CHAPTER FIVE

5.0 STABILITY OF CUT SLOPES IN THE STUDY AREA

5.1. Introduction

Ukay Perdana area is a developing community with continuous building activities and road construction. There are thus only left a few natural slopes with accessibility to them limited by a thick canopy of vegetation and steep slope angles. Hence most of the slopes are man-made cut slopes with houses and roads being dangerously built both on the tops and at the foots of the slopes. No failures have furthermore, been observed where benched slopes and retaining walls have been constructed. In the areas with natural vegetation cover, no failure was observed as the plant roots have probably helped to increase cohesion while the leaves intercept rain drops that could otherwise lead to a decrease in cohesion.

For the purpose of this research project, field investigations were carried out at a number of cut slopes both stable and where failures have occurred. This chapter describes the sites, the slope stabilisation methods applied, and the suitability of such techniques in terms of possible slope failures. The failure modes involved finally are compared with similar situations reported in literature, and suggested mitigation methods outlined.

5.2 Failures of cut slopes in Ukay Perdana

Pronounced failures occurred in Jalan UP 5/7, Jalan UP 3/1, Jalan UP 3/2, and adjacent to Sri Baiduri apartment. Other minor failures encountered involved small volumes of materials, with the failed materials sometimes retaining its original shape after failure, though usually disaggregating to form shallow heaps at the foot of the affected cut (Raj 1983). The older unbenched slope cuts of steep slope angles were however affected by shallow slips (fig. 5.1).

The type of failure encountered in Jalan UP 5/7, Vierra Ukay is Topple within the slightly weathered zone. The failure here was initiated by rapid layer separation with movement in the direction of the excavation. It is closely observed that there were presence of cross joints which were associated with the block weight and stress relief forces. Figure 5.2 shows the overturning of the rock block.

Complex failure was observed in Jalan UP 3/1 beneath Summer Set Villa, on an unbenched slope cut of up to 80m high. It is of the opinion of the writer that this failure occurred because of the heavy vibrations resulting from the general constructions of the numerous houses and streets of Summer Set Villa, as well as water movements down the slope . Intense, short period rainfall and prolonged high rainfalls are major causal factors; the gradual disintegration of the bedrock encouraging infiltration and, starting with hair-line cracks that subdivide the weathered materials into angular fragments. The failure at this location involved rockfalls and planar sliding. Hanging nets were employed as protection for blocks tumbling from above (fig.5.3a and 5.3b). It is observed that a portion of the rockfall detached itself and underwent a planar sliding. Figure 5.4 is a schematic diagram that clearly shows the profile of this complex failure.

Wedge failure occurred in Jalan UP 3/2. Big rock blocks fall, break, and slide along joint planes. The geometric boundaries imposed by the orientation, spacing and continuity of the joints, as well as the free surface boundaries imposed by the excavation, define the modes of failure. Woven wire fence were built to keep the rocks from tumbling forward out of the face of the slope (fig. 5.5).

Adjacent to Sri Baiduri Apartment was a relatively earth slump (Fig. 5.6). This failure occurred during the rainy season. The clayey material which was highly to completely weathered bedrock detached and slipped down as an apparent coherent mass, but remained on the slope, leaving a scalloped hollow. A bulge of materials (toe) developed at the base of the slope and the slump scarp exposed the roots of the trees making the trees susceptible to fall.

Other minor failures were observed during period of heavy rainfall with the primary maximum rainfall occurring from September - November while the secondary maximum occurs from March –July, with June being the highest month of rainfall.

Fig.5.1. Shallow slips at older unbenched cuts.

Fig.5.2. Topple in Jalan UP5/7. The rock block in position “B” overturned from position “A” due to cross jointing, the block weight, and stress relief forces.

Fig. 5.3a. Photograph of the complex failure involving rockfalls and planar sliding

Fig. 5.3b. Hanging nets protecting the tumbling blocks at the base of the cut.

