Ministry of Higher Education
and Scientific Research
University of Diyala
College of Engineering

ESTIMATION OF DAM BREACH PARAMETERS USING DIFFERENT APPROACHES FOR EARTH FILL DAM

A Thesis Submitted to the Council of College of Engineering, University of Diyala in Partial Fulfilment of the Requirements for the Degree of Master of Science in Civil Engineering

By
Israa Dheyaa Abdulrazzaq

Supervised by
Assist. Prof. Dr. Qassem H. Jalut
Prof. Dr. Jasim M. Abbas

November
2021

Rabi' Al-Awal
1443

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

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I certify that this thesis entitled "**Estimation of Dam Breach Parameters Using Different Approaches for Earth Fill Dam**" Was prepared by "**Israa Dheyaa Abdulrazzaq**" under my supervision in the University of Diyala in partial of fulfilment of the requirements for the degree of Master of Science in Civil Engineering.

Signature:

Name: Assist. Prof. Dr. Qassem H. Jalut

(Supervisor)

Date: / /2021

Signature:

Name: Prof. Dr. Jasim M. Abbas

(Co-Supervisor)

Date: / /2021

COMMITTEE CERTIFICATION

We certify that we have read the thesis entitled (**Estimation of Dam Breach Parameters Using Different Approaches for Earth Fill Dam)** and we have examined the student (**Israa Dheyaa Abdulrazzaq**) in its content and what is related with it and in our opinion, it is adequate as a thesis for the Degree of Master of Science in Civil Engineering.

Examination Committee		**Signature**
1. Assist. Prof. Dr. Qassem H. Jalut	(Supervisor)	.....
2. Prof. Dr. Jasim M. Abbas	(Co-Supervisor)	.....
3. Assist. Prof. Dr. Yahya Kadhim Hussein	(Member)	.....
4. Assist. Prof. Dr. Qutaiba G. Majeed	(Member)	.....
5. Assist. Prof. Dr. Hassan Obaid Abbas	(Chairman)	.....
Prof. Dr. Wissam D. Salman	(Head of Department)	.....

The thesis was ratified at the Council of College of Engineering / University of Diyala.

Signature: …….

Name: Prof. Dr. Aness A. Khadom

Dean of College of Engineering / University of Diyala

Date:

Dedication

To

My beloved parents…

My husband (Ibrahim)…

My lovely siblings (Ahmed, Maryam, Shahad and Taha)…

Everyone who wish me a good luck…

I dedicate this work…

Acknowledgements

In the name of Allah, the most gracious, the most merciful. Before anything, I thank the almighty Allah who enabled me to achieve this thesis. I wish to express my sincere gratitude and appreciation to my supervisors; **Assist. Prof. Dr. Qassem H. Jalut** and **Prof. Dr. Jassim M. Abbas** for their supervisions, precious advices, technical guidance, continuous encouragements, and remarkable patience in reviewing my thesis, I am indebted to them.

Appreciation and thanks are also extended to **Eng. Majed Rodan Hussein** for his cooperation and help.

Finally, thanks very much to my family for what they presented for me on the hope that their endeavors crowned me the fruit of my success to prove to them that it will not go in vain.

ESTIMATION OF DAM BREACH PARAMETERS USING DIFFERENT APPROACHES FOR EARTH FILL DAM

Abstract

Analysing and simulating dam breach events and the resulting floods is critical for differentiating and reducing impendences due to possibility failure of dams. Hydrological Engineering Centre (HEC-RAS) River Analysis System was used for developing dam failure model. HEC-GeoRAS was used to extract geometric information from a Digital Elevation Model (DEM) and then imported into HEC-RAS version (5.0.7).

