# LANDSLIDE RISKS ALONG MAJOR ROADS HEADING TO UiTM PAHANG

*Mohd Fairuz Bachok*
*Mohd Razmi Zainudin*
*Wan Zukri Wan Abdullah*
*Noraida Mohd Saim*
*Rohaya Alias*
*Faculty ofCivil Engineering, UiTM Pahang*
*mohdfairuz@pahang.uitm.edu.my, razmi74@pahang. uitm.edu.my, wanz@pahang.uitm.edu.my.*
*aidams2000@pahang.uitm.edu.my, rohaya_alias@pahang. uitm.edu.my.*

**ABSTRACT**

*Series on landslide that had taken placed along major roads heading to UiTM Pahang namely lerantut to UiTM Pahang road, Maran to UiTM Pahang road and Temerloh to UiTM Pahang road indicates that slopes alongside those particular roads have a potential oflandslide occurrence. This is due that alongside those roads have many slopes. Landslide is one ofthe natural disasters in Malaysia and commonly occurred during rainy season. Landslide will pose serious threats such as damages ofproperties, claim life and injuries and delays development planning. In Malaysia, most ofthe landslides have occurred on cut slopes or on embankments alongside roads and highways in mountainous areas. When a landslide occurred at any location along the road, it does not only block the road and cut offthe connection from one place to another but also might cause the risk ofinjury or deathfor those using the road Thus, this study is carried out to identify slopes that prone oflandslide occurrence, so that UiTM Pahang staffshould take further action and precaution every time they are travelling near to risk slopes at those particular roads. Beside than highlighted information oflandslide risk early warning, this study also will highlight which ofthose roads should be given a priority in preventive measures. Therefore, it is hopes that this study could become and initial example for preventive action ofstaffsafety not only for UiTM Pahang but also for others UiTM campuses especially that are constructed on uneven terrain.*

**Keywords :** *landslide risks, major roads, UiTM Pahang*

## INTRODUCTION

Cut-off the connection, claimed life, injury to the road users and damages of the road structures are the some examples of adverse effects if landslide had taken placed on the slope alongside the road. Study by a variety of researchers such as (Varnes, 1984) found that landslide has a potential damaging phenomenon where risks are lives lost, persons injured, damage to property and disruption to economic activities. Wilson (2004) added another two more consequences which are knock down trees and obstructing drainages and roadways. Nakano and Miki (2000) agreed that landslides could be divided into two types which are direct and indirect losses. Direct losses included losses due to injury or death and the cost restoring the damaged road while indirect losses included time losses, travel cost losses and office operating losses. In Malaysia, the locations that landslide commonly take place are roads and highways constructed in mountainous areas (Lee and Pradhan, 2006).

Road is a major transportation being used by UiTM Pahang staff to go back and forth for work to UiTM Pahang. However, some of them do not live nearby UiTM Pahang but reside in Jerantut, Maran and Temerloh districts. Due to that, they need to use any of these three roads heading to UiTM Pahang namely Jerantut to UiTM Pahang road, Maran to UiTM Pahang road and Temerloh to UiTM Pahang road **(Figure** 1). All these roads have many cut slopes or embankments alongside it which are potential to cause adverse effects if landslide occurs. On the other hand, staff that live in Jerantut, Maran and Temerloh district actually will face a possibility of landslide occurrence at least twice a day in working days.

Series of landslide that occurred at these three roads prove that these three roads have a high possibility to experience landslide occurrence in the future **(Table 1, Figure 1 and Figure** 2). Therefore, this study was carried out to identify landslide risks along those particular roads, so UiTM Pahang could take extra precaution at risk locations especially during risk time. Finding from the study also will assist local authorities to plan preventive measures.

