Analysis Of Dam Breach Through Software And Empirical Formulas

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***Abstract*—**This work first characterised the dam break in terms of ideas and models. Predicting break characteristics, knowing dam physics, and forecasting peak outflow are crucial for analysing dam breaks and determining damage loss by using The US Army Corps of Engineers' Hydrologic Engineering Centre River Analysis System (HEC-RAS) and Empirical Formulae. Equations give by Macdonald and Langridge-Monopolis (1984) [1] and Froehlich (1995) [2] is used to predict. This Study focuses on the Jayakwadi Dam located near Paithan city, Aurangabad District which one of the major Dam in Maharashtra. The results demonstrate that, the time of peak flood, Peak Discharge, Prediction of breach, time to failure dam. Implementing the aforementioned results. Forecast dam breach floods to plan and regulate downstream development. Developing emergency response plans and proper warning systems study reveals that the adjustments of dam break parameters have no major affect on the downstream.

***Index Terms*—**Empirical Formulae, HEC-RAS, Breach, Time to Failure, Peak Discharge

I. INTRODUCTION

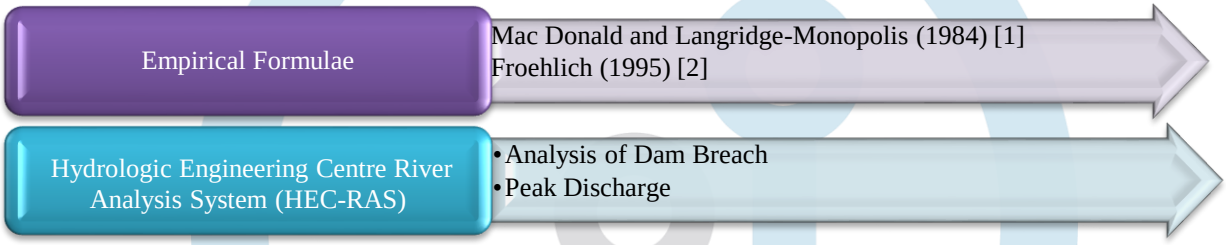
Dams are created for several purposes, including flood control, irrigation, and energy generating. Even with all of the advantages, a collapsing dam might cause an unexpected flood downstream, resulting in significant losses. To reduce these hazards, dam break analysis is essential to estimate flooding levels and dam's downstream. A dam is a physical barrier that keeps back water, which is essential to the country's economy. The stored water is commonly utilised for irrigation, aquaculture, industrial use, human consumption, and other uses. However, in the extremely unlikely and unforeseen case that they collapse, this would result in catastrophic floods in the downstream region, inflicting tremendous loss and destruction to humans. There are several forms of dam failures, including overtopping, piping, foundation failure, and structural failure, with overtopping being the most prevalent cause of dam structural collapse, according to historical research. Overtopping is one of the most devastating failures induced by severe and these failure is mostly caused by two sources. The first is a constant flow that occurs when the surface elevation rises over the whole structural elevation profile. The second major cause is wave which occurs when the water's surface is lower than the building's elevation profile. The majority of embankment dams are not strong enough to sustain overtopping action.

II. LITERATURE

sophy et al. [1] performed a dam break study utilising field data and computer simulations to quantify flood hazards downstream of dams, with an emphasis on inundation mapping and disaster management. despite its age and safety issues during the 2018 floods, the peringalkuthu dam has not previously been investigated for breach scenarios. the study used hec-ras and gis to model overtopping failure, map flood extents, and generate a time series of flow characteristics. the results revealed considerable downstream risk, affecting about 1,90,000 persons, emphasising the necessity for early warning. Xiong [2] utilised the HEC-RAS model to examine dam failure scenarios for the Foster Joseph Sayers Dam on the Susquehanna River under three different conditions: no dam break, dam breach, and no dam. The study discovered that piping-induced failures extend high water levels, increasing downstream flood risk but without considerably rising peak water surface elevations. It also emphasised the complexities of dam breakdown causes and found that parameter modifications had little effect on downstream flood limits. Mrunal et al. [8] used a 2D HEC-RAS model to simulate a dam break of the Ujjani Dam, focusing on flood-prone areas in Pandharpur city, a major pilgrimage site. The study highlighted that a failure at 41,000 m^3/s discharge could flood several key areas,

