DAM BREACH ANALYSIS
USING HEC-RAS

Submitted in partial fulfilment of the requirements

For the degree of

BACHELOR OF ENGINEERING

CIVIL ENGINEERING

By

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CERTIFICATE

This is to certify that the project report entitled '**DAM BREACH ANAYLYSIS USING HEC-RAS**' submitted partial fulfilment of the requirements for the award of **Bachelors of Engineering** degree in **Civil Engineering** during 2020-2021 session at the Anjuman-I-Islam's Kalsekar Technical Campus, New-Panvel is an authentic work carried out by her under my supervision and guidance.

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PROJECT APPROVAL SHEET

This dissertation report entitled **'DAM BREAK ANALYSIS USING HEC-RAS'** by **AMMARAH EJAZ AHMED (17CE01), ADITYA SUBASH BHAT (17CE12), GAZALI SAMEER IMTIYAZ (17CE18), PATIL RUSHIKESH NATHAJI (18DCE10)** after presenting their thesis work in form of PowerPoint presentation is hereby approved in partial fulfillment for the award of Degree of Bachelors in Civil Engineering of Mumbai University, Mumbai.

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Place: New-Panvel**.**

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ABSTRACT

This Thesis mainly provides an overview of the methods used to predict the breach outflow hydrographs with a detailed case study of hypothetical breach failure of dam '**Kaliasot Dam**' using HEC-RAS software. The parameters describing a breach are typically taken to be the breach depth, width, side slope and breach formation time. The process of gathering data and preparing data and analysis of unsteady flow model in HEC-RAS, entry of dam breach parameters, performing the failure analysis and flood mapping in ARC-GIS is discussed. Here the maximum discharge, velocity, elevation and top width is obtained to find out the villages that are going to be affected at the downstream side of Kaliasot dam upto 30 km. It is easy to estimate flood and flood routing but it is very difficult to estimate the cost of maintenance and safety precautions for the given dam.

INDEX

LIST OF FIGURES

LIST OF TABLES

NOMINCLATURE

GUI	Graphical User Interface
1-D	One Dimensional
2-D	Two Dimensional
PMF	Probable Maximum Flood
.prj file	Project file
DEM	Digital Elevation Model
US	United States
SA	Surface Area
cumec	metre cube per second
ha	hectare

CHAPTER 1

INTRODUCTION

1.1 General Introduction

Dams are the hydraulic structures constructed across the water to impound water in the upstream reservoir formed to supply water to irrigation, hydropower generation, domestic and industrial water supply, multipurpose reservoir serves as flood control and drought mitigation structures and storage place for arresting the sediment. Change in land use and interrupting activities of human beings in the upstream catchment area will cause larger volume of soil erosion to takes place and it will get deposited in reservoir. The amount of siltation is increasing every year resulting in reduction of useful life of reservoir and decrease in storage capacity and when the high flood occurs, there is no enough space to attenuate the approaching flood and excess flood overflow over dam section leading to dam breach scenario resulting in generation of massive amount of flood wave inundating downstream reaches of dam.

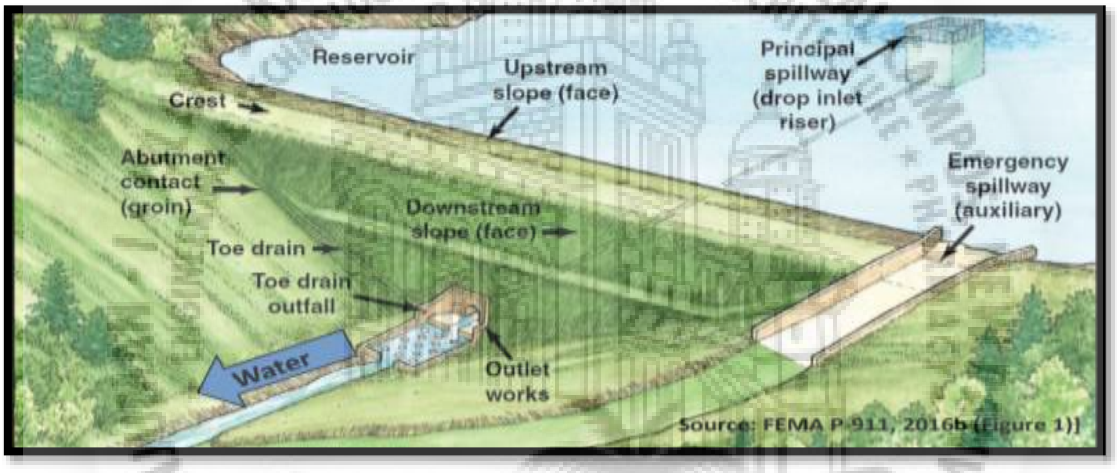


Fig 1.1: Dam Components

Even though we have latest technologies in design methodologies and construction techniques, failure of dams still occurs. Study conducted on various failure of dams occurred in India and all over world indicated the hazard caused by the dam failures. Hence emphasis to be given on better management of the flood by preparing emergency action plan to minimize the hazards of the flood in the floodplain rather than prevention of the flood. It is necessary to analyse the behaviour flood before suggesting flood management measures, this can be done by analysing the flood based on the observed floods. Numerical models simulate the dam break and flood event based on the various parameters, hence numerical models are t very important tools to analyse the flood event.

