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Human Error Causes in Slope Engineering Practices

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Abstract. Landslide/slope failures have been accounted, as the second natural disaster for Malaysia after flood.From the landslides investigations reports, it is shown that landslides in Malaysia were caused mainly by factors like lack of maintenance, less coordination during construction stage and design problem apart from rainfall. The slant of this study facilitated multidisciplinary perceptions regarding human error causes in existing practices to be captured. This approach has the worth to offer the usefulness of progressive actions that are taken to strengthen the slopes. Conducting the surveys with focussed group respondents, could provide benchmarking to gauge any change in influences and resource use as efforts are made to advance the consideration of slope stability in hill site developments.

Introduction

A natural disaster, by its nature is always multifaceted and unpredictable. Landslide is one of the major geo-hazard accompanied by uncertainties that give rise to hundreds of deaths every year. From the landslides investigations reports, it is shown that landslides in Malaysia were caused mainly by failures of the retaining wall and other factors like lack of maintenance, less coordination during construction stage and design problem apart from rainfall [1,2.3,4,5,6,7,8].

Human uncertainty is not new, the calamitous failure of Kwun Lung Lau landslide in Hong Kong is the participation of human uncertainty [9]. Human errors can be abusing of the prescriptive method [6], construction errors like over excavation or wrong side excavation and in case of maintenance errors, broken drainage facilities [10,11,12,13,14] as tabulated in Table. 1. According to Madelsohn [15], 75% of the problems on the construction sites are generated in the design phase. Landslide came into prominence in Malaysia in 1993, when an apartment block near Kuala Lumpur collapsed due to a landslide as shown in Fig.1. In one of the very latest reports of “The Penang Safety Guideline for Hillsite Development 2012” the major causes of slope failures have been accounted. It can be summarized as design, construction maintenance and communication errors [16].

Table 1. Engineering Classification of Human Errors [14]

Human Errors	Description of Human Errors
Design Errors	A. Improper Drainage Facility B. Inappropriate Gradient C. Unread ground water conditions D. Inaccurate soil parameters used
Construction Errors	A. Wrong/Over excavation B. Poor Compaction/Improper Topsoil/Filled material
Maintenance Errors	A. Clogged Drains B. Gulley Formation C. Internal Erosion D. Lateral Movements/Settling of ground

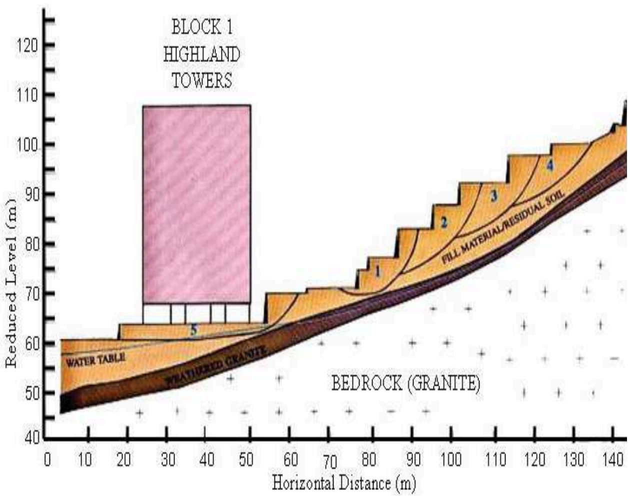

Figure 1. Highland Towers Collapse [6]

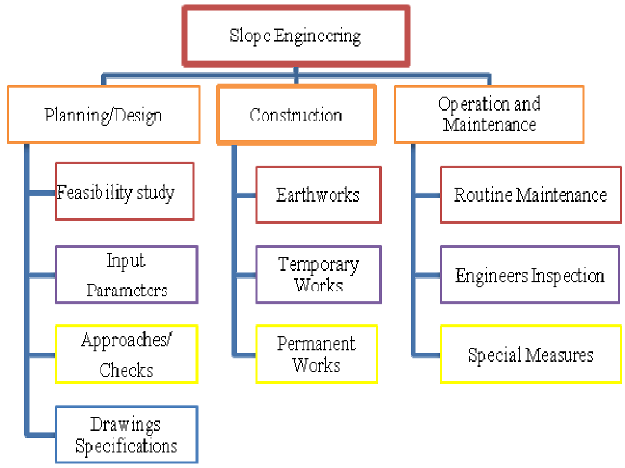

Figure 2. Slope Engineering Tasks

In this paper author has taken three main objectives:

i. To classify the stages which are responsible for slope instability/slope failures.
ii. To identify the human error causes of the identified stages by utilizing absolute probability judgement criteria.
iii. To verify the human error causes in relation with other studies.