posing high risk to both residents and pilgrims. It emphasized the importance of flood prediction and emergency planning due to the city's large seasonal population. The findings aim to aid local authorities in future infrastructure and disaster management. A. Bharath et al. [13] performed a dam break study for the Hidkal Dam utilising the 1D HEC-RAS model, Cartosat-1 DEM, and HEC-GeoRAS for flood mapping. The study evaluated both pipe and overtopping failure scenarios under unsteady flow, demonstrating that overtopping results in more severe floods, affecting around 20 downstream settlements. Peak flows exceeded 78,000 m^3/s, resulting in flood extents up to 79.2 km^2. Sensitivity research revealed the impact of breach parameters, which aids catastrophe planning and mitigation activities. Ankita Sawai et al.[ ] conducted a literature assessment on dam break analysis, emphasising its significance in reducing the catastrophic impacts of dam failure on downstream communities. The article describes the basic technique to forecasting breach parameters and constructing dam break models. It demonstrates how combining analytic findings with GIS may assist develop inundation maps, which are critical for detecting flood-prone areas. The evaluation emphasises the importance of dam breach analysis in improving flood readiness and safeguarding downstream people.

III. METHODOLOGY



By help of Equations and HEC-RAS software Dam Break Analysis should be done for the Jayakwadi Dam As a Paithan City as a Study area in Chhatrapati Sambhajinagar Dictrict, Maharashtra

Table 1: Details of Dam

Dam	Jayakwadi Dam
Type	Earthen
Length	9998 m
Height	41.30 m
Gate Type	Radial
Number of Gates	27
River	Godavari

1. Empirical Equations which are used for the Prediction of Breach

   a. MacDonald & Langridge-Monopolis (1984) [1]

$$V_{er} = 0.0261 (V_w h_w)^{0.769}$$

$$= 0.0261 (2.909 \times 10^9 \times 41.30)^{0.769}$$

$$= 8646185.942 \ m^3$$

$$t_f = 0.0179 V_{er}0.364$$

$$= 0.0179 \times (8646185.942)^{0.364}$$

$$=5.996$$

Where,
V_{er} = volume of the material eroded (m^3)
V_w = volume of water that passes through the breach (m^3)
h_w = depth of water above the bottom of the breach (m)
t_f = failure time (hour)

b. Froehlich (1995) [2]

$B_{avg} = 0.1803_{K0}\, V_w^{0.32}\, h_b^{0.19}$

$= 0.1803 \times 1.4 \times (2.909 \times 10^9) \times (41.30)^{0.19}$

$= 5464.523$ m

$t_f = 0.00254\,(V_w 0.53\, h_b - 0.9)$

$= 0.00254\,(2.909 \times 10^9)^{0.53} \times (41.30)^{-0.9}$

$= 3.252$

Where,

K_o = failure coefficient (for overtopping value is taken as 1.4)

B_{avg} = breach width (m)

t_f = failure time (hours)

h_b = breach height (m)

2. Empirical Equations for estimation peak discharge through breach

a. MacDonald & Langridge-Monopolis [1]

$Q = 1.154\,(V_w\, h_w)^{0.412}$

$= 1.154\,(2.909 \times 10^9 \times 41.30)^{0.412}$

$= 42368.163$

b. Froehlich (1995) [2]

$Q_p = 0.607\,(V_w^{0.295}\, h_w^{1.24})$

$= 0.607\,(2.909 \times 10^9)^{0.295} \times (41.30)^{1.24}$

$= 37911.516$

3. Using Hydrologic Engineering Centre River Analysis System (HEC-RAS)

a. Data Collected for HEC-RAS Software

i. Digital Elevation Model (Indian Space Research Organisation www.bhuvan.nrsc.gov.in)
ii. Land use land cover (www.usgs.gov) for manning's n
iii. Storage Volume Data of Jayakwadi dams

b. Terrain Model has been generated using Digital Elevation Model data. Shown in figure 1.

