WEATHERING AND STABILITY OF CUT SLOPES IN QUARTZ-MICA SCHISTS OF THE SEREMBAN-SILIAU AREA, NEGERI SEMBILAN, MALAYSIA.

BY

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WHAT ISN'T TRIED, WON'T WORK

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~OM SREEM HREEM~

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ABSTRACT

Weathering profiles over quartz-mica schist in the Seremban-Silau area which are found along only the Seremban-Mantin-Silau and Silau-Rantau-Seremban roads are characterized by a vertical zonation of weathered materials with laterally similar features and properties. A complete weathering profile over quartz-mica schist in the study area consists of Soil, Pedoplasmation Zone, Saprolite, Saprock and Rock. This complete profile can at first be divided into three main morphological zones, namely the upper ZI, the intermediate ZII and the lower ZIII zones. ZI consists of Soil and Pedoplasmation Zone, ZII consists of Saprolite and Saprock and ZIII consists of Rock. ZI is pedologically and geochemically altered, ZII is geochemically altered and ZIII is unaltered and fresh. The weathering front is between ZIII (Rock) and lower ZII (Saprock) while the pedoplasmation front is between the upper ZII (Saprolite) and lower ZI (Pedoplasmation Zone). These morphological zones are then divided further into smaller subzones or horizons. ZI is further divided into horizons IA, IB and IC based on the hardness and grain size distribution. Horizons IA and IB consist of Soil and horizon IC consists of Pedoplasmation Zone. ZII is also divided further into subzones or horizons IIA, IIB and IIC based on the degree of weathering. Saprolite makes up the horizon IIA and upper horizon IIB. Saprock makes up the lower horizon IIB and horizon IIC. With the advance of weathering, vertical and lateral changes are noted in the inherent properties (grain size distribution, Atterberg limits, activity index) and engineering properties [illegible] (C) and angle of internal friction (φ)) of the [illegible] vertical variations are apparent between the various [illegible] especially distinct in the grain size distribution which varies [illegible] materials at the lower zones to clayey materials at the upper zones. The Atterberg limits too vary corresponding to these changes. Vertical variation is also seen in the type of clay minerals present in these zones. Illite is the main clay mineral found in the lower zones (least weathered) which alters into interstratified illite-montmorillonite in the intermediate zones (less weathered) and subsequently alters into kaolinite in the upper zones (more weathered). The C and φ values show general increase with weathering. Lateral variations are apparent amongst similar zones of profiles exposed on adjacent cut slopes. These variations though slight, can be seen in the grain size distributions that vary within their respective soil classifications. Other inherent and engineering properties vary in correspondence with these aforementioned lateral variations. Stability analyses on existing cut slopes and existing failures in quartz-mica schist show that most of the existing slopes are very stable slope with very high minimum factors of safety, except for an existing failure that is expected to fail again soon and another with an expected high possibility of failing again. On the risk ranking, two cut slopes are found to be less dangerous in case it fails because the spillage of debris onto the adjacent road would be minimal and of minor hindrance to the road users. All other existing cut slopes and failures are of no danger to the road users or adjacent premises since the computed potential failure would not involve the adjacent roads or premise and no spillage onto the adjacent road is expected. The existing instabilities are due to unsuitable slope geometry, high seasonal rainfall, exposed slope surface and the presence of poorly preserved relict structures.

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SUMMARY

Two main lithological units have been found in the study area. They are the Older Schist Series (Silurian-Ordovician) and the Younger Schist Series (Lower Devonian). The Older Schist Series consists of two main lithological subunits, a dominant light grey to grey quartz-mica schists interbedded with quartz-schist and a minor dark to very dark grey graphite and quartz-graphite-mica schist. The dominant subunit is considered equivalent to the Dinding Formation (Pre-Silurian) of the Kuala Lumpur area while the minor subunit is considered equivalent to the Hawthornden Formation (Silurian). The Older Schist Series is also similar to the Pilah Schist. The Younger Schist Series consist of immature to moderately mature sandstone with minor intercalations of light grey shale and is variably metamorphosed to metaquartzite and slate or phyllite. The Younger Schist Series is found to be similar to the Kenny Hill Formation (Lower Devonian) of the Kuala Lumpur area. Quartz-mica schists studied in the study area are part of the dominant subunit of the Older Schist Series (Silurian-Ordovician) and is found towards the north, northwest, west and southwest of the study area. A total of seven exposed cut slopes (S1-S7) and three existing failures (F1-F3) are identified in the quartz-mica schist. These features are all found only along the Seremban-Mambau-Sisgo and Sijiau-Rantau-Seremban roads.

