

DAM BREAK FLOOD INUNDATION MODELLING FOR
KLANG GATE DAM

NURASHIKIN BINTI ZAINAL ABIDIN

A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Civil-Hydrology & Water Resources)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

JUNE 2015

Specially dedicated to my beloved husband Mohd Irsyam Noorfawana Bin Masri and
my lovely daughters, Nurin and Nadia.

I love you.

ACKNOWLEDGEMENT

Prima facie, I am grateful to Allah S.W.T for the good health and wellbeing that were necessary to complete this dissertation.

I was really appreciated to many people that contribute towards my understanding and thoughts in order to finish this study. I wish to express my sincere thanks to my supervisor, Assoc. Prof. Dr. Supiah Binti Shamsudin for her guidance and encouragement. Also to Dr. Zuhlilmi B Ismail and Dr. Mohamad Hidayat B. Jamal for their critics, advice and guidance.

I place on record, my sincere thank you to Jabatan Perkhidmatan Awam (JPA) and Jabatan Kerja Raya, for the education fees sponsorship.

My sincere appreciation to my colleagues Mr. Irsyam, Miss Farihan, Mrs. Niza, Mrs. Norhayati and Mr. Aliff for their supportive, motivation, love, advice and friendship. Thank you for sharing expertise and experience to me.

I take this opportunity to express gratitude to all of the Hydrology and Water Resources lecturers for their knowledge's and experiences. I also thank my parents and parents in law for the unceasing Dua's, encouragement, support and attention.

Last but not least, to my beloved husband Mr. Mohd Irsyam Noorfawana Bin Masri, I am extremely thankful and indebted to him for sharing expertise, and sincere encouragement extended to me. To my lovely daughters, Nurin and Nadia, thank you for being such a lovely and understanding along mummy's journey.

I also place on record, my sense of gratitude to one and all, who directly or indirectly, have lent their hand in this venture.

ABSTRACT

Dams play a very vital role in the economy of a country by providing essential benefits like irrigation, hydropower, flood control and mitigation, drinking water and recreation. However in the unlikely and rare event of their failure, these may cause catastrophic flooding in the downstream area which may result in huge loss and damage to human life and property. In Malaysia, we have not had the experience of any such dam failures. However as the dams in the country get older, we cannot avoid but to face the reality that we have to take notice of the conditions of these dams from the safety point of view. This project report presents flood inundation mapping due to dam break of Klang Gate Dam. The Klang Gate Dam were modelled using a HEC-RAS one-dimensional hydraulic model to capture the hydraulic response of the river and its floodplains in extreme flooding condition due to dam break. Klang Gate Dam has been chosen as the study area where the dam has been classified as a significant high hazard. The purpose of this study is to determine maximum inundation depth of the flood waves, peak discharge and flood wave arrival time at various locations of the downstream valley and to develop flood inundation map depending on the severity of the flood in event of the failure of the Klang Gate Dam by using HEC-RAS. A steady flow HEC-RAS Model is developed for a probable maximum flood (PMF) failure for overtopping mode and the breach parameter of possible worst case scenario were considered in the study. The result showed that the peak discharge due to overtopping failure is 21,272 m³/s with possible maximum velocity of 12 m/s. The result indicated that impact of breach outflow to the downstream area is significant. The finding, could benefit authorities or dam owner in an emergency response plans to prevent catastrophic damage at downstream in case of a dam break occurs.

