Embankment Breach Analysis of Durgawati Dam Using HEC RAS Software

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Abstract: This paper describes the Embankment Breach analysis of Durgawati Reservoir Dam (also known as Karamchat Dam), which is located in Kaimur district in the Indian state of Bihar. The Dam Breach analysis has been performed on HEC RAS software. HEC-RAS is a computer program developed by the United States Army Corps of Engineers. To perform the Dam Breach analysis, various other software has been used such as Google Earth and Global Mapper. The main aim of Embankment Breach analysis is to simulate the movement of an embankment breach flood flow along the downstream area that would be flooded as the result of embankment breach. Breach modelling is essential to understand breach mechanisms, behaviors and prediction of breach parameters. Dam Break Analysis is useful to identify the inundated area, flood depth, flood velocity and travel time of flood waves. For the dam safety, dam failure, early warning system and planning for emergency evacuation, is essential for the disaster mitigation measure.

Keywords — Durgawati Dam, Embankment dam; Failure of embankment dam, Modes of failure of embankment dam, Stability of embankment dams, Dam break analysis of an embankment dams.

I. INTRODUCTION

The main aim of embankment breach analysis is to simulate the movement of an embankment breach flood flow along the downstream area that would be flooded as the result of embankment breach. Embankment breach Analysis is useful to identify the inundated area, flood depth, flood velocity and travel time of flood flow.

The Embankment dam breach study of Durgawati Reservoir Dam (also known as Karamchat Dam), which is located in Kaimur district in the Indian state of Bihar has been carried out. The Dam Breach analysis has been performed on HEC RAS software. HEC-RAS is a computer program developed by the United States Army Corps of Engineers. The HEC RAS 6.2 version have been used for the Embankment breach analysis. This software is available to use without charges and use of this software is not restricted for the individuals outside of USACE (US Army corps of Engineers).

The scope of the study is restricted to failure of the dam due to overtopping and piping only. However, inundation maps are prepared for both the cases of failure and for large controlled releases. No other failure scenarios such as landslide and earthquake are considered in this study because the HEC-RAS software cannot simulate these conditions.

II. DATA FOR EMBANKMENT BREACH ANALYSIS

A. Data Required

Data required for dam break modelling and analysis are given below:

1) Salient features of all the hydraulic structures at the dam site also in the study reach of the river
2) Design flood hydrograph or Probable Maximum Flood
3) SRTM DEM 30 m Resolution
4) Stage-volume relationship for the reservoir

B. Data Collection

1) The details of hydraulic structures of Durgawati Dam have been taken from the website of Water Resources Department of Government of Bihar.
2) Design flood hydrograph and Peak Flood have been calculated using Flood Estimation Report for Sone Sub

 DOI : 10.35291/2454-9150.2022.0339

Zone – 1(d) by Central Water Commission (CWC), New Delhi has been referred for estimation of flood.

3) DIGITAL ELEVATION MODEL (DEM) DATA - The SRTM DEM 1arc resolution data has been used for the dam breach analysis. The first step involves the preparation *.kmz file. The *.kmz marking the Durgawati reservoir and downstream area is prepared. Then this kmz file is used in Global Mapper software to locate and create the required SRTM DEM data of the required area. After the extraction of SRTM DEM data from Global Mapper software, it is used in the HEC RAS software for further analysis. Figure 1 showing the SRTM data used for the Embankment Breach analysis.
4) The Stage capacity curve of the Durgawati reservoir is derived from the HEC RAS Software using SRTM DEM 1arc resolution data and used for the Embankment breach analysis. The Stage capacity curve is shown in Figure 2.

