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"Dam Break Analysis and Flood Inundation Mapping Using two dimensional HEC-RAS model for Kanher Dam"

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Abstract – Dams are constructed for using water for various uses however large storage of water behind dam has hazardous potential after its failure. This paper presents the results of hypothetical dam break flood routing and flood inundation mapping carried out by using USACE two dimensional HEC-RAS model for Kanher dam. HEC RAS model with 2D flow analysis capability is very useful for simulating, dam breach study and flood inundation mapping. The maximum flood outflow obtained at Kanher dam is 41052 m3/s at 1.04 hours after dam break for piping failure mode. This inundation maps will be useful for assisting the dam owners and emergency management authorities in identifying critical infrastructure and sites with huge population at risk.

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KEYWORDS- *Flood, Dam Break, Flood Inundation mapping, HEC-RAS 2D model.*

1. INTRODUCTION

Dams were constructed for using water for various uses however large storage of water behind dam has hazardous potential after its failure. Hazard potential of these dams can be moderated if hypothetical failure of dam simulated for working out flood peak and its time of arrival on downstream side of dam. Full flood prevention cannot be possible in advance but flood analysis model such as Hydrologic Engineers Centre's River Analysis System (HEC-RAS), MIKE11, MIKE12, TUFLOW and many more can minimize the hazard by previously knowing the inundated areas.

2. STUDY AREA AND METHODOLOGY

2.1. Description of the study area

The Kanher Dam, a major irrigation project is located across Venna River which is tributary of Krishna River, near Village Kanher in Satara District in the State of Maharashtra. The latitude and longitude of Kanher dam site is 17 44' 17'' N and 73 54' 59" E respectively. According to 2011 census the population of Satara district as per 2011 census is 30.04 lakhs and its geographical area in 10480 sq. kilometers.

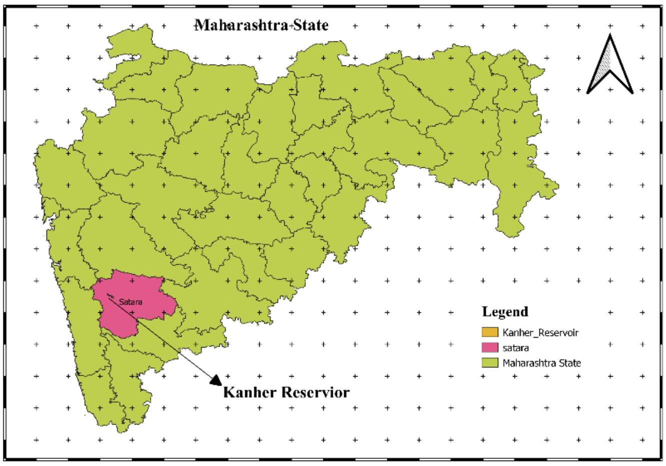

Fig -1: Study area map

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2.2. Data collection

Data collected from Dam owner i.e. W.R.D. Government of Maharashtra

1) Salient features of dam and other important geographical information of dam and nearby area.
2) Various cross sectional drawings with sectional elevation of a dam.
3) Elevation-Volume table of the reservoir from Satara Irrigation Circle, Satara.

Data collection from other sources

1) Digital Elevation Model (DEM) from open access SRTM-1s DEM, Earth-explorer (www.earthexplorer.usgs.gov) with 30m resolution.
2) Number of affected Villages and its Population is made available from Google website and Satara District collector web site.

Table 1: Kanher Dam salient features

Name of Reservoir	Kanher Reservoir
Type of Dam	Earthen dam
Name of River	Venna
District	Satara
Catchment Area	217 Sq. Km.
Length of dam	1955 m
Maximum Height	50.34 m
Types of Spillway Gates	Ogee Spillway
Size of Gates	12 x 8.50 m
No. of Gates	04

HEC-RAS version 5.0.7 (2D) model is prepared and using its dam breach module dam break flood outflow and flood inundation on downstream of Kanher dam is determined. HEC RAS has added the ability to perform two dimensional (2D) hydrodynamic routing within the unsteady flow analysis portion of HEC-RAS to determine water depth, flood arrival time, inundated area and water surface elevation at any point in 2D flow area After dam breach, for routing of the flood peak hydrograph at D/S side there is unsteady flow and for this unsteady flow analysis HEC-RAS solves the full, dynamic, Saint Venant Equation using an implicit finite difference method and the resulting flood inundated area at downstream side of Kanher dam is estimated. [6]