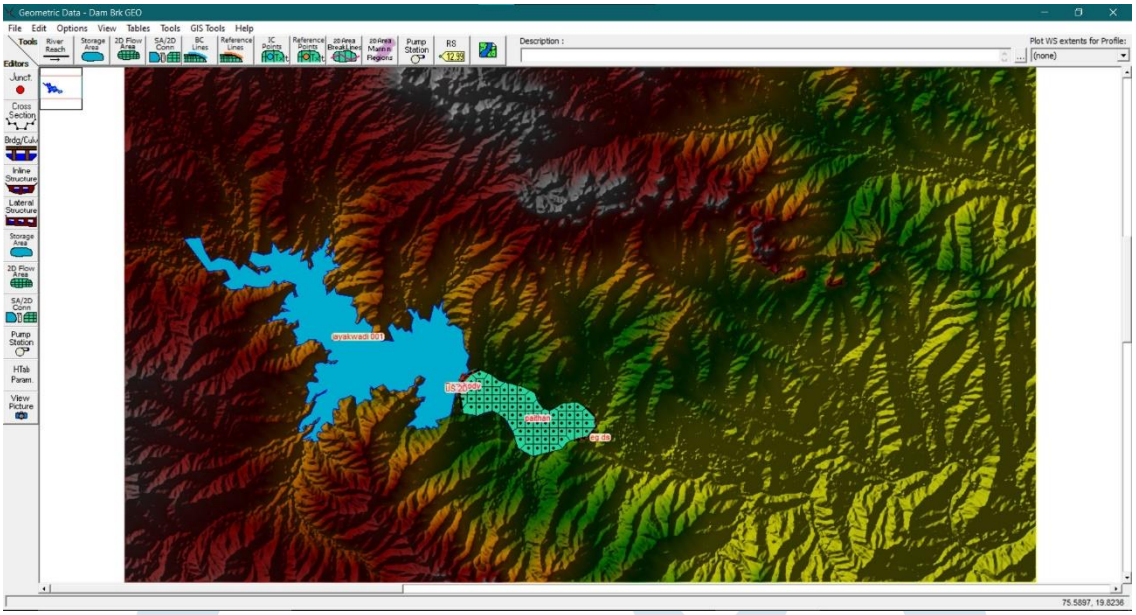


Fig. 1: Geometric Data

After that 2D flow area and Storage area drawn with respect to terrain and mesh generated in the following 2D flow area

c. Boundary Conditions set to the 2D flow area and Storage area shown in figure 2.

i. BC at Upstream side connection

ii. BC at Exit Gradient

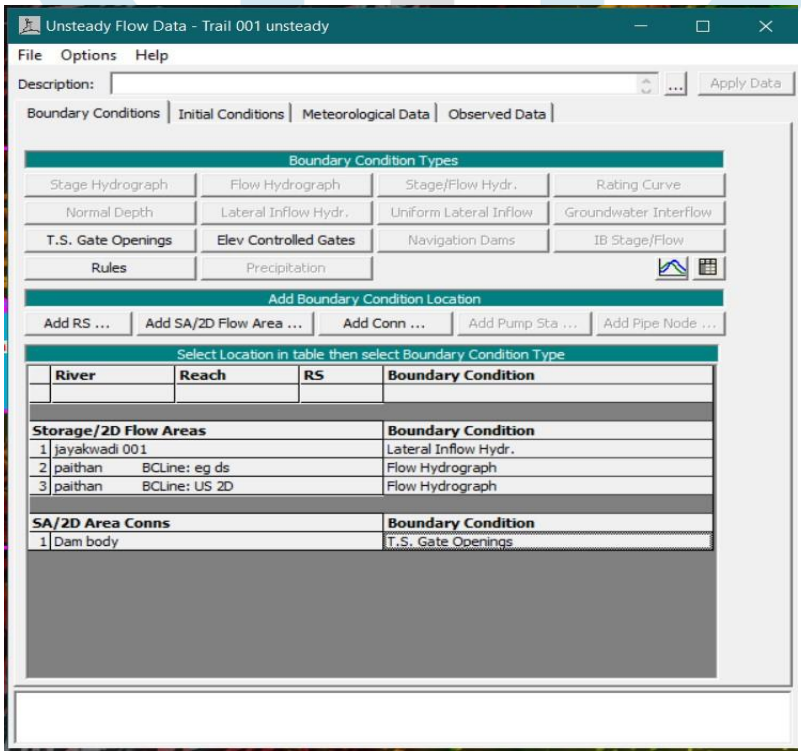


Fig. 2: Unsteady Flow Data

d. Parameters of Breach

The parameters of Breach are set to dam breaking. Breach criteria involve breach breadth, depth, duration of breach and side slope angle shown in figure 3. The peak outflow from the breached dam is estimated using the whole reservoir discharge. The study undertakes a dam break analysis for worst-case scenarios in order to determine the flooding zone downstream of the dam in Paithan city.

