How to Improve Slope Management
and Slope Engineering Practices in Malaysia

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Abstract

There is growing concern and confusion on the current status of slope management and engineering practices in Malaysia. In April 2008, the Selangor state government imposed a ban on Class III and above hillsite development , i.e. slopes having gradient more than 25°.

In fact, slope management and engineering in Malaysia has improved over the years since the collapse of Tower 1 of Highland Towers on 11th December, 1993 that killed 48 people. Numerous guidelines on policies for hillsite development were introduced with more stringent conditions for approval. The introduction of Accredited Checkers in 2007 by BEM for geotechnical designs of hillsite development and the establishment of the Slope Engineering Branch in Public Works Department (PWD) are some of the initiatives implemented to improve slope engineering practices and mitigate the risk of landslides

This keynote address outlines further improvement and initiatives needed in slope management and engineering practices. The proposed strategies begin with streamlining and harmonising existing policies and legislation to provide transparent and consistent guidelines for project application and approval. Subsequently, structured training modules are proposed for undergraduates and practitioners for capacity building. Recommendations are put forward to channel adequate resources for research and development in fulfilling the wish lists for slope management and engineering via technical support of local and international experts. Finally, appropriate systems for construction quality assurance and control (QA/QC) as well as supervision by Design Consultants are recommended together with guidelines on long-term slope maintenance.

Keywords: Slope Management; Slope Engineering; Policy and Legislation; Training Modules; Construction Control

1.0 INTRODUCTION

Since the collapse of Tower 1 of Highland Towers on 11th December 1993 that killed 48 people, the community towards appropriate slope management and slope engineering has increased. Table 1 tabulates significant historical landslide events and Figure 1 shows the total number of reported landslides between 1961 and 2007. The increase in media attention has also led to the formation of guidelines and policies by governmental departments and relevant associations to ensure stringent approval procedures for hillsite development. More importantly, the occurrence of Rock fall at Bukit Lanjan in 2003, which lead to a six-month highway closure, triggered the formation of the Slope Engineering Branch under JKR in February 2004. Furthermore, the recent introduction of Accredited Checkers by BEM for geotechnical design of hillsite development attempts to mitigate risk of landslides and improveslope management and engineering.

Table 1 - Historical Landslides in Malaysia (after CDM (1999) and Web 1)

Date of Occurrence	Landslide Location (Name)	Fatality (Nos)	Injury (Nos)	Highway Closure
11 Dec 1993	Highland Towers	48	-	
30 Jun 1995	Genting Sempah	20	22	
6 Jan 1996	Km 303.8, Gua Tempurung	1	-	✓
29 Aug 1996	Pos Dipang, Perak	44	-	
26 Dec 1996	Keningau, Sabah	238		
20 Nov 2002	Taman Hillview	8		
26 Oct 2003	Km 21.8, Bukit Lanjan	-	-	✓
12 Oct 2004	Km 303, Gua Tempurung	-	1	✓

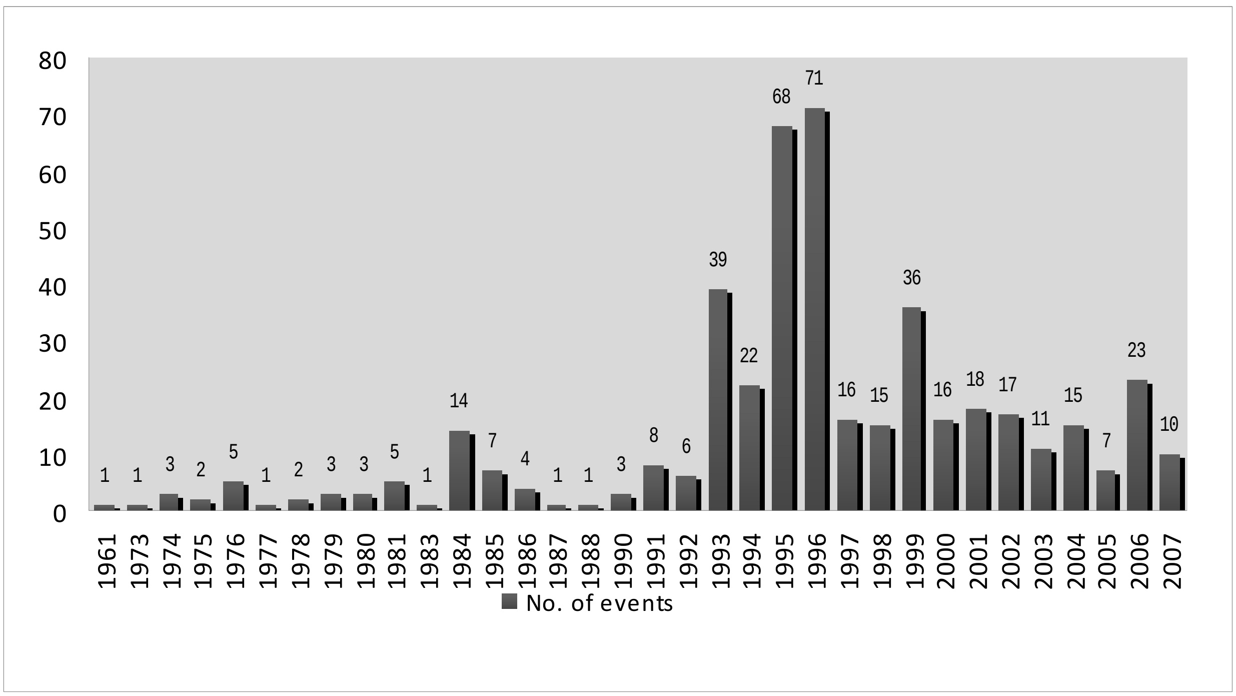

Figure 1: Number of Landslide Events In Malaysia, 1961 – 2007 (after PWD (2008))

Based on 49 cases investigated by the Authors (Gue & Tan, 2006), 60% of failure on man-made slopes are due to inadequacy in design alone. This inadequacy in design is generally the result of a lack of understanding and appreciation of the subsoil conditions and geotechnical issues. In addition, failure due to construction errors alone either on workmanship, materials and/or lack of site supervision contributed to 8% of the total cases of landslides. About 20% of the landslides investigated are caused by a combination of design and construction errors. The results clearly reveal that the majority of these failures were avoidable if extra care was taken and input from engineers with relevant experience in geotechnical engineering was sought from planning to construction. As such, the recommended areas for improvement focus on intensifying undergraduate education, structured training for practitioners and construction control and enforcement. In addition to that, the Authors have also proposed strategies to streamline and harmonise existing policies and legislation to provide practical guidelines for project approval and control. Figure 2 summarises the identified key areas where improvement and initiatives are needed in slope management and engineering.