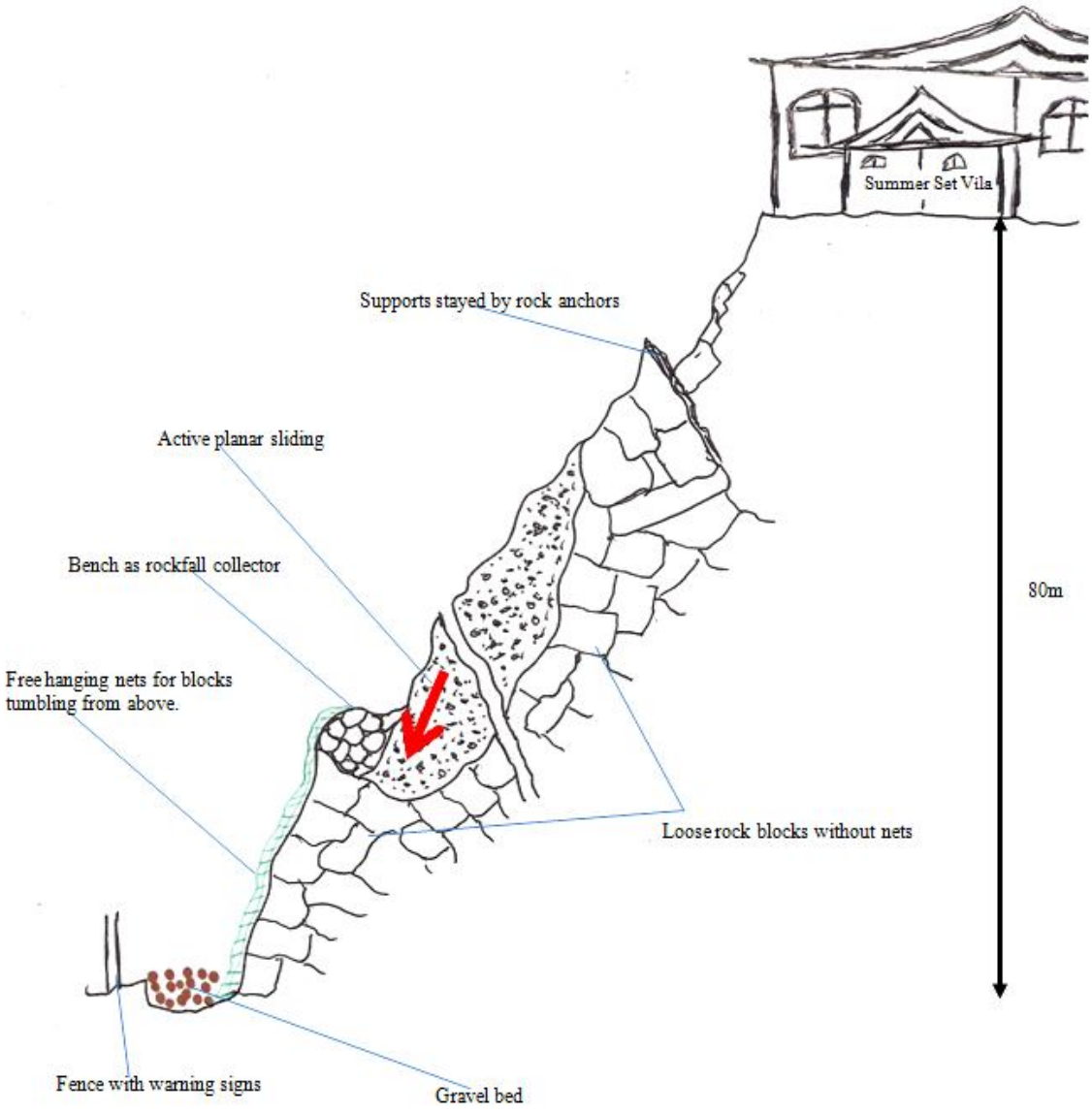

Fig. 5.4. Schematic diagram showing the profile of the complex failure at Jalan UP 3/1.

Fig.5.5. Wedge failure in Jalan UP 3/2.

Fig. 5.6: A slump type of failure adjacent to Sri Baiduri apartment.