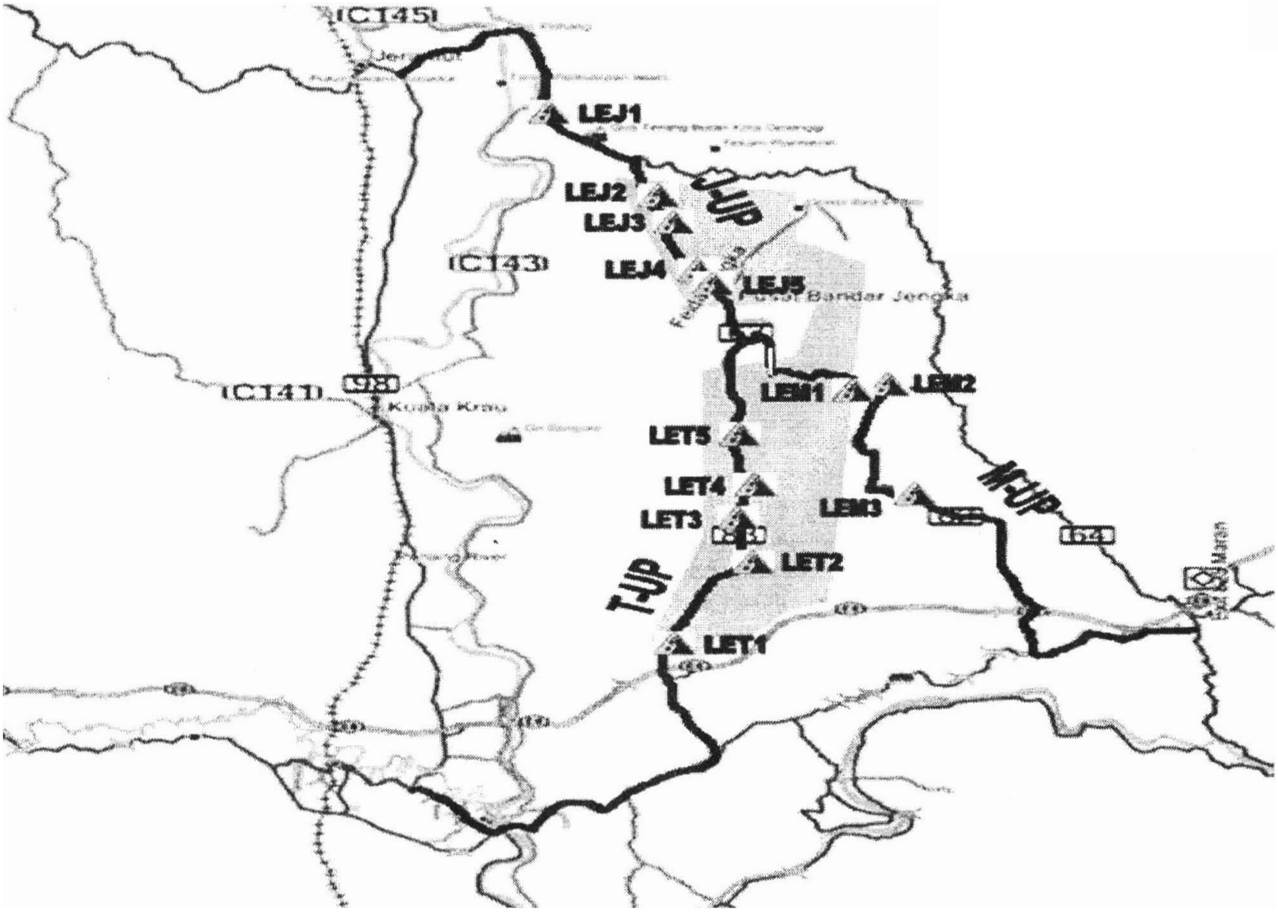


Figure 1 : Major roads heading to UiTM Pahang and locations of landslide occurrence

Table 1 : Series of landslide occurrences at major roads heading to UiTM Pahang

| No. | Road | Landslide occurence | Longitude | Latitude | Year occurence | Total |
|---|---|---|---|---|---|---|
| 1. | J-UP | LEJI | N 3° 54' 45.3" | E 102° 26' 47.7" | 2010 | 5 |
| | | LEJ2 | N3° 51'16.6" | E 102° 29' 46.8" | 2009 | |
| | | LEJ3 | N 3° 50' 35.3" | E 102° 30' 21.3" | 2011 | |
| | | LEJ4 | N 3° 50' 07.2" | E 102° 30' 28.2" | 2011 | |
| | | LEJ5 | N 3° 49' 59.7" | E 102° 30' 28.9" | 2011 | |
| 2. | M-UP | LEMI | N 3° 39' 38.8" | E 102° 37' 22.4" | 2010 | 3 |
| | | LEM2 | N 3° 43' 57.1 " | E 102° 36' 42.3" | 2010 | |
| | | LEM3 | N 3° 43' 57.7" | E 102° 36' 42.0" | 2011 | |
| 3. | T-UP | LET! | N 3° 34' 47.6" | E 102° 31' 00.5" | 2011 | 5 |
| | | LEU | N3° 37' 13.1" | E 102° 32' 33.0" | 2011 | |
| | | LET3 | N 3° 40' 22.6" | E 102° 32' 38.6" | 2011 | |
| | | LET4 | N 3° 41' 14.8" | E 102° 32' 29.5" | 2010 | |
| | | LET5 | N 3° 42' 04.9" | E 102° 32'23.8" | 2009 | |