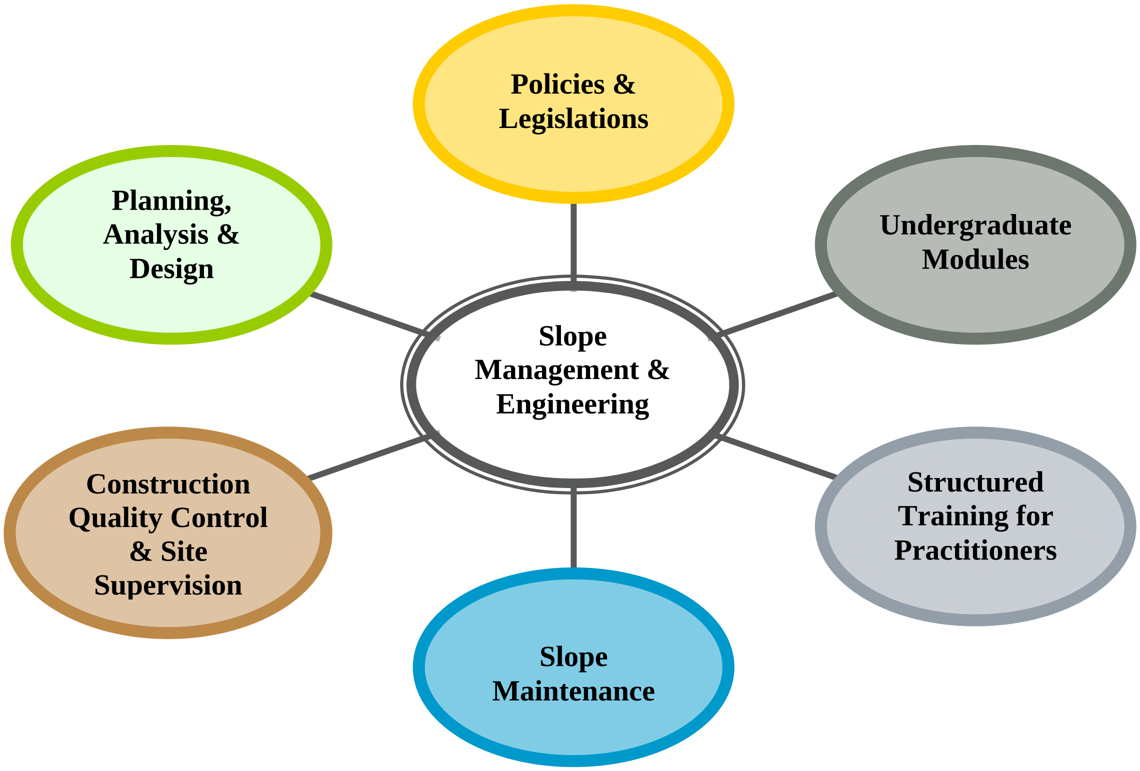

Figure 2: Key areas for improvement in slope management and engineering

2.0 POLICIES & LEGISLATION

The first authority to document hillsite development was the Urban and Rural Planning Department in 1997. The guidelines addressed the issues of planning and development in highlands on slopes, natural waterways, and water catchment areas (Abdullah et al., 2007). In June 2002, the Minerals and GeoScience Department Malaysia produced guidelines on hillsite development. The guidelines considered the angle of the natural slopes, type of terrain, type of activities, severity of erosion and extent of vegetation. The areas were then classified into four categories termed as Classes I, II, III and IV. Class I is the least severe in terms of terrain grading whereby slope angles are less than 15°. Class IV for slopes with angle of more than 35° are classified as the highest risk, where no development is allowed.

Apart from this, there are also numerous other guidelines and regulations related to slope management from the following governmental and private agencies: -

a) Department of Environment (DOE)
b) Minerals and GeoScience Department (JMG)
c) Majlis Perbandaran Ampang Jaya (MPAJ)
d) Ministry of Housing and Local Governments (MHLG)
e) Urban and Rural Planning Department (JPBD)

f) The Institution of Engineers Malaysia (IEM)
g) Kumpulan Ikram Sdn Bhd (IKRAM)

However, some of these guidelines and regulations are unclear and do not add value in terms of safety enhancement, slope stability and protection, environment friendliness and sustainability of engineering projects. These guidelines and regulations should be harmonized and improved by developing unified guidelines for good practices in the planning, design, construction, site supervision, maintenance and monitoring of slope engineering projects. In fact, the Institution of Engineers, Malaysia (IEM), under its own initiative, formed a taskforce in 1999 to formulate policies and procedures for mitigating the risk of landslides for hillsite developments. IEM (2000) produced a report entitled, "The policies and procedures for mitigating the risk of landslide on hill-site development" with the aim of providing uniform, consistent, and effective policies and procedures for consideration and implementation by the Government of Malaysia. However, the recommendations by IEM were not immediately accepted and acted on by the Government or the main stakeholder. The two recommendations implemented are as follows:

1. The establishment of a centralised agency for slope management and engineering under the Ministry of Housing and Local Government. However, Malaysian Government has appointed Public Works Department (PWD) to set up the centralised agency called Slope Engineering Branch.
2. The introduction of accredited checkers for geotechnical and structural works for hill-site development by The Board of Engineers, Malaysia.