5.3 Cut slope stabilization methods in Ukay Perdana

Most parts of Ukay Perdana are made up of cut slopes. Developers in this study area have employed various methods to stabilize the cut slopes. Some of the methods employed include;

i. Guniting- whereby the wire mesh is installed with pipes onto the wall. The gunite is then produced by means of pressure applied through a continuously feeding pressure vessel. This method is employed to increase the resisting force of the rock slope (fig.5.7).

ii. Benched slope- This method of reducing the driving force is shown in figure 5.8.

iii. Flattened slope by grading

iv. Retaining walls- Fig 5.9 shows a section of the retaining wall in Taman Ukay Perdana.

v. Drainage hose- Subsequent to the failure in Jalan UP 3/1 beneath Summer Set Villa, two large drainage hoses were installed to collect run-off water from the residential units down the slope and emptying into the gutter drain at the foot of the slope (figs. 5.10a and 5.10b).

Fig.5.7: Guniting – Wire mesh used with pipes almost half buried within the sprayed concrete.

Fig.5.8: Photo of benched slope in Vierra Ukay.

Fig. 5.9. Retaining walls in Taman Ukay Perdana.

Fig. 5.10a. Drainage hose from Summer Set residential units down the slope.

Fig. 5.10b. The drainage hose empties into the gutter drain at the foot of the slope.

5.4 Possible future instability of slopes

In view of the failures that have occurred, it is expected that similar failures may occur in the future, especially at the steeper cuts (fig. 5.11). The growth of the city and the tradition of the wealthy to build prestigious homes along slope cuts led to the relatively rapid development of the slopes in Ukay Perdana. As cuts are made into the slope of the steeper parts of the sites, slope stability problems will increase. Exposure of partially weathered bedrocks in cuts may result in severe damage if the surface water is not controlled, thereby causing planar sliding, rock falls, and slumping by intense rainfalls.

Though accessibility for detailed study to the site between Jalan UP 3/2 and Taman Ukay Perdana was denied, the steep cut in this very site exposed moderately weathered bed rock devoid of vegetation cover. Considering the steepness of the cut, no drainage hose installed to control surface water and no gutter drains at the foot of the slope, prolonged intense rainfall can possibly trigger failure. Under such heavy rainfall conditions, water can penetrate rapidly through the discontinuities between the moderately weathered materials, and may lead to changes in permeability and thus the build up of high pore water pressures which can trigger slumping. Moreso, the vibrations caused by heavy construction machineries down the slope might trigger rockfalls.

There is possibility of future sliding and rock falls of the loose materials along the steep cut in Jalan UP 3/1 beneath Summer Set Villa. These loose materials and plant debris are constantly splashed and washed down the slope during heavy rainstorms. The free hanging nets are torn and worn out (fig. 5.3a and 5.3b) and cannot hold further tumbling blocks and loose materials.

Burning and clearing of vegetation along cut slopes in Jalan UP5 Vierra Ukay (fig. 5.12) can weaken the cohesion of the rock materials and enhance penetration of surface water, and further movement of rock debris down the slope.

Future failure sites might be further identified as the development of the study area is rapidly on the rise.