1.2 Origin of Dam Breach Analysis

Dam Break study was started in 1850s in France. From 1850 to 1950 there were no computers so the dam break study was focused on finding theoretical solutions and physical model test. From 1950 to 1990 study was focused on factors responsible for dam break and flooding disaster at downstream of dam. From the period of 1990, to present date study is focused on dam safety analysis.

1.3 General Objective

The general objective of the study is to analyse the Dam break using hydraulic models.

1. To determine parameters of the dam break.
2. To determine peak outflow hydrograph when dam break occurs by overtopping or piping mode of failure.
3. To estimate the hydraulic conditions (water level, top width and arrival time of flood wave) at critical downstream locations.
4. To inundate flood-prone areas of downstream area due to dam failure.

1.4 About HEC-RAS software

HEC-RAS is a software which was developed by Hydrologic Engineering Center of the U.S. Army Corps of Engineering. It is an integrated system of software, designed for interactive use multitasking use in the environment. The system is comprised of (GUI), separate analysis components, data storage and management capabilities, graphics and reporting facilities. HEC-RAS is used for modelling of water flowing through systems of open channel flow and computation of water surface elevations. HEC-RAS finds particular commercial application in floodplain management. For unsteady flow analysis hec-ras depends on 1-D saint venants equation.

1-D saint venant's equation.

All of these assumptions combined arrives at the 1-dimensional Saint-Venants equation in the *x* direction:

$$\underset{(a)}{\frac{\partial u}{\partial t}} + \underset{(b)}{u\frac{\partial u}{\partial x}} + \underset{(c)}{g\frac{\partial h}{\partial x}} + \underset{(d)}{g(S - S_f)} = \underset{(e)}{0}$$

where (a) is the local acceleration term, (b) is the convective acceleration term,(c) is the pressure gradient term, (d) is the gravity term, and (e) is the friction term.

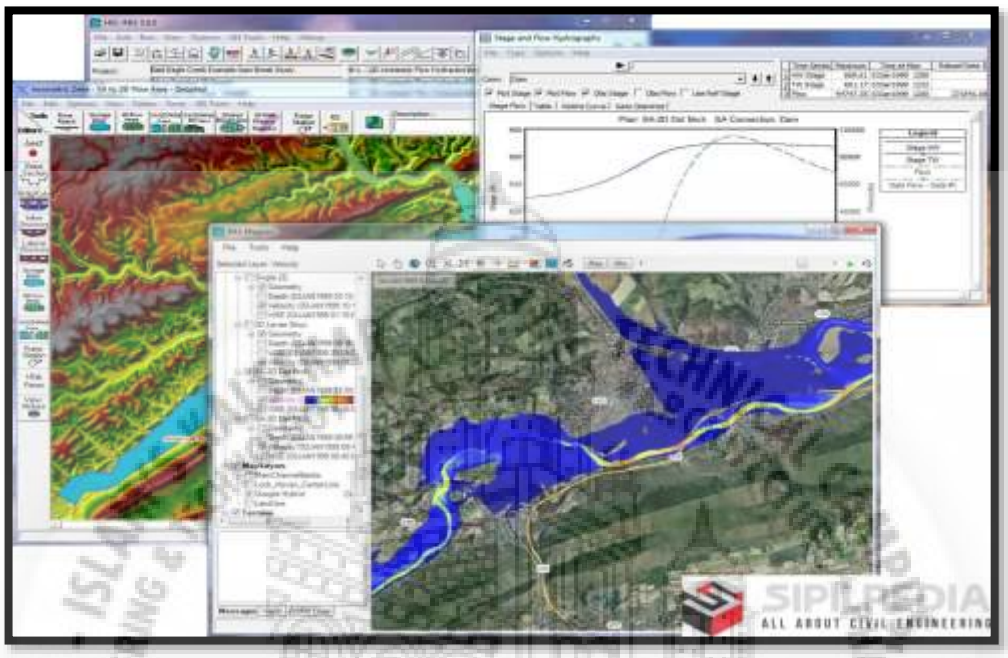


Fig 1.2: HEC-RAS Software

1.5 About HEC-GEORAS

HEC-Geo RAS model is a set of GIS tools that used to create

1. River network including stream line
2. Cross-section, banks, inline structure
3. Storage area for import into HEC-RAS
4. Generate the flood inundation data from the HEC-RAS output

The resulting flood from dam failure can be inundated with HEC-Geo RAS at available GIS data. RAS Mapper creates an inundation width and floodplain boundary from computed water surface profiles and HEC-RAS geometry.