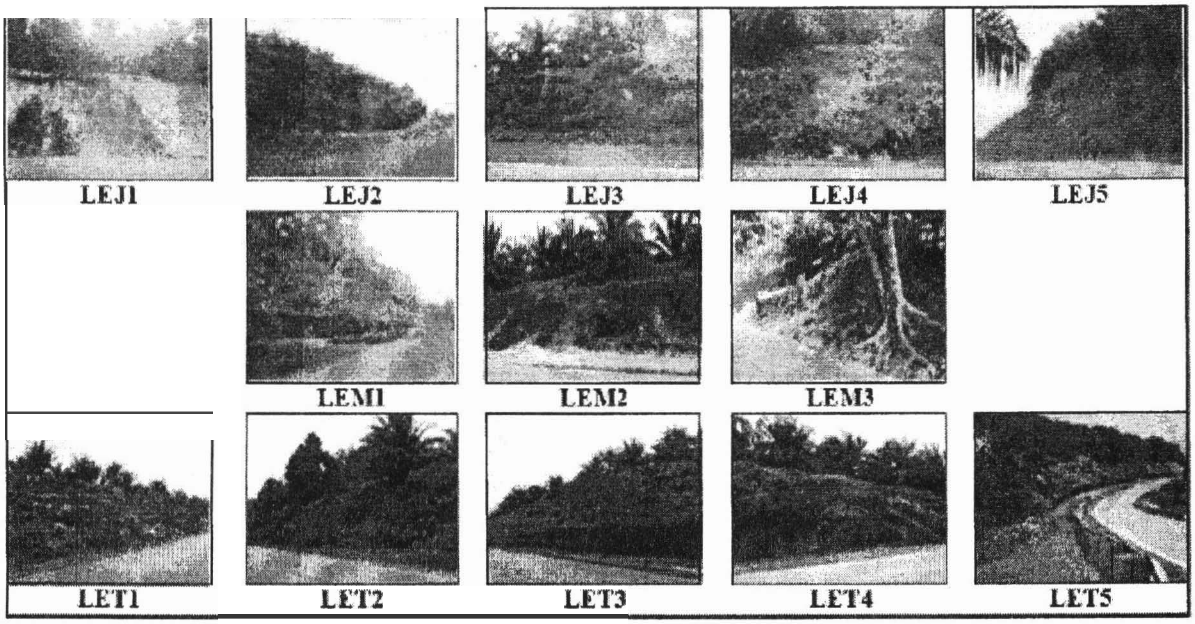


Figure 2 Photos of landslide occurrences along major roads heading to UiTM Pahang

## LITERATURE REVIEW

Erosion induced landslide is a nature process of a soil degradation. This process occurred when raindrops fall on the bare surface of the slope, then slopes will be eroded and exhibiting erosion features. Increasing and repeating external stimulus of intense rainfall would gradually cause slope failure or commonly known as landslide Rainfall erosivity and soil erodibility are two dominant factors that contribute to this process.

Erosivity is defined as the potential ability of the rain to cause erosion thus poses as a triggering factor in most of the erosion induced landslides problems. Roslan and Tew (1996) suggested that erosive properties of a rainfall were rainfall amount, duration, intensity, raindrops (size velocity and shape), kinetic energy and seasonal distribution of the rain. The quantum of rainfall erosivity or also known as degree of rainfall erosiveness according to ROSE Index is an indicator of ability of the rainfall that could trigger a landslide and this information can be used as an early warning to all sensitive sloping areas. ROSE Index (Table 2) that has been produced by Roslan and Shafee (2006) categorizes rainfall erosivity and its significant threshold that can contribute to landslide occurrence.

Table 2 : 'ROSE' Index in categorizing rainfall erosivity

| Rainfall erosivity (ton.m$^2$/ha.hr) | Degree of 'ROSE' Index |
|---|---|
| < 500 | Low |
| 500 - 1000 | Moderate |
| 1000 – 1500 | High |
| 1500 - 2000 | Very high |
| > 2000 | Critical |

Source : *(Roslan and Shafee, 2006)*

Beside rainfall erosivity, soil erodibility is another factor that has great influence either impede or expedite the erosion process towards erosion induced landslide. Erodibility is defined as a resistance of the soil to both detachment and transport, although many other factors such as topography and soil management may affect soil erodibility. Soil erodibility is associated with soil physical properties such as sand, silt and clay. Middleton (1930) introduced soil erodibility as silt content plus with clay content of undispersed soil was compared with that of soil dispersed in water. This concept was later been modified by Bouyoucos (1935) where used clay ratio as one of the parameter. Roslan and Mazidah (2002) introduced advanced and new improved soil erodibility scale that clearly shows significant value and threshold for soil erodibility demarcation known as 'ROM' Scale (Table 3). This scale is developed since available erodibility index only provide an index of soil erodibility but do not demarcate any threshold. 'ROM' Scale is used to categorise soil erodibility which indicate the degree of soil that contributes to the erosion process.

Table 3 'ROM' Scale with regards to soil erodibility

| 'ROM'Scale | Degree of soil erodibility |
|---|---|
| < 1.5 | Low |
| 1.5 - 4.0 | Moderate |
| 4.0 - 8.0 | High |
| 8.0 - 12.0 | Very high |
| > 12.0 | Critical |

Source : *(Ros/an and Mazldah, 2002)*

Potential damaging by natural hazards is within specified time period and given area (Varnes, 1984) and (Organisation of American States, 1991). This potential damaging should be mitigated so effects of a hazard event can be lessened. Due to that, 9 different approaches have been introduced to mitigate these hazards where it's includes risk and hazard assessment. Risk and hazard assessment are identified as a successful landslide hazards reduction programmes in 1982 by USGS (Schuster & Kockelman, 1996). Fairuz et. a1. (2010) have developed severity rating (Table 4) by using concept of risk and hazard assessment to classify road, thus it will assist to identify road that should be given a priority in planning a preventive measure of landslide.

