Hydraulic Physical Model of Debris Flow for Malaysia Case Study

M R R Mohd Arif Zainol\textsuperscript{1,2} and M K Awahab\textsuperscript{1}

\textsuperscript{1}School of Civil Engineering, Universiti Sains Malaysia (USM), Penang, Malaysia.
\textsuperscript{2}Center of Excellence Geopolymer and Green Technology (CEGeoGTech), School of Materials Engineering, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia

E-mail: ceremy@usm.my

Abstract. In the recent decade, several debris flow events occurred and caused hundreds of deaths, missing or injury and damaged many facilities. In addition to causing significant morphological changes along riverbeds and mountain slopes, these flows are frequently reported to bring about extensive property damage and loss of life. Debris flow phenomena occasionally occur in Malaysia and numbers of death reported cause by this event. In order to investigate the debris flow and its deposition process, experiments were conducted at the School of Civil Engineering Laboratory, Universiti Sains Malaysia. The models consists of three main parts which are water tank, rectangular flume and deposition board. A high speed video camera (HSVC) had been placed nearly downstream of the rectangular flume to capture the movement characteristics of particle grain. From this study, the characteristics of particle routing segregation can be understand clearly, therefore this input will be a very useful information to other researchers for further investigation in terms of knowledge sharing between researchers. Catastrophic cause by debris flow event can be minimized therefore in term of economy losses can be reduce and human life can be safe.

1. Introduction
Debris flows and avalanches consist of multiple mixtures of solids, sand, gravel, rocks, ice, snow, and water that move down slopes under the driving force of gravity [1].

The high flowing velocity, large impact forces, and long run-out distance, combined with poor temporal predictability, cause debris flows and debris avalanches to be one of the most hazardous types of landslide [2]. Debris flow is a natural phenomenon in mountainous terrains where uphill valleys or streams are fed by high annual rainfalls.

The occurrences of debris flows have been well documented in some countries such as Japan, United States of America, Taiwan and Indonesia [3, 4] where the mountainous terrains combined with heavy rainfalls provide ideal settings or predispositions for the development of debris flow. In Malaysia, the occurrences of debris flow in the mountainous terrains must, undoubtedly, have taken place from time to time, albeit away from man's view and unreported so long as they do not impact on human lives or infrastructures.

It is when human lives and/or infrastructures are impacted that such debris flow incidents are investigated and reported. This paper presents three such incidents of debris flow in Peninsular Malaysia which had resulted in loss of lives and damage to infrastructures.
2. Cases of debris flow in Malaysia

Many researcher had conducted a debris flow study in Malaysia [6-9]. Kampung Dipangis located in Jeram, Perak. The Kampung Dipang debris flow would have been one of those naturally occurring debris flows in the highlands that would have gone un-reported for the existence of a small village settlement at the base of the hilly area. The debris flow triggered during heavy storm and occurred down a steep valley on the western flank of the Main Range near Kuala Dipang. Debris transported consist of mud to boulders and tree trunks as are typical of debris flows, and swept through a small village settlement and practically wiped out the entire village, with numerous fatalities and casualties. According to the Tan and Ting (2008), debris flow occurred at Genting Sempah, Pahang after heavy rainfall and a series of sequential events which are typical of debris flows have been involved. Resulted in 20 deaths, 22 people injured and some vehicles damaged. Figure 1 shows the aerial photograph taken after the event.

![Figure 1](image1.png)

Figure 1. General view of debris flow at Genting Sempah.

Another related visual phenomenon is the large amount of water involved flow along with high velocity. In the case of the North-South Expressway, triggered by storm flow, the "dam-break" phenomenon has been concluded that caused by breach of a naturally formed barrier. The views of the debris flow are as shown in Figure 2. The debris flow reaches the bridge site and partly flows over the bridge, after a large number of debris through the opening of the bridge (Tan and Ting, 2008).

