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BORANG FRGS – P3(R

KEMENTERIAN PENDIDIKAN MALAYSIA

FINAL REPORT
FUNDAMENTAL RESEARCH GRANT SCHEME (FRGS)

Laporan Akhir Skim Geran Penyelidikan Fundamental (FRGS)
Pindaan 1/2014

A

RESEARCH TITLE: Developing Empirical Relationship of Hydrodynamic Forces of Floodwater during Road Crossing

PHASE & YEAR: 1/2012

START DATE:June 1, 2012
END DATE:
EXTENSION PERIOD (DATE): November 30 2014

PROJECT LEADER: Ir Dr Abdul Naser Abdul Ghani

PROJECT MEMBERS: 1. **Dr Ahmad Hilmy Abdul hamid**
(including GRA) 2. Nursriafitah Kasnon

PROJECT ACHIEVEMENT *(Prestasi Projek)*

B

ACHIEVEMENT PERCENTAGE			
Project progress according to milestones achieved up to this period	**0 - 50%**	**51 - 75%**	**76 - 100%**
Percentage (please state #%)			100 %

RESEARCH OUTPUT		
Number of articles/ manuscripts/ books *(Please attach the First Page of Publication)*	**Indexed Journal**	***Non-Indexed Journal***
	4	
Conference Proceeding *(Please attach the First Page of Publication)*	**International**	***National***
	1	2
Intellectual Property *(Please specify)*		

HUMAN CAPITAL DEVELOPMENT					
Human Capital	**Number**				**Others** (please specify)
	On-going		**Graduated**		
Citizen	Malaysian	Non Malaysian	Malaysian	Non Malaysian	
PhD Student					
Master Student			1		
Undergraduate Student			2		
Total			3		

RESEARCH ABSTRACT – Not More Than 200 Words *(Abstrak Penyelidikan – Tidak Melebihi 200 patah perkataan)*

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Laboratory experimental investigations were conducted to identify suitable shape and dimension of objects as well as its capability to reduce flow velocity. The first stage of study was to identify suitable shape and its arrangement. In this test, a scale of 1:20 was used in a flow table experiment. The water flow pattern was recorded focusing on the distance and amplitude as water flow pass the obstructing objects.The results are classified into three distinguishable patterns of diffusion .

The second stage of the investigation involved a laboratory hydraulic model investigation. In this investigation, the velocity reduction effects of the selected objects shapes were studied. Two objects shapes and arrangements selected for use in the hydraulic model investigation indicated its capability to reduce flow velocity satisfactorily consistent with the flow pattern in the preliminary findings.

Finally, computer simulation based on input data from actual realistic site prone to flooding were carried out. The findings indicated the capability of the selected object geometrical shape to reduce velocity and road surface shear stresses.

Date : 9/12/2014
Tarikh

Project Leader's Signature:
Tandatangan Ketua Projek

COMMENTS, IF ANY/ ENDORSEMENT BY RESEARCH MANAGEMENT CENTER (RMC)
(Komen, sekiranya ada/ Pengesahan oleh Pusat Pengurusan Penyelidikan)

H

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STUDY ON THE USE OF OBSTRUCTING OBJECTS TO DIFFUSE FLOOD WATER VELOCITY DURING ROAD CROSSING

Abdul Naser Abdul Ghani[1], Ahmad Hilmy Abdul Hamid[2] and Nursriafitah Kasnon[3]

[1,2] Sch of Housing Building and Planning; [3] Postgraduate Student, Sch of Housing Building and Planning, Universiti Sains Malaysia, Malaysia.

ABSTRACT: Laboratory experimental investigations were conducted to identify suitable shape and dimension of objects as well as its capability to reduce flow velocity. The first stage of the study was to identify suitable shape and its arrangement. In this test a scale of 1:20 was used in a flow table experiment. The water flow pattern was recorded focusing on the distance and amplitude of the pattern as water flow pass the obstructing objects. The second stage of the investigation involved a hydraulic model investigation. In this investigation, the velocity reduction effects of the selected objects shapes were studied. The results are classified into three distinguishable patterns of diffusion. Two objects shapes and arrangements selected for use in the hydraulic model investigation indicated its capability to reduce flow velocity satisfactorily consistent with the flow pattern in the preliminary findings.

Keywords: Flood, Road Crossing, Water Velocity, Velocity Attenuator

1. INTRODUCTION

In a general flooding scenario, water levels rise causing areas neighboring water bodies and some road stretch to be flooded. The primary effects of flooding include loss of life, damage to buildings and other structures such as roadways and canals. Flooded roads and transport infrastructure make it difficult to mobilize aid to those affected or to provide emergency health treatment [1].

