Dam Break Analysis using Arc-GIS and HEC-RAS:-A Review

[1]Arjun M. Kakadiya, [2]Prof. M.K. Chudasama [3]Prof. P.H. Pandya
[1]P.G. Student, [2]Assistant Professor, [3]Assistant Professor [1,] Department of Civil Engineering
[1,]Shantilal Shah Engineering College, Bhavnagar, Gujarat, India

Abstract-. Dam break analysis basically refers to the process of assuming a breach section in the dam and routing the flood wave in the downstream area. The prime objective of such analysis is to facilitate emergency action planning for a possible dam failure. The present work focuses on carrying out Dam break analysis of shetrunji dam by assuming an overtopping failure and corresponding breach dimension. This study deals using HEC-RAS with the SRTM digital elevation model. The preparation of inundation map is done using HEC-GeoRAS and ARC-GIS.

Index Terms- **Dam break analysis, Breach failure, Arc-GIS, HEC-RAS**

I. INTRODUCTION

Dams are the best imperative structures in the field of water resources engineering. Dam are directly deals to the human benefits but some time floods resulting from the failure of dams have also produced the most devastating disaster. Dam failure is of particular concern because it rarely occurs but its occurrence may be very catastrophic which causes more deaths and destruction compare to other man made structure. Dam may be susceptible to failure from multiple causes depending on the types of dam and site-specific location. Some of the causers are: overtopping, seismic failure, erosion of upstream side of dam, piping and seepage, internal erosion. The above causes lead to problem as a result of dam break occurrence. Some of the failure of dam led to the inception of ne field of research which focuses on dam failure and its resulting outcomes. So that analysis of dam failure has helped in the emergency action plans which are meant to be incorporated during failure of dam.

The failure of dam such as piping and overtopping that time use the HEC –RAS software because HEC-RAS make break analysis model for both failure breaches of the dam. Sometime suddenly failure of concrete dams than HEC-RAS c a n be modeled. In the HEC-RAS resulting flood wave is routed downstream using the unsteady flow equation. Inundation mapping of the resulting flood wave can be done with The HEC-GeoRAS program when GIS data are available.

HEC-RAS is a combined system of software, designed for communicating use in a multitasking envoirment. The system is comprised of a ‘Graphical User Interface’, discrete analysis components, data storage and management abilities, graphical and reporting facilities. The HEC-RAS system find out some content of river analysis components such as Steady flow water surface profile, one- and two-dimensional unsteady flow simulation, movable boundary sediment transport computations, and water quality analysis.

HEC-GeoRAS is nothing separate software but it is a small and very important tool in ArcGIS. It is specially designed to process geospatial data for use with the ‘Hydrologic Engineering Center’s River Analysis System’. The extension permits the users with limited GIS experience to create an HEC-RAS import file containing geometric data from an existing digital terrain model (DEM) and complimentary data sets. Result exported from HEC-RAS may also be processed. Prior to performing hydraulic computation in HES-RAS the geometric data must be imported and completed and flow data must be entered. After the hydraulic simulation done in HEC-RAS and achieved the water surface, velocity, maximum flood water level ect. Data then export to the HEC-GeoRAS and imported again back to the GIS for various analysis.

ArcGIS is a Geographical information system (GIS) is deal with the map and geographic information. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database. The system provides an infrastructure for making maps and Geographic information available throughout an organization, across a community, and openly on the Web. The present work makes use of ArcGIS, is a GIS tool developed by ESRI (Environmental System Research Institute) and is one of the most widely used GIS software. The basic task of GIS in current work is to facilitate creation of Digital Elevation Model and further creation of inundation map.

II. Dam break analysis

Dam break analysis can be done using the flood routing techniques proposed by St. Venant's equations for unsteady flow. His methodology solves both the continuity and momentum equations for one-dimensional flow, and at that time the forces on the control volume are limited to the effect of gravity, pressure variation, and friction or roughness of the channel walls.

Mass is conserved in the solution and the effect of acceleration within the control volume and momentum flux across the upstream and downstream faces are considered. It consists of two independent variables Q and t. Solution of this equation depends on the number of cross-sections. Because of the complexity in solving the entire equation simultaneously software HEC-RAS has been selected. HEC-RAS is Hydrologic Engineering Center's River Analysis System software. It is developed by U.S Army Corps of Engineers. This software allows to perform one dimensional steady flow, unsteady flow calculations, sediment transport computations and water quality analysis. One dimensional approach to flood inundation modeling only considers one dimension of the flood flows in the direction of x axis (downstream direction). It is best represented by St. Venant's formula used for calculating the one-dimensional flow of the flood wave. The lateral and longitudinal geometry of the stream determines how peak of the flood wave s reduced as it moves downstream, the travel time of the peak flood between points of interest, maximum water stage at point of interest and change in shape of hydrograph as it moves downstream. These effects are governed by factors such as bed slope, cross sectional area and geography of the main channel. In order to do the dam break analysis and flood modelling the salient features regarding the reservoir, the dams that have to be analyzed etc. are to be collected. To analyze the dam for dam break analysis we require data like breach data flow data, Manning's n etc. The input for flood modelling are input for flood modelling storage area data, inline structure data, geometric data, entering flow data and the boundary conditions.