![Figure 2](image2.png)

Figure 2. (a) aerial view of debris flow toward Bridge site (b) accumulation of debris at bridge opening (Tan and Ting, 2008).
3. Experimental setup

Experimental setup of the debris flow physical model was carried out at the School of Civil Engineering Laboratory, Universiti Sains Malaysia. This laboratory provided complete facilities to operate our study in good form. The model consists of three main parts which are rectangular flume, deposition board and water tank. Figure 3 shows the debris flow experimental model. At the top end there is water tank (storage container) with 1 m long, 0.7 m width and 0.7 m height can be filled up to 0.49 m³ of water. It is equipped with a gate that can be opened instantaneously by a gate controller. The gate is located at the bottom of the intake tank as a function to supply water through the rectangular flume. The debris flow rectangular flume dimensions were 0.1 m width, 0.1 m depth and with 3 m effective flow length. The flume is supported with a moveable prop, which could be moved back and forth to adjust the flume slope ranging from 5° to 30°.

![Image of experimental setup](image-url)

**Figure 3.** Component of hydraulic physical model of debris flow (a) deposition board (b) rectangular flume (c) water tank.

The debris flow deposition board with at each side 1.5 m long was divided into grid. The gridding system is different depend on the deposition area. In the middle of the deposition board, the grid size was smaller than other part because in this area the concentration of the materials is higher. The board was designed as an experimental device, so that its slope could be adjusted as wanted. The board and flume were smoothly connected at one end and at the other end is located materials collection sump.

The deposition board slope varied from 0° to 5°. Figure 4 shows the experimental procedure conducted by [10]. The hydraulic physical model conducted in School of Civil Engineering followed this procedure.
4. Conclusions
This study is very important to give some relevant insight of debris flow phenomenon for Malaysia case study. The experimental setup and procedure that been conducted at School of Civil Engineering, Universiti Sains Malaysia gave meaningful understanding of debris flow study. Many researchers and parties will get benefits from this study especially on understanding of debris flow particle movements through high speed video camera (HSVC).

5. References
[1] Hunt B 1994 Journal of Hydraulic Engineering, ASCE 120(12) 1350-1363
[2] Jakob Mand Hungr O 2005 Debris-flow hazards and related phenomena. Praxis: Springer Berlin Heidelberg
[3] Yamashiki Y, Mohd Remy Rozainy M A Z, Matsumoto T, Takahashi T, Takara K 2012 Journal of Global Environment Engineering 17 9-18
[4] Jamaludin S, Abdullah C H and Kasim N 2014 Landslide Science for a Safer Geoenvironment 167-172.
[5] Tan B Kand Ting W 2008 Geotechnical Engineering for Disaster Mitigation and Rehabilitation 231-235
[6] Sum C W, Mior Jadid M Sand Yaacob S 1996 Warta Geologi 22 5
[7] Zaini M M Sand Nasir M K A 2016 Conceptual Design for Flood Warning Study for Gunung Pulai Recreational Area at Gunung Pulai, Johor
[8] Ghazali M A, Rafek A G, Desa K M and Jamaluddin S 2013 Journal of Geological Research 1-11
[9] Kuraoka S, Sze L T, Abdullah C H, Jamaludin S, Nazri Mand Kasim N 2016 Study on the Mechanisms of Debris Flows that Damaged Flexible Barriers in the Channel of Fraser Hill, Malaysia

Figure 4. Experimental procedure [10].
[10] Yamashiki Y, Mohd Remy Rozainy M A Z, Matsumoto T, Takahashi T, Takara K
2013 APCBEE Procedia 5 527-534

Acknowledgments
This research was carried out with financial support from the Fundamental Research Grant Scheme (FRGS) under Ministry of Higher Education of Malaysia (Grant No. 7611800357). A very special thanks goes to the School of Civil Engineering, Universiti Sains Malaysia for the support on conducting this research. Also thanks to Mr. Mr. Taib Yacob, Mr. Halmi Ghazalli, Mr. Dziauddin Zainol Abidin and Mr. Nabil Semailfor their assistance on performing the experiments.