ABSTRAK

Empangan memainkan peranan yang amat penting dalam ekonomi sesebuah negara dengan menyediakan manfaat seperti pengairan, janakuasa tenaga elektrik, kawalan dan mitigasi banjir, air minuman dan rekreasi. Walau bagaimanapun, kegagalan empangan boleh menyebabkan banjir di kawasan hiliran yang memberi kesan yang ketara dari segi kehilangan nyawa dan kerosakan harta benda. Di Malaysia, kita tidak berpengalaman dengan kegagalan empangan. Walau bagaimanapun memandangkan empangan di negara ini semakin tua, kita tidak dapat mengelak untuk menghadapi kenyataan bahawa kita perlu memperhatikan keadaan empangan dari sudut keselamatan. Laporan projek ini membentangkan pemetaan banjir terhadap jangkaan berlakunya kegagalan empangan di Empangan Klang Gate. Kegagalan Empangan Klang Gate telah dimodelkan menggunakan pendekatan permodelan hidrodinamik HEC-RAS satu dimensi untuk mengetahui sistem hidraulik sungai dan dataran banjir dalam keadaan banjir yang melampau/ekstrem disebabkan kegagalan empangan. Empangan Klang Gate telah dipilih sebagai kawasan kajian di mana empangan telah diklasifikasikan sebagai empangan berisiko tinggi. Tujuan kajian ini adalah untuk menentukan kedalaman banjir maksimum, kadar limpahan aliran puncak dan masa ketibaan banjir di pelbagai lokasi hiliran dan membangunkan pemetaan banjir bergantung kepada keterukan banjir sekiranya berlaku kegagalan Empangan Klang Gate dengan menggunakan HEC-RAS. Satu Model HEC-RAS aliran mantap dibangunkan untuk kegagalan kemungkinan maksimum (PMF) untuk mod 'overtopping' dan parameter senario kes terburuk pelanggaran yang mungkin berlaku telah dipertimbangkan dalam kajian. Keputusan menunjukkan bahawa kadar limpahan aliran puncak kerana 'overtopping' ialah $21,272 \text{ m}^3/\text{s}$ dengan halaju maksimum 12 m/s . Hasil dari kajian ini, dapat memberi manfaat kepada pihak berkuasa atau pemilik empangan untuk digunapakai dalam merancang tindakan kecemasan untuk mengelakkan kerosakan bencana di hiliran sekiranya kegagalan empangan berlaku.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xi
	LIST OF SYMBOLS	xiv
	LIST OF APPENDICES	xvi
1	INTRODUCTION	1
	1.1 Introduction	1
	1.2 Background of the Problem	2
	1.3 Statement of the Problem	2
	1.4 Objectives of the Study	4
	1.5 Scope of the Study	4
	1.6 Significance of the Study	5
2	LITERATURE REVIEW	6
	2.1 Introduction	6
	2.2 Dam Failure	7
	2.3 Modes of Dam Failure	10
	2.3.1 Overtopping Failure	11
	2.3.2 Piping Failure	12
	2.3.3 Structural Failure	12

2.4	Review of Available Computational Tools for Dam Break Analysis	13
2.5	Hydraulic Model Software	17
2.5.1	Simplified Numerical Models	17
I.	SMPDBK / Simplified Dam break Modelling by National Weather Service (NWS)	17
2.5.2	One Dimensional Models	19
I.	Full Equations (FEQ) Model	19
II.	FLDWAV Model developed by National Weather Service	19
III.	HEC-RAS Model	20
IV.	ISIS Flow/Hydrology Model by Wallingford Software	23
2.5.3	Two Dimensional and Coupled 1d- 2d Models	24
I.	MIKE FLOOD	24
II.	BASEMENT	25
III.	CCHE2DFLOOD	25
IV.	FLO2D: Two Dimensional Flood Routing	29
V.	TELEMAC2D Model	30
2.6	Flood Mapping	30
2.7	Flood Modelling	32
2.8	Flood Modelling using HEC-RAS	33
2.9	Summary	35
3	RESEARCH METHODOLOGY	36
3.1	Introduction	36
3.2	Research Boundary	37
3.3	Design Methodology	38
3.4	Area of Study	42
3.5	Data Collection	47
3.5.1	LIDAR (Light Detection and Ranging) Data	47
3.5.2	Dam Data and Rainfall Data	48
3.6	Data Segmentation	49

