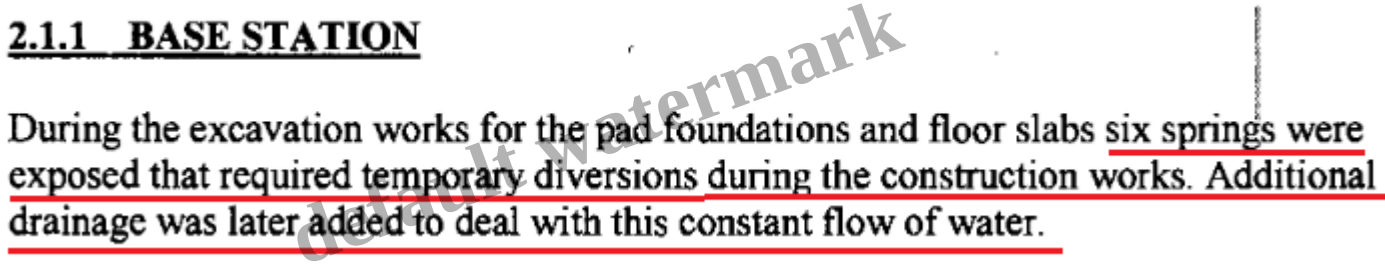
The funicular construction health and safety file and its implications (2)

Description

Last September I described how Highlands and Islands Enterprise (HIE) released the Health and Safety file from the funicular construction nine months after I had requested it and how information within it undermined the official explanation to why the repairs to the funicular had been delayed (see here). With the recent revelations about how HIE has no money to pay for the soaring repair bill (see here), this post takes a look at the information in the Health and Safety file about ground conditions at Cairn Gorm which suggests that the funicular should never have been built and why work should now be halted.

Water, water, everywhere



2.1.1 BASE STATION

During the excavation works for the pad foundations and floor slabs six springs were exposed that required temporary diversions during the construction works. Additional drainage was later added to deal with this constant flow of water.

Screen shots courtesy of HIE FOI.

This and the following extracts are from the first health and safety file (see here)

2.1.2 PTARMIGAN STATION

The existing Ptarmigan structure was demolished leaving the top chairlift station intact and operational. On the full issue of the Implementation Plan excavation work commenced. The rock out cropped very near the surface and heavy machine breakers were utilised for all the excavation works. Blasting was not an option so close to the operational chairlift station as its foundations were unknown.

There was a delay in the design of the structural steel for this building so the planned sequence of construction i.e. as the Base Station could not happen. Box outs were left in the floor slabs down to the pad foundation bolts. The concrete retaining walls could not be built as the structural steel was cast into these walls. As an alternative blockwork walls were built to speed up construction but mainly to allow some external drainage to be installed to divert the substantial spring and ground water flows encountered on the site. Twelve strong flowing springs were encountered during excavation that required pumping or diversion.

3.3 CUT AND COVER TUNNEL

All the vegetation and lichen covered boulders were removed as per the Implementation Plan and stored at the agreed locations. A further layer of gritty soil was found below the organic soil that was also set aside for reuse, this should be noted for any future works at this altitude as it was not apparent in the trial pits.

The rock was drilled and blasted using presplit in an effort to form solid vertical walls to the tunnel. From the SI only the top meter of the granite was expected to be weathered. This was not the case as the weathering extended down the full depth of the tunnel. This point should be noted for any future excavation works in this area.

Due to the blocky nature of the granite it was impossible to form the vertical walls and rock seating shelf for the Asset arch. Concrete block walls capped by a reinforced beam were constructed. The beam was doweled into the rock horizontally for added stability.

The base slab and the arch progressed up from the tunnel anchor block and portal structure. At least twelve strong flowing springs were encountered during construction.

What this shows is that the three single largest elements of the funicular construction exposed strong flowing springs, probably what most of us would call streams, which required pumping or diversion. Twenty-four of which were located right at the top of the funicular, i.e well-placed to flow down the line of the support piers.

Questions that should have been answered at the time and the information recorded in these Health & Safety files are:-

Q1. Where was that water diverted to?

Q2. Where was it resurfacing post-construction?

Q3. Did anyone take note of any new streams appearing that may have been formed by the diverted water?

Q4. If so, were these recorded for future reference?

All this raises the question of whether it is that water that has caused some of the problems that have caused the support piers to tilt? If this volume of water has travelled towards the funicular foundations it could be washing these away! There is no information publicly available to suggest that HIE investigated this issue before deciding to proceed with the repairs.

HIE has also been spending considerable sums on renovating the Ptarmigan, which I understand has been plagued by damp issues. The Health and Safety file shows that the roof was guaranteed for 20 years, raising the question whether it is one of these springs that is causing the damp to rise from

below?