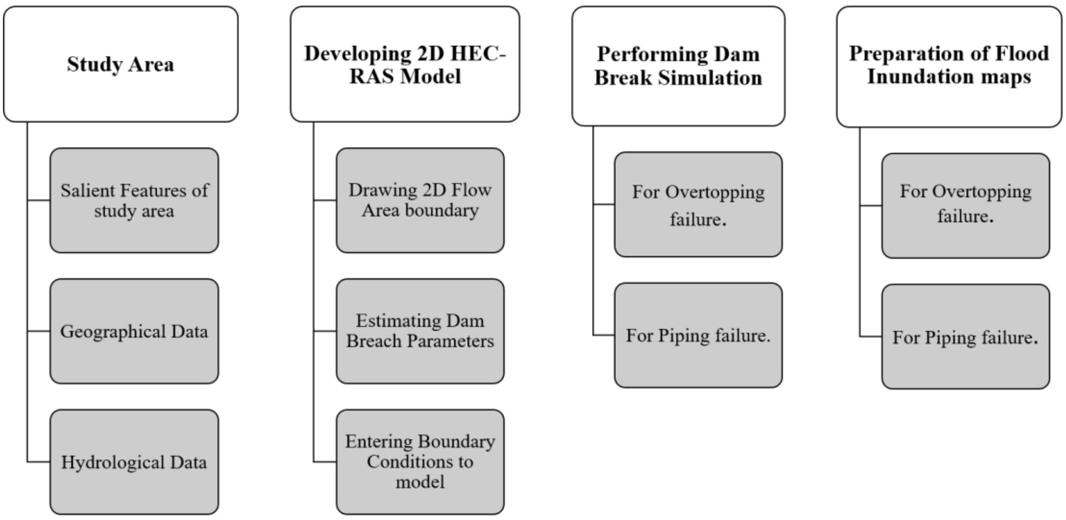

Fig 2: Methodology flowchart

2.3. Failure modes considered

a) Overtopping Failure

Failure of dam begins when water starts overflowing the dam, eroding its surface along the path. The opening created by erosion expands gradually, almost in the shape of a trapezoid.

b) Piping Failure

Piping failure occurs when concentrated seepage paths develop within an embankment dam. The failure begins when water seeping through the dam core increases in velocity and quantity, starting to erode fine sediments out of the soil matrix.

2.4. Dam breach parameters

Breach parameters include breach width, breach depth, breach side slope, and breach formation time. Using the facility of calculation of dam breach parameters in HEC-RAS, Kanher dam breach parameters were worked out for overtopping and piping failure. It is found that, for Kanher dam breach parameters worked out by Von Thun & Gillete methods warrants in line with general guidelines for assuming breach geometry by USACE, 2014 for both failure modes. [4]

2.5. Hydraulic modelling using HEC-RAS

2.5.1. Terrain model

Digital Elevation model (DEM) from USGS, earth explorer with 30 m resolution is used to create DEM terrain in HEC-RAS Mapper.

After creation of terrain model, add a 2D Flow Area polygon to represent the boundary of the 2D Area which will be included in flow calculations. To simplify the parameters involved in computation, a mesh formation was done.

For this study, Kanher dam was modelled as storage area. The input data given to storage reservoir is volume v/s elevation relationship of reservoir collected from irrigation department