Consequently, the current legal and regulatory framework should be reviewed and enhanced, including policies and legislation on landslide risk reduction management, mechanisms and processes in ensuring legal accountability, mechanisms for effective implementation, enforcement etc. In the aspect of development planning, the relevant policy should cut across development in both urban and rural areas for housing, infrastructure, agricultural, forestry, mining, etc. Procedures and guidelines on planning and implementation should incorporate an effective risk assessment and mitigation system with attention to possible environmental impact, mitigation, enhancement and sustainability. The Malaysian legal framework can be enhanced by emulating certain provisions in the legal and regulatory framework for development planning used by Hong Kong (Chan, 2007), Italy (Casale and Margottini, 1999), etc. For areas where field mapping have been done and hazard maps are available, these should be used to evaluate the level of inherent hazard at site and appropriate approval procedure may be implemented. As the Slope Engineering Branch of PWD has already started with ground mapping to compute hazard maps at sensitive areas like Ulu Klang, usage of such hazard maps should be incorporated into the current system of development approval and enforcement.

The main stakeholders involved in the harmonization and standardization of policies and legislations are illustrated in Figure 3. Participation from these stakeholders is very important for the success of developing comprehensive policies and regulations for subsequent implementation.

In order to achieve profound improvements in landslide mitigation and risk reduction, success at the implementation stage is vital. As such, two different stages of implementation are identified before, during and after a landslide event. The two major stages are preparedness stage and mitigation stage. In the preparedness stage, the appropriate laws and regulations, implementation and enforcement policies and guidelines for development planning, training schemes for stakeholders and promotion schemes for community awareness should be geared towards effective landslide mitigation and risk reduction management.

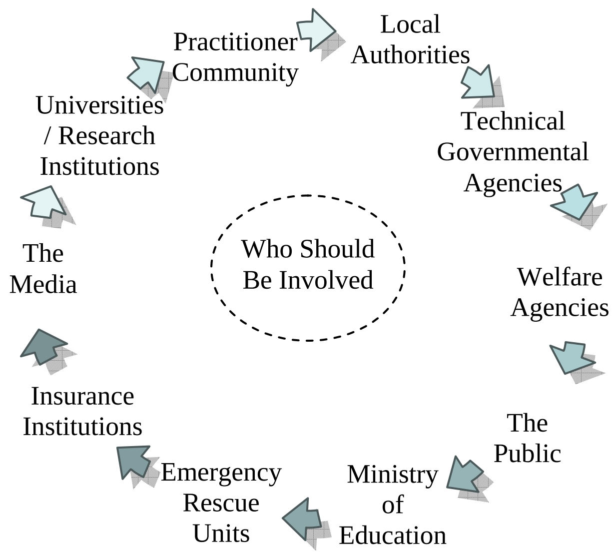

Figure 3: Formation and Implementation of a National Slope Master Plan (after Gue *et al*., 2008)

In the mitigation stage, significant resource allocation from the main stakeholders is essential as it consists of planning and enforcement of good practices in new development, retrofitting of existing areas at risk, research and development and exploring advancement in technology and methodology. A similar approach has been adopted in Hong Kong where landslide mitigation and risk reduction have been incorporated into two (2) components, first in planning control of new development, and subsequently in retrofitting existing slopes at risk (Chan, 2007). Such policies have contributed significantly to landslide mitigation and risk reduction in Hong Kong with tremendous success. Furthermore, the entire implementation procedure should be entrenched with a “check and review” benchmarking system for continuous policy refinement. With that, the formulated template of a National Slope Master Plan may become a flagship programme, serving as a blueprint for a structured and systematic implementation plan.

3.0 PLANNING, ANALYSIS AND DESIGN OF SLOPES

Desk Study

Desk study includes reviewing of geological maps, memoirs, topographic maps and aerial photographs of the site and adjacent areas so that the engineers are aware of the geology of the site, geomorphology features, previous and present land use, current developments, construction activities, problem areas like previous slope failures, etc.

Site Reconnaissance

Site reconnaissance is required to confirm the information acquired from the desk study and also to obtain additional information from the site. For hillsite development, it is also very important to locate and study the landslip features to identify previous landslides or collapses that can act as indicators of the stability of the existing slopes.

Subsurface Investigation

Subsurface investigation (SI) should be properly planned to obtain representative subsurface conditions of the whole slope such as the depth of soft soil, hard stratum, depth of bedrock, geological weak zones, clay seams or layers, and the groundwater regime. The planning of exploratory boreholes should take into consideration the slope profile instead of following a general grid pattern. A minimum of three (3) boreholes per cross-section (one on slope crest, one at mid-slope and one at slope toe) is recommended to obtain representative subsurface conditions of the whole slope. In addition, the design engineer must attempt to identify clay seam with the potential of inducing perch water. This could be done by superimposing the classification of subsoil in proportion on the cross-section of a slope, as shown in Figure 4 to examine its influence on the stability of a slope.

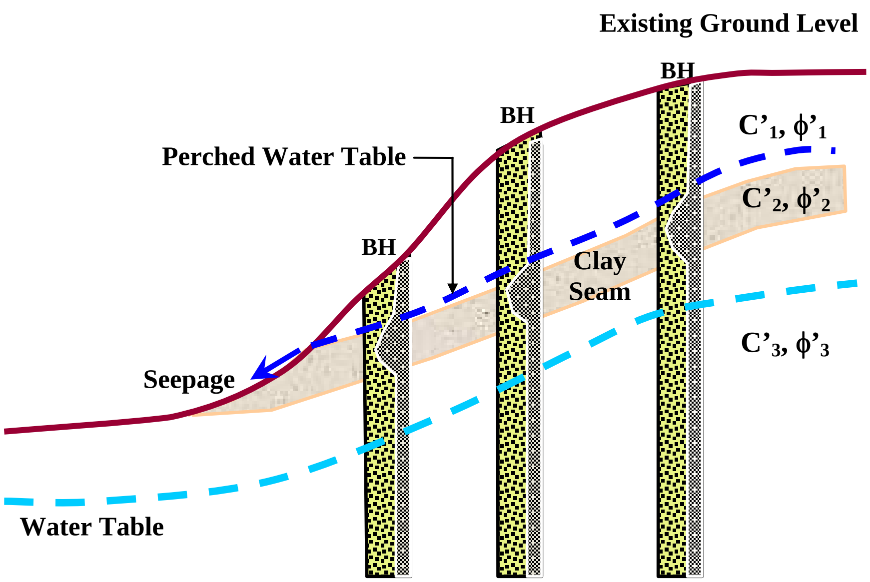

Figure 4: Potential clay seam on slope

Analysis and Design of slopes

For the design of the slopes, correct information on soil properties, groundwater regime, site geology, selection and methodology for analysis are important factors that require the special attention of the design engineer. A detailed analysis of soil slopes can be found in Tan & Chow (2004) and Gue & Tan (2000).