The most regular and frequent type of disaster in Malaysia is flooding. When large amount of rainfall occurs, and the fact that it is more frequent these days, especially over a short period of time - drain, rivers and low lying areas will be filled with waters. With the ever increasing and higher frequency of events, the rainfall runoff will turn into floods or flash floods. In its way to lower area and finally the sea, the floodwater will cross urban, residential, industrial and agricultural area causing damages not only to properties but also creating hindrance for escape and blocking emergency access to the affected areas.

Road infrastructure is the main access for escape and emergency supplies. In flood events, some part of low lying roads will be inundated creating blockage for vehicle movement. Statistics clearly point out the high risk of driving in and around flooded roads and low lying areas [2].

Intensive literature search indicated very few previous works or information related to how floodwater exerts pressure on crossing vehicles or human and how the pressure can be attenuated. Most of previous and current works deal with flood risk assessment and mapping; scour of channel, river, bridge piers and drains; policy and structural measures for flood control and abatement; and flood prediction. Figure 1 illustrates typical situation of floodwater during road crossing and how it affected the vehicles.

Fig.1 Dangerous crossing [3]

Yazici and Ozlay [4] proposed an evacuation route modeling to deal with transportation route planning during flooding - in other words, how to avoid flooded area. Meyer and Weigel [5] suggested an adaptive physical and management systems as an approach to mitigate potential problems. Physical approach of adaptive systems was studied by Pisani and Francesco [6] in the form of a moveable bridge that can be adjusted during floods. Meanwhile, Cai and Rahman [7] studied the used of road barriers as part of an emergency evacuation systems. A conceptual study of using Submerged Floating Tunnel (SFT) was carried out by Grantz [8].

Drobot et al. [9] described the risk factors of

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Effect of Flood Water Diffuser on Flow Pattern of Water during Road Crossing

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Abstract. One of the methods to reduce the velocity of flood water flow across roads is to design obstacle objects as diffusers and place them alongside the road shoulder. The velocity reduction of water flow depends on the diffusion pattern of water. The pattern of diffused water depends on the design of the obstacle objects. The main purpose of this study is to investigate the design of obstacle objects and their water diffusing patterns and their capability to reduce the velocity of the flood water flow during road crossing. Variety of designs and orientation of the obstacle objects were tested in the environmental laboratory on a scale of 1:20. The results are classified into three distinguishable patterns of diffusion. Finally, two diffuser shapes and arrangements are recommended for further investigations in full scale or CFD model.

1 Introduction

A flood is an overflow of water that submerges or drowns land. In a general community flooding scenario, the rise in water level causes neighbouring water bodies and some road segments in these areas to be flooded [1]. When the water body flood reaches a water level higher than its normal storage level, it will flow to the surrounding areas. In the process, the flowing water interacts with roads, covering road segments. The primary effects of flooding include traffic obstruction, damage to buildings as well as other roadway structures, and in extreme cases, loss of life. High velocity flow also causes damage to the road pavement and other transport infrastructures. Mobilization of aid or emergency evacuation in response to the flood, will be affected by not only the flooding but also the damaged structures.

The detrimental impact of flooding on roadways is not so easily determined. There are many impacts from flooding [2]. In the United States, the Kentucky Transportation Cabinet (KYTC) estimated their June 2011 floods that impacted the state cause USD30 million in damages to the state's roadways. Future flooding events will lead to further monetary costs and impair the operational structure and integrity of the state's roads [3]. The loss of critical infrastructure produces negative effects over the short-term and long-term.

The primary effects of floods are those due to direct contact with the flood waters. Water velocities tend to be high in flood roadway crossings. The high velocity flood water that crosses roadways consequently results in difficulties in mobilization, damage to vehicles and road structures as well as endangering people's life. Furthermore, flood water could cause traffic congestion and in extreme cases, sweep people and vehicles away.

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THE VELOCITY REDUCTION EFFECT OF OBSTRUCTING STRUCTURES ON FLOOD WATER FLOWS DURING ROAD CROSSING

Abdul Naser Abdul Ghani[1], Ahmad Hilmy Abdul Hamid[2] and Nursriafitah Kasnon[3]
[1,2] Sch of Housing Building and Planning, USM, Malaysia; [3] Postgraduate Student, Sch of Housing Building and Planning, USM, Malaysia.