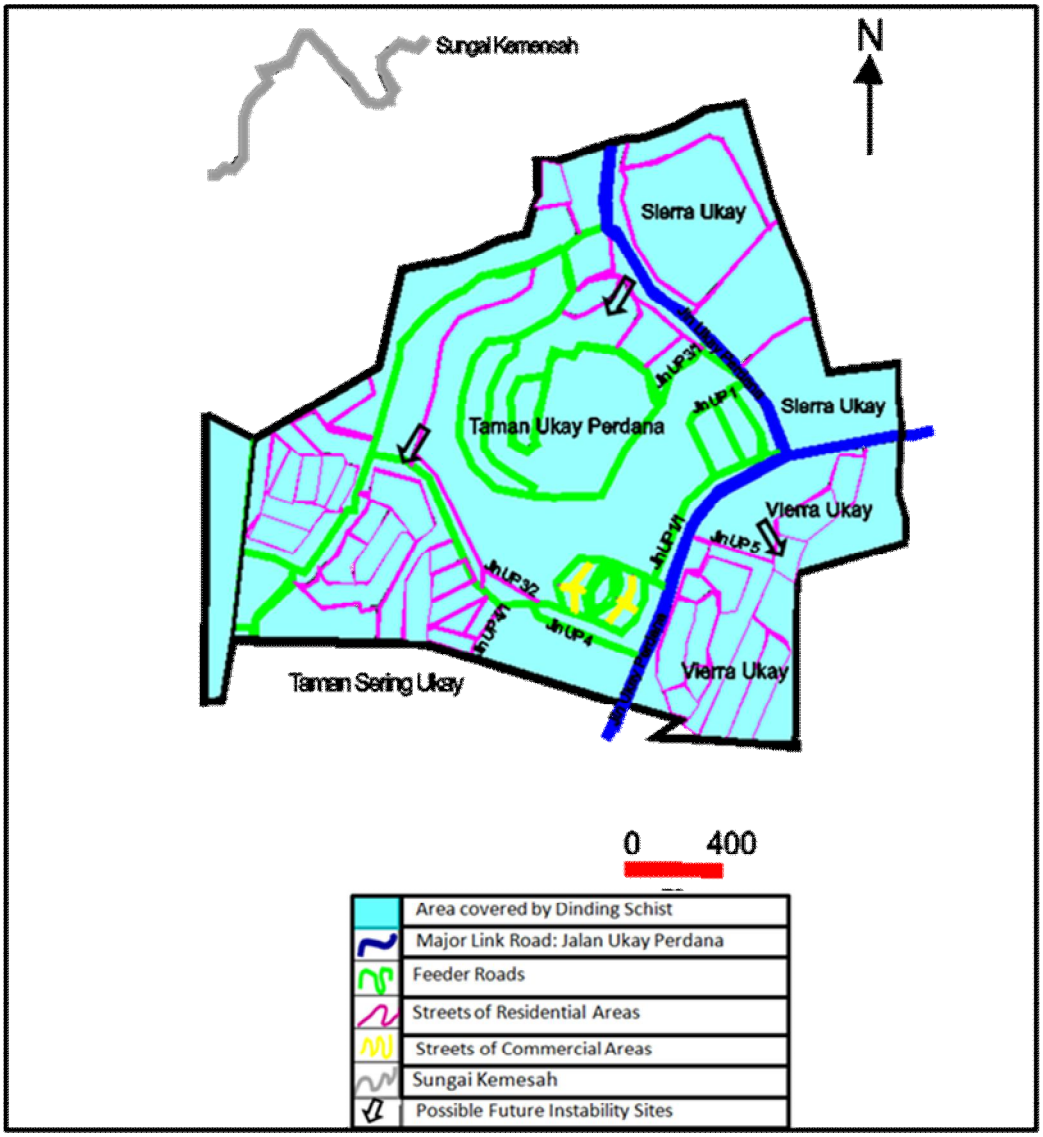

Fig. 5.11. Location map of study area showing possible future instability sites.

Fig. 5.12. Burning and clearing of vegetation in Jalan UP5.

5.5 Suggested mitigation methods for future failures

How unstable a slope is depends on many environmental factors, and so mitigation of slope failures can be complicated. However, the mitigation of slope failures often needs to be prescribed on a case by case basis because every slope is unique. Considering the cut slopes in the study area, future slope failures can be mitigated thus:

i. Avoid the failure hazard:- Development should not be carried out on top and along very steep and very high cut slopes.

ii. Protect the site from future failure:- to minimize the effect of failures, building of diversion or barrier walls, fences, or embankments are strongly advised following completion of slope excavation, since most slides occur some months after slope excavation especially during continuous rainfall.

iii. Reduction of driving forces:- as suggested by Abramson et al (1996), failure hazards in Ukay Perdana can be reduced by installing more drainage hoses in areas of high and steep cuts to reduce the effect of surface water, construction of benched slopes especially behind Sri Baiduri apartment areas, behind Jalan UP 4/4, and behind Sri Wira Rivera Rise Apartment in Sierra Ukay.

iv. Increase in resisting forces:- this can be achieved by pinning individual blocks, covering the slope with mesh or net, or installing rock anchors or rock bolts on dense spacing. This is advised to be carried out on the slope beneath Summer Set Villa along Jalan UP3/1, and the steep slope located between Jalan UP3/2 and Taman Ukay Perdana.

v. To alleviate build-up of pore pressures, construction of proper drainage systems in the study area and especially northwest of Sierra Ukay should be carried out.

vi. Finally, the government should impose stringent conditions for building along slope cuts, and also educate the public on potential hazard zones.