Fig 1.3: HEC-RAS Toolbar

1.6 Scope of Thesis

Developing the dam break model and risk assessments due to flood produced from the dam break models for already constructed dams and dikes is becoming a necessity for a variety of reasons such as decreasing human casualties and economic damage. For carrying out the analysis HEC-RAS dam break model is used. This model is used to estimate the consequences of dam break for downstream areas in terms of water elevation, travel time of flood waves, flow velocity etc. that cope up with hazards caused by structural failure events by decreasing their consequences. We consider events, though not likely to happen in any given year, if occurring will be extremely catastrophic and will have an enormous socio–economic impact.

CHAPTER 2

LITERATURE REVIEW

2.1 Review of Literature

Mrunal M. Joshi, S. Shahapure conducted dam break study on Ujjani Dam which is situated in Baramati, Solapur in journal 'International Journal of Engineering and Technology (IJET)'. The dam was built around the year 1969 to 1980. Ujjani Dam is an earthfill gravity dam. Here HEC-RAS 5.01.2 (2D) model was used to create simulation for analysing flood susceptible area of Pandharpur region. Thus, unsteady flow simulation was carried out and hydrograph output interval was taken as one hour and computational interval was taken as 15 sec. Thus Ujjani Dam failed at lateral flow discharge of 41000 m^3/sec.

Pushkar Sharma, Sanskriti Mujumdar studied Ajwa reservoir which is situated 20 km north-east of Vadodara city built around the year 1885-1892 in the journal 'Journal of water resources and Ocean Science'. Ajwa sarovar is an earthen dam. Here they performed the unsteady flow analysis for mixed flow regime with the boundary conditions incorporated as discharge of 600 m^3/sec, normal depth as 0.0006 and starting water surface elevation as 65.83m. Here the model is simulated for 24 hours and vulnerable cross sections are obtained with their peak discharge, maximum water surface elevation and channel velocity. Dam break analysis is done for various water surface elevations in the reservoir.

S.R Kulkarni, Seema. A. Jagtap performed dam break analysis on Pawana dam. It is a gravity dam constructed on Pawana river near Lonavala in the year 1972. Here the maximum discharge, velocity, elevation and top width is obtained to find out the number of villages that are going to be affected at the downstream side of Pawana river. It is easy to estimate flood and flood routing but it is very difficult to estimate the cost of maintenance and safety precautions for the given dam.

Mangesh Dhumal performed dam break analysis on Morbe dam using HEC-RAS which is constructed on Dharavi river. He studied the time taken to reach peak flood waves on downstream of dam site is more or less linear in all the cases in flood waves due to PMF and dam breach.

Yi (Frank) Xiong studied Foster Sayers Dam and published it in 'Journal of Water Resource and Protection, Published Online June 2011. This dam is an earthfill dam which is situated in Howard, Pennsylvania and built in year 1971. The study shows that the dam break due to piping elongates the time period of high water surface level, which increases the duration of risk.

Anjana K.T.K., Dijo Joy, Revathy Manikuttan, Sachin Sas, Binoy Alias M performed their research on Idukki Dam in their journal 'International Research Journal of Engineering and Technology (IRJET)'. This dam is an arch dam which is situated in Cheruthony, Idukki, Kerala and built in 1969-1973. Here the study gives the prediction of dam breach flood hydrograph. It helps in routing the same through downstream valley to get the time series of discharge and water level at different locations of the valley.

Chinthu Naresh's study on NAGARJUNASAGAR DAM which is a masonry dam situated in Guntur, Andhra Pradesh and built in 1955-1967. The study shows that due to improper timing of gate opening at the time of PMF, the dam slightly overtopped by PMF and then dam failed due to breaching.

2.2 Summary

Dam break is a complex process so actual failure mechanics is not well understood. It is very difficult to estimate the cost of maintenance and safety precautions for the given dam. The comprehensive dam break analysis is a very important step in assessment and decision-making of the damage following a dam break accident. The details of water surface elevations at different locations of the valley, gives an idea about extent of flooding.

We selected Kaliasot dam which is situated in Bhopal, M.P, due to the availability of all required data for executing dam breach analysis. HEC-RAS 5.0.7 (2D) model will be used to create simulation for analysing flood susceptible area upto 30 km from base of the dam.

CHAPTER 3

METHODOLOGY AND SIMULATION PROCEDURE

3.1 Step-wise procedure

Steps to be followed for dam breach analysis using HEC-RAS are:-

1) Start a new project

First go to file menu and then create a new project by making a new folder of the required name and then save it. This file must be in .prj format. Then go to options and change the units into metric system.