3.6.1	HEC-Geo RAS Development	49
I.	Digitizing Process	50
3.6.2	HEC-RAS Model Development	60
I.	Channel Data	61
II.	Hydraulic Analysis in HEC-RAS	61
3.7	HEC-RAS Model	62
3.8	Data Analysis	74
3.9	Pros and Cons of HEC-RAS Modelling	76
3.9.1	Steady and Unsteady Flow Analysis in HEC RAS	77
3.10	Research Limitations	80
3.11	Conclusion	81
4	RESULT & ANALYSIS	82
4.1	Introduction	82
4.2	To Determine Maximum Inundation Depth of the Flood Waves, Peak Discharge and Flood Wave Travel Time at Various Location of the Downstream Valley When the Dam Failure.	83
4.2.1	Calibration	84
4.2.2	Breach Parameter	86
4.2.3	Overtopping Failure of Klang Gate Dam	89
4.3	To Develop Flood Inundation Map Depending on the Severity of the Flood in Event of the Failure of the Klang Gate Dam by Using HEC-RAS.	94
4.4	Conclusion	98
5	CONCLUSION & RECOMMENDATION	99
5.1	Conclusion	99
5.2	Recommendation	101
	REFERENCES	104
	Appendices	108

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Statistics of Dams in Malaysia	9
3.1	Salient Features of Klang Gate Dam	44
4.1	Reservoir Routing	83
4.2	The Summary of Rainfall Data During 4 th September 2012 Storm Event	85
4.3	Breach Parameter	87
4.4	Klang River Longitudinal Section Vs Infrastructure	87
4.5	Peak Flow Results for 100 years and PMF Failure	90
4.6	The Floodwater Depth for 100 years and PMF Failure	90
4.7	The Flood Wave Arrival Time for 100 years and PMF Failure	91
4.8	The Predicted Maximum Velocity for 100 years and PMF Failure	91

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Modes of Dam Failure	11
2.2	Steps for converting one-dimensional simulation results into two-dimensional flood delineation maps	16
2.3	Simplified Dam-Break (SMPDBK)	18
2.4	Flood Inundation Map	31
2.5	Flood Hazard Map	31
2.6	Flood Risk Map	32
2.7	Flood Inundation Map of Sg. Kinta Dam	33
2.8	Flood Prone Area	34
3.1	Research Approaches	41
3.2	Area of Study	43
3.3	Plan and Elevation of Klang Gate Dam	45
3.4	Cross-sections of Klang Gate Dam	46
3.5	The Klang Gate Dam	46
3.6	Remote Sensing Image of the Study Area	47
3.7	Map of Klang Gate Dam	48
3.8	Steps In Digitizing Process	50
3.9	ArcGIS 10.3	51
3.10	New Map	51
3.11	Add Data	52
3.12	Base Map/ LIDAR Data	52
3.13	Create RAS Layers	53
3.14	Create All Layers	54
3.15	RAS Layers Are Successfully Created	54
3.16	Editor Toolbar	55

3.17	Digitizing the Stream	55
3.18	Create River Topology	56
3.19	Complete Digitizing Process	57
3.20	Layer Setup- Required Surface	58
3.21	Layer Setup- Required Layers	58
3.22	Layer Setup- Optional Tables	59
3.23	Layer Setup- Optional Layers	59
3.24	Export GIS Data	60
3.25	Dam Break Analysis Flow Chart	61
3.26	Steps for HEC-RAS Model	62
3.27	HEC-RAS 4.1.0	62
3.28	Save Project As	63
3.29	River Reach Streamlines	63
3.30	Cross Section and IB Nodes	64
3.31	Georeferenced Schematic Of The River System	64
3.32	Edit Geometric Data	65
3.33	Flow data	66
3.34	Steady Flow Boundary Condition	66
3.35	Steady Flow Analysis	67
3.36	A dam is represented as an inline structure in HEC-RAS	68
3.37	Dam breach information entered in HEC-RAS	68
3.38	Enter/Edit Unsteady Flow Data	69
3.39	Initial boundary	70
3.40	Initial Stages	70
3.41	Normal Depth	71
3.42	Unsteady Flow Analysis	72
3.43	GIS Export	73
3.44	Convert RAS Output File to XML	73
3.45	Flood Inundation Map	74
3.46	Example profile comparison of dam failure scenarios in HEC-RAS	75
3.47	Stage hydrographs at river mile locations downstream of the dam	76

