ROCK MASS CLASSIFICATION SYSTEM OF THE CROCKER FORMATION IN KOTA KINABALU FOR ROCK SLOPE ENGINEERING PURPOSE, SABAH, MALAYSIA

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DECLARATION

This thesis is the result of my own work with the exception of quotations, excerpts, equation, summaries and references, the source of which have been duly acknowledged.

11 August 2011

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CERTIFICATION

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ABSTRACT

ROCK MASS CLASSIFICATION SYSTEM OF THE CROCKER FORMATION IN KOTA KINABALU FOR ROCK SLOPE ENGINEERING PURPOSE, SABAH, MALAYSIA

This study aims to classify the rock mass of the interbedded Crocker Formation in Kota Kinabalu, Sabah. The rock cut slopes in CPSB Stone Quarry Sdn Bhd (slope B1, B2, B3 and B4) and Lakang Point (slope LP) in Tamparuli, Tuaran Hospital (slope TH) in Tuaran and Telipok-Sulaman by-pass (slope TS1 east, TS1 west, TS2 east and TS2 west of Telipok) in Telipok were selected for this study. The facies types in the study area are very thick-bedded sandstone unit (facies B), thick to medium-bedded sandstone unit (facies C), thin-bedded sandstone unit (facies D), thin-bedded siltstone and/or sandstone unit (facies E) and thick-bedded shale unit (facies F) which form the channel, channel-lobe, lobe prograding and basin plain facies associations. Application and evaluation of four selected existing rock mass classification system contribute to the formulation of Modified Slope Mass Rating (M-SMR) system for classifying the Crocker Formation rock mass. The M-SMR is obtained from basic Rock Mass Rating (RMR_{basic}) by adding an adjustment factor (discontinuity orientation parameter). The M-SMR parameter calculation for interbedded Crocker Formation rock mass quality are lithological unit thickness (LUT) approaches, classical RQD calculation method, weighted averaged of discontinuity set, weighted averaged, normal condition and new adjustment factor (NAF) for UCS, RQD, discontinuity spacing, discontinuity condition, water flow and discontinuity orientation parameters, respectively. For the safety of rock slope design, the weighted averaged of worst discontinuity set spacing, worst rating of discontinuity condition and worst condition of water flow are recommended. The M-SMR system is divided into class I (very low risk, very stable) to class VI (extremely risky, extremely unstable). Slope TS1 east, TS2 west and LP representing class II, slope B3 class III, slope B4, TS1 west and TS2 east class IV, slope B1 and B2 class V and slope TH class VI in the study area. The M-SMR system was formulate in order to propose the rock cut slope design in term of rock cut slope stabilization and protection measure, design model review and slope remapping and optimal slope angle for the interbedded Crocker Formation in the study area. Suggested risk mitigation measure for Crocker Formation are slope re-excavation for 'extremely risky' slope TH and only some scaling for 'low risk' slope LP, TS1 east and TS2 west. Detailed design model review (DMR) and slope remapping by expert and experienced engineering geologists or geotechnical engineers is highly recommended for class VI and V and IV of M-SMR in slope TH and slope B1 and B2 and slope B4, TS2 east and TS1 west, respectively. Slope TS1 east, TS2 west and LP of stable class II is only recommended for DMR and slope remapping by engineering geologist or geotechnical engineer. The range of optimum slope angle for less than 50m height slope of the Crocker Formation in the study area is between 65^{o} to 70^{o} and 40^{o} to 45^{o} for class II and IV of M-SMR system, respectively. Correlation between the Modified Slope Mass Rating (M-SMR) with geomechanical characteristics of the Crocker Formation such as facies characteristic, orientation of bedding planes with respect to slopes face, rate of weathering and degree of deformation and mode of rock slope failure is also produced. The diagonal orientation of bedding plane with respect to slope face of the channel, channel-lobe, migrating lobe and basin plain facies has been representing class II, class III to V (depending to channel and lobe facies ratio), class IV and class VI, respectively in the study area.