ABSTRACT

Laboratory experimental investigations were conducted to identify suitable shape and dimension of objects as well as its capability to reduce flow velocity. The first stage of the study was to identify suitable shape and its arrangement. In this test a scale of 1:20 was used in a flow table experiment. The water flow pattern was recorded focusing on the distance and amplitude of the pattern as water flow pass the obstructing objects. The second stage of the investigation involved a hydraulic model investigation. In this investigation, the velocity reduction effect of the selected objects shapes were studied. The results are classified into three distinguishable patterns of diffusion. Two objects shapes and arrangements selected for use in the hydraulic model investigation indicated its capability to reduce flow velocity satisfactorily consistent with the flow pattern in the preliminary findings.

Keywords: Flood, Road Crossing, Water Velocity, Velocity Attenuator

INTRODUCTION

In a general flooding scenario, water levels rise causing areas neighboring water bodies and some road stretch to be flooded. The primary effects of flooding include loss of life, damage to buildings and other structures such as roadways and canals. Flooded roads and transport infrastructure make it difficult to mobilize aid to those affected or to provide emergency health treatment [1].

The most regular and frequent type of disaster in Malaysia is flooding. When large amount of rainfall occurs, and the fact that it is more frequent these days, especially over a short period of time - drain, rivers and low lying areas will be filled with waters. With the ever increasing and higher frequency of events, the rainfall runoff will turn into floods or flash floods. In its way to lower area and finally the sea, the floodwater will cross urban, residential, industrial and agricultural area causing damages not only to properties but also creating hindrance for escape and blocking emergency access to the affected areas.

Road infrastructure is the main access for escape and emergency supplies. In flood events, some part of low lying roads will be inundated creating blockage for vehicle movement. Statistics clearly point out the high risk of driving in and around flooded roads and low lying areas [2].

Intensive literature search indicated very few previous works or information related to how floodwater exert pressure on crossing vehicles or human and how the pressure can be attenuated. Most of the previous and current works deals with flood risk assessment and mapping; scour of channel, river, bridge piers and drains; policy and structural measures for flood control and abatement; and flood prediction. Figure 1 illustrates typical situation of floodwater during road crossing and how it affected the vehicles.

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Effect of Flood Water Diffuser on Flow Pattern of Water During Road Crossing

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Abstract:

One of the methods to reduce the velocity of flood water flow across road is to design obstacle objects as diffuser and place it along beside road shoulder. The velocity of water flow will depends on the diffusion pattern of water. The pattern of diffused water will depends on the design of the obstacle objects. The main purpose of this study is to investigate the design of obstacle objects and their water diffusing pattern and its capability to reduce the velocity of the flood water flow during road crossing. Variety of design and orientation of the obstacle objects were tested in the environmental laboratory with a scale of 1:20. The results are classified into three distinguishable patterns of diffusion. Two diffuser shapes and arrangements are recommended for further investigations in full scale or CFD model.

Keywords: Flood water flow, road, obstacle objects, diffuser, pattern diffusion, water velocity

1.0 Introduction

A flood is an overflow of water that submerges or drowns land. Cai et al. (2007) described that in general community flooding scenario, water level rise cause neighboring water bodies and some road segments in these areas to be flooded. When the water body flood reaches a water level higher than its normal storage level, it will flow to the surrounding areas. In the process, the flowing water interacts with roads, covering road segments. The primary effects of flooding include traffic obstruction, loss of life, damage to buildings as well as other road way structures. High velocity flow also causes damage to road pavement and other transport infrastructures. Mobilization of aids or emergency evacuation will be affected by not only the flooding but also the damage structures.

Zhang et al. (2008) concluded that the detrimental impact of flooding on roadways would not be so easily determined. There are many impacts from flooding. In the United States, the Kentucky Transportation Cabinet (KYTC) estimated their June 2011 floods that impacted the state cause 30 million in damages to the state's roadways, future flooding events will lead to further monetary costs and impair the operational structure integrity of the state's roads (Mc Cormack et al., 2012). The loss of critical infrastructure produces negative effects over the short-term and long-term.

The primary effects of floods are those due to direct contact with the flood waters. Water velocities tend to be high in flood roadway crossing. The high velocity flood water that cross roadway consequently resulted in difficulties in mobilization, damages to vehicles and road structures as well as endangering people's life. Furthermore, flood water could sweep people and vehicle away and also cause traffic congestion. The high velocity of water flows can be diffused by suitable object / structure for safer crossing and preventing damages to road structures. There must be a method to decrease the energy and velocity of flood water during road crossing. The method must slow down the flow of water to allow for smooth mobilization and to prevent damages.

