Repair of Major Road Embankment Failure Using Reinforced Earth (re) wall

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Abstract

A case history of repair works of major road embankment failure along Genting Highlands to Bukit Cincin, Pahang is presented. Failures at 10 locations along Genting Highlands to Bukit Cincin road occurred on 30th October 1997 during the monsoon seasons. The repair works at Location 1 using reinforced earth wall was considered since there was enough space available at the downslope section and also the soil at the downslope section of the failed embankment was strong enough to construct the wall safely. This paper fully explained the details remedial works using reinforced earth wall at Location 1.

Introduction

In Malaysia, like in many other tropical and subtropical countries, rocks are weathered at great depth as a result of warm and wet climatic conditions. Othman (1990) explained that deep cuttings into residual soils suffer severe instability problems particularly during the wet seasons between October and February.

As mentioned by Neoh (1997) and Omar at al. (1997), the roads in mountainous terrains of tropical regions are characterized by steep and deep weathered rocks which are prone to landslide and slope failures during prolong intense rainfall. Rain induced landslide and slope instability are really a costly recurring problem faced by many tropical countries like Malaysia. Millions of ringgits are spent in slope repairs. Slope stability depends on the complex interplay between slope gradient, geological conditions, soil properties and ground water condition of which they are all of dynamic in nature. It is also influence by the road design, its construction and maintenance. This paper presents the detail remedial works to repair a major road embankment failure.

Background Of The Road

The Genting Highlands to Bukit Cincin road is a road linking the Genting Highlands and the Department of Civil Aviation (DCA) Radar station. Figure 1 shows the location plan of the road while Figure 2 shows the location of the road failure. The total length of this hilly and winding road was about 2 km and it was 3.5m wide. It was constructed 1975. On 30th October 1997, 10 locations of road instability or failure had occurred during the monsoon season. Of the 10 repaired locations, the repair works at Location 1 is fully

Fig. 1 : Location plan of the failed Road near Genting Highlands town.

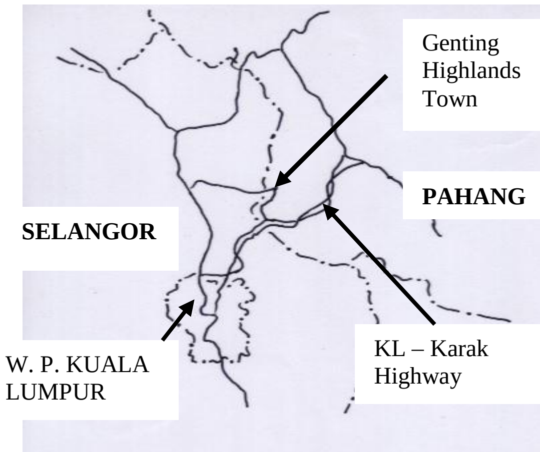
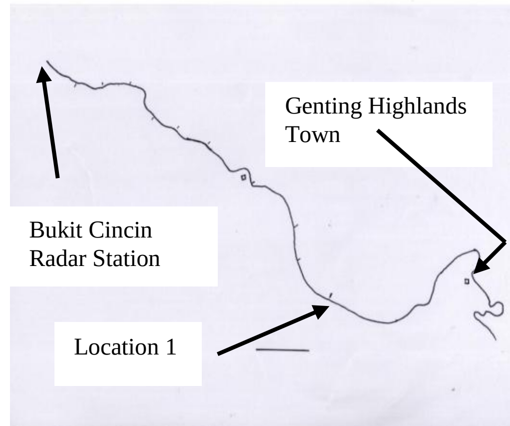


Fig. 2 : Location of road failure at Location 1



described in detail. The total cost of the repair works was RM 3.7 million and was repaired on design and construct basis. The site possession was on 10 May 1999 and was completed on 15 May 2000.

Causes Of The Failure

The road embankment was totally collapsed and was impassable to vehicles. The existing pavement, drains as well as gabion stabilizing and supporting the embankment at its toe also collapsed. Temporary access was carried out by Genting Berhad by dumping soil on the failed embankment so that vehicles can pass through the failed road.
The causes of failure for this embankment were predominantly due to (a) soil erosion since roadside drains were not connected to cascading drain to lead rain water and surface runoff to the toe of slope and (b) improper compaction of the fill material resulting in critical battering of the slope. Erosion caused the toe of slope to progressively fail. Figure 3 shows erosion causing the major road failure while Figure 4 shows the failure at Location 1.