The term 'Breach modeling' basically refers to the process of understanding and simulating the breach development in a dam. Breach modeling generally relates to the first perspective of this research field as stated earlier. Two breach forming mechanisms are identified: erosion and head cut-erosion. The Erosion process is modelled using the sediment transport equations that are conventionally derived for steady subcritical flow conditions, specific types and certain diameter ranges of sediment. Various computer models are developed which simulate the breaching process.

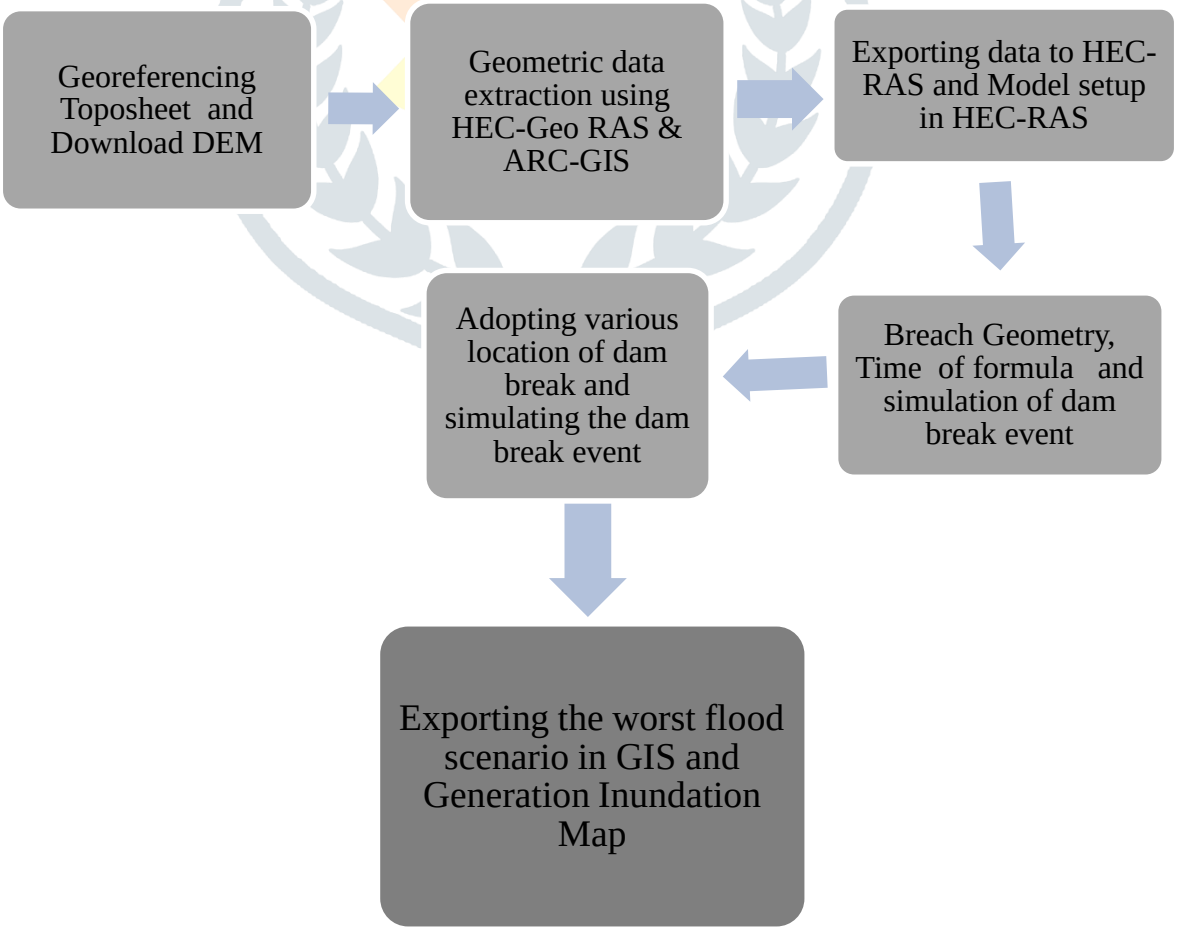

Fig. 1 Flow chart showing the methodology

III. LITERATURE REVIEW

The literature regarding various aspects of the research field dealing with dam break analysis. The literature has been presented under various sub divisions parameters associated with breaching and the contribution of various researchers to it.