The process of dam breach modelling is to analyse the downstream flooding risks of the dam by the simulating of possible failure of dam scenarios. The prediction of geometry for dams breach is important in studies of dam breach. Flood hydrograph characteristics that result from dam breach depend on breach geometry and time required for the breach forming. For investigating the effect of breach parameters on breach maximum outflows, five empirical equations are used in order to predict dam breach parameters by using HEC-RAS model. Hamrin dam was selected as a case study in this research. The dam has been checked for overtopping and piping failure modes by the use of two dimensional river analysis model HEC-RAS and for use in the model. The unsteady flow calculations performed in HEC-RAS.

For Hamrin dam, we used five empirical equations for predicting breach geometry and breach formation time. The equations used are Singh and Snorrason (1982), MacDonald and Langridge-Monopolis (1984), Bureau of Reclamation (USBR) (1988), Von Thun and Gillette (1990) and Froehlich (2008). Three water levels for each method were considered. Peak discharge value and time of peak discharge were analysed and discussed for each scenario. The results showed that Froehlich approach was most adequate empirical equation to estimate the breach parameters for Hamrin dam. Overtopping failure mode tends to provide higher

peak discharge ($61909.64 m^3/hr$) comparison with piping failure mode ($52532.33 m^3/hr$) for Froehlich approach.

Sensitivity analysis was performed in order to assess the influence of each parameter on resulting flood hydrograph. HEC-RAS model was used to calculate the influence of each parameter on flood hydrograph that resulted. The breach width (B_{avg}), side slope (z) and breach formation time (t_f) increased respectively by 25%, 50%, 75% and 100% and decreased respectively by 25%, 50% and 75%. Sensitivity analysis was performed with Froehlich approach with the overtopping failure mode and maximum operating level at 107.5 meter above sea level. Flood hydrograph was estimated at the dam site for each case. Result of sensitivity analysis show that peak discharge and time to reach it is adequately sensitive to breach side slope, it has high sensitivity to breach formation time and less sensitivity to breach width.

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LIST OF SYMBOLS

Item	Description
H	Water surface elevation.
t	Time.
h	Depth of water.
q	Lateral inflow per unit length.
S_f	Frictional slope.
Q	Lateral flow entering the control volume.
B_{ave}	Average Breach Width.
$K_\circ$	Constant.
V_w	Reservoir volume at time of failure.
h_b	Height of the final breach.
g	Gravitational acceleration.
t_f	Breach formation time.
V_{eroded}	Volume of material eroded from the dam embankment.
V_{out}	Volume of water that passes through the breach.
h_w	Depth of water above the bottom of the breach.
W_b	Bottom width of the breach.
h_b	Height from the top of the dam to bottom of breach.
C	Crest width of the top of dam.
Z_1	Average slope (Z_1:1) of the upstream face of dam.
Z_2	Average slope (Z_2:1) of the upstream face of dam.
Z_b	Breach side slope (Z_b: 1), 0.5 for the MacDonald method.
C_b	Coefficient, which is a function of reservoir size.
h_d	height of the dam.

LIST OF ABBREVIATIONS

Abbreviation	Total name
HEC-RAS	Hydrological Engineering Centre-River Analysis System.
DEM	Digital Elevation Model.
GIS	Geographic Information Systems.
USACE	United States Army Corps of Engineers.
FEMA	Federal Emergency Management Agency.
1D	One Dimension.
2D	Two Dimension.
USGC	United States Geological Survey.
FERC	Federal Energy Regulatory Commission.
USBR	United States Bureau of Reclamation.
a.s.l.	Above sea level.

CHAPTER ONE
INTRODUCTION

1.1 General

The analysis of dam breach deals with the events after gradual or sudden failure of dams. Dam is a hydraulic structure primarily used for providing the necessary amount of water downstream, protect against flooding, and Power generation. On the other hand, floods resulting from the failure of dams are considered a national disaster and are classified as accidents of the first degree of damage that they cause to human life, property and economic systems.

The reasons for the failure of the dam could be caused by the overtopping of dam because of the capacity of spillway is insufficient and insufficient freeboard during large flows into the reservoir, piping or seepage (internal erosion), Earthquakes liquefaction, failure of dam foundations, Settlements due to slopes downstream or downstream of the dam body. In any case, most of dam failures start to form with the breach forming (Xiong, 2011).