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Based on the weathering [illegible] schist outcrops in the study area, a complete [illegible] of laterally similar properties is identified [illegible] Zone, Saprolite, Saprock and Rock. The complete weathering is divided into three main thermal morphological zones, namely ZI, ZII and ZIII. ZI consists of Soil and Pedoplasmation Zone, ZII of Saprolite and Saprock, and ZIII of Rock. ZI is pedologically and geochemically altered while ZII is only geochemically altered. ZIII is unaltered and fresh. These morphological zones can be further divided into smaller subzones or horizons. ZI is divided into horizons IA, IB and IC based on their hardness and grain size distribution. Horizon IA, IB and IC are yellowish red, red and reddish yellow in colour respectively. Horizons IA and IB make up Soil and horizon IC make up Pedoplasmation Zone. ZII is divided into horizons IIA, IIB and IIC based on the degree of weathering or alteration from the original bedrock. Horizon IIC is the least weathered (α), horizon IIB is the less weathered (β) and horizon IIA is the most weathered (γ) of the ZII horizons. Horizon IIA and upper horizon IIB make up Saprolite while lower horizon IIB and horizon IIC make up Saprock. The weathering front is between zones ZIII (Rock) and lower ZII (Saprock) while the pedoplasmation front is between zones upper ZII (Saprolite) and lower ZI (Pedoplasmation Zone). Only zones ZI and ZII are found exposed in the study area.

As weathering progresses, variations are observed in the inherent and engineering properties of the slope forming materials. The inherent properties considered are the grain size distribution, Atterberg limits and activity index (I_A). The engineering properties are the shear strength parameters, C (cohesion) and ϕ (angle of internal friction). The variations observed are both vertical and lateral.

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Based on the weathering profiles exposed on the quartz-mica schist outcrops in the study area, a complete weathering profile of vertical zonation of laterally similar properties is identified and it consists of Soil, Pedoplasmation Zone, Saprolite, Saprock and Rock. The complete weathering is divided into three main distinct morphological zones, namely ZI, ZII and ZIII. ZI consists of Soil and Pedoplasmation Zone, ZII of Saprolite and Saprock, and ZIII of Rock. ZI is pedologically and geochemically altered while ZII is only geochemically altered. ZIII is unaltered and fresh. These morphological zones can be further divided into smaller subzones or horizons. ZI is divided into horizons IA, IB and IC based on their hardness and grain size distribution. Horizon IA, IB and IC are yellowish red, red and reddish yellow in colour respectively. Horizons IA and IB make up Soil and horizon IC make up Pedoplasmation Zone. ZII is divided into horizons IIA, IIB and IIC based on the degree of weathering or alteration from the original bedrock. Horizon IIC is the least weathered (α), horizon IIB is the less weathered (β) and horizon IIA is the most weathered (γ) of the ZII horizons. Horizon IIA and upper horizon IIB make up Saprolite while lower horizon IIB and horizon IIC make up Saprock. The weathering front is between zones ZIII (Rock) and lower ZII (Saprock) while the pedoplasmation front is between zones upper ZII (Saprolite) and lower ZI (Pedoplasmation Zone). Only zones ZI and ZII are found exposed in the study area.

As weathering progresses, variations are observed in the inherent and engineering properties of the slope forming materials. The inherent properties considered are the grain size distribution, Atterberg limits and activity index (*Ia*). The engineering properties are the shear strength parameters, C (cohesion) and ϕ (angle of internal friction). The variations observed are both vertical and lateral.