For the selection of Factor of Safety (FOS) against a slope failure, the recommendations by Geotechnical Manual for Slopes (GEO, 2000) of Hong Kong, with minor modifications to suit local conditions, are normally selected with consideration to two main factors, namely, Risk-to-life or Consequence to life (e.g. casualties) and Economic Risk or Consequence (e.g. damage to property or services). Further details on selection of FOS can be found in Gue & Tan (2004).

Design of Cut and Fill Slopes

The vertical interval of slopes between intermediate berm is usually about 5m to 6m in Malaysia. GEO (2000) recommends that the vertical interval of slopes should not be more than 7.5m. The berms must be at least 1.5m wide for easy maintenance. The purpose of berms with drains is to reduce the volume and velocity of runoff on the slope surface and the consequent reduction of erosion potential and infiltration. The adopted slope gradient should depend on the results of analysis and design based on moderately conservative strength parameters and representative groundwater levels.

For fill slopes, the vegetation, topsoil and any other unsuitable materials should be properly removed before placing the fill. The foundation should also be benched to key the fill into an existing slope. A free-draining layer conforming to the filter criteria is normally required between the fill and natural ground to eliminate the possibility of high pore pressures developing and causing slope instability, especially when there are existing intermittent streams and depressions. Sufficient numbers of discharge drains should be placed to collect the water in the filter layer and discharge it outside the limits of the fill and away from the slope.

Surface Protection and Drainage
Surface drainage and protection are necessary to maintain the stability of the designed slopes through reduction of infiltration and erosion caused by heavy rain, especially during monsoon seasons. Runoffs from both the slopes and the catchment areas upslope should be effectively cut off, collected and led to convenient points of discharge away from the slopes. Details on surface protection and drainage can be found in Gue & Tan (2004).

Catchment Study
Catchment study should be carried out for the provision of surface drainage capacity to carry the runoffs to a safe discharge point. Under-provision of surface and subsurface drainages can lead to infiltration and spillage of the surface runoffs to the slopes, cause saturation of slopes, surface erosion and could result in slope deterioration over time.

Fill Slopes Over Depressions or Valleys
Depressions or valleys are the preferred water path of natural surface runoffs. Streams or intermittent streams are usually formed at these depressions and valleys, especially during heavy rain. Intermittent streams at depressions or valleys also transport sediments from upstream and deposit these sediments at the depression or valley and form a layer of soft or loose material and debris. For slopes which are formed by filling over a depression or valley, the possibility of saturation of slopes and slip planes through the pre-existence of weak, soft or loose layers with debris is high.

Therefore, extra care should be exercised on the fill slopes over depressions or valleys by adopting the following measures to mitigate risk of slope failures: -

1) To provide adequate surface drainage by calculating the capacity required based on catchment study to reduce infiltration of surface runoffs to slopes.
2) Subsurface drainages should be adequately provided to drain water from slopes to avoid saturation and rising of the groundwater level. Increase in ground water level will reduce the FOS of slopes.
3) To replace shallow and weak materials with a compacted good fill material during the filling works to enhance the slope stability.

Slopes Next to Water Courses
For slopes adjacent to water courses such as river bank slopes, beaches, pond side slopes, etc, the slopes should be robustly designed by considering the probable critical conditions such as saturated slopes with rapid drawn-down conditions, scouring of slope toes due to flow and wave actions, etc. Properly designed riprap or other protection measures are needed over the fluctuating water levels.

4.0 UNDERGRADUATE TRAINING

Apart from improving the policies and legislation for implementation by the government on slope engineering and management, emphasis should also be given to improve undergraduates' understanding of slope engineering fundamentals. This is currently lacking, and is one of the most important components to improve slope engineering.

As such, the proposed strategy is to develop training modules for undergraduate curriculum and course notes for engineering undergraduates. The training modules should have adequate fundamentals on slope engineering, which include planning of S.I. works, compiling and interpreting soil parameters and water profiles from the S.I. works, followed by analysis, design, specifications, site supervision, construction control, monitoring and maintenance.

Government and private universities should review and update the undergraduate syllabus on slope engineering from time to time with the assistance of active, experienced practitioners to ensure graduates possess enough fundamentals to meet industry needs. The regular updates may be further improved by pooling resources from a group of universities and passionate practitioners to ease the workload of the lecturers so that the content and quality of the lecture modules are not compromised. Knowledge sharing between lecturers and practitioners can also be achieved through workshops and forums to share experiences on landslide mitigation and risk reduction.

5.0 STRUCTURED TRAINING MODULES FOR PRACTITIONERS

As Engineers are the professionals involved in specifying the required landslide mitigations measures, providing structured training to practitioners would be the best way to improve slope engineering practices. Such training should also serve as a reminder to practitioners and professionals who are involved in slope engineering works to practice ethically and professionally, and only practice in the area of their expertise to ensure the safety of the design. Therefore, the continuing professional development (CPD) scheme implemented by the Board of Engineer, Malaysia (BEM) should be adopted as training programmes for practising engineers. Furthermore, collaboration and working partnership should be established between professional bodies like the Institution of Engineers, Malaysia (IEM), technical agencies, academia, federal, state and local governments, private industry, Non-Governmental Organisations (NGOs) involved in slope engineering and management to recognize and accredit professionals and/or semi-professionals undergoing the structured training. Through the structured training programmes, a certification and accreditation system should also be implemented to update and improve the capacity, competency and professionalism of stakeholders involved in slope engineering and management.