Human Error Causes Responsible for Slope Failures

A general survey was conducted in response of literature review findings, a total of 155 Malaysian based civil engineering industry practitioners (including architects, engineers, quantity surveyors, academicians and contractors) were enquired about the factors responsible for slope failures. The survey questions are prepared on the bases of the available literature and the records of slope failure reports prepared by various governmental and nongovernmental agencies involved with slope failure mitigation and management measures. The designed questionnaire, tries to catch up those factors (apart from rainfall) due to which slope failures are increasing. For the choice of respondents, snowball sampling technique is used. The snowball sampling technique is much like asking your subjects to nominate another person with the same trait as your next subject. The researcher then observes the nominated subjects and continues in the same way until the obtaining sufficient number ofsubjects. Snowball sampling technique works like a chain referral. Respondents were encouraged to furnish further causes that they measured imperative, and in reply there was some suggestion related with the individuals virtues (like communication ability and decisive power) and to “practices” were significant as tabulated in Table 2. This paper deliberates on the identification of the human error causes in different stages (from planning until maintenance), but with reference to the interview study as shown in Fig. 2.

Results and Discussion

Regarding different stages involved to confirm slope stability, from planning until maintenance numbers of human error causes (HECs) are governing, and the affect of the governing causes are further used to overcome the chances of slope instabilities or slope failures. Under the category of feasibility study, development plans, planning for drainage facility, site reassessment and counter checking of survey data has been considered. All the subtask items of feasibility study show more or less same HECs. Most of them are reflecting individual’s attitude /organizational trends (namely poor feedback, time constraints, inexperienced, etc.). This is in real the validation of the findings put forwarded by Too and associates [17]. According to Too and associates [17]many of the problems linked with hillside are due to human errors, in the early phase with the development. This is also propped up by Corrie [18] who found that the reasons of project failures going on during implementation or after completion can often be sketched back to deficiencies in the planning stages. Likewise, Frimpong and associates [19] reported that most of hillside failures can be overcome if located at the initial stage during the development project. Hence, good practice and successful project planning, controlling and monitoring should be fixed early in order to develop project performance. Gue and Wong [10] also admitted and emphasized to cover these flaws through desk study, site reconnaissance and sub surface investigations [10]. All the failures can be avoided, if proper care has been given during planning, sub surface investigation, analyses, design and construction. The need of specialist input is usually neglected due to over confidence. Therefore, many projects suffer due to inexperienced professionals [20]. According to Oakes [21], the benefits of a good project development plans must include earlier identification of risks and issues; adoption of good practice; availability of skills and experience; improved communication; improved ability to allocate resources; improved predictability of project delivery; and greater confidence to take risks.

Table 2. Human Error Causes at Different Stages of Slopes Engineering Practices

Stages	Sub-Stages	Human Error Causes
Planning and Design	Feasibility study Input Parameters Approaches and Checks Technical drawings/specifications	inadequacy of the available data
		Inexperience
		ambiguous/ outdated standards
		Absolute judgement required
		Inaccurate soil parameters
		Deficient thumb rules
		Improper experimental setup
Construction	Earthworks Temporary works Permanent works	Improper sequencing
		Lacking in supervision
		Inexperience
		Over excavation/improper method of excavation
		Inadequate temporary support
		Excessive construction loads
		Material deficiencies
		ambiguous/ outdated standards
Operation and Maintenance	Routine monitoring/maintenance Engineers inspection Special measures	communication power
		No independent check
		Mismatch between perceived and real risk
		Application of unsuitable maintenance criteria
		Following outdated strategies
		Weak decisive power
		Inexperience

In category of "selection of input parameters" the two most important parameters required for analyzing and design cut slopes in residual soils are effective stress strength parameters and ground water table. As Taha and associates reported [22], that information about the shear strength of soil and its behaviour is essential for safe and economic design of geotechnical structures. Gue and Cheah [23] also confirmed that sub surface investigations and laboratory tests are not carried out to determine representative soil parameters, subsoil and ground water profile for analysis and design of slopes. A lack of good understanding of soil behaviour is usually a significant cause to slope failures [23].One of the facts discovered through experts that improper experimental setup has also been observed in many of the projects. According to Tan and Gue [24], selection of appropriate shear strength parameters is very crucial in design of cut slopes. It is significant to admit that stiff materials like residual soils have discontinuities which the small scale tests may sometimes unable to detect, and over-estimate soil shear strength. On the other hand, if large-sized particles, of the residual soil mass cannot be quantitatively assessed and the small-scale laboratory tests carried out on the matrix material of the residual soils will usually under-estimate the shear strength parameters of the in-situ material mass. Hence special care has to be taken, in the selection of representative soil strength for slope stability analysis [24].