The study of dam breach relies on two main functions, Estimate breach flood hydrograph and this hydrograph be routed at the location of dam downstream. Flood hydrograph of breach is mainly based on breach geometry prediction and time of breach formation. The prediction of dam breach parameters includes the highest uncertainty in estimating flooding of dam breach (Wurbs, 1987).

The empirical approaches that used for predicting breach parameters are based on data information gained from historical failures of dams. Numerous simulation models of dam breach request the user for estimating breach dimensions individually and supply this information as an input data to the model simulation. Different approaches for prediction of breach

parameters are illustrate in chapter three. Although there are plenty of Software programs for this purpose. The software package from the US Corps of Engineers, Hydrological Engineering Centre (USACE HEC), River Analysis System (RAS) version 5.0.7 is used with this study.

Hamrin Dam project is one of important, strategic, and vital projects built on the Diyala River in Iraq, which is located around 120 km northeast of Baghdad, Iraq. Due to the presence of small cities at the dam downstream, an analysis of the breach of the dam must be conducted as a condition for the reasons that may result due to the failure of the dam (The Ministry of Water Resources' 2016-2017).

1.2 Research Importance

The dams are important part of the infrastructure of this country. Provide flood control, hydropower, irrigation and water supply benefits. Due to the possibility of dams failing and causing catastrophic floods, they pose catastrophic risks to life and property. This study used by those responsible for managing the Hamrin dam if the failure will happen in the future, which leads to flooding.

1.3 Statement of Problem

Dam failure usually occurred from several problems like piping, overtopping, landslide, earthquake, etc. our world have experienced several catastrophic failure of dams because of this reason. Like Banqiao dam that failed in August 8, 1975 and killed appreciation of 171,000 people, and 11 million people missing their homes. As dams, pose earnest threat to the population, infrastructures, businesses, crops, landowners, etc. The downstream of them, always been important to the analysis of the causes and results of the dam failure.

Hamrin Dam is used as a case study throughout the current study to verify the stability of the earthen dam in the event of breach in the dam body

as a result of overtopping and piping failure mode. Full details on the subject of breaching dams will be discussed in detail in the third and fourth chapters of this study.

In Iraq, in inversion to the dams development, like that event analysis does not executed by researchers or designers. Hence, modelling of dam breach is necessary to recognize the possible causes of failure of dam, breach simulation process to review the design parameters, mapping the area that will be flooded so as for demarcating the prone areas while designing the areas of downstream for various infrastructures, notice the competent authorities to a caution on formulate the hazard management system and dam safety plans.

1.4 Research Objectives

The aims of the research are:

Estimation of dam breach parameters using different approaches for earth fill dams, with the following specific objectives:

1. In this study the dam breach parameters will be estimates in which includes dam breach dimensions and the breach formation time. The scenario of dam breach will be selected and the outflow hydrograph from the breach will be routing.
2. The simulation of two-dimensional flood model that is based on the equations of unsteady flow will be used in the analysis. The resulting flood from the breach will be mapped by the using of software's. Digital Elevation Model (DEM) of 12.5 x 12.5m grid will be used in order to prepare the geometric data that represents the elevations of the study area with some error.

1.5 Thesis Layout

This thesis is organized into five chapters and several sections. The following chapters involves this thesis as follow:

Chapter one: this chapter include a brief introduction that deal with dam breach analysis, research importance and the statement of problem.

Chapter two: this chapter constructed on the definitions of dam breach parameters and dam breach mechanism as well as a review of previous studies are present in this chapter.

Chapter three: description of the study area, numerical methods and modelling using HEC-RAS version 5.0.7 software.

Chapter four: the analysis results for overtopping failure mode and the sensitivity analysis for each parameter are represented.

Chapter five: conclusions and recommendations of the study were given in the last chapter.

References: the scientific references that were relied upon in this study. Additionally, the Appendices contain additional data about the thesis.