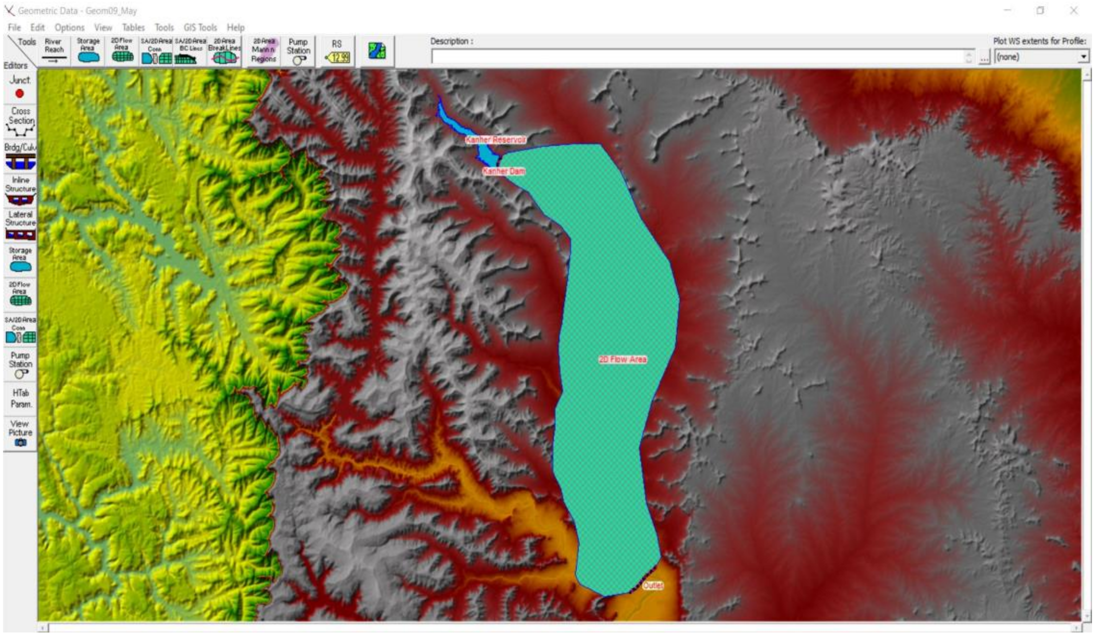

Fig – 3: Geometric data of Kanher dam

2.5.2. Geometric data on HEC-RAS

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2.5.3. Dam Breach parameters considered for Kanher dam breach simulation

HEC-RAS has now ability to calculate breach parameter by taking some input. The dam breach width developed was 134 m, and breach bottom elevation was 655.06. The breach side slopes was found to be 1: 0.5 and breach formation time was estimated as 1.04 hr.

2.5.4. Unsteady flow analysis

After preparing 2D flow geometric data in HEC-RAS, boundary conditions are entered and unsteady flow analysis is performed. The boundary conditions considered are as below.

Boundary Conditions –

1. Upstream Boundary condition - Lateral Inflow Hydrograph –
2. Exit Boundary - Normal Depth

3. RESULTS

For Kanher dam the maximum outflow discharge observed from overtopping failure mode is 37316 m3/s at 1.02 hours and from piping failure mode is 41052 m3/s at 1.04 hours. Following area in under flooding.

The flood inundation maps for the maximum depth, flood arrival time, and inundation boundary were generated using HEC-RAS and QGIS software in WGS- 84 UTM zone 43 N which is shown in figure below.

