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Foreword

Alhamdulillah. First of all a big thank you and congratulations to the Editorial Board of ESTEEM Academic Journal of Universiti Teknologi MARA (UiTM), Pulau Pinang for their diligent work in producing this issue. I also would like to thank the academicians for their contributions and the reviewers for their meticulous vetting of the manuscripts. A special thanks to UiTM Press (Penerbit UiTM) for giving us this precious opportunity to publish this first issue of volume 7.

In this issue, we have compiled an array of seven interesting engineering research and technical based articles for your reading. Mazlan Mohamed, Rahim Atan and Mohd. Zulkifly Abdullah presents the simulation of three dimensional numerical analysis of heat and fluid flow through chip package. 3D model of chip packages is built using GAMBIT and simulated using FLUENT software. The authors had made comparison between three types of material in the term of junction temperature and found that the junction temperature of the nano-silver had the lowest junction temperature compared to epoxy and composite polymer. It was also found that the nano-silver had the highest value of thermal conductivity.

Solahuddin Yusuf Fadhlullah, Mohamad Adha Mohamad Idin and Mohd Halim Mohd Noor wrote an article that looks at Intrusion Detection System (IDS). In this study major and well known evasion techniques are exposed and discussed. Countermeasures are also mentioned and listed down in order to mitigate the threat of IDS evasion.

The third article written by Fairosidi Idrus et al. looked at the effect of wick structure and filling ratio to the vapour chamber performance in electronic cooling using an experimental method. The experimental results show that the rectangular wick structure gives the lowest thermal resistance and the wick structure with the working fluid and the boiling phenomenon is practically effective for a 45% fill ratio.

The article entitled "an introduction to e-ssc test kit as a new technique to characterize swelling and shrinkage potential of rock material" authored by Intan Shafika Saiful Bahri et al. A study was conducted to re-characterize the properties and behaviors of these weakly cemented rocks which were found to be very sensitive to moisture changes. A real time laboratory study determines the typical free swell and shrinkage behavior of the materials that potentially induced slope failures.

The fiftth article by Rozaini Ramli and Intan Shafika Saiful Bahri examine on the determination of soil erodibility, k factor for sungai kurau soil series. The author concluded that *Tew* equation indicates the smallest error for RMSE and suggested to be the most applicable method for statistical determination of soil erodibility for Malaysian soil series.

Rizal Mat Jusoh, Sharifah Saliha Syed Bahrom and Saiful Fadzli Salian present the Skin Detection Using Color Component Subtraction and Texture Information. In this study the algorithm is tested on color images focusing on palm and face skin regions. The author concluded that the algorithm is able to achieve more than 90% of detection rate.

The last article is entitled effect of various sizes extraction of wood-wool on the properties of wood-wool cement board manufactured from kelampayan (*neolamarckia cadamba*). The authors, Mohd Azrizal Fauzi and Zakiah Ahmad found that the performance of WWCB is influenced by wood-wool size and density.

We do hope that you not only have an enjoyable time reading the articles but also find them useful. Thank you.

Soffian Noor Mat Saliah
Chief Editor
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(Engineering)

An Introduction to e-SSC Test Kit as a New Technique to Characterize Swelling and Shrinkage Potential of Rock Material

Intan Shafika Saiful Bahri
Zainab Mohamed
Rozaini Ramli
Mohd Hidayat Mior Abas

ABSTRACT

The strength and deformation characteristics of rock masses are required for almost any form of analysis used for the design of slopes, foundations and underground excavations. However, weak rock engineering in tropical climate frequently encountered problem of ground swelling and shrinkage. Swelling and shrinkage of rock are relevant in civil engineering such as ground heaving and closure of tunnel opening and slope failures, where these are the most alarming phenomenon in geotechniques. Previous records have proven that it is complex to differentiate between swelling and shrinkage conditions since both conditions are often present at the same time. The deformations and loss of strength usually can only be recognized months or even years later. Argillaceous sedimentary formation along Route 6, Balik Pulau District, Penang especially along the stretch from KM 3.9 to KM 7.0 has been extensively exposed as cut slopes. It was observed that the design and construction of the cut slopes did not comply with any slope engineering rules. It is suspected that the lack of understanding of the heterogenous formation and their physical and engineering properties had caused severe geotechnical hazards not to mention the cost incurred. A proper and systematic characterization and classification of these rock materials could provide an answer to better explain what has and will be the future cause of failure of the geological structures in wet tropical climate. A study was conducted to re-characterize the properties and behaviors of these weakly cemented rocks which were found to be very sensitive to moisture changes.