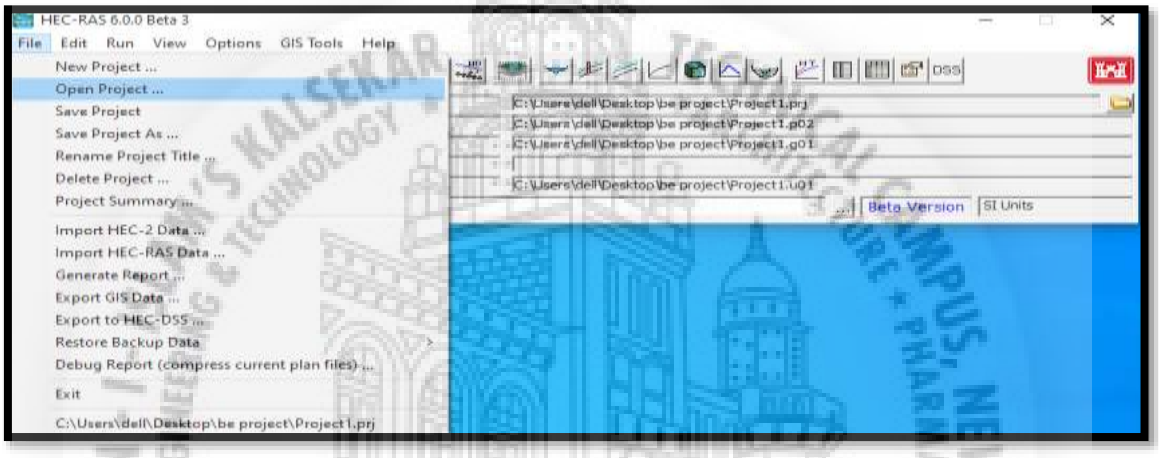


Fig 3.1: HEC-RAS file menu

2) Open Ras mapper and select the .prj file and change the unit to meters and then click apply. After this go to tools and select 'New Terrain Layer' and add the terrain file (which should be downloaded from "bhuvan.nrsc.gov.in") by clicking + (Add layer) button on the arc map desktop and click OK, the DEM is added to arc map.

3) Right click on map layer and select 'add web imagery' and select 'Arc GIS World Imagery' and click on OK.

4) Zoom in to the dam location and go to the geometries and create a new geometry naming 'breach' and select 2D flow area and storage area.

5) In 2D flow area, go to perimeter and right click on it, then go to edit geometry and select the downstream area.

6) Click on storage area and mark the required storage area and click OK. Thus both the geometries are created then save the geometry and close it.

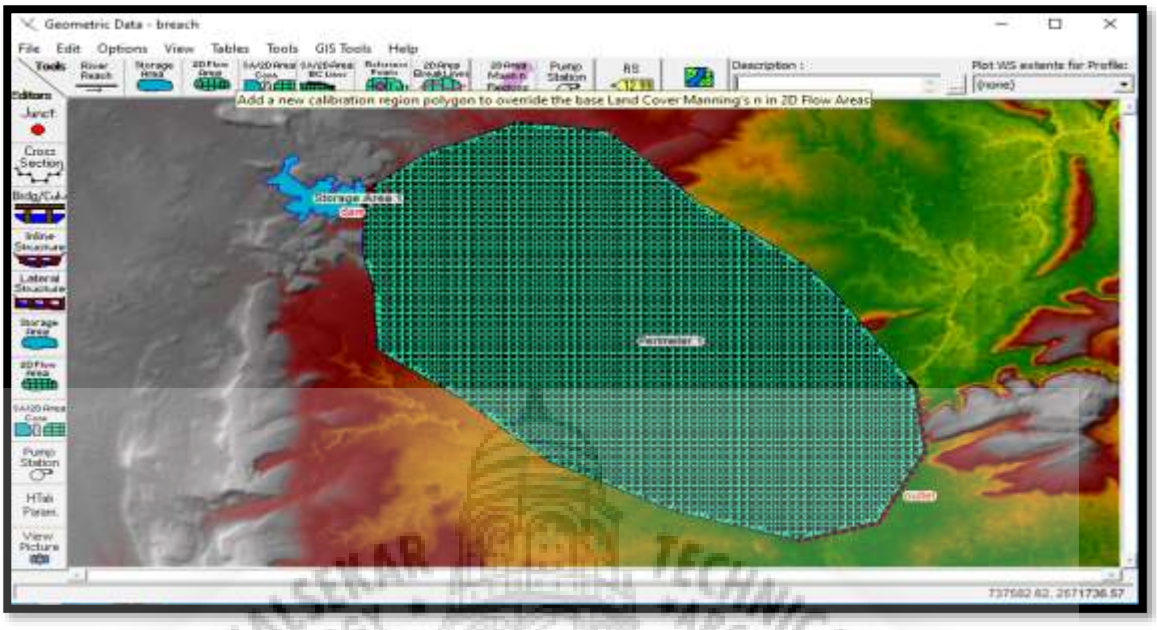


Fig 3.2: Storage and Perimeter

7) Click on 'View/Edit geometric data' then go to file and open the geometric data, zoom in towards the dam section and add the dam by selecting SA/2D Area Connection and mark a straight line and name it as 'Dam' and click OK.

8) For marking the boundary condition click on SA/2D Area BC line and mark the outlet on downstream of dam and click OK.