4.1	Klang Gate Dam Storage-Stage Curve	83
4.2	The Rainfall at AU6 Station on 4 September 2012	84
4.3	The Rainfall at Kelang Gate Station on 4 September 2012	84
4.4	The Rainfall at AU3 Station on 4 September 2012	85
4.5	The Rainfall at Ampang, Klang Station on 4 September 2012	85
4.6	The Result of Water Level Hydrograph from Observed and Simulation for 4 September 2012 Storm Event	86
4.7	The Longitudinal Profile Of The Section Versus The Infrastructure/Villages Near The Klang River	88
4.8	The Longitudinal Profile Of The Floodwater Depth Due to Dam Break	92
4.9	The Predicted Maximum Velocity for 100 years and PMF Failure	93
4.10	Flood Inundation Map of Klang Gate Dam due to Dam Break of PMF Failure	95
4.11	Riverview Kemensah	96
4.12	Sek. St Maris and Sg. Klang & Sg Ampang Confluence	97

LIST OF SYMBOLS

DID	-	Drainage and Irrigation Department
GIS	-	Geographic Information System
DEM	-	Digital Elevation Model
LiDAR	-	Light Detection and Ranging
HEC-RAS	-	Hydrologic Engineering Center's River Analysis System
PMF	-	Probable Maximum Flood
km ²	-	Kilometre Square
1D	-	1 Dimension
SMPDBK	-	Simplified Dam-Break
NWS	-	National Weather Service
FEQ	-	Full Equations
FLDWAV	-	Flood Wave
DWOPER	-	Dynamic Wave Operation Network Model
DAMBRK	-	Dam-Break Forecasting Model
UNET	-	Unsteady Flow Engine
ISIS	-	Full Hydrodynamic Simulator
FSR	-	Flood Studies Report
FEH	-	Flood Estimation Handbook
USSCS	-	US Soil Conservation Service
VAW	-	Laboratory of Hydraulics, Hydrology and Glaciology
ETH	-	Swiss Federal Institute of Technology
CCHE2DFLOOD	-	Computational Hydroscience and Engineering
DSS-WISE	-	Decision Support System for Water Infrastructural Security
HEC-GeoRAS	-	Hydrologic Engineering Center's Geographic River Analysis System

JUPEM	-	Jabatan Ukur dan Pemetaan Malaysia
TIN	-	Triangular Irregular Networks
m^3/s	-	meter cubic per second
m/s	-	meter per second

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Taman Melawati and Zoo Negara Flood Inundation Map	109
	Taman Lembah Keramat and Taman Sepakat Flood Inundation Map	110
	JPS Water Level and Rainfall Stations in Wilayah Persekutuan Kuala Lumpur	111
	Flood Risk Map of Sungai Klang River Basin	112
	Model of Sg. Klang Upstream of the Klang Gate Dam Until Confluence of Sg Klang & Sg. Ampang	113

CHAPTER 1

INTRODUCTION

This chapter consist of introduction, research problem, research objectives, research scope and significant of research.

1.1 Introduction

Dams play a very vital role in the economy of a country by providing essential benefits like irrigation, hydropower, flood control and mitigation, drinking water, recreation etc. A dam can also be used to collect water or for storage of water which can be evenly distributed between locations. However in the unlikely and rare event of their failure, these may cause catastrophic flooding in the downstream area which may result in huge loss and damage to human life and property. Some notable historic dam failure include Ka Loko Dam in Hawaii, 2006 ; Koshi Barrage in Nepal, 2009; Delhi Dam in United States, 2010 and Nieodo Dam in Poland, 2010 (Wikipedia, 2013a). In 1975 the failure of the Banqiao Reservoir Dam and other dams in Henan Province, China caused more casualties than any other dam failure in history. The disaster killed an estimated 171,000 people and 11 million people lost their homes (Wikipedia, 2013a). This loss and damage to life and property would vary with extent of inundation area, size of population at risk, and the amount of warning time available (S. Masood Husain, 1999).

1.2 Background of the Problem

In Malaysia, we have not had the experience of any such dam failures. However as the dams in the country get older, we cannot avoid but to face the reality that we have to take notice of the conditions of these dams from the safety point of view. We should not wait until failure occurs which may endanger public safety.