Water management is an essential factor in controlling slope stability. Surface drainage and protection are necessary to reduce infiltration and erosion caused by heavy rainfall especially during monsoon. When designing surface drainage on steep slopes, it is important to make sure that drains have sufficient capacity to take run off. General guidelines for design of permanent drainage are based upon a 100-year return -period of rainfall and temporary drainage is based upon a 10-year return periods [25, 26]. Deep underdrains can be utilized to lower groundwater levels in slopes and intercept seepage before it can reach the slope face. In drainage facility planning and design, the major basic event is non conformance/inadequacy of the available data like groundwater conditions (resulting from 10 years return-period from rainfall or representative groundwater level (through observation and estimation), peak runoff, discharge capacity, etc. This basic event can be assessed easily by keeping in view the findings of Gue and Wong [10]. Irrespective of the expansion pattern, because of urbanization in the hilly area, imperviousness of the surface increases and this leads to high runoff generation. Safe drainage of such high runoff to the ultimate outlet (river or water bodies in the form of lake) always remains a challenging task [27]. The design discharge must have the provision to adjust the future possible development of the area. Discharge may increase with time primarily due to three factors: 1) increase in building density and paved area, 2) increase in rainfall intensity because of impact climate change, and 3) increase of per capita water utilization because of improved life style and better water supply [27]. Considering these factors, it is advisable to go for an appropriate design of the drainage system, so that the system remains sufficient to meet the increasing future demand at least for the next 50 years [27].The construction of the structures such as soil nailing, contiguous bored piles and retaining walls needs full expertise.As pouring of concrete/spraying of concrete, twisting and placing of steel as the structures requires proper sequence and experienced supervision in the tasks. It is also supported by the investigation results indicated that the collapsed of the segmental retaining wall wasmainly due to the internal instability. Due to the space constraints and the existing reservoiron top of the slope, the excavation into the toe of the slope was limited. The anchorage lengthfor the segmental retaining wall was also limited resulting insufficient resistance [28]. The bad construction practices can be prevented if proper supervision by design consultants collectively with reliable experienced contractors having clear methods/statements for construction is followed [6]. According to Gue and Tan [2] the personnel supervising hill-site developments must have enough familiarity and experience in geotechnical engineering and geology to spot any irregularities that might be dissimilar from those predict and advocate in design [2].

Undoubtedly, in maintenance issues, most of the time abrupt but wise/proper judgements and decisions have to be made by the analyst. Of course in tropical countries like Malaysia where an average rainfall is 2550mm, which is above the global average, drainage is the major concern from every aspect (from planning till maintenance) [10]. Malaysian practice on slope maintenance has always consulted the guidelines published by Hong Kong GEO for both routine maintenance and layman and Engineer's inspection. Detailed recommendations for the necessary maintenance regime are stated in Geoguide 5 (2003). However, such a scheme has only become popular after it has been identified as one of the root causes of landslide incidents. These are damaged/clogged drains, inadequate surface erosion control, etc [29]. Landslide cases like Bukit Antarabangsa (2008), Bukit Antarabangsa (1999), and Highland Towers (1993) are the examples of the above mentioned root causes [11, 13, 30, 31]. In concern with slope maintenance factors, it is suggested that awareness alone is not enough, it is the authorities involved must know how to take up the work and must have in hand proper set of standards of good practice for slope maintenance [2].

Conclusion

Through conducting surveys and concerning materials, it is apparent that the causes of slope failures are related to poor and/or flawed design and construction and non-preferential maintenance criteria. It is also pertinent to note that at every related tasks/subtasks involved in slope engineering practices, human errors are observed. The quantification or the significant level of these human errors can be overcome by countering the causes responsible for its generations.This research aims to reduce cases of slope failures and construction collapses due to unintended human errors in structural design and construction in the country. Although it is not so straightforward, but by identifying human error causes, it can be minimized with some extent.

Reerences

[1] Gue, S.S. and T.Y. Chin, Mitigating the Risk of Landslide on Hill -site Development in Malaysia. 2nd World Engineering Congress, Srawak Malaysia, 2002.

[2] Gue, S.S. and Y.C. Tan, Landslides: Cases histories, lessen learned and mitigation measures. Paper presented at the Landslide, sinkhole, structure failure: Myth or science? Ipoh, Malaysia. 2006.

[3] Samah, F.A., Landslide in hillside development in the Hulu Kelang, Klang Valley. presented at the Post-Graduate Seminar Universiti Teknologi Malaysia, 2007.

[4] Jamaluddin, T.A., Human Factors and Slope Failures in Malaysia, . Bulletin of the Geological Society of Malaysia, 2006(52): p. 75-84.

[5] Rasip, M.K., Isu pembangunan di kawasan tanah tinggi dan berbukit (kes kajian: Majlis Perbandaran Ampang Jaya) Universiti Teknologi Malaysia, Johor Bahru. 2006.

[6] Gue, S.S. and Y.C. Tan, Landslides: Abuses of The Prescriptive Method. International Conference on Slope 2006 Kuala Lumpur, 2007.