9) Go to 2D flow area which is on the left side where we have to generate 2D mesh by clicking 'Generate Computation points on regular interval with all breaklines' and provide required spacing in x and y direction, and click on force mesh recomputation. Followed by which a mesh will be created.

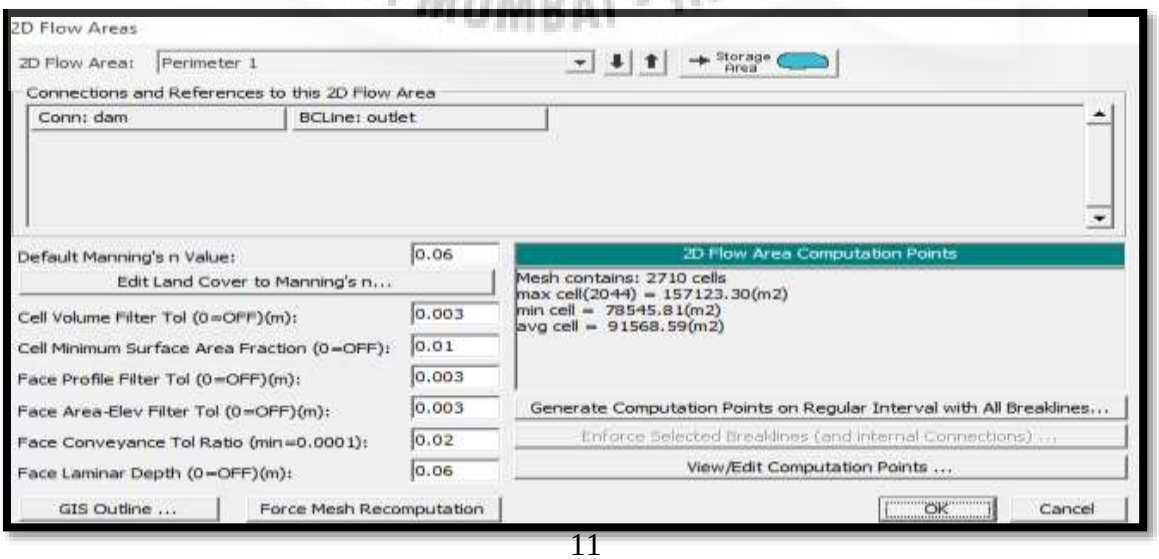


Fig 3.3: 2D Flow Area

10) Go to storage area where the elevations will be created then give the minimum elevation and click OK.

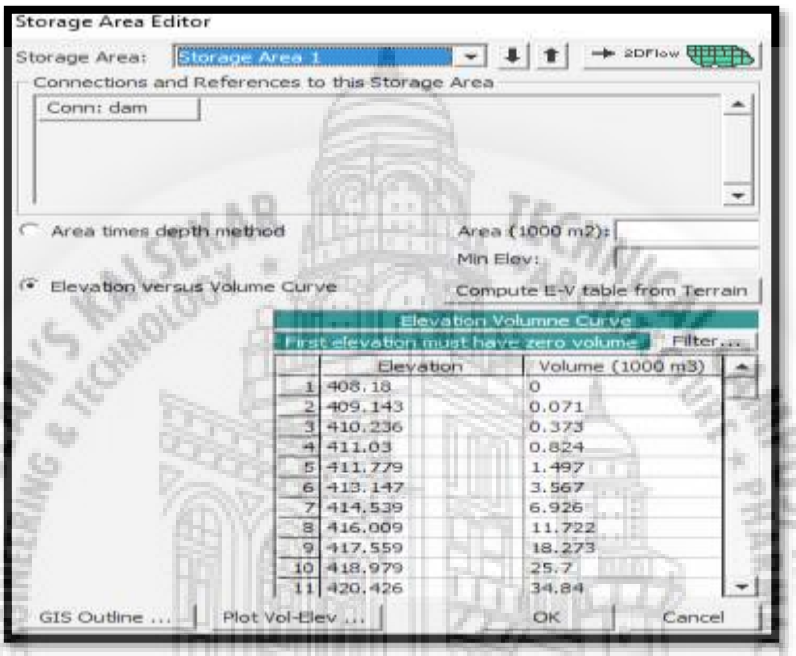


Fig 3.4: Storage Area Editor

11) Go to SA/2D Area Connection where we can see the graph of elevation v/s station i.e cross section of dam.

Fig 3.5: Connection Data Editor

12) Click weir/embankment give weir width and station and elevation and click OK.