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A real time laboratory study determines the typical free swell and shrinkage behavior of the materials that potentially induced slope failures.

Keywords: *swell, shrink, rock properties, characterization, slope failure*

Introduction

The term swelling of rock implies not only to the tendency of a material to increase in volume when water is available but also to the decrease in volume and shrink if water is removed. Whether a rock with high swelling potential will actually exhibit swelling characteristics depends on several factors: (1) the difference between the field moisture content at the time of construction and the final equilibrium, moisture content associated with the completed structure (2) the degree of compaction with more compaction favor swelling as moisture becomes available, (3) the final stress to which the material will be subjected after construction is complete. Weak rocks with high propensity to swelling potentially generated higher risk to geo-hazard especially in tropical environment. Weakly cemented siltstone and shale for examples are some of the common weak rock known for its critical swell and slake behavior that relate to its generic, texture and mineralogy. Conventionally these characteristics were measured by adopting soil mechanics approach as recommended by ISRM 1981, for characterizing the swell propensity of weak rock (Sadisun et al., 2002, Venter, 1981). However, the laboratory test procedures will totally destroy the original microstructure, fabric, porosity and density of weak rock, thus the result obtained may not truly reflect the in-situ behavior. For instance, Santi and Shakoor (1997) have comprehensively conducted through studies on the physical characterization of shale with respect to moisture content. Unfortunately, the system was not able to provide an added value to the engineering understanding with respect to its real time swell behavior. Various tests have been proposed in the literature to determine the swelling potential of rocks. In 1994, the ISRM proposed some suggested methods for rapid field identification of swelling and slaking of rocks (Einstein, 1994). The swelling potential can be assessed by conducting a swelling test using an apparatus called oedometer, where a rock specimen is placed in a rigid ring. Then, an initial vertical load is applied on the specimen. As water is added, the specimen swells and the vertical load is adjusted to maintain zero specimen swell. The swelling pressure is defined as the

maximum swelling vertical force recorded during the test divided by the specimen cross-sectional area. Swelling strain or displacement can also be measured on unconfined specimens after immersion in water (as long as the specimens do not slake or disintegrate upon contact with water). Franklin (1984) also proposed the ring swell test to measure swelling or shrinking. This test allows an account for axisymmetric radial confinement and axial loading on swelling. Robert (1995) quantified the percentage of swell or collapse potential of compacted soil by using triaxial equipment and oedometer apparatus. Whereas, Al-Hamoud et al. (1995) measured the swell potential of expansive clay using consolidation cell. Reznik (2000) found that the collapse of soils or fill material was due to its sudden volume (porosity) decrease. He measured the increasing soil/fill water content under various changing total stresses by using double oedometer apparatus. The collapse potential of clay soil was also calculated by using Atterberg limit values. Despite the extensive test methods adopted by implementing soil testing procedures, the major drawback was that the in-situ texture of the weak rock has been destroyed. Therefore, the results obtained may not truly reflect the real time behaviors on the site.

Location of Cut Slopes

A total of 10 cut slopes were identified along Route 6, Balik Pulau District, Penang. Two typical types of rock of sedimentary formation which are carbonatious sandstone (CSS) and carbonatious shale (CS) were selected from these areas. **Figure 1** shows the overview of identified cut slope locations in Penang, whereby **Figure 2** shows the detailed locations of cut slopes along Route 6, Balik Pulau District, Penang.

Development of e-SSC Test Kit

A need for a systematic geotechnical characterization of weak rock is vital despite of its complex problems. Weak rock especially of argillaceous type was known for its critical swelling and slaking behavior. **Figure 3** shows three different modes of sedimentary rock masses deterioration subjected to wet tropical climate.