Table 4 : Severity rating of landslide hazards for road

| Rating | Severity |
|---|---|
| 10 | • People life<br>• People injured |
| 9 | • Slope structure damage<br>• Road structure damage |
| 8 | • Heavy vehicle (lorry etc.) damage |
| 7 | • Medium vehicle (car etc.) damage |
| 6 | • Light vehicle (motorcycle etc.) damage |
| 5 | • Drainage structure damage<br>• Road blocked (2 ways) > 12 hours |
| 4 | • Road blocked (2 ways) < 12 hours<br>• Road blocked (l way) > 12 hours |
| 3 | • Road blocked (1 way) < 12 hours<br>• Water supply disruption < 12 hours<br>• Electricity transmission disruption > 12 hours |
| 2 | • Water supply disruption < 12 hours<br>• Electricity transmission disruption < 12 hours<br>• Communication breakdown > 12 hours<br>• Landslide area > 2000 $m^3$ (medium to huge) |
| 1 | • Communication breakdown < 12 hours<br>• Landslide area < 2000 $m^3$ (very small to small) |
| 0 | • No landslide hazard |

Source (*Fairuz et af. 20/0)*

## PROBLEM STATEMENT

Landslide poses enonnous threats and has caused severe damages. Road is one of the highest location in Malaysia where commonly landslide had taken placed. Series of landslide occurrence along major roads heading to UiTM Pahang show that road users (UiTM Pahang staft) is threated by this natural disaster if they are using these roads. However, to date, there is no study has been carried out to profile the landslide risk for these roads that could be use as an early warning infonnation for the road users. Profiling these roads should be done because it will assist road users to take early precaution and action and local authorities to plan preventive measures.

## OBJECTIVE

The objectives of this study are:

i. To ascertain the risk months based on the rainfall erosivity factor
ii. To prepare landslide risk profile along the roads based on soil erodibility factor
iii. To rank the roads according to soil erodibility factor, rainfall erosivity factor and severity rating

## METHODOLOGY

The framework of this study is to detennine two dominant factors that contribute to the soil erosion process which will lead to erosion induced landslide namely rainfall erosivity and soil erodibility factor. In brief, the study methodology is shown in Figure 3.

### Collection of rainfall data

Daily rainfall which is used in this study is from nearest automatic rainfall for each road acquired from Department of Drainage and Irrigation (DID) Cheras, Selangor from year 2000 to 2008. Table 5 shows the nearest automatic rainfall station for each road.

Table 5 Nearest rainfall station to the major roads heading to UiTM Pahang

| No. | Road | Rainfall station | Number | Longitude | Latitude |
|---|---|---|---|---|---|
| 1. | J-UP | Rumah Pam Paya Kangsar | 3924072 | N 3° 54' 15" | E 102° 26' 00" |
| 2. | M-UP | Pintu Kawalan Paya Kertam | 3628001 | N 3° 38' 00" | E 102° 51' 20" |
| 3. | T-UP | Petak Ujian Padi Kerdau | 3523079 | N 3° 34' 25" | E 102° 22' 35" |

### Rainfall analysis

Rainfall erosivity is the only rainfall parameter that needs to be quantified in this study. Rainfall erosivity factor, R is detennined using the equation:

$$R \qquad EI_{30}$$

where Energy of rainfall
Maximum 30 minutes rainfall intensity

### Risk months

Risk months are detennined based on mean for total risk days that had been categorised based on 'ROSE' Index. This mean is adapted from Likert Scale concept. Table 6 shows value that represent each risk category for day while Table 7 shows mean for the risk category for month.