A distinguishing feature of dam breach floods is the great magnitude of the peak discharge in comparison to any precipitation runoff-generated floods, and its consequences are often catastrophic if human developments exist downstream of the dam. The prediction of the dam break flood is very important for the purposes of planning and decision making concerning to dam safety, controlling downstream developments, contingency evacuation planning and real time flood forecasting. For assessing the flood damage due to dam breach it is necessary to predict not only the possibility and mode of a dam failure, but also the flood hydrograph of discharge from the dam breach and the propagation of the flood waves. The studies are to map or delineate areas of potential flood inundation resulting from a dam breach, flood depth, flow velocity and travel time of the flood waves etc. Knowledge of the flood wave and flood-inundation area caused by a dam breach can potentially mitigate loss of life and property damage.

1.3 Statement of the Problem

A flood produced by a dam breach is very different from a flood produced by a rainfall event. In a dam-breach scenario, the subsequent flood wave develops over a relatively short time and flows rapidly through the downstream area as opposed to a rainfall event that would propagate more slowly through the downstream area.

When a dam fails or is deliberately demolished, large quantities of water are suddenly released, creating major flood waves capable of causing disastrous damage to downstream valley. Major flood waves may seriously damage or destroy power

plants, industrial plants, roads and bridges and may cause loss of life, adverse ecological and environment impact.

Dam can fail either gradually or suddenly. The type of failure depends upon the cause of failure and the type of dam. The failure can be because of the prolonged periods of rainfall and flooding, inadequate spillway capacity, resulting in excess overtopping of the embankment, internal erosion caused by embankment or foundation leakage or piping, failure of upstream dams in the same drainage basin and improper maintenance, including failure to remove trees, repair internal seepage problems, or maintain gates, valves, and other operational components.

When the dam fails instantaneously, one assumes removal of the entire structure or a large portion thereof. The sudden release of water generates a flood wave that propagates over the initial stream flow and its front has the form of the bore. A negative wave is created upstream of the dam and it propagates up along the reservoir. The ruptured dam section becomes the pivotal point for the mass of water to be released. The topography of the reservoir controls the movement of the negative wave. (Muradee, 2009)

According to Emily Sirib (2005), there are about 75 dams in Malaysia and most of the dams located next to the residential area. Dams that located near to the residential posed high hazard to the downstream population. As results of the situation, Dam-breach analysis and flood-inundation maps are vital for providing data to make a better plan for and respond quickly and effectively to flooding. Advanced knowledge of what areas may flood, what infrastructures may be impacted, how long flooding may persist is necessary if units are to be able to respond to such treats in timely manners.

Regarding to the significant of dam break study, a cooperative study has to be done to simulate dam-break scenarios at Klang Gate Dam and to map the potentially resulting flood-inundation areas.

1.4 Research Objectives

Followings are the objectives proposed for this study:-

- (1) To determine maximum inundation depth of the flood waves, peak discharge and flood wave arrival time at various locations of the downstream valley when the dam failure.
- (2) To develop flood inundation map depending on the severity of the flood in event of the failure of the Klang Gate Dam by using HEC-RAS.
- (3) To predict river flood risk map in Sungai Klang river basin.

1.5 Scope of the Study

A dam break flood modelling development of accurate flood-inundation maps requires high-resolution topographic data of known accuracy. More accurate topographic data lead to more accurate flood-inundation maps (Horritt and Bates, 2001). Field surveying produces the most accurate elevation data but can be time consuming and expensive. Light detection and ranging (LiDAR) is an airborne laser-profiling system that produces location and elevation data to define the surface of the Earth and the heights of aboveground features. LiDAR can produce a digital elevation model (DEM) with 1-foot (ft) contours that can be imported to a geographic information system (GIS) in a relatively short amount of time.

Dam-breach flood-inundation maps indicate areas that would be flooded as a result of a dam failure. The inundated areas depicted on flood-inundation maps are approximate, and accuracy of such maps is a function of the accuracy of the topographic data, the hydraulic models on which the maps are based, the assumptions made about the dam failure mode, and the initial flood wave. For this report, LiDAR data with a vertical accuracy of about 3.3 inches (in) were used to develop a 1-ft contour elevation map for the study area of Klang Gate Dam. The

Hydrologic Engineering Center's River Analysis System (HEC-RAS) modelling software developed by the U.S. Army Corps of Engineers, a standard for dam-breach flood-inundation models, was used to perform steady-flow simulations to model the dynamic nature of the flood wave produced by a dam-breach scenario (Hydrologic Engineering Center, 2010a).