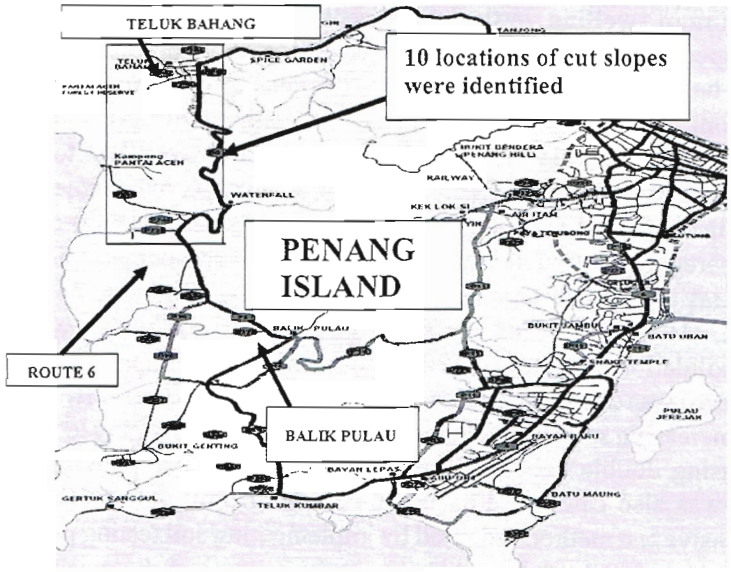

Figure 1: Map of Penang Island Showing Location of Cut Slopes

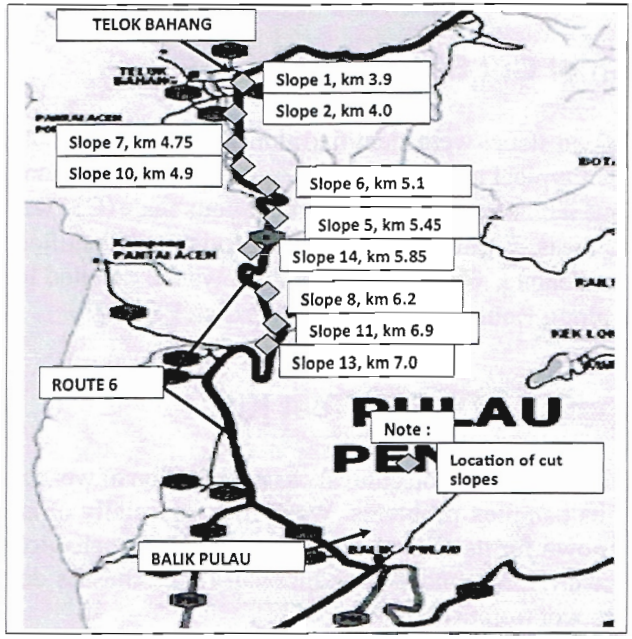

Figure 2: Detailed Locations of Identified Cut Slopes Along Route 6, Balik Pulau District, Penang

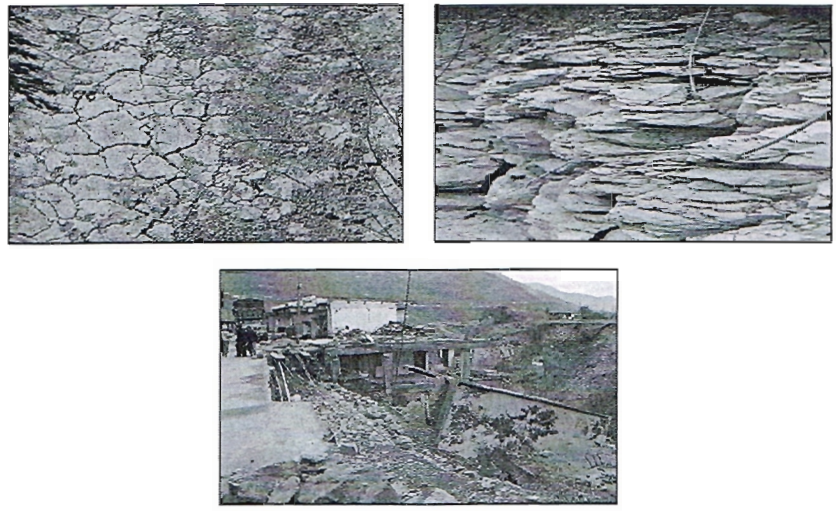

Figure 3: Modes of Weak Rock Deterioration in Malaysian Climate Showing the Significant Effect of Swell, Slake and Collapse Characteristics in Three Different Conditions