In terms of training programmes for government agencies, the emphasis should be in three (3) stages:

1. Approval Stage: Training programmes on legal framework to enhance the knowledge and capabilities of the local authorities with the process flow of land development such as planning, application, approval, design, construction and maintenance. This is important to ensure proper enforcement of loss reduction measures in accordance with laws and regulations.
2. Preparedness and mitigation Stage: Training programmes on guidelines and technical modules on analysis, design, construction control, site supervision and maintenance of slopes
3. Response and recovery Stage: Training programmes on administrative management in the use of guidelines in responding to landslide disasters and providing scientific and technical information needed for response and recovery .

Training of different stakeholders, gathering of comments on conflicts and weaknessness of existing guidelines or procedures can facilitate standardisation or harmonisation of practices/procedures and formulation of relevant guidelines related to slope engineering and management. With appropriate and sufficient training, the adoption of best practices and technology (which needs to be updated from time to time) can be on par with international standards. International best practices can be adopted and/or adapted to local conditions to mitigate landslides/slope failures and their related consequences.

6.0 RESEARCH AND DEVELOPMENT

Apart from structured training modules, all practitioners can take another step ahead with Research and Development (R&D) to enhance safety, environmental protection and sustainability, speed of construction and economical aspects related to slope engineering and management.

Among others, R&D on a simplified laboratory test to derive soil properties would be beneficial. This is particularly useful in establishing a framework of relationship between friction angle and soil descriptions. In addition, efforts could also be channelled to correlate soil friction angle against percentage of fines. By understanding such inversely proportional relationships, practitioners may be able to appreciate the change in material behaviour and its sensitivity toward material particle size distribution. However, the above proposed R&D topics would not be achievable without high quality sampling and testing techniques. Therefore, these are the challenges in current slope engineering industry waiting to be tackled by practitioners and academicians.

As slope stability analyses are heavily dependent on the accuracy of groundwater level estimation, the behaviour of groundwater fluctuation during dry and wet seasons should be evaluated through research and development. Such understanding of ground water fluctuation for countries with tropical weather like Malaysia would be highly beneficial as terrestrial rainfall is known to be highly unpredictable. The knowledge on groundwater fluctuation can help formulate design procedures for subsoil drainage systems, like horizontal drain spacing.

7.0 CONSTRUCTION CONTROL AND SITE SUPERVISION

Site supervision and Coordination

Supervising personnel should have sufficient knowledge and experience in geotechnical engineering to identify any irregularities in the subsurface conditions (e.g. soil types, surface drainage, groundwater, weak planes such as clay seams etc.) that may be different from those envisaged and adopted in the design. Close coordination and communication between design engineer(s) in the office and supervising engineer(s) are necessary so that modification of the design to suit the change of site conditions could be carried out when needed. This should be carried out effectively during construction to prevent failure and unnecessary remedial works during the service life of the slope. Site staff should keep detailed records of the progress and the conditions encountered when carrying out the work, in particular, if irregularities like clay seams, significant seepage of groundwater are observed. Sufficient photographs of the site before, during and after construction should be taken. These photographs should be supplemented by information such as dates, weather conditions or irregularities of the subsoil conditions observed during excavation.

Construction Control via Contractual Measures

For all earthworks, there should be contractual provisions in protecting the environment against inappropriate ground disturbance by contractors for both temporary and permanent works. Such legal provision should be included in the relevant Earthworks Specification. An extract from a sample Specifications for Earthworks is shown Figure 5, in which clause 12.7 specifies Engineer’s requirements on temporary works (see Figure 5a), clauses 24.3 and 24.4 specifies protection of borrow pit (see Figure 5b), clauses 33.5 specifies on turfing and clause 33.21 penalties imposed for non-compliance (see Figure 5c).

12.0 TEMPORARY WORKS

12.1 The Contractor shall allow in the tender for the cost of providing the necessary design, statutory submission, construction, testing and monitoring of all temporary works, including the subsequent removal of all recoverable temporary structures, for the satisfactory completion of the earthworks. He shall be responsible for the overall adequacy and safety of all temporary works. All temporary works shall comply with requirements of BS 5975.

12.2 Temporary works means all planning and works carried out by the Contractor to construct the permanent works designed by the Consultant complying with all specifications, drawings and workscope. This includes but not limited to necessary field and laboratory tests, temporary tracks, excavation, filling, proper cover and protection to exposed slopes, sequence and timing of works, necessary temporary drainage, pumping of water, emergency contingency measures, safety of site, rectification and strengthening measures, methodology and method statement of all works, and etc.

12.3 The scope of temporary construction shall include but not limited to:
(a) Life safety measures such as hoardings, barricades, nettings, signboards, etc.
(b) Ground improvement and/or ground water cut off systems using jet grout piling, etc.
(c) Ground water recharging systems, surface and groundwater drainage system using surface or subsoil drains, sumps, etc.
(d) All other measures necessary for the safe performance of the temporary works, such as maintaining, adding, upgrading, strengthening, adapting, modifying, re-positioning, taking down and re-fixing from time to time, etc.

12.4 Temporary works shall be the sole responsibilities of the Con… temporary works shall not relieve the Contractor's sole responsib… Contractor's own time and cost to rectify any defects, non-compl… serviceability problems of the temporary works or caused by temp…

12.5 The Contractor shall employ a Professional Engineer to design a… design calculations and construction drawings for the temporary …

12.6 The Contractor shall make all necessary statutory submissions in… required clearances and the statutory permit to commence work. … design and construction of the temporary works, including any st… of the contract.

12.7 All temporary works especially but not limited to temporary ac… cause failure and shall not induce instability or serviceabili… left behind after completion of permanent works s… works. These temporary works by Contr… similar type of permanent works (e.g. slope an… necessary, etc).