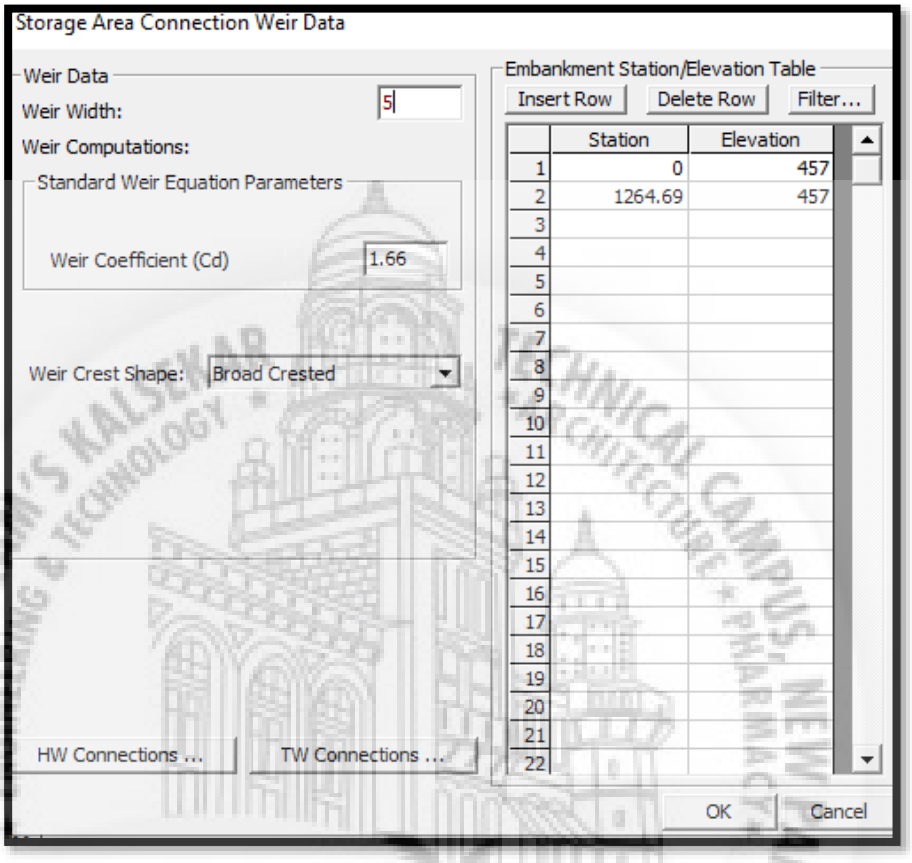


Fig 3.6: Storage Area Connection Weir Data

13) Go to Breach (plan data) and mark 'Breach this structure' and give the data required and close all the tabs.

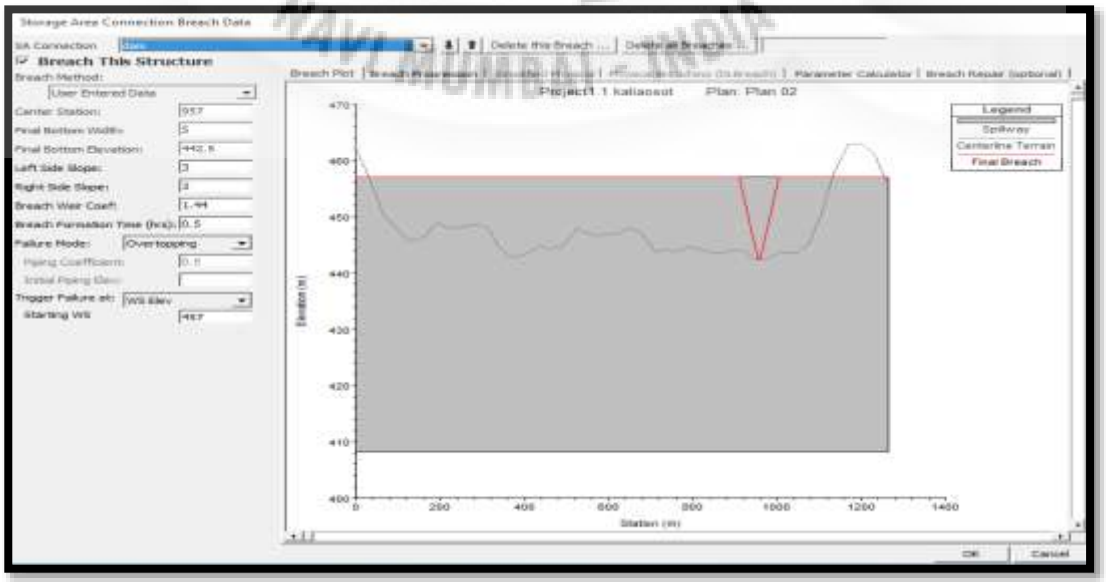


Fig 3.7: Breach (plan data)

14) Go to view/edit unsteady flow data and add normal depth for perimeter and then add storage area by clicking on SA/2D flow area.

For storage area we will provide lateral inflow hydrograph data and give the fixed timings for the same and click OK.