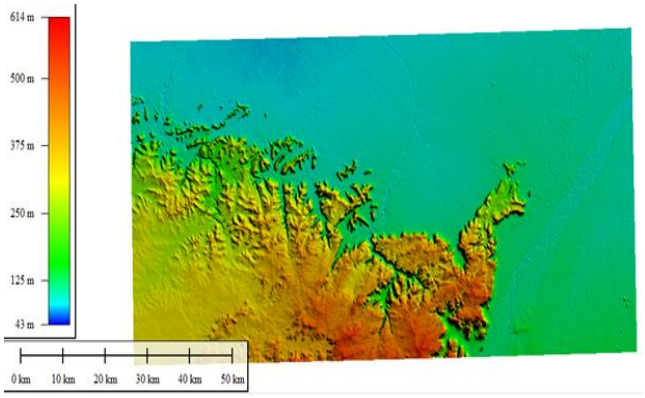

Figure 1: SRTM DEM 1arc resolution data of Durgawati Dam area

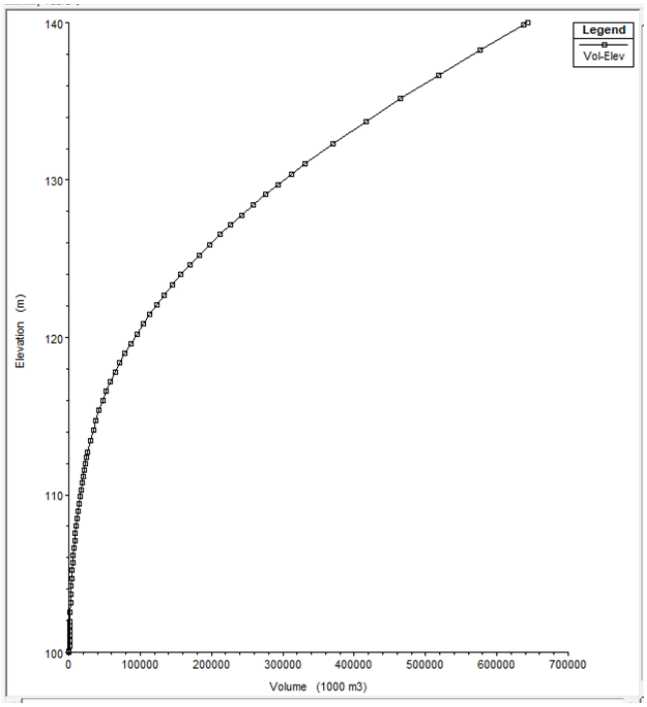

Figure 2: Stage capacity curve of the Durgawati reservoir

III. BREACH PARAMETERS

The estimation of the breach location, size, and development time are critical in order to make accurate estimate of the outflow hydrographs and downstream inundation. Once the breaching parameters are estimated, the HEC-RAS can be used to compute the out-flow hydrograph from the dam breach and perform downstream routing. The user is required to enter information like failure location, failure mode, breach development time, breach shape, weir and piping coefficient and trigger mechanism into HEC- RAS model to define the embankment breach.

Breach Parameter Calculator in HEC RAS software contains five regression equations. The embankment breach analysis of the Durgawati dam have been carried out using HEC RAS software by evaluating breach parameter by following four methods for both overtopping and piping failure conditions:

1) Froehlich 1995;
2) Froehlich 2008;
3) Von Thun and Gillete; and
4) Xu & Zhang

The Breach parameters calculated using HEC RAS software for overtopping failure are given in Table 1.

Table 1: Breach Parameter for Overtopping failure

S. No.	Method	Breach Bottom Width (m)	Side Slope (H:V)	Breach Development Time (Hours)
1.	Froehlich (1995)	237	1.4	5.43
2.	Froehlich (2008)	208	1	4.76
3.	Von Thun and Gillete	104	0.5	0.74
4.	Xu & Zhang	131	1.03	7.71

The Breach parameters calculated using HEC RAS software for piping failure are given in Table 2.

Table 2: Breach Parameter for Piping failure

S. No.	Method	Breach Bottom Width (m)	Side Slope (H:V)	Breach Development Time (Hours)
1.	Froehlich (1995)	171	0.9	5.43
2.	Froehlich (2008)	162	0.7	4.79
3.	Von Thun and Gillete	104	0.5	0.74
4.	Xu & Zhang	76	0.6	7.47

IV. ASSUMPTIONS

There are various assumptions have been made for embankment breach analysis of Durgawati Dam. All the assumption has been considered due to non-availability of certain data regarding Durgawati dam project, local surrounding villages and population data etc. The assumptions have been carefully taken considering the critical condition for the embankment breach disaster. The

 DOI : 10.35291/2454-9150.2022.0339

various assumption made are listed below:

1) The Durgawati reservoir capacity curve has been plotted using SRTM data. HEC RAS software allow user to calculate the reservoir capacity curve using SRTM DEM data.
2) The study area includes the Durgawati reservoir area and downstream area of up to 15Km areal distance.
3) The breaching of embankment has been considered in all condition to be occurred when the reservoir level is E.L. 134.60m i.e., top level of the earth dam.
4) The top width of the embankment dam has been considered as 10.0m with upstream slope of 3H:1V and downstream slope of 2.5H:1V.
5) Breach bottom elevation and Piping elevation has been considered as E.L. 110.0m.
6) Earth fill type in HEC RAS software has been considered as Fine Homogeneous and Dam type has been considered as Homogeneous/Zoned-fill dam.
7) Dam Erodibility in HEC RAS software has been considered as Medium.
8) The Peak flood has been considered according to the calculated value of 3917 cumecs.
9) STRM DEM data of 1arc resolution has been downloaded by Global Mapper software and used for the embankment breach analysis.
10) This Embankment breach analysis have been carried out for study purpose only and to evaluate the results of breach analysis using different methods.