12.8 Temporary works by the Contractor that in the opinion of the S… term) in any way, the S.O. will order remedial works to be … performance time. Such instruction will not relieve the Contracto… out shall comply to all requirements, specifications, drawings and workscope of similar type of permanent works (e.g. cut, fill, retaining walls, strengthening works, etc).

> 12.7 All **temporary works** especially but not limited to temporary accesses and temporary earthworks (temporary cut or temporary fill) shall not cause failure and shall not induce instability or serviceability problems in the long term. All temporary cut and fill by Contractor that will be left behind after completion of permanent works shall have the **same Factor of Safety on stability and Serviceability conditions as permanent works**. These temporary works by Contractor shall also comply with all requirements, specifications, drawings and workscope applicable for similar type of permanent works (e.g. slope angle, compaction of fill, surface drainage, retaining structures, strengthening measures if necessary, etc).

Figure 5a: Extract from the Specifications for Earthworks (Clauses 12.0: Temporary Works)

24.2 Fill materials for use in formin… materials is inadequate, the Co… been approved by the S.O.

Borrow Pit

24.3 The Co… potential a… ascertain the … Contractor shall … keep the borrow p… protection measures f…

24.4 The contractor shall submi… cutting or dumping, all the s… method. Provision of drainage,…

Soft Spots

24.5 Where any undue movements … of the fill, it shall be excavat… excavation shall be backfilled … compacted as described above,…

24.6 The Contractor shall allow for … compaction.

Filling under Floors, Aprons,…

24.7 Filling shall be provided and … deposited in loose lifts not exc… Generally, clay shall be used f… difficult due to space constrain… S.O.

25.0 FILL MATERIALS

25.1 In general, fill material shall b… shall not be used at any loca… laboratory tests to determine th…

25.2 The safety of workmen, ease of placement and compaction are primary considerations when carrying out filling operations in narrow, confined spaces. Under these conditions, only granular soil will be permitted for use as fill material. The Contractor shall take this requirement into

> **Borrow Pit**
>
> 24.3 The Contractor shall be responsible for locating borrow pits. Designated borrow pits shown on the Drawings only indicate to the Contractor potential areas for borrow. Whether the Contractor obtains materials from the designated or his own borrow pit, it shall be his responsibility to ascertain the suitability of the pit with respect to the quantity and quality of the materials, which shall be subject to the approval of the S.O. The Contractor shall pay all necessary fees, taxes or royalties to the appropriate authorities and observe all relevant regulations. The Contractor shall keep the borrow pits free from ponding water and the excavation neat and tidy and shall carry out necessary erosion and environmental protection measures following the agreed method statement or as instructed by the S.O.
>
> 24.4 The contractor shall submit method statement on cutting or filling and turfing at the borrow pit or dump site for approval of the S.O.. After cutting or dumping, all the slopes shall be formed to a stable gradient and close turfed or protected by other approved surface protection method. Provision of drainage, siltation pond and preventive measures of pollution shall also be included in the method statement.

Figure 5b: Extract from the Specifications for Earthworks (Clauses 24.0: Protection of Borrow Pit)

33.0 PROTECTIVE VEGETATION FOR EROSION CONTROL

33.1 If specified in the drawings, directed by the Engineer or required to be used by the Contractor to protect the slope via vegetation, the following sections shall be adhered to unless otherwise directed by the Engineer.

33.2 If due to unforeseen circumstances turfing or hydroseed… duration as specified hereafter, temporary protection/cover… be laid on exposed slopes by the Contractor.

Topsoil

33.3 Topsoil stockpiled for the Works shall be spread and light… 50mm as directed by the Engineer in areas to be turfed and…

33.4 Topsoil stockpiled for the Works in accordance with Sub-… spread and lightly compacted to an even thickness of 50 m… be turfed and/or hydroseeded, or used as the S.O. shall… other purposes.

Turfing

33.5 Turfing shall be carried out within seven (7)… shown in the Drawings and/or where direct… the right to engage external party to… accordingly from the contract. The type… alternative type as approved by the Engineer and shall be… weeds.

33.6 Turf shall be obtained in unbroken sods with a substa… approximately 250mmx250mm in size and 100mm thick, fr… placed in position as soon as practical after cutting.

33.7 Turf sods shall be stacked and watered when they cannot be laid immediately after cutting. The surfaces to be turfed shall be trimmed and thoroughly wetted. The turf shall then be carefully laid to form a complete and uniform cover as shown on the Drawings. Turf laid on slopes steeper than 1(vertical) : 3 (horizontal) shall be pegged down with bamboo stakes approximately 250mm

33.5 Turfing shall be carried out within seven (7) days after formation of the final slope profile as shown in the Drawings and/or where directed by the Engineer. Otherwise, the Engineer reserves the right to engage external party to carry out the work and deduct the additional cost incurred accordingly from the contract. The type of turf shall be as indicated in the Drawings or other alternative type as approved by the Engineer and shall be free of lallang and essentially free of weeds.

Penalty

33.21 The Contractor who fails to implement the Works as per above Sub-sections 2.2.8.1, 2.2.8.2 and 2.2.8.3 shall bear the time and cost of turfing/hydroseeding works carried out by others under the direction of the S.O.

Figure 5c: Extract from the Specifications for Earthworks (Clauses 33.0: Protective Vegetation for Erosion Control and Penalty for Non-compliance)

Furthermore, contractors are required to quote temporary slope protection works (see extracted sample in Figure 6a) so that the Engineer's specifications for temporary protection are not compromised. With that, the contractor would be penalised for not providing the required precautionary measures during the course of works, especially on the protection of borrow pit (see extracted sample in Figure 6b). The control on temporary works should also be included in the construction drawings as drawing notes. In addition, the construction drawings should also include the appropriate construction sequence for cut and fill slopes, as shown in Figures 7a and 7b, respectively.

In the event a borrow pit was used, the Engineers should ensure it being cut to a gentle and stable gradient to allow for appropriate discharge of surface run-off. Meanwhile, the slopes should be closed turfed to minimise soil erosion which may cause slope instability or washing away of fine particles, hence, clogging downstream drainage system. The above requirements should be made known to the contractor through specifications, as per clause 24.3 and 24.4 in Figure 5b.