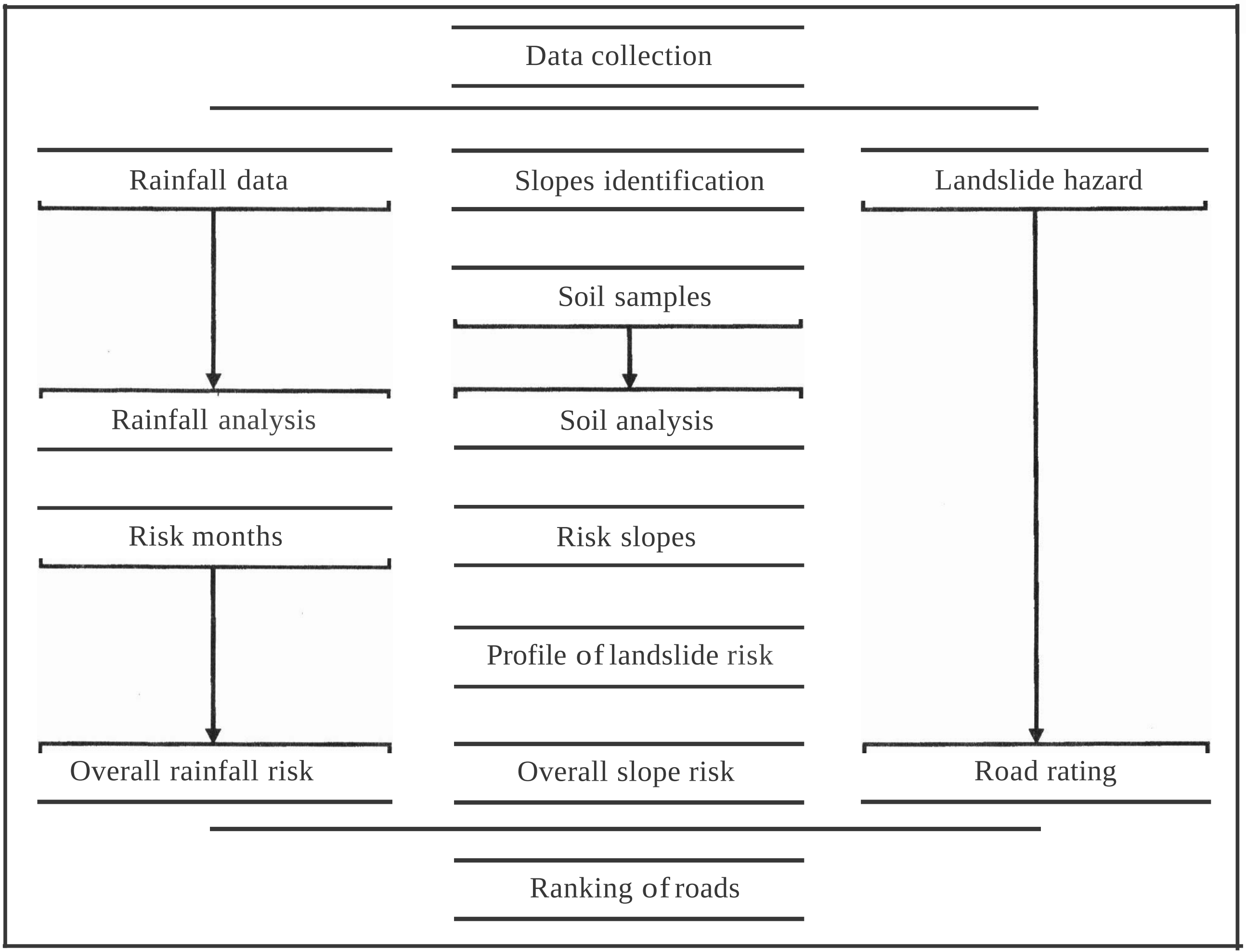


Figure 3 : Step by step study stages

Table 6 : Value of risk category for day

| Low | Moderate | High | Very high | Critikal |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Table 7 Mean of risk category for month

| Low | Moderate | High | Very high | Critikal |
|---|---|---|---|---|
| 1.0 - 1.9 | 2.0 - 2.9 | 3.0-3.4 | 3.5 - 4.4 | 4.5 -5.0 |

Overall rainfall risk

Risk for road with regards to rainfall erosivity is determined based on mean for total risk months.

Slopes identification

Identification of slopes along these roads is conducted by observation of their physical features. Slopes which have features of erosion and assumed would cause severe damages are considered as s study slopes. There are 19 study slopes along J-UP road (Table 8), 21 slopes along M-UP road (Table 9) and 8 slopes along T-UP road (Table 10).

Table 8 : Study slopes along J-UP road

| No. | Slope | Coordinate | | To UiTM Pahang | | Development |
|---|---|---|---|---|---|---|
| | | Latitude | Longitude | KM | Side | |
| 1. | J-UPI | N 3° 56' 12.1" | E 102° 23' 04.3"0. | 8 | Left | Upslope |
| 2. | J-UP2 | N 3° 56' 11.4" | E 102° 23' 06.0"0. | 8 | Right | Upslope |
| 3. | J-UP3 | N 3° 56' 13.9" | E 102° 23' 07.6"0. | 9 | Right | Upslope |
| 4. | J-UP4 | N 3° 57' 32.5" | E 102° 25' 05.5"5. | 5 | Left | Upslope |
| 5. | J-UP5 | N 3° 57' 36.0" | E 102° 25' 47.7"6. | 8 | Right | Upslope |
| 6. | J-UP6 | N 3° 57' 10.1" | E 102° 26' 28.8"8. | 4 | Left | Upslope |
| 7. | J-UP7 | N 3° 56' 57.8" | E 102° 26' 33.3"8. | 9 | Left | Upslope |
| 8. | J-UP8 | N 3° 56' 41.4" | E 102° 26' 39.0"9. | 4 | Left | Upslope |
| 9. | J-UP9 | N 3° 56' 34.9" | . E 102° 26' 40.7"9. | 5 | Left | Upslope |
| 10. | J-UPIO | N 3° 56' 27.8" | E 102° 26' 43.2"9. | 9 | Left | Upslope |
| II. | J-UP11 | N 3° 56' 18.7" | E 102° 26' 46.5" | 10.2 | Left | Upslope |
| 12. | J-UPI2 | N 3° 55' 39.6" | E 102° 26' 56.9" | 11.5 | Left | Upslope |
| 13. | J-UPI 3 | N 3° 55' 29.5" | E 102° 26' 54.9" | 11.8 | Left | Upslope |
| 14. | J-UP14 | N 3° 55' 25.3" | E 102° 26' 54.6" | 11.9 | Left | Upslope |
| 15. | J-UP15 | N 3° 52' 50.4" | E 102° 29' 04.5" | 18.8 | Left | Upslope |
| 16. | J-UP16 | N 3° 52' 49.1" | E 102° 29' 03.4" | 18.8 | Right | Upslope |
| 17. | J-UPI7 | N 3° 49' 29.2" | E 102° 30'34.1" | 26.3 | Right | Upslope |
| 18. | J-UP18 | N 3° 49' 23.0" | E 102° 30' 33.8" | 26.4 | Right | Upslope |
| 19. | J-UPI9 | N 3° 47' 58.5" | E ]02° 31'33.1" | 29.6 | Left | Upslope |