The vertical variations are apparent in the inherent and engineering properties of zones of the same cut. The grain size distribution show a vertical variation from that of siltier least weathered lower zones to a clayey more weathered upper zones with a general increase in clay content and a relative drop in sand content. As the clay content increases with weathering, there is also vertical variation in the clay type. The least weathered lower zones have high concentrates of mainly illite. The less weathered intermediate zones have less concentrates of illite and more of interstratified illite-montmorillonite. The more weathered upper zones have a lesser concentrate of illite, less of interstratified illite-montmorillonite and more of kaolinite. This variation is due to the main clay mineral in the lower zones of a weathering profile, illite, which alters first into interstratified illite-monmorillonite and subsequently into kaolinite as the degree of weathering progresses. There is also a general vertical increase in the plasticity index (*Ip*) as weathering progresses. The vertical variations noted in the undisturbed C and ϕ values are a generally increase with weathering. The remoulded C value which is smaller than its undisturbed value and the remoulded ϕ value which is larger that its undisturbed value too show an increase as weathering advances. Vertical variations in the inherent and engineering properties within the same zone of a weathering profile is very slight, almost non-existent and is insignificant.

The lateral variations are noted in the inherent and engineering properties of similar zones of adjacent cuts. The grain size distribution shows lateral variations which differ within their respective soil classification. Other inherent and engineering properties too show lateral variations which correspond with the lateral variation in grain size distribution. The smaller remoulded C value and larger remoulded ϕ too show slight lateral variations to this effect. Lateral variations of inherent and engineering properties within the same zone of a weathering profile is very slight and insignificant.

The stability analysis using the SLOPE/W programme calculates the minimum factor of safety as well as the respective critical failure surface. Based on this existing cut slopes and existing failures are ranked in the stability status which are categorized as I-'failed', II-'soon to fail', III-'possibility of failing' and IV-'very stable'. Existing failure F1 shows the potential to fail again real soon and is ranked in category II. Existing failure F2 which has a strong possibility to failing again sometime in the future is in category III. The others, S1, S2, S3, S4, S5, S6, S7 and F3 which have very high factors of safety are very stable and unlikely to fail; therefore are categorized in category IV. These existing cut slopes and existing failures are then ranked on the risk categories based on the danger towards road users and adjacent premise. There are four risk categories and they are the RI-'very dangerous', RII-'dangerous, RIII-'less dangerous' and RIV-'not dangerous'. Of the seven existing cut slopes, S1, S2, S4, S6 and S7 are ranked as RIV-'not dangerous'. This is because the computed critical failure surface in case of a failure does not involve the adjacent road or premise and the expected debris will not spill onto the road causing obstruction to the traffic. The cut slopes S3 and S5 ,though very stable, are ranked under RIII-'less dangerous'. This is due to the fact that the computed critical failure surface which does not affect the adjacent road or premise but may spill onto the road and cause minor hindrance to road users. Of the three existing failures, all are ranked in the RIV-'not dangerous'. Though F1 and F2 are expected to fail again, the computed critical failure surfaces do not involve adjacent road or premise. Moreover, the expected failure debris is minimal and will not spill over onto the road. F3 which is ranked as stable has a computed critical failure surface that does not involve any adjacent road or premise and no debris spillage onto the road.

Therefore, it can be stated that these existing cut slopes in quartz-mica schist are of danger to neither road users nor property in the vicinity and are of no hindrance to the traffic on the Seremban-Mambau-Siliau road. The existing instabilities along the Seremban-Mambau-Siliau and Siliau-Rantau-Seremban roads are mainly due to unsuitable slope geometry, seasonal fluctuation in total rainfall, exposed slope surfaces and the presence of poorly preserved relict structures such as foliation and joints which on weathering become weak zones that serve as potential failure surfaces.

CONTENTS

CONTENTS

CONTENTS

Page

Page

LIST OF FIGURES

List of Figures

Figure		Pg

Figure		Pg

Figure		Pg

LIST OF PLATES

List of Plates

List of Plates

Plates **Pg**

Plates **Pg**

LIST OF TABLES

List of Tables