The scope of this study is within this related area:-

- Data collection and analysis
- Dam breaks analysis with HEC-RAC modelling.

A dam break flood modelling will be conducted to determine the flood inundation extents of a failure of the Klang Gate Dam. A steady flow HEC-RAS Model is developed for a probable maximum flood (PMF) failure.

1.6 Significance of the Study

The significant of the study is to develop the river hydraulics model, simulate a dam failure and map the resulting flood wave. The proper modelling of the hazards associated with dam break will assist in land use planning and developing emergency response plan to help mitigate catastrophic loss to human life and property that might be inflicted by floods.

REFERENCES

- Abbott, M. (1976). *Computational hydraulics: A short pathology*. Journal of Hydraulic Research, Vol. 14, No. 4
- Angkasa Consulting Services Sdn. Bhd. (2012). Dam Break Risk Assessment. Prepared for Seminar Pengurusan Risiko dalam Pengurusan Projek. Putrajaya International Convention Centre, Malaysia. 12 July 2012.
- Ariffin, M. (2006). *Action Plan toward Effective Flood Hazard Mapping in My Country in Malaysia* (Concluding report). Available from: http://www.icharm.pwri.go.jp/html/training/fhm/2006-d/ariffin_malaysia.pdf [Accessed 12 December 2013]
- Cameron T. Ackerman, Gary, W.B., (2006). Dam Failure Analysis Using HEC-RAS and HEC-GeoRAS. Available from: http://www.gcmrc.gov/library/reports/physical/Fine_Sed/8thFISC2006/3rdFIHMC/11F_Ackerman.pdf [Accessed 29 April 2013]
- Cameron T. Ackerman, Matthew, J.F., Gary, W.B., (2008). Hydrologic and Hydraulic Models for Performing Dam Break Studies. *Journal of World Environmental and Water Resources Congress 2008*. Ahupua'a, Hawaii, 1-11.
- Centre, G.E. (2015). *River of Life (ROL) 2012*. Available from <http://www.myrol.my/> [cited 20 April 2015]
- Division of Water Resources, State of Colorado (June 1983). *Dam Safety Manual*. State Engineer's Office, Denver, Colorado.
- Fread (1988) (revised 1991). *BREACH: An Erosion Model for Earth Dam Failure*, National Weather Service, National Oceanic and Atmospheric Administration, Silver Spring, Maryland.
- Fread, D.L., Some Limitations of Dam-Breach Flood Routing Models, *ASCE Fall Convention*, St. Louis, MO, October 26-30, 1981.

- Government of Malaysia, Department of Irrigation and Drainage (March 2009). DID Manual- Dam Dam Safety, Inspection and Monitoring. Kuala Lumpur, Malaysia.
- Guadalupe-Blanco River Authority (2011). Hazard Mitigation Plan Update-Dam Failure. Available from <http://www.gbra.org/documents/hazardmitigation/update/Section14-Failure.pdf>. [Accessed 15 December 2013]
- Henry H., John H., Daniel H (2000). *Dam Break Inundation Analysis for Lake Youngs Reservoirs*. Available from <http://ussdams.com/proceedings/2012Proc/1411.pdf>. [Accessed 20 November 2013]
- HEC (2005). HEC-GeoRAS- *An extension for support of HEC RAS using ArcGIS*, CPD-83, September 2005. Hydrologic Engineering Center, Institute for Water Resources, U.S. Corps of Engineering, Davis, CA.
- HEC (2008). *HEC-RAS River Analysis System, User's Manual, Version 4.0*, CPD-3, January 2008. Hydrologic Engineering Center, Institute for Water Resources, U.S. Corps of Engineering, Davis, CA.
- HEC (2014). HEC-RAS River Analysis System, Using HEC-RAS for Dam Break Studies, Version 4.0, CPD-39, August 2014. Hydrologic Engineering Center, Institute for Water Resources, U.S. Corps of Engineering, Davis, CA.
- Jansen, R.B. (1988). *Advanced Dam Engineering for Design, Construction and Rehabilitation*. Edited by S. Edition. New York: Van Nostrand Reinhold.
- Japan International Cooperation Agency (JICA) (1989). *Study of Flood Mitigation of the Klang River Basin*. unpublished report to the Government of Malaysia, Kuala Lumpur.
- Lembaga Urus Air Selangor (LUAS) (1999). Maklumat Empangan. Available from <http://iwrimis.luas.gov.my/> [Accessed 1 May 2015]
- Malaysia Inter-Departmental Committee on Dam Safety (1989). Guidelines for Operation, Maintenance and Surveillance for Dam, Jabatan Kerja Raya, Malaysia.
- Masood S.H., Nitya N.R.(1999). One Dimensional Dam Break Flood Analysis For Kameng Hydro Project, India. Available from: <http://www.ymparisto.fi/default.asp?contentid>. [Accessed 12 December 2013]