The occurrences of geo-hazards, significantly on hilly terrains have indicated that to date practitioners are not able to easily quantify this aspect of environmental load to better predict and explain the potential deterioration of rock mass before failure. The e-SSC test kit and its laboratory set up is used to introduce a new engineering technique that is able to quantify and measure the real time, the free swell behavior of weak rock. Understanding the mechanism and ability to measure the real time properties in advance significantly help engineers to have better prediction of the weak rock mass stress-dependent behavior due to climatic changes, the influence of distinct anisotropy and the long time lapse performances. The e-SSC abbreviation is meant for measuring the swelling, shrinkage and collapse potential behavior for real time series of rock materials subjected to wet and dry cycles. Swelling, shrinkage and collapse properties (names as SSC index) are among the significant geo-hazards to geotechnical engineering structure in tropical climate. It is very essential to be able to quantify the swell, shrink and collapse strains and its real time behavior for mitigation of geo-hazards. It will help in predicting the pre and post construction performances of geotechnical structure against potential mode of failure and long term stability.

Experimental Set-up

The e-SSC laboratory set up is as shown in **Figure 4**. The experiment allows for the unconfined and confined free swell of weak rock to be quantified for real time behavior. The objective of this research is to quantify the real time of swell and shrink characteristics and possible collapse potential of weak rock's inherent physical properties. The choice of test methods is normally decided based on the durability of weak rock. Carbonatious sandstone (CSS) has high durability of more than 85% slake durability index after 5 cycles, while carbonatious shale (CS) has less than 50% durability index. Therefore Unconfined Swelling Test (UST) can be carried out on CSS sample (**Figure 5a**); The CS sample is only suitable for Confined Swelling Test (CST) (**Figure 5b**). The aim of UST is only to measure volumetric strains while CST only measures the axial strain. Plaster of Paris was used to provide confinement to CST samples since it only measures axial strain (**Figure 6**). A cyclic wetting and drying test was done by continuously soaking and drying the samples to simulate the swelling and shrinkage characteristics of weak rock in tropical climate. The drying process was done by using a bright yellow bulb that produces heat of controlled temperature and at the same time it allows the transducers to record the shrinking profiles concurrently. The versatility of the e-SSC are due to its ability to produce 3-D real time volumetric strains of durable weak rock, the real time axial strain of non durable weak rock and finally a real time graphical output for further empirical analysis.

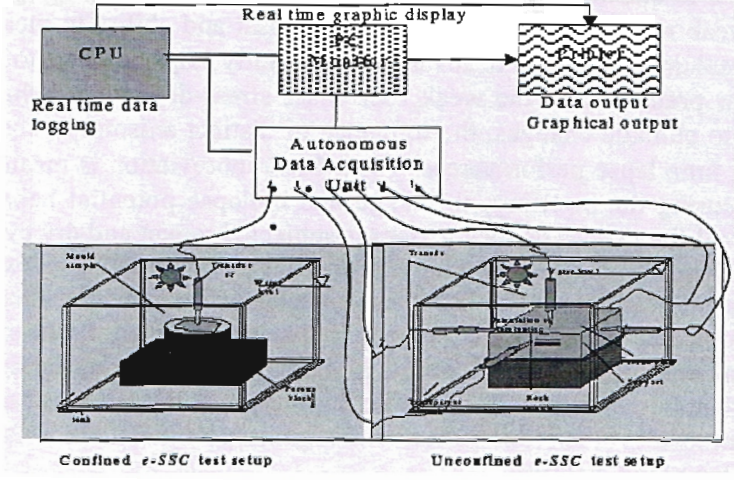

Figure 4: Schematic Laboratory Set-up of E-SSC Test Kit (Mohamed, 2007)

