The Achilles heel of State Highway 3

By Giancarlo (John) Hannan

News that the Manawatu Gorge road will be closed indefinitely has raised a storm of protest from residents and businesses in the lower North Island. Why is the route so unstable and what are the options going forward?

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Imagine if the southern approach to the Auckland Harbour Bridge was regularly blocked by rock falls from the adjacent bluffs and traffic had to divert through the upper harbour, and the best that the roading authorities could do is clear the road, year in and year out. The howls of Auckland commuters and transport operators would be deafening, and politicians would be scrambling to be seen as the first to demand answers.

A parallel type of situation currently exists in the lower North Island where a short but critical link of road on State Highway 3 (SH3) through the Manawatu Gorge is closed again due to landslides, but this time the closure is indefinite as the area is considered unsafe for work.

Closures of this logistics corridor are regular: from 2004 to the present day, this link road has been closed for around 550 days – and at increasingly frequent intervals. Thousands of commuters and hundreds of businesses incur extra costs and inconvenience every day this link is closed, yet it has taken 13 years for the government to seriously explore a solution. The alternate routes of the Saddle Road and Pahiatua Track are both substandard and not viable long-term solutions.

Corporate Logistics has calculated that conservatively these closures cost around $100,000 per day to the regional economy.

This equates to around $55 million in the last 13 years. In addition, over $30 million has been spent by the NZ Transport Agency (Transit NZ prior to 2008) on emergency work and repairs during this period. Conservatively, a further $15 million has been spent in upgrades or repairing the damage to the alternative routes.

In short, over $100 million has been jointly incurred by road users and the NZTA/Transit NZ following periodic closures of SH3 through the Manawatu Gorge since 2004, and this cost continues to rise as time ticks on.

THE CAUSE OF FAILURE – GEOLOGICAL SPEAK

The Manawatu Gorge opened in 1872, so it is a very old link road of economic significance. The problems with the rock falls and landslides have become more prevalent since the major road widening and straightening initiatives when the slopes of the gorge became a lot steeper. Recently, heavier vehicles may have exacerbated the problem, but this is anecdotal.

The geology of the Manawatu Gorge is composed of interbedded, indurated (hardened) greywacke sandstone and weaker, brittle and sheared argillite i.e. mudstone – try saying that rapidly after four beers! These rocks belong to the Esk Head Belt Formation of the Torlesse Supergroup (Triassic age) and are 140–200 million years old (My). The sequence contains thick bands and lenses of chert, limestone, submarine volcanics and red argillite.

Over millions of years, these rocks have been subjected to extreme tension and pressure from the adjacent plate boundary subduction zone. The Manawatu Gorge rocks are now highly deformed, brecciated (broken up) and excessively fragmented.

There is little cohesion within the formation, apart from the harder sandstone, and the materials are now highly susceptible to slope failure, especially when slopes become too steep.

The angle of bedding and foliation (layering) in the Manawatu Gorge is generally between 55–80 degrees to the east and southeast. This leads to the interbedded harder sandstones forming the more erosion-resistant sandstone bluffs that are visible in most photos of the gorge.

The weaker connecting argillite bands are easily eroded and highly prone to failure, hence the landslips. There are 18 sandstone bluffs on SH3 as it passes through the Manawatu Gorge. Each bluff is interlinked with a mixture of fractured argillite.

Thick deposits of prehistoric landslide colluvium (rock debris) cover both sides of the Manawatu Gorge. It is thought these materials began to be eroded away from the in-situ bedrock as the ranges emerged from the sea 1.5 My ago as uplift progressed.

The planar surface of the Ruahine and Tararua Ranges represents an old erosion surface. Over the last 5 million years this surface has been overlain with thick marine sediments and terrestrial alluvial gravels. These materials are also a potential source of easily eroded material on the north side of the gorge.

In summary, the flanks of the Manawatu Gorge are composed of prehistoric landslide colluvium interspersed between the harder more erosion-resistant sandstone bluffs. These fractured and sheared materials covering the sides of the gorge are the source of slope instability. It is difficult to mechanically bond these loose and unconsolidated materials, so any remedial slope stabilisation measures are heavily reliant on the harder sandstone bluffs.

MAN-MADE INTERVENTIONS

The cause of repeated slope failure of SH3 through the Manawatu Gorge is well known by geologists and geotechnical slope engineers. By far the greatest cause of slope instability is directly attributable to the continual road widening and straightening since the road's inception in 1872.

There have been two major periods of works – in the 1920s–1940s and in the 1960s–1980s – to widen and straighten the road. Each period has preceded a new era in slope instability.

In contrast, the opposite side of the gorge with the railway line has experienced less slope instability. The railway has suffered fewer slope instability movements for two reasons: firstly, the smaller cuts required for the railway have required less of the toe slope support being removed; and secondly, the use of tunnels bypassing the steeper portions of the gorge avoids adjacent toe slope interference.

Conversely, on SH3 there has been repeated removal of the adjacent toe support on the slopes where they meet the roadway as it traverses the gorge. This has stimulated numerous slope instability episodes as the basal support was removed. Consequently, the road has been regularly inundated with debris.

Excavations in the 1980s trimmed back 15 of the gorge's 18 strongly jointed sandstone bluffs. This directly caused several small to moderate rock falls (colluvial debris falls). Mesh, rock bolting and drainage stabilisation measures were immediately installed to prevent further erosion of the slope faces.

Significant slope failure (necessitating closure of the road) did not occur until 1990 when a 5000 cu m landslide occurred. The slope failure problem and road closures accelerated from 1990 with several large events, with the largest landslide in 2011 measuring 160,000 cu m. These events have become the Achilles heel of the Manawatu Gorge, undermining its operational efficiency.

These recent failures are related to the aggressive trimming of the harder sandstone bluffs earlier in the 1980s where the toe of the slope was undercut to recess the line of the slope away from the road. This provided a 'safe' area to accommodate small rock falls following prolonged high-intensity rainfall.

The overall negative effect of this work, however, was two-fold. Firstly, it remobilised the toes of the ancient landslide deposits that line the side of the gorge; secondly, it destabilised the already fractured, weakened and landslide-prone argillite rock. The upshot? An ongoing problem for the future.

RIVER ACTIONS

Massey University has dated an aggregational terrace at the western entrance to the Manawatu Gorge. The terrace is thought to have formed at the end of the last glaciation some 12,000–13,000 years ago. It lies approximately 50 m above the current bed of the Manawatu River.

This suggests that 12,000–13,000 years ago the base of the river was 50 m higher than it is today, and indicates the river has down-cut its base at a rate of 4 m per 1000 years since the end of the last glaciation.

Based on this rate of down-cutting, the river is rapidly (geologically speaking) incising down into the underlying bedrock base. This high rate of down-cutting is potential testament to the fractured and fragmented nature of the underlying bedrock