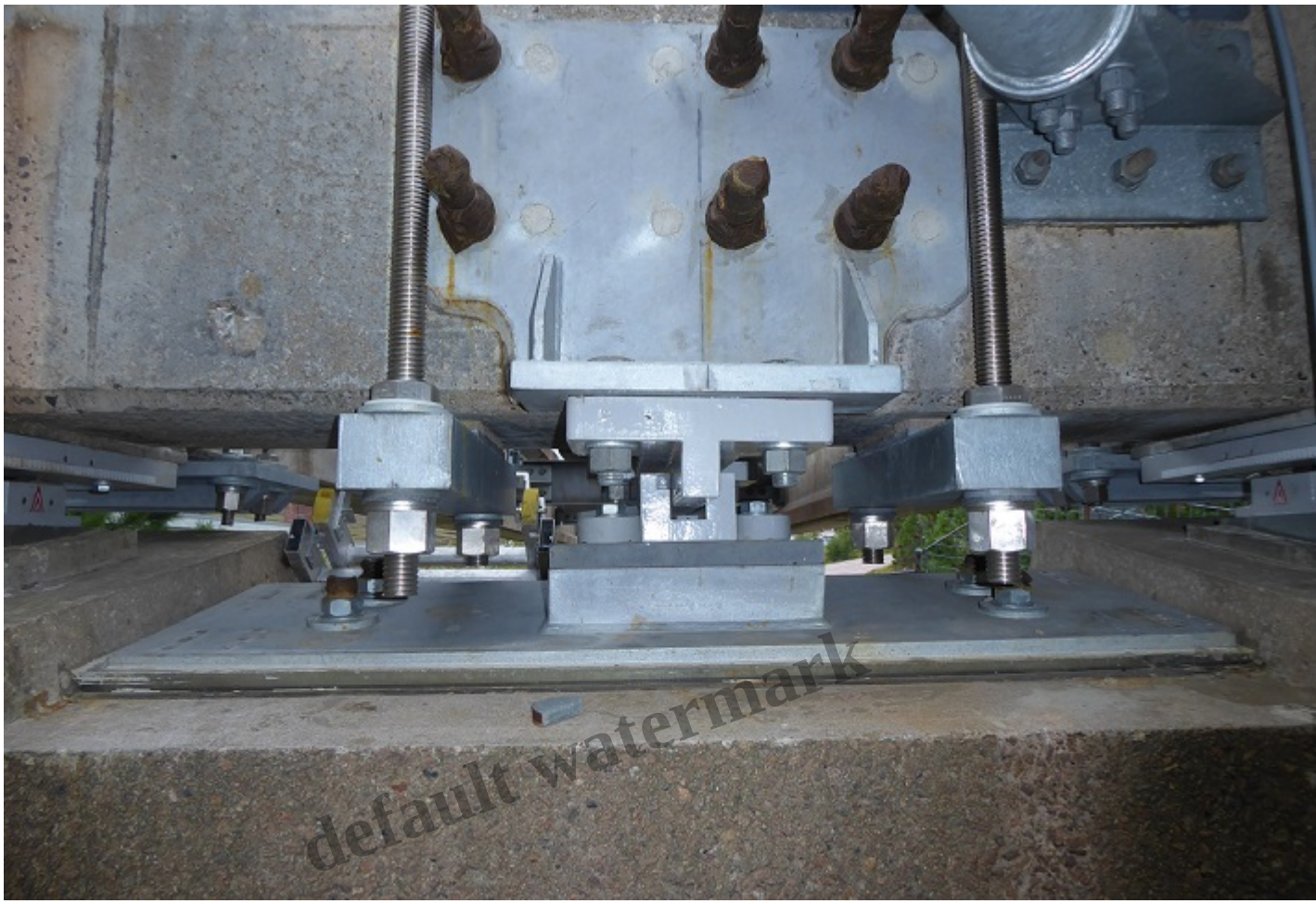
Photo credits LECS Consulting

with this next one taken in September 2023:

That is a massive quantity of steelwork that has been added.