[7] IEM, .Official statement of Bukit Antarabangsa lanslide accident on 6 December 2008, Jurutera. Selangor, Malaysia: The Institution of Engineers, Malaysia. 2009.

[8] Too, E., N. Adnan, and B. Trigunarsyah. Project Governance in Malaysia Hillside Developments. in Proceedings of the Sixth International Conference on Construction in the 21st Century: Construction Challenges in the New Decade, Kuala Lumpur. 2011. Quensland University of Technology Australia.

[9] Morgenstern, N.R. Managing risk in geotechnical engineering. in $10t_h$ Pan American Conference on Soil Mechanics and Foundation Engineering. 1995.

[10] Gue, S.S. and S.Y. Wong, How to Improve Slope Management and Slope Engineering Practices in Malaysia.www.gnpgeo.com.my, 2008.

[11] JKR, Jabatan Kerja Raya Final Investigation Report Investigation of Slope Failure at Taman Bukit Mewah, Bukit Antarabangsa Hulu Klang Salengor, in Cawangan Kejuruteraan Cerun, Jabatan Kerja Raya Malaysia. 2009.

[12] Raya, J.K., National Slope Master Plan Sectoral Report Research and Development, 2009. Jabatan Kerja Raya Malaysia.

[13] Aun, O.T., Mitigation And Rehabilitation of Natural Disasters In Malaysia. The Ingenieur, 2008. 39.

[14] Qasim, S. and I.S.H. Harahap, Human Error related Risks of Malaysian Landslides, in Geotechnical Engineering For Disaster Mitigation And Rehabilitation And Highway Engineering 2011. 2011. p. 527-533.

[15] Madelsohn, R., The Constructability Review Process: A Contractor's Perspective,". Journal of Management in Engineering ASCE, 1997. 13(3): p. 17-19.

[16] Ahamad, H.Z., Safety Guidelines for Hillsite Development. Penang Town and Country Planning Department, 2012.

[17] Too, E., N. Adnan, and B. Trigunarsyah. Project Governance in Malaysia Hillside Developments. in Sixth International Conference on Construction in the 21st Century (CITC-VI) "Construction Challenges in the New Decade". 2011. Kuala Lumpur, Malaysia.

[18] Corrie, R.K., Project Evaluation. London: Thomas Telford LTD. 1991.

[19] Frimpong, Y., J. Oluwoye, and L. Crawford, Causes of Delay and Cost Overruns in Construction of Groundwater Projects in Developing Countries; Ghana as a case study. . International Journal of Project Management, 2003. 21(5): p. 321-326.

[20] Gue, S.S., S.S. Liew, and Y.C. Tan. Lessons Learned from Some Failures of Housing Projects. in Seminar on Failures Related to Geotechnical Works. 2000. IEM 23-24 October.

[21] Oakes, G., Project Reviews, Assurance and Governance Aldershot, England ; Burlington, VT: Gower, 2008.

[22] Taha, M.R., et al., Geotechnical behaviour of a Malaysian residual granite soil. Pertanika Journal of Science & Technology, 1999. 7(2): p. 151-169.

[23] Gue, S.S. and S.W. Cheah, Geotechnical Challenges in Slope Engineering of Infrastructures. International Conference on Infrastructure Development, Putrajaya 2008.

[24] Chin, T.Y. and G.S. Sew, The Determination of Shear Strength in Residual Soils for Slope Stability Analysis, in Seminar Cerun Kebangsaan. 2001: Cameron Highlands p. 1-18.

[25] Gue, S.S. and Y.C. Tan, Guidelines for development on hill-sites. Tropical Residual Soils Engineering, 2004: p. 121.

[26] Mohamad, A.b., et al., Guidelines for Slope Design. Slope Engineering Branch, Jabatan Kerja Raya MALAYSIA, 2010.

[27] Sarma, A.K., Planning and Design of Drainage in Hilly Area: A Conceptual Guideline Integrated Landuse Planning and Water Resources Management (ILPWRM), 2012: p. 1-27.

[28] Siong, L.C. and T.S. Meng. Collapse 0f A Reinforced Soil Segmental Retaining Wall. in IEM-GSM Oktoberforum2005: "Case Histories in Engineering Geology and Geotechnical Engineering". 2005. Petaling Jaya.

[29] Gue, S.S. and S.Y. Wong, Slope Engineering Design and Construction Practice in Malaysia. CIE-IEM Joint Seminar on Geotechnical Engineering, Yilan, Taiwan, 2009.

[30] Jaapar, A.R.B., A framework of a national slope safety system for Malaysia. 2006, University of Hong Kong.

[31] Aiun, O.T. and O.H. Miin, Geotechnical Failures/Issues,Dispute Resolution and Mitigation. The Journal of the Institute of Engineers Malaysia, 2010. 71(1).

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