Time	Discharge (cumec/sec)	Time	Discharge (cumec/sec)	Time	Discharge (cumec/sec)
1	68	38	699	61	95
2	87	39	672	62	85
3	100	40	645	63	75
4	120	41	618	64	65
5	140	42	591	65	55
6	167	43	564	66	53
7	245	44	537	67	51
8	345	45	510	68	49
9	456	46	483	69	47
10	489	47	456	70	45
11	500	48	429	71	43
12	560	49	402	72	41
13	610	50	375	73	39
14	650	51	348	74	37
15	678	52	321	75	35
16	700	53	294	76	33
17	756	54	267	77	31
18	767	55	240	78	29
19	789	56	213	79	27
20	800	57	186	80	23
21	900	58	159	81	21
22	1200	59	132	82	19
23	1220	60	105	83	17
24	1205	31	938	84	15
25	1160	32	901	85	13
26	1123	33	864	86	11
27	1086	34	827	87	9
28	1049	35	790	88	7
29	1012	36	753	89	5
30	975	37	726	90	3

Table 3.1: Lateral Inflow Data

15) Give the initial condition for storage area then click on perform unsteady flow simulation and select the geometry pre-processor ,unsteady flow simulation, post processor, flood plain mapping.

16) Give the short ID, starting date and time as well as ending date and time and give computation interval and then click on COMPUTE button. HEC-RAS will compute the dam breach and will give the results.

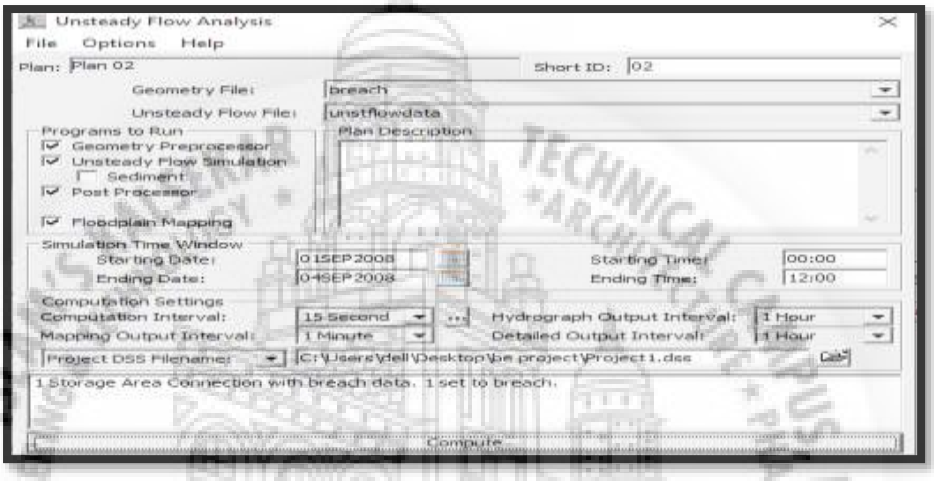


Fig 3.8: Unsteady Flow Analysis

17) Open RAS mapper to see the results by selecting depth.

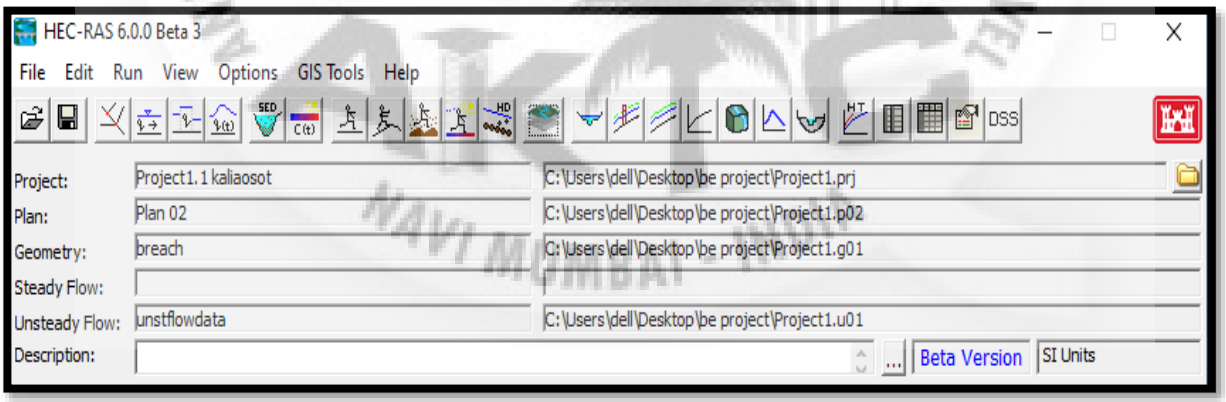


Fig 3.9: Final Data

CHAPTER 4

DATA COLLECTION AND ANALYSIS

4.1 General introduction about dam

Kaliasot Dam

The Kaliasot dam based on Kaliasot River is a tributary of River Betwa. Kaliasot dam is situated in Bhopal and its co-ordinates it Latitude 23°12"3' N and longitude 77° 24"29' E. The dam is near Chuna Bhatti village, constructed for irrigation purpose, it irrigates about 10425 ha area annually of Bhopal and Raisen District of M.P. The Kaliasot dam is an earthen homogeneous dam and its height is 34.25 m, length 1080 m, top width 6.30 m, FRL (full Reservoir Level) is 505.67m, and MWL (Maximum Water Level) is 505.67m. The dam has gross storage capacity of 35.387 cumec; live storage 34.41 cumec, discharging capacity is 1355 cumec with 13 radial gates of size (6.40 × 4.57) m. Kaliasot reservoir is under environmental stress due to siltation, human encroachment, high macrophytic population and sewage input from various resources. The biological productivity of reservoir is greatly influenced by their hydro biological features. The soil inflow from the catchment area and basin affects the water quality of the reservoir.