Apart from the passing loop the majority of the other Type 1 brackets are where there are changes in stresses acting on the track e.g. where the track curves, changes in elevation, etc.

TYPE 2.



Central bearing with in situ block above and new brackets on each side

All the in-situ joints, apart from the anchor blocks, have at least two Type 2 brackets whose purpose appears to be to strengthen the block around the new central bearings that have been fitted.

TYPE 3.

Every scarf joint, except those at the 6 anchor blocks and on piers 51, 52, 55, 56 and 57 which have been reconstructed, are fitted with a Type 3 bracket. As I have explained before (see here), these brackets are being used to compensate for the lack of steel support under the weakest part of the "I" beams, the sloping ends, but it appears that their use has created more problems!

HIE have admitted that there are tensioning issues at the scarf joints, i.e with the Type 3 brackets, and after a conversation with a civil engineer I will now offer an explanation.

(1) Torque and Tension

This explanation is from the Rimex blog (see here):

To examine stud and nut tension, we'll conduct an experiment that tests the tension achieved in a fastener, given specific amounts of torque. This will demonstrate how friction affects the tension achieved in the fastener, and the dramatic consequences of increasing that friction.

With the help of a Skidmore-Wilhelm torque-tension tester, we will monitor the tension achieved in the fastener with varying amounts of torque. To ensure accurate torque is being applied, we will use the RAD-1800 pneumatic torque wrench.

Using a new stud and a new nut:

ATTEMPT	TORQUE (FT/LBS)	TENSION ACHIEVED (FT/LBS)
1	500	20,000
2	600	28,000
3	700	31,000

At this point, we want to see what the tension will be if we continue to use the same stud and nut, but decrease the amount of torque applied - back to the original 500 ft/lbs. If the result shows a lower tension than was originally achieved, we will then see how much more torque is required to achieve 28,000 ft/lbs (as shown above, this was originally arrived at with 600 ft/lbs of torque).

Results

ATTEMPT	TORQUE (FT/LBS)	TENSION ACHIEVED (FT/LBS)
4	500	17,000
5	800	28,000

With each successive application of the fastener, the amount of tension decreases. To achieve the same amount of tension that we reached in the third attempt, we needed to apply 33% more torque. We made two more applications, at 500 ft/lbs of pressure, and the tension continued to decrease (15,000 and 14,000).

If the tension was found to be too low when the brackets were first fitted around the funicular structure, then increasing the torque will increase the tension. But what this also explains is that if a nut has been slackened off or vibrated loose it requires more torque, i.e turning of a spanner, to attain the same initial amount of tension in the studding. There is, however, a point at which the studding will start to stretch and eventually snap!

(2) The effects of temperature?

(a) If a nut is torqued to a specific setting on a hot day as the temperature drops the studding will contract INCREASING the tension. Thiscould cause the brackets to crush the concrete that they are supposed to be strengthening!

(b) If a nut is torqued to the same setting on a cold day, as the temperature increases the studding will expand DECREASING the tension.

IT'S A NO WIN SITUATION.

(3) Poor working practices!

Anyone who has replaced the cylinder head on an engine will know that the cylinder head bolts have a tightening sequence AND gradually increasing torque settings. The reason for this is to ensure even loading on all parts of the cylinder head. The same applies to the brackets on the "I" beams and the insitu blocks but are even more critical on the type 3 brackets fitted to the scarf joints because there are four lengths of studding as opposed to two. One corner could be putting excessive force onto the concrete at that point. Is that what has happened here?

(4) Heat dissipation.

Stainless steel is one of the worst metals I have ever worked with. Because it has a very low rate of heat transfer, as you tighten and even slacken a nut the heat generated can fuse/ weld the threads of the nut and the studding together giving a false indication of torque, although this should be picked up IF THE TENSION ON EVERY STUD IS CHECKED!

If there is one recurring theme discussed in reports and documents over the lifetime of the funicular it is poor maintenance and repairs.

Even with the current repair work there are more issues.

(B) The two types of ABS plastic caps.

The following picture shows one type of cap as fitted to what I have labeled as a type 3 or scarf joint bracket.