Fig. 3 : No cascading drains causing erosion which lead to embankment failure.

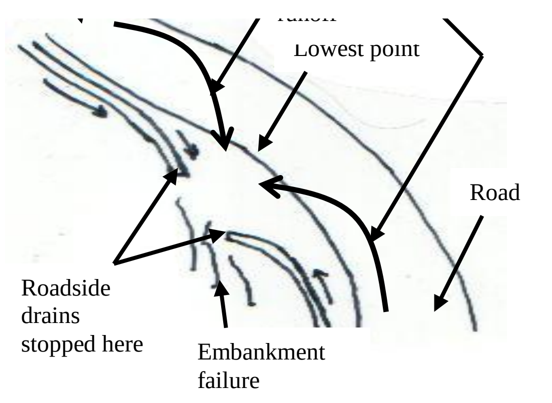
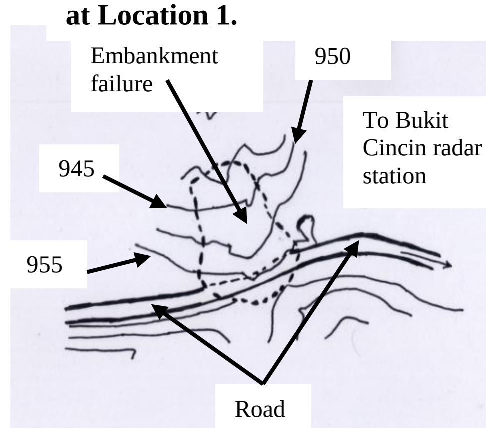


Fig. 4 : Road embankment failure at Location 1.



The shallow slips retrogressively moved towards the crest of the embankment created instability to the embankment. As this phenomena proceed, slumping of soil mass occurred and forming a vertical scarp at the crest of the embankment as described by Bumi Hiway (1998). Figures 5 and 6 show the road embankment failure.

Fig. 5 : Major road embankment failure.

Fig. 6 : Another view of the road embankment failure. The road was totally impassable to vehicles.

Reinforced earth wall was suitable and used as the repair works for the failed embankment since the soil to place the wall was strong and also enough space was available to place the wall safely as recommended by Neoh et al. (1997). The base of the wall was decided at 9.5m below the existing road level. From BH/1, at this level, the soil type was medium dense clayey SAND with SPT N value of 9.