V. SUMMARY OF RESULTS

A. *Overtopping Failure*

The summary of results of Embankment breach analysis of Durgawati dam from various method due to Overtopping failure are given in Table 3.

Table 3: Summary of results for Overtopping failure

S. No.	Description	Froehlich (1995)	Froehlich (2008)	Von Thun and Gillete
1.	Total Flow (CMS)	17341.8	18051.1	16782.6
2.	Breach Flow (CMS)	17341.8	18051.1	16782.6
3.	Headwater Elevation (m)	128.93	128.34	130.63
4.	Tailwater Elevation (m)	134.6	134.6	134.6
5.	Velocity Through Breach (m/s)	6.41	6.56	6.63
6.	Breach Bottom Width (m)	237	208	104
7.	Side Slope (H:V)	1.4	1.0	0.5
8.	Breach Development Time (Hours)	5.43	4.76	0.74

B. *Piping Failure*

The summary of results of Embankment breach analysis of Durgawati dam from various method due to Piping failure are given in Table 4.

Table 4: Summary of results for Piping failure

S. No.	Description	Froehlich (1995)	Froehlich (2008)	Von Thun and Gillete
1.	Total Flow (CMS)	17435.2	17674.7	16704.4
2.	Breach Flow (CMS)	17435.2	17674.7	16704.4
3.	Headwater Elevation (m)	124.97	125.28	127.75
4.	Tailwater Elevation (m)	134.6	134.6	134.6
5.	Velocity Through Breach (m/s)	7.08	7.07	6.99
6.	Breach Bottom Width (m)	171	162	104
7.	Side Slope (H:V)	0.9	0.7	0.5
8.	Breach Development Time (Hours)	5.43	4.79	0.74

C. *Flood Inundation Map*

The Flood Inundation map of Durgawati Embankment Breach for all eight analysis that were performed are presented in this report. According to the examination of the Flood Inundation map derived from various methods, all shows similar flooding pattern in the downstream area of the dam with varying time factor. A typical Flood Inundation map is shown in Figure 1.

Figure 1: Flood Inundation Map of Durgawati Embankment Breach failure

VI. CONCLUSION

Embankment Breach analysis of Durgawati Reservoir Dam (also known as Karamchat Dam) has been carried out using HEC RAS software. The Flood Inundation map of Durgawati Embankment Breach for all eight analysis have been analyzed.

Hence, it can be concluded that the breach of embankment breach may result in a very high flood wave traveling with quite high speed. The impact of such a wave on developed areas can be very devastating. Such destructive force brings with it an inevitable loss of life if advance warning and timely evacuation is not made possible.

For the Embankment dam safety, embankment failure,

 DOI : 10.35291/2454-9150.2022.0339

early warning system and planning for emergency evacuation, is essential for the disaster mitigation measure.

VII. FUTURE SCOPE OF STUDY

Embankment Breach analysis of Durgawati Reservoir Dam has been carried out using HEC RAS software. The Flood Inundation map of Durgawati Embankment Breach for all eight analysis have been analyzed.

There is great scope for the further study of the Embankment breach disaster of Durgawati dam with various other numerical modelling process, which also help in the study of other breach analysis of embankment dams. Following scope of future work includes the following:

1) The study of Embankment Breach Disaster can be performed on other numerical modelling software for evaluation of critical condition in the event of Embankment breach.
2) More detailed SRTM DEM can be used for the Embankment breach analysis.
3) Detailed rainfall data can be collected from Indian Meteorological Department (IMD) and State Government Water Resources/ Irrigation Departments for evaluation of Peak Flood. It will help in the Embankment breach analysis.
4) Detailed population data, villages, industries, establishments etc. data can be collected for evaluation of possible damage due to Embankment Breach Disaster.
5) Other embankments dams in the vicinity can be studied for the possible Embankment Breach Disaster to correlate the results with Durgawati Embankment Breach Disaster to know the similarities and deviations.

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