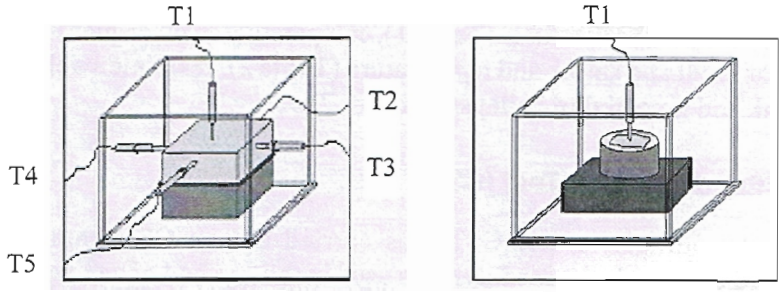

Figure 5: Unconfined Swelling Test and Confined Swelling Test (Mohamed, 2007)

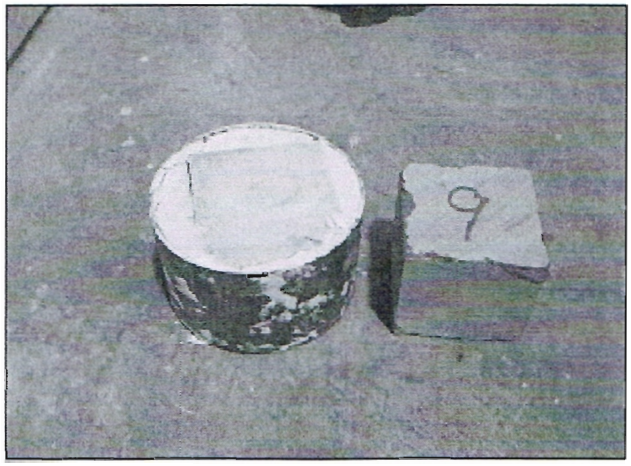

Figure 6: Use of Plaster of Paris to Provide Confinement for CST Sample

Unconfined Swelling Test (UST)

Unconfined swelling test was conducted on CSS sample under a process called wetting and drying where the sample was immersed into the water tank. One transducer was set vertically on the sample to measure the axial displacement, while 4 transducers were set at each side of samples to measure the horizontal displacements (**Figure 5a**). Concurrently, the drying process was done by drawing out the water from the tank using a tube attached to it. A light was switched on so that the sample shrinks and the water is dried out. The displacements were recorded using a data logger. The time graphic output was also displayed on the computer monitor. Technically, many parameters can

be obtained by using this method of testing namely; maximum swell recorded by each transducer (**Table 1**), comparative swell displacement, rate of swell and shrink and temperature (**Table 2**), real time swell and shrink and potential of collapse (**Figure 7**).

Confined Swelling Test (CST)

Correspondingly, cyclic CST was carried out on CS sample. In contradictory, only 1 transducer was used in this method of testing. The transducer was set perpendicular to the sample lamination (**Figure 5b**). **Figure 8** shows the graphical output display for CS sample. The typical data output for CS sample is as shown in **Table 3**.

Table 1: Typical Maximum Swell Strains Recorded by Each Transducer

No	T1 (mm)	T2 (mm)	T3 (mm)	T4 (mm)	T5 (mm)
1	2.496	0.414	0.532	0.692	0.337
2	0.680	0.566	0.152	0.224	0.072
3	3.860	3.360	0.797	2.189	0.546
4	3.800	2.497	0.541	1.177	0.438

Table 2: Rate of Swell Shrink for All CSS Samples

No	1st cycle 10^{-5} (mm/sec)		2nd cycle 10^{-5} (mm/sec)		Temperature (°C)	
	Swell	Shrink	Swell	Shrink	Max	Min
1	24.96	3.70	-	-	40	26
2	6.10	4.80	6.80	1.93	40	26
3	38.60	19.58	-	-	40	25
4	38.00	10.41	-	-	40	25

Table 3: Rate of Swell Shrink Results for CS Samples

No	1st cycle 10^{-5} (mm/sec)		2nd cycle 10^{-5} (mm/sec)		Temperature (°C)	
	Swell	Shrink	Swell	Shrink	Max	Min
1	3.31	1.90	-	-	39	25
2	24.97	3.94	-	-	40	26
3	3.31	0.80	2.30	1.90	38	26
4	18.67	11.84	-	-	40	25