Fig. 7 : The plan view of the repaired zone

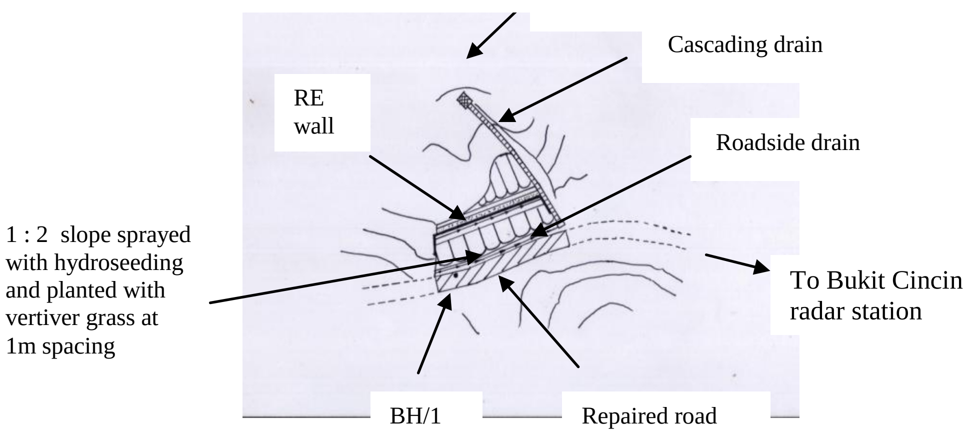
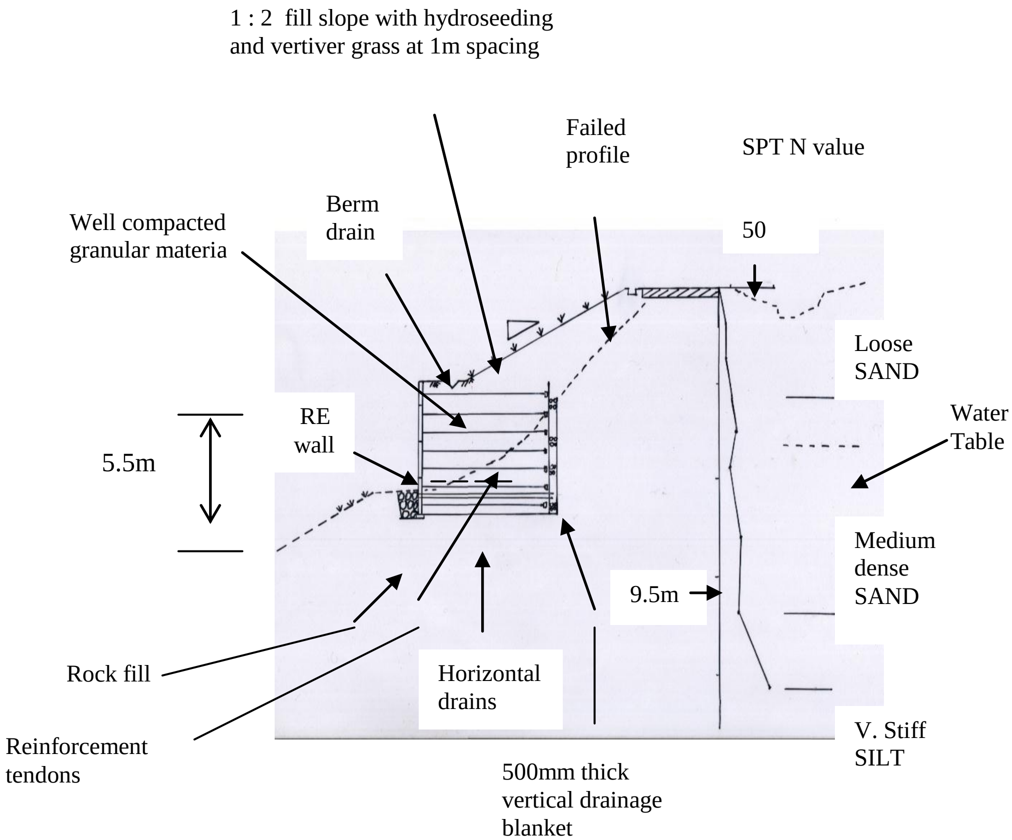


Fig. 8 : Typical cross section of the repair works and the results of BH/1.



The wall height was 5.5m by 5.9m wide and about 29m long. Figure 7 shows the plan view of the repaired zone while the typical cross section of the repair works and the results of BH/1 are shown in Figure 8.

A minimum horizontal distance of 2m was provided between the toe of the reinforced earth wall and top edge of down slope. Weak and failed materials were removed and the base was placed on firm ground. JKR probe tests were carried out to confirm the allowable bearing capacity of the base. Figure 9 shows JKR probe test is in the progress of being carried out.

A vertical drainage blanket 500mm thick was constructed between the reinforced earth wall and the existing embankment. It consisted of gravel wrapped with filter geotextile material. Rock fill 300mm by 600mm wrapped with geotextile TS20 was placed at the front toe of the reinforced earth wall as shown in Figures 10 and 11. Horizontal PVC drains 150mm diameter with spacing of 6000mm were placed almost at the base of the reinforced earth wall to drain groundwater collected in the vertical drainage blanket to the rock fill. Good external and internal drainage must be provided as recommended by Jones (1985) since large catchment area and also water table was found at 6.5m below road level. Drainage was provided by rock fill at toe, berm drain and shoulder drain in which all were connected to a cascading drain. Stone filled gabion mattress was constructed at the toe of the cascading drain to prevent toe erosion as shown in Figure 7.

The reinforced earth wall consisted of hexagonal shaped precast concrete panel connected to hot dipped galvanised reinforcing tendons as shown in Figures 12 and 13.

Precast anchor blocks were placed at the end of t
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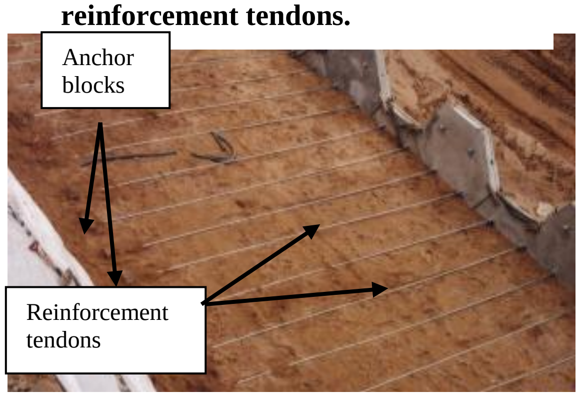
Fig. 9 : Conducting JKR probe at the base level.