Table 9 : Study slopes along M-UP road

| No. | Slope | Coordinate | | To UiTM Pahang | | Development |
|---|---|---|---|---|---|---|
| | | Latitude | Longitude | KM | Side | |
| 1. | M-UPI | N 3° 34' 24.1" | E 102° 45' 25.6" 1. | 4 | Left | Upslope |
| 2. | M-UP2 | N 3° 34' 19.3" | E 102° 45' 13.7" 1. | 9 | Left | Upslope |
| 3. | M-UP3 | N 3° 34' I5,S" | E 102° 44' 53.9"2. | 6 | Left | Upslope |
| 4. | M-UP4 | N 3° 34' 05.3" | E 102° 43' 58.3"4. | 3 | Left | Upslope |
| 5. | M-UP5 | N 3° 34' 15.6" | E 102° 42' 53.9"6. | 4 | Left | Upslope |
| 6. | M-UP6 | N 3° 34' 07.2" | E 102° 42' 40.9"6. | 9 | Left | Upslope |
| 7. | M-UP7 | N 3° 33' 42.8" | E 102° 42' 24.4"7. | 8 | Left | Upslope |
| 8. | M-UP8 | N 3° 35' 29.7" | E 102° 40' 46.2" | ]4.7 | Right | Upslope |
| 9. | M-UP9 | N 3° 39' 02.3" | E 102° 38' 29.5" | 24.3 | Left | Upslope |
| ]0. | M-UPIO | N 3° 39' 03.0" | E 102° 38' 28.4" | 24.5 | Left | Upslope |
| ]1. | M-UPI] | N 3° 39' 08.6" | E 102° 38' 16.6" | 25.0 | Right | Upslope |
| 12. | M-UP1 2 | N 3° 39' 21.1" | E 102° 38' 01.7" | 25.6 | Left | Upslope |
| 13. | M-UPI3 | N 3° 39' 20.1" | E 102° 38' 00.6" | 25.6 | Right | Upslope |

| | | | | | | |
|---|---|---|---|---|---|---|
| 14. | M-UPI4 | N 3° 39' 25.6" | E 102° 37' 46.3" | 26.1 | Right | Upslope |
| 15. | M-UPI5 | N 3° 39' 27.7" | E 102° 37' 36.3" | 26.4 | Right | Upslope |
| 16. | M-UPI6 | N 3° 42' 17.0" | E 102° 36' 24.5" | 34.6 | Left | Upslope |
| 17. | M-UPI7 | N 3° 43' 48.2" | E 102° 36' 57.8" | 37.6 | Right | Upslope |
| 18. | M-UPI8 | N3°43' 49.1" | E 102° 36' 55.6" | 37.6 | Left | Upslope |
| 19. | M-UPI9 | N 3°43' 57.1" | E 102° 36' 42.0" | 38.2 | Left | Upslope |
| 20. | M-UP20 | N 3° 44' 23.8" | E 102° 33' 33.1" | 42.1 | Left | Upslope |
| 21. | M-UP21 | N 3° 44' 22.1" | E 102° 34' 49.2" | 44.8 | Left | Upslope |

Table 10 Study slopes along T-UP road

| No. | Slope | Coordinate | | To UiTM Pahang | | Development |
|---|---|---|---|---|---|---|
| | | Latitude | Longitude | KM | Side | |
| 1. | T-UPI | N 3° 30' 29.8" | E 102°31' 16.5" | 23.2 | Left | Upslope |
| 2. | T-UP2 | N 3° 31' 36.5" | E 102° 30' 33.9" | 25.8 | Right | Upslope |
| 3. | T-UP3 | N 3° 37' 55.0" | E 102° 32' 38.9" | 39.0 | Right | Upslope |
| 4. | T-UP4 | N 3° 40' 10.7" | E 102° 32' 39.5" | 43.2 | Right | Upslope |
| 5. | T-UP5 | N 3° 40' 19.2" | E 102° 32' 39.6" | 43.5 | Right | Upslope |
| 6. | T-UP6 | N 3° 40' 29.0" | E 102° 32' 39.2" | 43.9 | Right | Upslope |
| 7. | T-UP7 | N 3° 40' 55.2" | E 102° 32' 32.1" | 44.7 | Right | Upslope |
| 8. | T-UP8 | N 3° 42' 06.2" | E 102° 32' 22.6" | 46.9 | Left | Upslope |

Collection of soil samples

Hand auger is used to take soil samples from study slopes at the depth of 0.30 m to 0.45 m from the surface. Minimum two samples are taken from each slope.

Soil analysis

Soil grading for each samples is analysed using particle size distribution (PSD) which comprises of sieve analysis and hydrometer tests to detelmine percentage of sand, silt and clay.

Risk slopes

Percentage of sand, silt and clay is applied into $EI_{ROM}$ equation to determine $EI_{ROM}$' Then, slope risk will be categorised according to 'ROM' Scale.

$$EI_{ROM} = \frac{\%\ Sand + \%\ Silt}{2\ (\%\ Clay)}$$

Profiling of landslide risk

Profile of landslide risk is prepared by remarks distance by distance along road according to slope risk category.

Overall slope risk

Risk for road with regards to soil erodibility is determined based on mean for total risk slopes.

Collection of landslide hazard

Hazard of each landslide occurrence is determined by observation. The area affected by landslide is measured using survey equipments.

Road rating

Rating of road is detennined according to Severity rating of landslide hazards for road. The worst hazard only is to be considered to represent hazard for each road.

Ranking of roads

Road is ranked according to overall rainfall risk, overall slope risk and road rating. Road which ranked at the top of the ranking is considered as having more risk compare to the road which ranked at the bottom.