Item No.	Description	Unit	Quantity	Rate	Amount RM
1	**TEMPORARY WORKS**				
	"Temp[illegible]rary [illegible] works [illegible] construc[illegible] the consul[illegible] drawings a[illegible] not limited t[illegible] tests, tempo[illegible] proper cove[illegible] slopes, seq[illegible] necessary t[illegible] water, emer[illegible] safety of site [illegible] measures, methodology and method statement of all works, and etc.				
	"Temporary works" shall be the sole responsibility of the contractor. Engineer's approval or the consent of contractor's method statement on all temporary works shall not relieve the contractor's sole responsibilities to ensure all temporary works comply to good engineering practice, and contractor's own time and cost to rectify and defects, non-compliance to good engineering practice or possible long term instability/failure and serviceability problems of the temporary works or caused by temporary works.				
	All temporary works particularly but not limited to temporary access and temporary earthworks (temporary cut or temporary fill)				

Temporary Works

All temporary works particularly but not limited to temporary access and temporary earthworks (temporary cut or temporary fill) shall not cause failure and shall not induce instability or serviceability problems in the long term. All temporary cut and fill by contractor that will be left behind after completion of permanent works shall have the same factor of safety on stability and serviceability conditions as the permanent works.

Figure 6a: Sample Bill of Quantities for quotation of temporary works

Item No.	Description	Unit	Quantity	Rate	Amount RM
2	**Borrow Pit**				
	The contractor shall submit method statement on cutting or filling and turfing at the borrow pit or dump site for approval of the S.O.. After cutting or dumping, all the slopes shall be formed to a stable gradient and close turfed or protected by other approved surface protection method. Provision of drainage, siltation pond and preventive measures of pollution shall also be included in the method statement. Failure to implement the Works as per specification shall bear the time and cost of turfing/hydroseeding works carried out by others under the direction of the S.O.	L.S.			