- Merwade V. (2012). Tutorial on Using HEC-GeoRAS with ArcGIS 10 and HEC-RAS Modelling, School of Civil Engineering, Purdue University. Available from: <https://web.ics.purdue.edu/~vmerwade/education/georastutorial.pdf>. [Accessed 23 February 2015]
- Meyer S., Olivera F. (2007) Floodplain Mapping & Hydraulic Analysis with HEC-GeoRAS 4.1.1 and ArcGIS 9.1, Zachry Department of Civil Engineering, Texas A&M University. Available from: http://waterinfotech.com/hec_ras/hecgeoras%20%20meyer%20and%20olivera.pdf. [Accessed 23 February 2015]
- Montana Department of Natural Resources and Conservation. (2013). Dam Safety. Water Resources Division. Helena, MT.
- M. S. Altinakar, E. E. Matheu, and M. Z. McGrath (2009). New Generation Modeling and Decision Support Tools for Studying Impacts of Dam Failures. Proceedings of the *ASDSO Dam Safety 2009 Annual Conference*. Hollywood, FL. Sept 27-Oct 1 2009.
- Muradee, N.A. (2009). *Dam Break Study for Earthfill Dam*, Master of Civil Engineering, University Teknologi Malaysia, Skudai.
- Neill, J. (2013). Qualitative versus Quantitative Research: Key Points in a Classic Debate 2007. Available from <http://wilderdom.com/research/QualitativeVersusQuantitativeResearch.html>. [Accessed 12 December 2013]
- Omar, I.B.Z.B.C. (2014). Flood Hazard Map: An update. Article of JPS Bulletin.
- Osman, I.Z.A.B. (2006). *Overview of Dam Safety in Malaysia*. Article in *Jurutera*, January 2006, 22-23.
- Sirib, E. (2005). Dam Break Study, Master Thesis of Civil Engineering, University Teknologi Malaysia, Skudai.
- Trade, N.Z.M.o.F.A.a. (2013). *Preventing Loss of Life and Economic Damage from Natural Hazards Causing Extreme Dam Discharges in Viet Nam*. Paper presented at Technical Excellence in Safe Dam-Potential Failure Modes Workshop, May 2013, at Vietnam.
- USBR (1998). Prediction of Embankment Dam Breach Parameters, Dam Safety Research Report DS0-98- 004. Dam Safety Office, U.S. Department of the Interior.
- USBR (1983). Hydraulic Model Studies of Modification to Klang Gates Dam, Malaysia, Dam Safety Research Report GR-82-12. Division of Research, U.S. Department of the Interior.

U.S. Army Corps of Engineers (1980). *Flood Emergency Plans, Guidelines for Corps Dams*. Research Document 13. Hydrologic Engineering Center. Davis, CA.

Washington State Department of Ecology (July 1992). *Dam Safety Guidelines- Dam Break Inundation Analysis and Downstream Hazard Classification*. Dam Safety Section. Olympia, Washington.

Wikipedia (2013). *Dam Failure*. Available from http://en.wikipedia.org/wiki/Dam_failure [Accessed 7 May 2013].

Wikipedia (2013). *Literature Review*. Available from http://en.wikipedia.org/wiki/Literature_review [Accessed 14 December 2013].

Zahri, A.M. (2015). *Flood Mapping Using Geographic Information System (GIS)*, Faculty of Civil Engineering, Universiti Teknologi Malaysia, Malaysia.