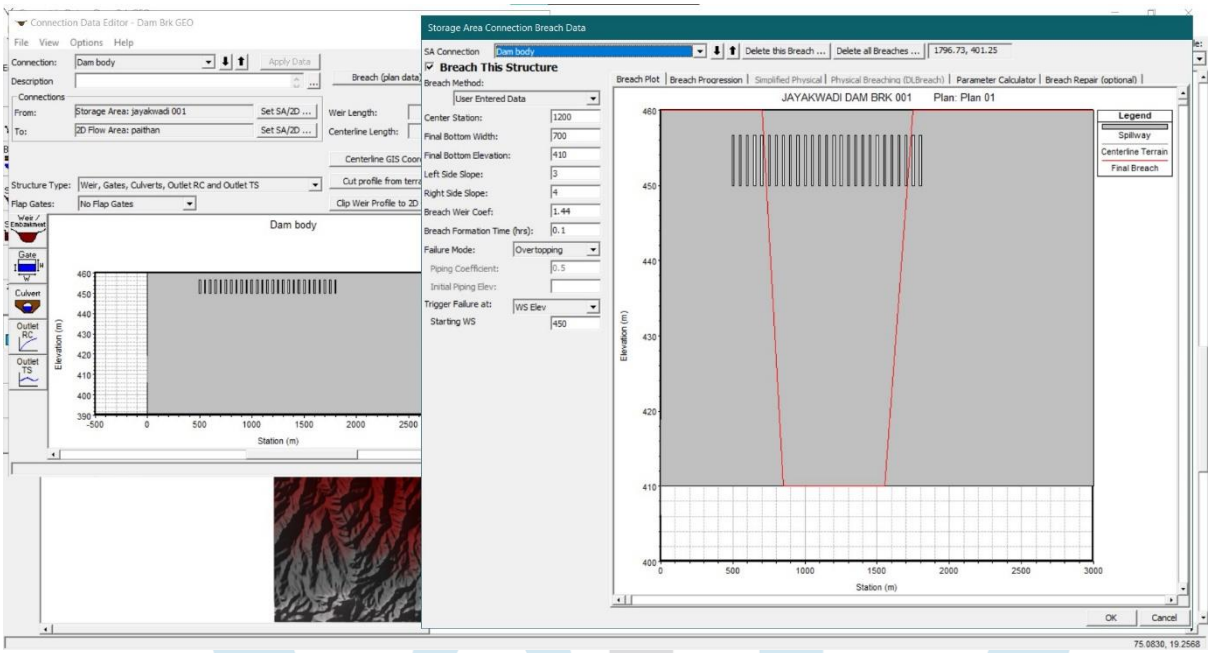


Fig. 3: Connection Data Editor shows Breach Details of Jayakwadi Dam

e. Hec-Ras Computed Peak Discharge by unsteady flow analysis as shown in figure 4.

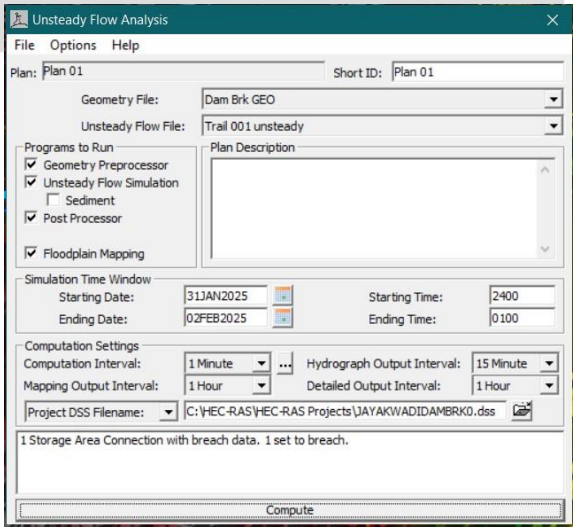


Fig 4: Unsteady Flow Analysis

IV. RESULTS

Table 2: shows failure time of dam and peak discharge

Empirical Methods	failure time (hours)	peak discharge (m^3/s)
MacDonald & Langridge-Monopolis (1984) [1]	5.996	42368.163
Froehlich (1995) [2]	3.252	37911.516

Computation of Unsteady flow HEC-RAS modelling is used to investigate dam breaches. Downstream area is experiencing floods. The hydrograph output interval is two hour, with a 1 minute computational interval. dam broke with a lateral flow discharge of 39000 m3/sec. Time taken to Failure is 4 hours.

V. CONCLUSION

a. Real-world empirical equations created by professionals and tools such as HEC-RAS are used in this study to estimate peak discharge and dam failure duration.
b. Flood modelling with HEC-RAS is an excellent instrument for hydraulic analysis and disaster management planning.
c. The HEC-RAS generates a flood profile for the worst flood intensity. This profile will help to implement proper flood catastrophe mitigation strategies.
d. According to our findings peak discharge, we propose considering whichever is maximum, the sooner we prepare and execute an emergency action plan.

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