This cap actually has a specific purpose as described here:.

Plastic Nut & Bolt Caps

Plastic nut and bolt protection caps are used to cover hexagon bolt heads or hexagon nuts offering protectio
weather conditions. Simply push on to the hexagon bolt head or the nut. They also create a neat decorative f
and white.

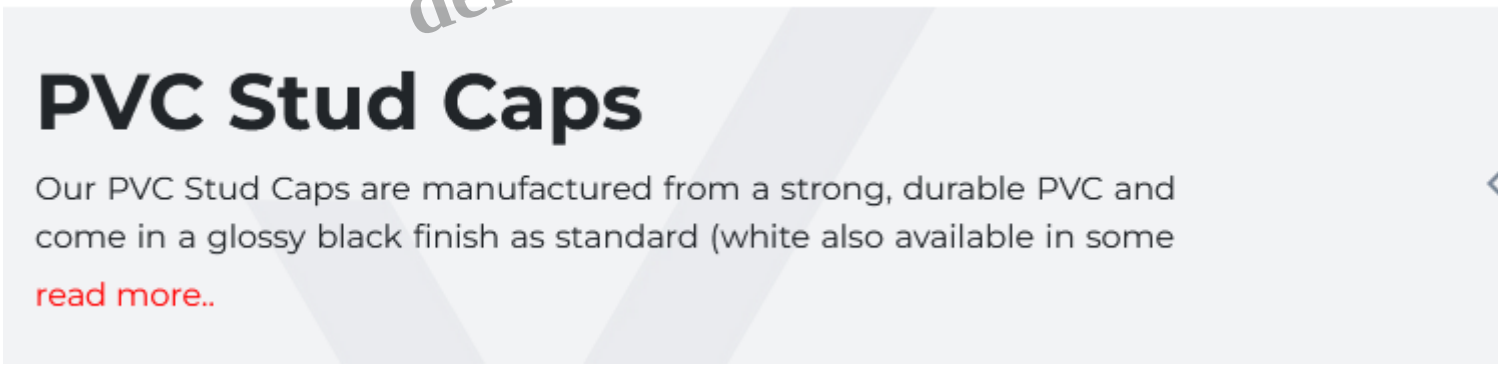
It is used to stop the ingress of water into the threads of the nut/ studding interface which reduces corrosion. The positioning of the caps should therefore have been on the top of all vertical studding NOT the bottom.

Some caps on bottom, none on top of brackets where most needed!

How many times in the past have we been told about poor workmanship and quality control (see photo above and below)? Did someone not carry enough plastic caps to do the job and forgot to get and fit the extra ones? Has nothing been learned from past mistakes? Apparently not.

While not that easy to see there are three black plastic caps on the uphill side but none on the downhill side. The protruding stud on the uphill side, a health and safety risk, has not been capped.

The second type of covering is a plastic tube used to prevent damage to the studding threads and injury to people and should therefore be fitted as a safety precaution to EVERY piece of studding (see here):



And what about this close up from the top-most photo as another example of poor workmanship/ quality control as well as a H & S risk?

Exposed studding with no protective covering or “Tripping Hazard” warning signs just waiting for a moments lapse in concentration by maintenance staff on the new walkway! All excess lengths of studding should have been cut to less than one nut length above/ beyond the nut. Or a better idea, why not order the correct length in the first place instead of paying for material that is not needed?

Conclusion

In a series of PW posts I asked the question “Will the repair of the Cairngorm funicular work?” and at that time concluded that they would. I was wrong. If the repairs had worked then we wouldn’t be in this situation now, the funicular closed and with no definite re-opening date.

Is the problem so bad that without more major work costing £??M the funicular may not open for this ski season? Nobody knows because as usual HIE aren’t saying.

Postscript

I would like to thank everyone who has commented on my posts including the criticisms without which we can’t have an informed discussion. I would in particular like to thank those civil engineers who I have spoken to on the phone. Your help has been invaluable. I hope everyone is having a happy Xmas and a Happy New Year to you all.

Category

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Tags

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Date Created
December 27, 2023
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