Figure 6b: Sample Bill of Quantities for Borrow Pit protection

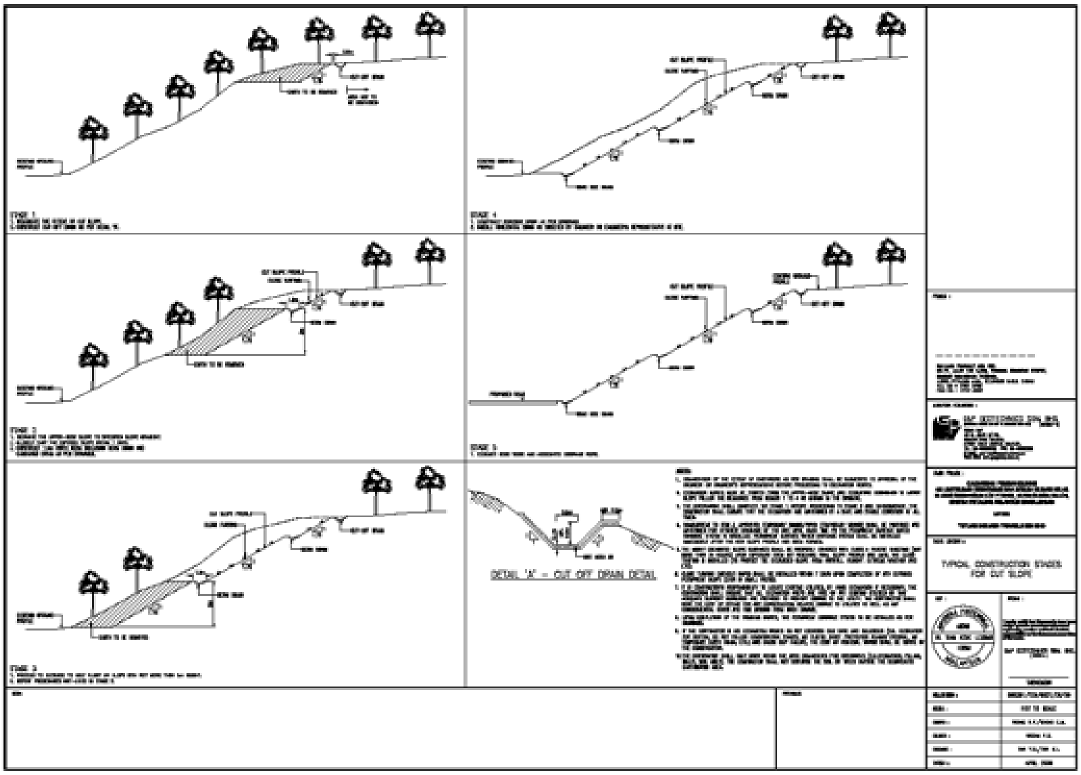

Figure 7a: Sample construction drawing on construction sequence for cut slopes

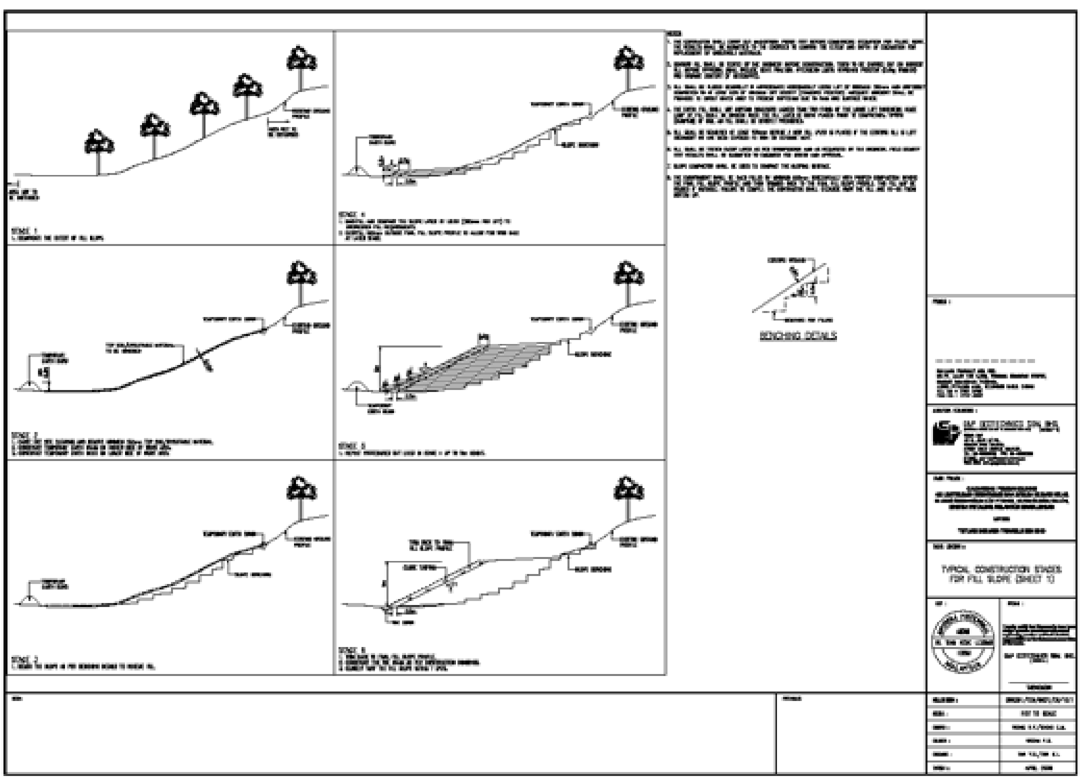

Figure 7b: Sample construction drawing on construction sequence for fill slopes

Filling of Slopes
Whenever possible, construction works should be arranged such that fill is placed during the dry season, when the moisture content of the fill can be more easily controlled. When filling, tipping should not be allowed and all fill should be placed in layers not exceeding 300mm to 450mm thick depending on the type of compacting plant used (unless compaction trails proved that thicker loose thickness is achievable) in loose form per layer and uniformly compacted in near-horizontal layers to achieve the required degree of compaction before the next layer is applied. The degree of compaction for fill to be placed on slopes is usually at least 90% to 95% of British Standard maximum dry density (Standard Proctor) depending on the height of the slope and the strength required.

Cutting of Slopes
Cutting of slopes is carried out from top-down followed by works like drains and closed turfing. When carrying out excavation of cut slopes, care must be taken to avoid overcutting and loosening of the finished surface which may lead to severe surface erosion. Minor trimming should be carried out either with light machinery or by hand as appropriate. It is also a good practice to construct first the interceptor drains or berm drains with proper permanent or temporary outlets and suitable dissipators before bulk excavation is carried out or before continuing to excavate the next bench.

Surface Protection of Slopes
For all exposed slopes, protection such as closed turfing or hydroseeding should be carried out within a short period (not more than 14 days and 7 days during the dry and wet seasons respectively) after the bulk excavation or filling for each berm. All cut slopes should be graded to form horizontal groves (not vertical groves) using suitable motor graders before hydroseeding. This is to prevent gullies from forming on the cut slopes by running water before the full growth of the vegetation, and also to enhance the growth of vegetation.

8.0 SLOPE MAINTENANCE

Guideline for Slope Maintenance
A good reference for engineers is Geoguide 5 – Guide to Slope Maintenance (2003) from GEO of Hong Kong and for laymen, the "Layman's Guide to Slope Maintenance"

Geoguide-5 (2003) recommends maintenance inspections be sub-divided into three categories:

(A) Routine Maintenance Inspections, which can be carried out adequately by any responsible person with no professional geotechnical knowledge (layman).
(B) Engineer Inspections for Maintenance, which should be carried out by a professionally qualified and experienced geotechnical engineer.
(C) Regular Monitoring of Special Measures, which should be carried out by a firm with special expertise in the particular type of monitoring service required. Such monitoring is only necessary where the long term stability of the slope or retaining wall relies on specific measures which are liable to become less effective or deteriorate with time.

Frequency of Maintenance Inspections
Since Malaysia has at least two monsoon seasons, Routine Maintenance Inspections (RMI) by a layman should be carried out a minimum of twice a year for slopes with negligible or low risk-to-life. For slopes with high risk-to-life, more frequent is required (once a month). In addition, it is good practice to inspect all the drainage channels to clear any blockage by siltation or vegetation growth and repair all cracked drains before the monsoon. Inspection should also be carried out after every heavy rainstorm.

Category B Engineer Inspections for Maintenance, should be taken to prevent slope failure when the Routine Maintenance Inspection by laymen observes something unusual or abnormal, such as the occurrence of cracks, settling ground, bulging or distorting of walls or settlement of the crest platform. Geoguide-5 (2003) recommends an Engineer Inspection for Maintenance be conducted at minimum of once every five years and more frequent if requested by those who carry out the Routine Maintenance Inspections. More frequent inspections may be desirable for slopes and retaining walls in the high risk-to-life category. Such regime of regular maintenance inspection should be made known to all property owners and be enforced by the relevant authorities. The regulator may then implement the appropriate orders (in accordance with the available legal/regulatory framework) if the property owners refuse to carry out their duty diligently.

9.0 CONCLUSION

The proposed strategies to improve slope management and slope engineering practices in Malaysia begin with streamlining and harmonising existing policies and legislation to provide transparent and consistent guidelines for project application and approval. At the same time, structured training modules are proposed with input from active practitioners for undergraduates and practicing engineers for capacity building. Subsequently, the appropriate system for construction quality assurance and control (QA/QC) as well as site supervisions by Design Consultants are recommended together with guidelines on long-term slope maintenance.

More importantly, this keynote address has emphasised on contractual provision, in protecting the environment against inappropriate ground disturbance by contractors especially during construction of temporary works and borrow pits. Extracts of sample Specifications for Earthworks and construction drawings were shown, indicating the Engineer's requirements on appropriate protection for temporary works and borrow sources. Contractors are required to give quotations for temporary works so that the Engineer's specifications for temporary protection are not compromised. With that, contractors can be penalised for not taking the required precautionary measures during the course of works.

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