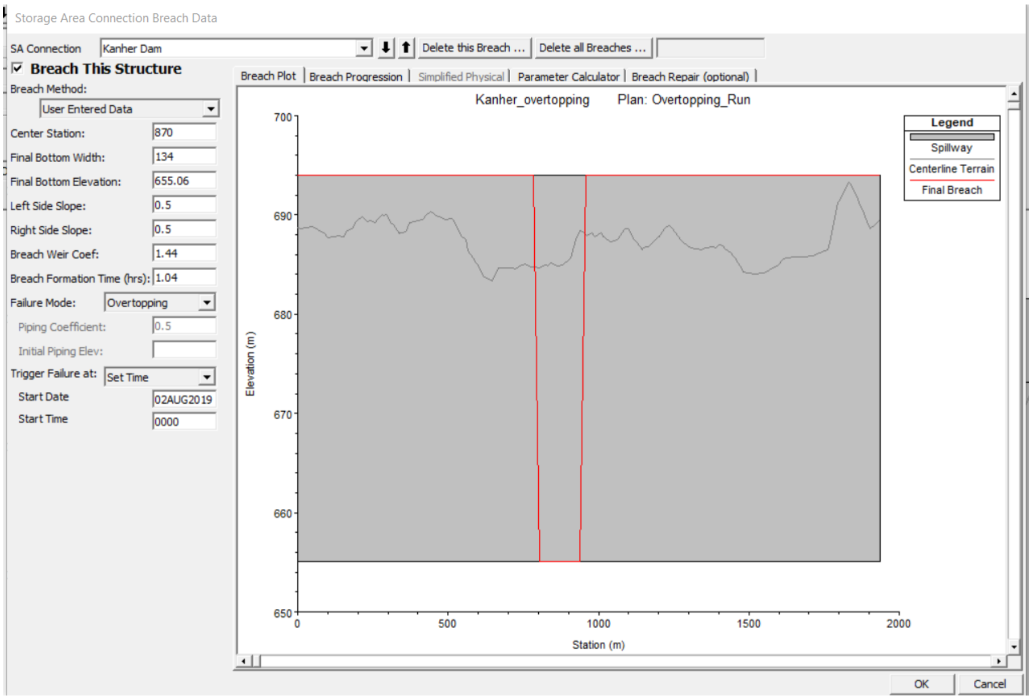

Fig 4: Breach details - Kanher dam

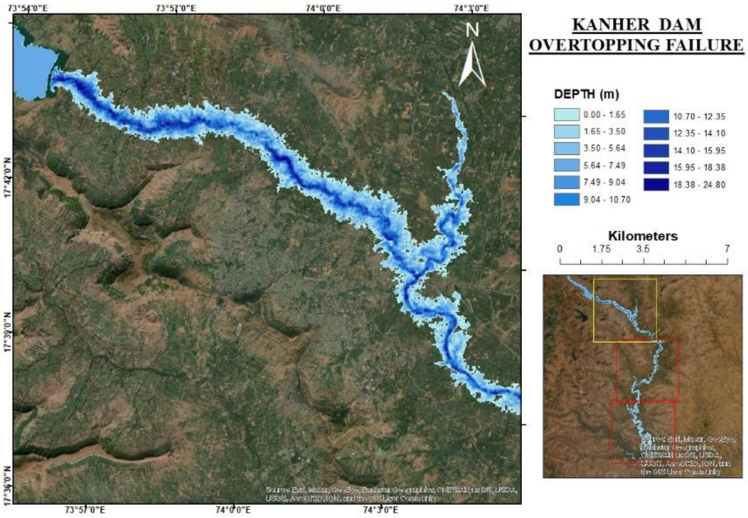

Fig 6: Maximum Depth flood inundation map

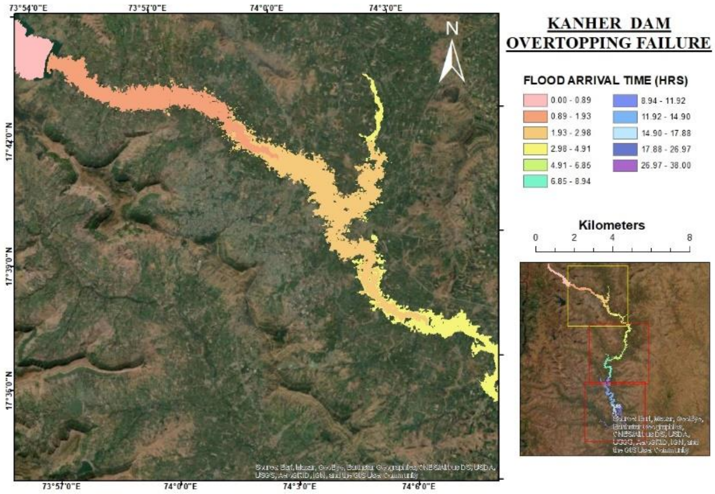

Fig 7: Flood arrival time inundation map

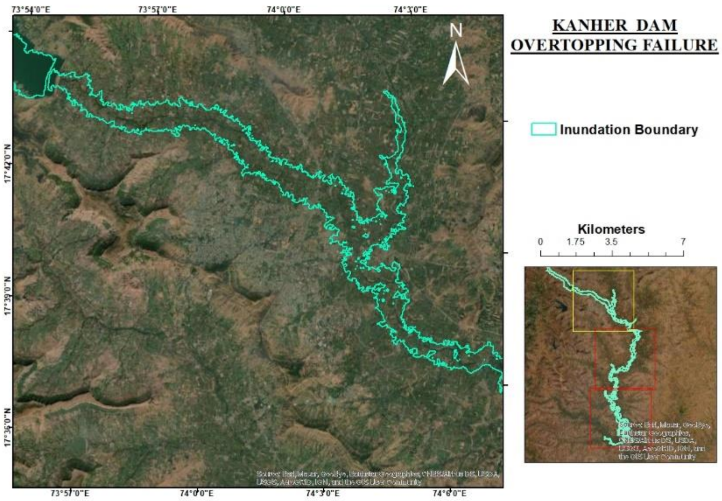

Fig 8: Inundation boundary inundation map

4. CONCLUSIONS

HEC RAS model with 2D flow analysis capability is very useful for simulating, dam breach study and flood inundation mapping. From the plotted flood map, it can be seen that Kanher dam break flood inundates 11,734 Ha of land for overtopping failure mode and 11,797 Ha of land for piping failure mode. It is found that about 28 villages in satara and Karad talukas measuring 60000 population is prone to flood inundation due to Kanher dam breach. From the dam breach flood inundation map it has been found that, among the all flood prone villages, Wanvas Wari is highly prone to flood with maximum of 12.299 m depth of inundation, whereas Nune is less prone to flood with only 1.03 m depth of inundation.

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