## RESULTS AND DISCUSSION

Early warning information is to provide prediction information of contribution factors which could trigger landslide occurrence. Thus, public will take extra precaution during high risk time due to rainfall erosivity and location due to soil erodibility. Table 11 shows that J-UP road is more risky than M-UP and T-UP road because throughout the year all the months is categorized as risk months where 6 months are critical. While M-UP and T-UP road, there is no critical month and most of the months are not risky. November is considered as the most risky month.

Table 11 : Ranking of month according to 'ROSE' Index for each road

| Rank no. | J-UProad | | M-UProad | | T-UP road | |
|---|---|---|---|---|---|---|
| | Month | Rainfall risk | Month | Rainfall risk | Month | Rainfall risk |
| 1 | November | Critical | August | Very high | November | Very high |
| 2 | October | Critical | September | High | October | Very high |
| 3 | December | Critical | November | High | January | Very high |
| 4 | August | Critical | December | Moderate | April | Very high |
| 5 | April | Critical | July | Moderate | March | Very high |
| 6 | March | Critical | May | Moderate | May | High |
| 7 | May | Very high | June | Moderate | December | High |
| 8 | July | Very high | April | Moderate | September | High |
| 9 | June | Very high | January | Moderate | July | Moderate |
| 10 | September | Very high | March | Moderate | June | Moderate |
| II | January | Very high | October | Moderate | February | Moderate |
| 12 | February | High | February | Low | August | Moderate |
| | Overall | Very high | Overall | Moderate | Overall | High |

Most of the study slopes are not risky since there are only two slopes categorised as high at J-UP road and another 4 slopes at M-UP road. There are no slopes categorised as very high and critical for these roads. This is shown at Table 12 and Table 13. All these roads are considered as low risk ofthe landslide occurrence but there are certain sections that still need to take attention. Table 12 shows that high risk section for J-UP road is at KM 11.5 – 12.0 where its takes 0.5 km, M-UP road is at KM 7.5 - 24.5 where it's take 17.0 km and none at T-UP road.

Table 12 : Study slopes risk category according to 'ROM' Scale

| No. | Slope | Risk | No. | Slope | Risk | No. | Slope | Risk |
|---|---|---|---|---|---|---|---|---|
| I. | J-UPI | Low | 17. | J-UPI7 | Low | 33. | M-UPI4 | Moderate |
| 2. | J-UP2 | Low | 18. | J-UPI8 | Low | 34. | M-UPI5 | Moderate |
| 3. | J-UP3 | Low | 19. | J-UPI9 | Low | 35. | M-UPI6 | Low |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4. | J-UP4 | Low | 20. | M-UPI | Low | 36. | M-UPI7 | Low |
| 5. | J-UP5 | Moderate | 21. | M-UP2 | Low | 37. | M-UPI8 | Low |
| 6. | J-UP6 | Low | 22. | M-UP3 | Low | 38. | M-UPI9 | Low |
| 7. | J-UP7 | Low | 23. | M-UP4 | Low | 39. | M-UP20 | Moderate |
| 8. | J-UP8 | Low | 24. | M-UP5 | Moderate | 40. | M-UP21 | Low |
| 9. | J-UP9 | Moderate | 25. | M-UP6 | High | 41. | T-UPI | Low |
| 10. | J-UPIO | Moderate | 26. | M-UP7 | High | 42. | T-UP2 | Low |
| II. | J-UPII | Moderate | 27. | M-UP8 | High | 43. | T-UP3 | Low |
| 12. | J-UPI2 | Moderate | 28. | M-UP9 | Moderate | 44. | T-UP4 | Low |
| 13. | J-UPI3 | High | 29. | M-UPIO | High | 45. | T-UP5 | Moderate |
| 14. | J-UPI4 | High | 30. | M-UPII | Moderate | 46. | T-UP6 | Moderate |
| 15. | J-UPI5 | Low | 31. | M-UPI2 | Low | 47. | T-UP7 | Low |
| 16. | J-UPI6 | Low | 32. | M-UP13 | Moderate | 48. | T-UP8 | Low |

Table 13 Summarise of study slopes for each road

| No. | Road | Slopes (no.) | | | | | Overall risk |
|---|---|---|---|---|---|---|---|
| | | Critical | Very high | High | Moderate | Low | |
| I. | J-UP | 0 | 0 | 2 | 5 | 12 | Moderate |
| 2. | M-UP | 0 | 0 | 4 | 7 | 10 | Moderate |
| 3. | T-UP | 0 | 0 | 0 | 2 | 6 | Low |

| Jerantut (Km) | 0.0 – 9.5 | 9.5 - 11.5 | 11.5 - 12.0 | 12.0 – 34.5 | UiTMPahang (Km) |
|---|---|---|---|---|---|
| Risk | Low | Moderate | High | Low | Risk |

| Maran (Km) | 0.0 - 7.5 | 7.5 - 24.5 | 24.5-26.5 | 26.5 -48.0 | UiTMPahang (Km) |
|---|---|---|---|---|---|
| Risk | Low | High | Moderate | Low | Risk |

| Temerloh (Km) | 0.0-43.5 | 43.5-44.0 | 44.0 - 54.5 | UiTMPahang (Km) |
|---|---|---|---|---|
| Risk | Low | Moderate | Low | Risk |

Figure 4 : Profile of landslide risk along each road

All the landslides that had taken place at these roads only affected the area of slopes and none cause damages either to properties and road users. Therefore, these roads are categorized as rating I and 2 because the worst hazard only affected area.