ABSTRAK

Kajian ini bertujuan untuk mengkelaskan jasad batuan Formasi Crocker yang berlapis di kawasan Kota Kinabalu, Sabah. Potongan cerun batuan di CPSB Stone Quarry Sdn Bhd (cerun B1, B2, B3 dan B4) dan Lakang Point (cerun LP) di kawasan Tamparuli, Hospital Tuaran (cerun TH) di Tuaran dan Telipok-Sulaman bypass (cerun TS1 east, TS1 west, TS2 east dan TS2 west) di Telipok telah dipilih untuk kajian ini. Jenis fasies di kawasan kajian adalah unit lapisan batu pasir sangat tebal (fasies B), unit lapisan batu pasir tebal ke sederhana (fasies C), unit lapisan batu pasir nipis (fasies D), unit lapisan batu lodak dan/atau batu pasir nipis (facies E) dan unit lapisan syal tebal (fasies F) yang membentuk asosiasi fasies alur, alur-lob, lob berpindah dan dataran lembangan. Penggunaan dan penilaian terhadap empat sistem pengelasan jasad batuan terpilih yang sedia ada menyumbang kepada penghasilan sistem Ubahsuai Perkadaran Jasad Cerun (M-SMR) untuk mengelaskan jasad batuan Formasi Crocker. M-SMR diperolehi daripada hasil tambah nilai Perkadaran Jasad Batuan asas (RMR_{asas}) dengan satu faktor ubahsuaian (parameter orientasi ketakselanjaran). Pengiraan parameter M-SMR bagi kualiti jasad batuan Formasi Crocker berlapis adalah masing-masing menggunakan pendekatan ketebalan unit litologi (LUT), Deere et al. (1967), kaedah purata set ketakselanjaran, kaedah purata, keadaan normal dan faktor ubahsuaian baru (NAF) bagi Kekuatan Mampatan Ekapaksi (UCS), Petanda Mutu Batuan (RQD), jarak ketakselanjaran, keadaan ketakselanjaran, aliran air dan orientasi ketakselanjaran. Untuk tujuan keselamatan rekabentuk cerun batuan, kaedah purata jarak set ketakselanjaran terburuk, kaedah purata keadaan ketakselanjaran terburuk dan keadaan aliran air terburuk adalah dicadangkan. Sistem M-SMR dibahagikan kepada kelas I (sangat rendah risiko, sangat stabil) hingga kelas VI (terlalu berisiko, terlalu tidak stabil). Cerun TS1 east, TS2 west dan LP mewakili kelas II, cerun B3 kelas III, cerun B4, TS1 west dan TS2 east kelas IV, cerun B1 dan B2 kelas V dan cerun TH kelas VI di kawasan kajian. Sistem M-SMR dirumuskan bertujuan untuk mencadangkan rekabentuk potongan cerun batuan dalam bentuk kaedah penstabilan dan perlindungan potongan cerun batuan, kajian semula model rekabentuk dan pemetaan semula cerun dan sudut cerun optima bagi Formasi Crocker di kawasan kajian. Korelasi antara M-SMR dengan sifat geomekanik Formasi Crocker seperti sifat facies, orientasi satah lapisan berbanding dengan muka cerun, kadar luluhawa dan darjah tegasan dan ragam kegagalan cerun batuan juga dihasilkan. Kajian semula model rekabentuk dan pemetaan semula cerun oleh pakar dan ahli geologi kejuruteraan atau jurutera geoteknik berpengalaman adalah sangat dicadangkan bagi kelas VI dan V dan IV, masing-masing bagi cerun TH dan cerun B1 dan B2 dan cerun B4, TS2 east dan TS1 west. Cerun kelas II TS1 east, TS2 west dan LP yang stabil hanya dicadangkan bagi kajian semula model rekabentuk dan pemetaan semula cerun oleh ahli geologi kejuruteraan atau jurutera geoteknik. Julat sudut cerun optima untuk cerun yang kurang dari 50m tinggi adalah di antara 65^{o} hingga 70^{o} dan 40^{o} hingga 45^{o}, masing-masing bagi kelas II dan VI sistem M-SMR. Korelasi antara M-SMR dengan sifat geomekanik Formasi Crocker seperti ciri fasies, orientasi satah lapisan berbanding cerun, kadar luluhawa dan darjah tegasan dan ragam kegagalan cerun juga dihasilkan. Orientasi satah lapisan yang bersudut, selari dan bertentangan dengan muka cerun bagi fasies alur, masing-masing mewakili kelas II, III ke V (bergantung kepada nisbah fasies alur dan lob), IV dan VI di kawasan kajian.

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