The condition of the bedrock

2.1.3 CUT AND COVER TUNNEL

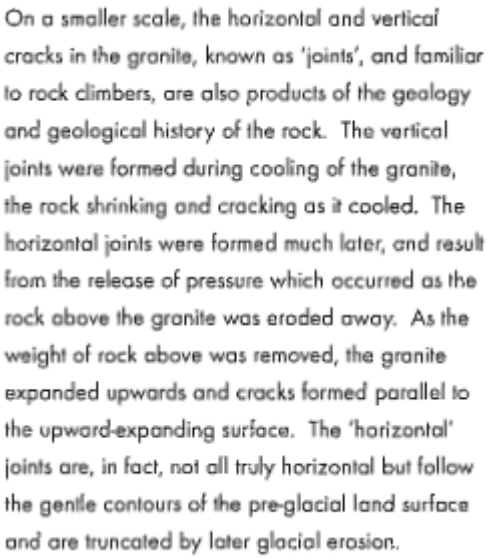
When the Implementation Plan was in place vegetation and soil removal started. A further layer of gritty soil was found under the organic soil. This soil was also set aside for reuse. The presence of this gritty soil is an important point for any future excavation works at this altitude as its extent was not apparent from trial pits.

Rock head was exposed throughout the length of the tunnel and the presplit lines were accurately marked out using GPS (the constant rain wind and mist made the use of optical setting out instruments impossible at times). A trial blast was carried out with the result that all following charges for the blast were reduced. The top meter or so of the granite was expected to be weather from the SI provided. This seemed to be proven from the trial blast. The blasted rock was carefully excavated using machine-mounted breakers for final trimming. For future works it must be noted that the rock was in fact weathered to the full depth of the excavation 6.5m. The interlocking block nature of the weathered granite made it impossible to form clean vertical faces or shelves as per the design but the rock faces formed although loose in appearance were quite stable and safe to work under.

Some of the information from this para is repeated in the extract 3.3 quoted above. The important point is that the “weathered” rock extended at least 6.5m and probably more.

Granite, the rock which forms Cairn Gorm, is an igneous rock known for being very hard, however, that is not the full story. Depending on how it has been formed, it can be as hard as the fine crystalline Granite from Ailsa Craig used for curling stones, or, when coarse and weathered, will end up as a coarse sand as found on the beach at Loch Morlich and causes the damage to ski bases. Cairn Gorm is mostly the latter and the extent of the problem is shown in this paragraph. While most of the funicular foundations are sunk into glacial till, there is no firm rock beneath to anchor the structure.

The next screenshot also helps to explain what is happening:-


On a smaller scale, the horizontal and vertical cracks in the granite, known as 'joints', and familiar to rock climbers, are also products of the geology and geological history of the rock. The vertical joints were formed during cooling of the granite, the rock shrinking and cracking as it cooled. The horizontal joints were formed much later, and result from the release of pressure which occurred as the rock above the granite was eroded away. As the weight of rock above was removed, the granite expanded upwards and cracks formed parallel to the upward-expanding surface. The 'horizontal' joints are, in fact, not all truly horizontal but follow the gentle contours of the pre-glacial land surface and are truncated by later glacial erosion.

Screenshot courtesy of Nature.Scot

The second part of this process is known as isostatic rebound and can also be caused by the melting of the glaciers that once covered the mountain. I have found no mention of this anywhere in the H & S file and yet it should have been a major concern when designing the original build.

Now consider the interaction between these rotten interlocking blocks and the water flowing on the mountain. As an example, if you take a pallet of bricks and pour water over the top layer, it will work its way through and mostly emerge at the bottom layer. However, if you now cover the top layer of bricks with sand or soil (peat) and again pour water over that layer, the water will start to emerge in different places as the sand or soil gets washed through the bricks and starts to block the channels that it was using before.

It appears likely that same thing is happening on Cairngorm, those strong flowing springs will over time change course creating fresh streams when they re-surface!

If a full geo-technical survey had been carried out prior to the funicular project being given the go ahead, it appears likely this would have shown that Cairn Gorm was a totally unsuitable environment to construct a railway. The failure to do so was all down to HIE's vain intent to run a funicular railway up the side of a mountain without proper consideration of all the relevant information and at any cost. Built in haste!

More recently, if a full geo-technical investigation into the reasons for the funicular failure had been carried out, then the £millions now being spent on the soaring repairs bill may not have been wasted! The funicular is basically built on unstable debris and rock which hasn't slipped, YET!

Conclusion

HIE's determination to bring the funicular back into service always returns to their stated belief that it

underpins the Strathspey and Badenoch economy and is necessary for snowsports on Cairn Gorm. What I hope I have shown here, and with my previous seven posts “Will the repair of the Cairngorm Funicular railway work?”, is that alongside the design issues Cairn Gorm was and is a completely unsuitable and **UNSTABLE** environment on which to build a train line.

The unstable ground conditions don’t affect chairlifts and tows to nearly the same extent because they:-

(1) require and use far fewer piers than the funicular;

(2) cause less strain on the foundations due to their lighter construction, and,

(3) are easier and cheaper to repair or replace when necessary.

In my seventh post on “Will the repair of the funicular work” (see here) I referenced the collapse of a railway in Mexico City. Given the flow of water and the ground conditions have HIE been lucky in the past that the funicular has not collapsed causing injury or even worse, loss of life? Will they be as lucky again?

Category

1. Cairngorms

Tags

1. Cairn Gorm
2. funicular
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