Martin J. Teal and Christopher Goodell (2008) presents the analysis of dam failure and their main focus on the hydraulic modeling and dam failure aspect of the studies. That is conducted for "Department of Land and Nature Resources" Their purpose of the dam break analyses is to estimate the inundation area of the dam downstream and flood depths in the case of a dam failure. Here total 11 selected dams in the State of Hawai'i. The analysis determined and gauged the impact of the 100-year flood and "Probable Maximum Flood" (PMF) as inflow scenarios as well as the full reservoir pool bright day failure scenario to account for non-rainfall induced failures such as earthquakes. The three dam failure scenarios were analyzed through computer modeling tools and the resulting downstream inundation maps for each scenario was created using the best available topographic data.
The HEC-RAS hydraulic model was used to calculated flood flows downstream and to generate dam failure hydrographs. The modeling and dam failure procedures are outlined. These were critical tasks leading to the development of dam failure inundation mapping, one of the major outcomes of these studies.

Christopher R. Goodell present the new improvement includes the creation of two tandem high-head earth embankment dams for water supply to infrastructure downstream. The two dams are located on an unnamed ephemeral stream in a steep, relatively small watershed. The lower dam creast is 0.5 miles d/s of the crest of the upper dam. An initial consideration for Dam 1 was that it should provide large storage capacity and a large enough spillway to be able to safely pass a dam break event from Dam 3. This paper will discuss the efforts recued to construct and successfully run both of these models. HEC-HMS uses the continuity equation, pretentious a level pool analysis for reservoirs, and applies hydrologic routing for channel flow. HEC-HMS allows for reservoir outflow to be calculated using orifice equations, weir equations or from a dam break simulation.
Although the HEC-RAS model requires much more effort to construct and to run for a dam break simulation over an HEC-HMS model, it is clear that to properly account for the travel time and flow attenuation through a large reservoir.

Steve Nuyen, and David Weston present The Dalles Dam involves of a powerhouse, spillway, navigation lock, concrete non-overflow sections, and earth-fill embankment on the Washington shore, a rock-fill embankment on the Oregon shore, and fish passage and appurtenant services. This dam is the largest navigation dams in the United States; it is approximately 2662 meter in length and over 61 meter hight.
Steve and David discuss the hydrologic and hydraulic methods for the dam failure analysis. It will also focus on the breach characteristics, type of failure and non-failure simulations that were used in the model analysis

Zadbar et al are find the outflow of the flooded area in the case of dam break and they are simulation with using WMS and SMPDBK software. They are present some methods for prediction of dam break parameters as the input of DAMBRK model. There is presents the results of other methods for comparison not in simulation and flood routing after the dam break. The conclusion is that 'SMPDBK' is the provides rapid, reasonable and accurate predictions helpful model in determination of maximum flood elevation, with give discharge and transition time. Insecurity the analysis shows that most of break time equations, predict a time less than the real break.

Gary W. Brunner and Cameron T. Ackerman et al present the use of mare thane one software such as the 'HEC-HMS', 'HEC-GeoHMS', 'HEC-RAS', 'HEC- GeoRAS', and 'FLOW-2D' for carrying out the hydrology, hydraulics, and inundation mapping required for performing a dam break analysis. The 'Local Partial Inertial' solution technique can be used to display the Froude number at each cross section during each time step .HEC-RAS provides tools for interpolating cross sections to fulfil the Courant condition shown below.

$$C_r = V_w \frac{\Delta t}{\Delta x} \leq 1.0$$

The conclusion is that one-dimensional modeling would not be passable for computing the direction, water surface elevations, and flood boundary extents so that made Two-dimensional flow models were the using the 'FLO-2D' program and' HEC-RAS' .Model assessments were made between'FLO-2D' results and 'HEC-RAS' results. From these comparisons, it was found that the results were reasonably close for both inundated area and water surface elevation between the two models.

IV.CONCLUSION

- During the literature review it was observed that different researcher's uses different software related to dam break analysis and different parameters such as size- shape of dam breach, different boundary condition etc. Most of the researchers are use the HEC-RAS and Arc-GIS software for dam break analysis because it is very reliable software which is not very complicated and easy to use.
- The inundation maps prepared as a final product of dam break analysis are extremely useful for emergency action plans. So that after this research area to save the loss of life and property.

V. REFERENCES

[1] **Hawaii Technical Dam Break Studies: Hydraulic Studies and Dam Break Scenarios (ASCE)** Journal of World Environmental and Water Resources Congress (ASCE-2008).

[2] **Dam Break Modeling for Tandem Reservoirs-A Case Study using HEC- RAS and HEC-HMS** Journal of World Environmental and Water Resources Congress (ASCE)

[3] **Dam Break for The Dalles Dam** Journal of World Environmental and Water Resources Congress (ASCE-2013).

[4] **Hydrologic and Hydraulic Models for Performing Dam Break Studies** Journal of World Environmental and Water Resources Congress (ASCE)

[5] **Modeling of Earth Dam Break with SMPDBK Case Study:** Bidekan Earth Dam World Applied Sciences Journal, IDOSI Publications (2012)

[6] **Dam failure analysis using hec-ras and hec-georas** P.E. Proceedings of the third federal interagency Hydraulic Modelling conference, April 2-6 2006, Reno, Nevada, USA