The big pool called the Pride of Bhopal, which was built by Parmar Rajabhoj. It was constructed between 2005 and 1055. In this pond, rain water comes from the Kolans River, but to prevent the excess amount of rainwater, Bhadbhada dam was constructed in the south direction of Bhopal in the year 1975 and overflow water was transferred to Kaliasot reservoir in the year 1975. There are also 13 gates in this reservoir, through which rainwater is discharged into the Kaliasot River, which is found in the Betwa River . The excess rainfall in Bhopal is controlled by Kaliasot waterlogging. Kaliasot Dam is mainly used for irrigation in Rabi crops in Bhopal and Raisen districts of Madhya Pradesh from November to mid-year. This dam has been constructed in a very beautiful way with respect to Bhopal's water reservoir, under which the rain water in Bhopal is maintained and rain water is fully utilized in irrigation.

4.2 Salient features of Kaliasot dam

1. Location

   a) State: Madhya Pradesh

   b) District: Bhopal

   c) River: Kaliasot

   d) Latitude and Longitude: Latitude 23°12"3' N and longitude 77° 24"29’ E

2. Dam

   a) Length of dam: 1080 m

   b) Height of dam: 67.08 m

   c) Catchment area at dam site: 365.2 sq. km

3. Reservoir

   a) Gross capacity: 35.387 m cum

   b) Live capacity as per minimum: 34.41 m cum

   c) Full reservoir elevation: 505.67 m

4. Spillway

   a) Type of spillway gates: radial

   b) No of spillway gates: 13

   c) Size of spillway gates: (6.40 × 4.57) m

   d) Spillway capacity: 1355 cumec

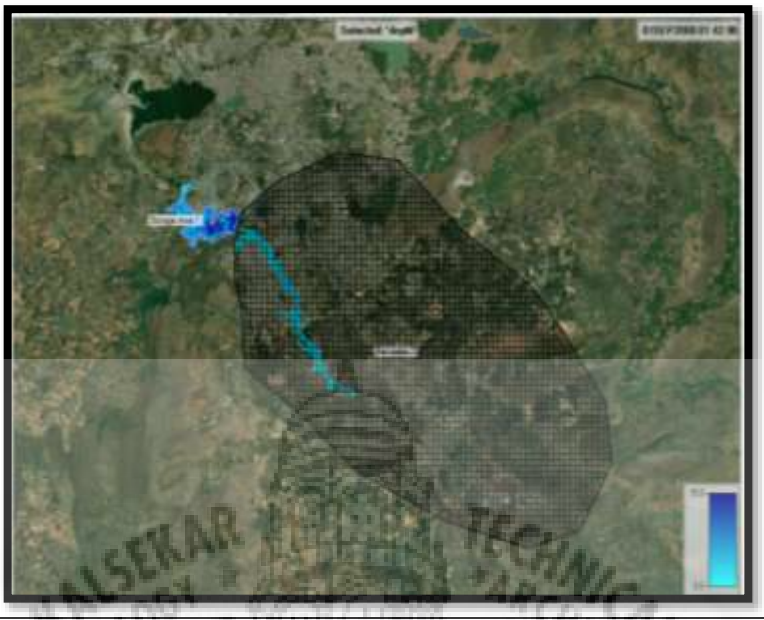
CHAPTER 5

RESULTS AND CONCLUSION

5.1 Results

Unsteady flow simulation is carried out for dam breach analysis. Following area is under flooding.

Date	Time	Image
1 Sep 2008	00:00	
1 Sep 2008	00:46	

1 Sep 2008	01:42	
1 Sep 2008	03:04	
1 Sep 2008	05:02	

1 Sep 2008	22:04	
2 Sep 2008	00:34	
2 Sep 2008	20:12	

3 Sep 2008	12:30	
4 Sep 2008	00:11	
4 Sep 2008	12:00	

Table 5.1: Result Table

5.2 Conclusion

- In case of breach of the dam the water from the dam may flood at an approximate distance of 5kms in a span of 46mins. Though the immediate neighboring area may get flooded but it will give sufficient time for evacuation of the habitants of the areas slightly away from the dam.
- It will take minimum 60 hours for the water to recede and drain out and will spread over an area of 30kms while receding when completely drain off.
- The data that we have used is only for a duration of 4 days. Through this we may be able to infer the time taken by water from the dam to recede completely (above prediction is based on a linear flow of water with minimal obstructions. Actual site conditions may interfere with the flow pattern).

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