Table 14 Road rating according to worst hazard

| J-UPRoad | | M-UPRoad | | T-UPRoad | |
|---|---|---|---|---|---|
| Worst hazard | Rating | Worst hazard | Rating | Worst hazard | Rating |
| Landslide area > 2000 $m^J$ | 2 | Landslide area > 2000 $m^J$ | 2 | Landslide area < 2000 $m^J$ | I |

J-UP road is considered as the most risky road because rainfall erosivity throughout the year at that particular road is in high risk even though most of the slopes are low risk. Rainfall with high erosivity that often falls on the slopes actually exposes the slopes to erosion process and lead to the landslide. It is also considered that there are many slopes along J-UP road. T-UP is less risky road because of the rainfall erosivity is not continuously high throughout the year except on the certain months. Besides, there are not many slopes alongside it compare to other roads. Landslide that had taken place at T-UP road also do not cause severe affect.

Table 15 : Rank of the road according to rainfall risk, slope risk and hazard rating

| Rank | Road | Triggering factor | | Hazard rating |
|---|---|---|---|---|
| | | Overall rainfall risk | Overall slope risk | |
| I | J-UP | Very high | Moderate | 2 |
| 2 | M-UP | Moderate | Moderate | 2 |
| 3 | T-UP | 'High | Low | I |

## CONCLUSION

All the major roads have potentials of landslide occurrence but the damages caused by the landslides will not lead to adverse affect. This is because most of the slopes are in low risk and also based on landslide that had taken placed shows that there are no landslides that contribute to the harmful damages. It is safe for road users to travel at the most distance of these roads except only a few distances that should be given attention. T-UP road is the safest road from potential damages of landslide. UiTM staff that lived in Jerantut district should give more attention than those that lived in Maran and Temerloh district. Regular maintenance is the only preventive measure that is suggested to be taken to all the slopes. It is hoped that this study would assist UiTM Pahang staffs in order to avoid this natural disaster and also could be extended as a preventive measure to other UiTM campuses especially that are constructed on uneven terrain area.

## REFERENCE


Bouyoucos, GJ, 1935. *The Clay Ratio as Criterion ofSusceptibility ofSoils to Erosion.* New York. Journal of Society Agronomists, Volume 27, p.738-74I.

Fairuz, B., Noraida, M. S. & Rohaya, A., 2010. *Establishment ofSeverity Rating ofLandslide Hazardsfor Road.* Kuantan. Proceedings of3rd National Seminar on Science, Technology and Social Sciences.

Lee, S. and Pradhan, B., 2006. *Probabilistic Landslide Hazards and Risk Mapping on Penang Island, Malaysia*. New Delhi. Journal on Earth System Science, Volume 115 no.6, pp.I-12)

Middleton, H.E., 1930. *Properties ofSoils which Influence Soil Erosion*. New York. U.S. Department Agriculture Technology.

Nakano, J. & Miki, 2000. *Risk Evaluation Methodfor Rock Bed and Slope Failures in Road Disaster Management.* Merlbourne. Geology Engineering.

Organisation of American States (OAS). 1991. *Landslide Hazard Asessment.* Washington D. Coo Primer on Natural Hazard Management in Integrated Regional Development.

Roslan, Z. A. & Mazidah, M., 2002. *Establishment ofSoil Erosion Scale with Regards to Soil Grading Characteristics*. Kuching. Proceeding of 2nd World Engineering Congress.

Roslan, Z. A. & Shafee, M., 2006. *'ROSE' Index for Predicting Rainfall Induced Landslide*. Port Dickson. Proceeding of National Conference - Water for Sustainable Development Towards a Developed Nation.

Roslan, Z. A. & Tew, K. H., 1996. *Determination ofthe Land Use Management Factors ofthe USLE in Reducing Soil Erosion Loss.* Langkawi. Proceeding of 10th Congress of the Asia and Pacific Division (APD) of the International Association for Hydraulic Research (IAHR), pp 126-135.

Schuster, R. L., & Kockelman, W. J., 1996. *Landslides: Investigation and Mitigation.* Washington D. C.. Transportation Research Board, National Research Council.

Varnes, D. J., 1984. *Landslide Hazard Zonation - A Review ofPrinciples and Practice*. Paris. UNESCO.

Wilson, R. C., 2004. *The Rise and Fall ofa Debris Flow Warning System for the San Francisco Bay Region, California*. West Sussex. John Wiley and Sons Ltd..


---


MOHD FAIRUZ BACHOK, Senior Lecturer, Faculty of Civil Engineering, UiTM Pahang
mohdfairuz@pahang.uitm.edu.my

MOHD RAZMI ZAINUDIN, Senior Lecturer, Faculty of Civil Engineering, UiTM Pahang
razmi74@pahang.uitm.edu.my

WAN ZUKRI WAN ABDULLAH, Lecturer, Faculty of Civil Engineering, UiTM Pahang
wanz@pahang.uitm.edu.my

NORAIDA MOHO SAIM, Lecturer, Faculty of Civil Engineering, UiTM Pahang
aidams2000@pahang.uitm.edu.my

ROHAYA ALIAS, Lecturer, Faculty of Civil Engineering, UiTM Pahang
Rohaya_alias@pahang.uitm.edu.my