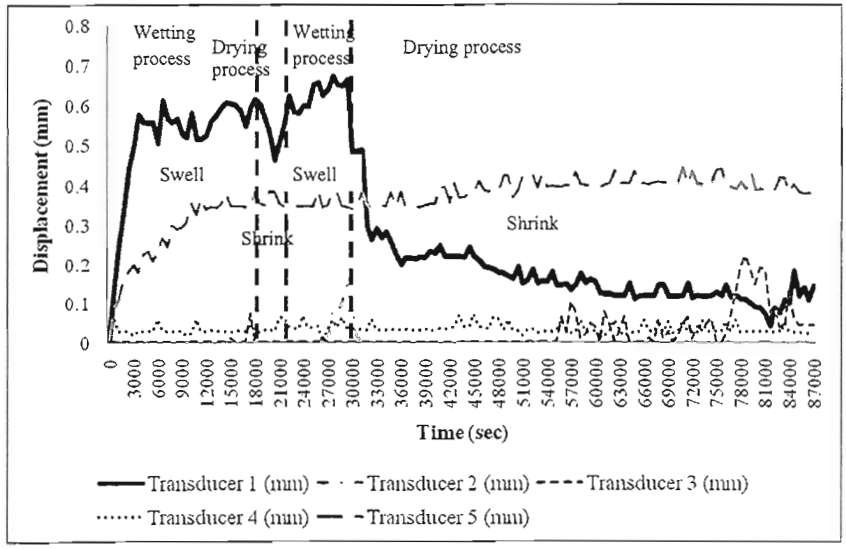

Figure 7: Graphical Output Showing Real Time Cyclic Swell and Shrink Profiles for UST

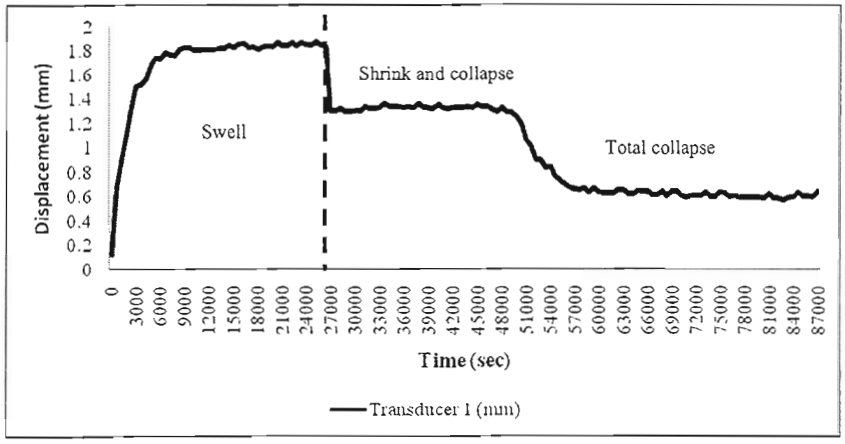

Figure 8: Graphical Output Showing Real Time Swell to Maximum Followed by Total Collapse of CS Sample

Conclusion

This paper is not intended to elaborate on the data obtained but rather to highlight the success of quantitatively characterizing the propensity of swell, shrink and collapse potential of argillaceous weak rock that induced to high risk of slope failure which was observed along Route 6, Balik Pulau District, Penang, specifically along the stretch from KM 3.9 to KM 7.0. It is obvious that high durability sample (CSS) has higher and longer resistance to cyclic wetting and drying load as compared to CS sample that collapse immediately after full absorption of moisture. The results indicated that the CS sample has weaker cemented texture that is not able to support its saturated self-weight. These typical results indicated that the proposed test method provides higher sensitivity, an acceptable testing procedures. It clearly measures the rate of swell-shrink and its durability against wet and dry cycle hence is able to determine the sustainability of the cut slope of argillaceous formation irrespective of the slope geometry. A repetitive test is ongoing to further establish the reliability of the e-SSC test kit. Further studies will be carried out to develop database of swell indices for different rock types as opposed to the conventional approach of characterization.

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