Fig. 10 : Trench is excavated at the toe of RE Wall to construct the Rock Fill.

Fig. 11: Gravel wrapped with geotextile is placed into the excavated trench to form Rock Fill.

Fig. 12 : Erecting the RE Wall.

Fig. 13 : Laying of the galvanised reinforcement tendons.



as the backfill material. Above the reinforced earth wall, slope with gradient of 1 : 2 was reconstructed as mentioned by Bumi Hiway (1998).

Hydroseeding grass was sprayed and vertiver grass at 1m spacing was planted on the reconstructed slope while at downslope, 3 rows of vertiver grass at 1m spacing were also planted. Berm drain and roadside drain were connected to a cascading drain with stone filled gabion mattress at its toe. Figure 15 shows the berm and roadside drains. The damaged road was also reconstructed on the pile embankment. Partially completed repair works are shown in Figure 14 while the fully completed repair works are shown in Figure 16.

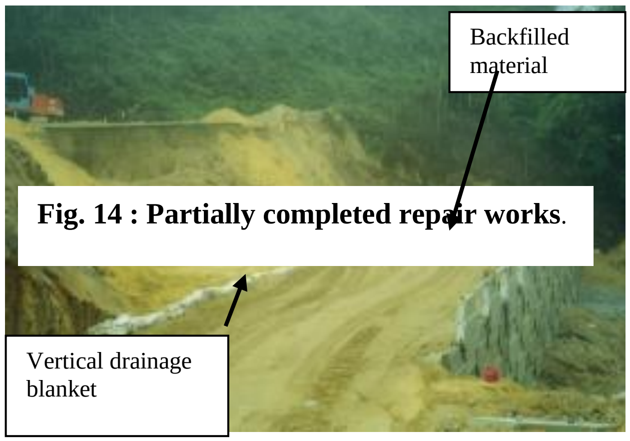


Fig. 14 : Partially completed repair works.

Fig. 15 : New roadside drain is constructed. Road shoulder is turfed.

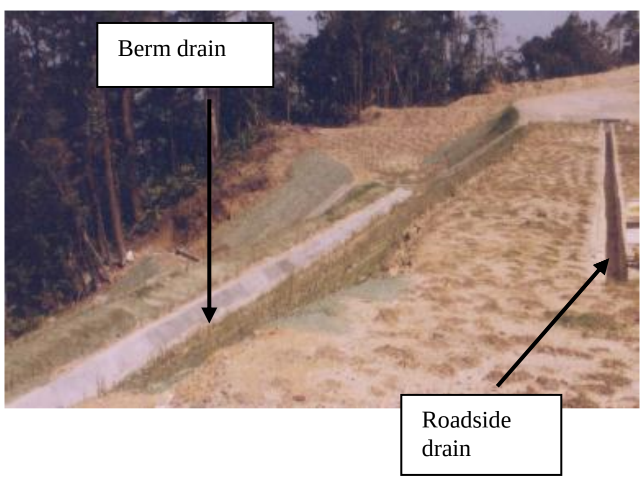
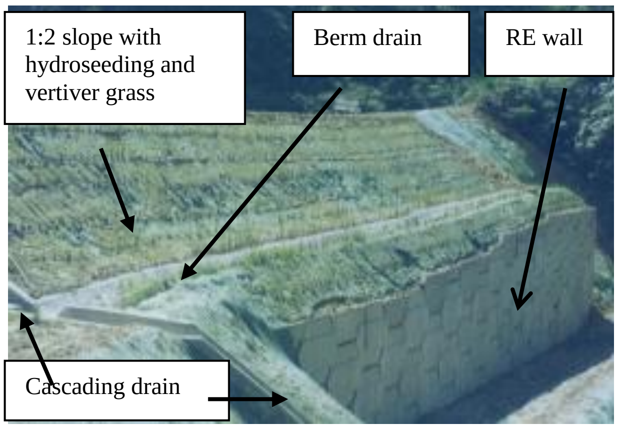


Fig. 16 : Completed RE wall with berm drain and cascading drain.



Conclusions

a) If the space at the downslope is large enough and the soil is strong, reinforced earth wall is an option to repair major embankment failure.

b) If the water table is high, suitable internal drainage systems such as vertical drainage blanket, horizontal drains and rock fill at toe of the wall must be provided.

c) Roadside drains, berm drains and cascading drains connected to stone filled gabion mattress must be provided to cater for surface runoff.

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