2.0 Methodology

Methodology used in this study was a lab experiment. The experiment was conducted in the laboratory using lab equipments and data was collected through observation. The lab experiment was conducted in environmental lab that was monitored by two of staffs. The apparatus used in this experiment were water flow table, water color,

$$Elevation_3 = [Voxel_{elevation}(0) + Voxel_{elevation}(-x) + Voxel_{elevation}(-x - z) + Voxel_{elevation}(-z)]/4$$
$$Elevation_4 = [Voxel_{elevation}(0) + Voxel_{elevation}(+z) + Voxel_{elevation}(-x + z) + Voxel_{elevation}(-x)]/4 \tag{4}$$

Equation (4) can be simplified further as (5)

$$\begin{aligned} Elevation_1 &= (3Elevation_1 + Elevation_2 + Elevation_3 - Elevation_4)/4 \\ Elevation_2 &= (Elevation_1 + 3Elevation_2 - Elevation_3 + Elevation_4)/4 \\ Elevation_3 &= (Elevation_1 - Elevation_2 + 3Elevation_3 + Elevation_4)/4 \\ Elevation_4 &= (-Elevation_1 + Elevation_2 + Elevation_3 + 3Elevation_4)/4 \end{aligned} \tag{5}$$

The direction of inclination (Ψ_0) and dip (β) can be calculate as equation (6) and (7)

$$Tan\,\beta = \frac{\sqrt{(Elevation_2 - Elevation_1)^2 + (Elevation_3 - Elevation_1)^2}}{d} \tag{6}$$

$$Tan\,\Psi_0 = \frac{-(Elevation_2 - Elevation_1)}{(Elevation_3 - Elevation_1)} \tag{7}$$

Strike as mentioned by Hovland (Ψ) can be calculated from angle of slip surface (Ψ_0) using equation (8)

If highest point is $Elevation_1$, $\Psi = 270 + \Psi_0$
If highest point is $Elevation_2$, $\Psi = 270 - \Psi_0$
If highest point is $Elevation_3$, $\Psi = 90 - \Psi_0$
If highest point is $Elevation_4$, $\Psi = 90 + \Psi_0$ (8)

From basic geometry, formula (9) (10) (11) can be derived

$$\alpha_{yz} = A\mathrm{Tan}\,(Sin\Psi.Tan\beta) \tag{9}$$

$$\alpha_{xz} = ATan(Cos\Psi.Tan\beta) \tag{10}$$

$$\theta = ACos(Sin\alpha_{yz}.Sin\alpha_{xz}) \tag{11}$$

With the grid ($\Delta X.\Delta Y$) small enough, the formula can be simplified further as (12)

$$FS = \frac{\sum_X \sum_Y \left(\frac{c.Sin\theta}{Cos\alpha_{xz}.Cos\alpha_{yz}}\right) + \sum_X \sum_Y \left(\gamma.Z.Cos(\beta) - \gamma w.hw.\frac{Sin\theta}{Cos\alpha_{xz}.Cos\alpha_{yz}}\right).Tan\emptyset}{\sum_X \sum_Y \gamma.Z.Sin\alpha_{yz}} \tag{12}$$

3.0 Findings and Arguments

The key factor to enable Hovland's 3D slope stability analysis to be compatible with MOR is to find out how to get dip and strike directly from MOR without converting MOR into intermediate 2D format such as raster. Converting MOR to other format will defeat the purpose of using MOR and will increase calculation complexity and unnecessary processing step. By treating each MOR neighbor voxel as elevation, dip and strike can be calculated from simple geometrical formula as shown in equation (4) to (8). The calculation is fast and complexity is comparable with 2D method.

4.0 Conclusion and Recommendation

The benefit of 3D GIS is clear and significant in order to accurately represent real word object in GIS (Abdul-Rahman & Pilouk, 2008). However 3D GIS is still in emerging stage and a lot of study still on going in order to suit it as mainstream solution and MOR is the one of the popular method proposed for 3D GIS data representation. However, the study of 3D GIS data for manipulation and analysis still especially in landslide still in infancy. This paper prove Hovland's 3D slope stability analysis directly using MOR is viable and didn't adding much complexity compared with 2D GIS solution. However, MOR itself require lot of computation power and high memory usage get find specific voxel and its relationship with other voxel. In order to get 1 column of safety factor, Hovland's method require additional 8 adjacent voxel attribute and finding those voxels in classical MOR will cause serious computational performance penalty as for each voxel attribute require maximum of $O(2^{3(p-1)})$ search, where p represents the maximum number of resolution (Castro, Lewiner, & Lopes, 2008). Since analyzing slope safety factor usually involve large area and high resolution, p usually large and the computational cost will make MOR impractical. In order to make MOR to be practical for real world usage, better implement of MOR needed and require for further study.

Acknowledgement

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