STUDY OF FLOW SIMULATION USING HEC-RAS

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ABSTRACT

Floods have always been a natural calamity that is difficult to prevent or control without prior prediction. To address this issue HEC-RAS model is used to analyze flood potential and destruction. The U.S. Army Corps of Engineers' River Analysis System (HEC-RAS) is software that allows you to perform one-dimensional steady and unsteady flow river hydraulics calculations, sediment transport modelling, and water temperature analysis. They play an important part in river hydraulic analysis, hydrology simulation, flood forecasting, river renovation and reservoir management and programming. This introduces the composition and the function of HEC-RAS model, a 1D steady and 2D unsteady flow models were established.

Keyword: Floods, Hydraulic model, steady flow, unsteady flow, sediment transport modelling, water temperature analysis, flood forecasting, reservoir management.

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1. INTRODUCATION

In the last 50 years, urbanization has become a necessary part of economic growth. With more than 50% of the world's population now residing in urban areas, the hazards of environmental degradation and changes are increasing rapidly. One of the major natural calamities which the world is facing in this 21st century is Floods. In today's time human activities have emerged as one of the major cause of floods. Floods are a significant natural disaster that the world is currently involved with in the 21st century. In recent times, it has become clear that human actions have played a considerable role in causing floods. The rising human activities close to river floodplains, coupled with intense rainfall brought on by the effects of climate change, have resulted in flood risks during monsoon. The impact of these causing loss of life and damage to the economy in affected regions. Over the last ten years, India has experienced several severe flooding incidents. India has witnessed serious flooding events in last decade. Floods of Mumbai (2005), Uttarakhand (2013, 2016), Kashmir (2014), Chennai (2015) and Madhya Pradesh (2016) have proved the adverse effects it has on living beings and economy of the states. With the rise in such events and noticing the common cause of it, the government and local bodies have started giving importance to the flood management. Due to the advancement in technology hydraulic modelling software is created like HEC-RAS. HEC-RAS is a software for one-dimension or two-dimensions simulations of the evolution of a flood, which could have a stable or an unstable flow rate, sediment transport, change of the river bed etc. The name "HEC-RAS" is derived from the creators of the software: Hydrologic Engineering

Centre, which stands as a subdivision of the Institute of Water Resources, U.S Army Corps of Engineers (HEC), and "RAS" is an acronym from "River Analysis System". The main focus of this paper is on simulating a consistent water flow rate and determining the total surface area covered by flood water for various probabilities of flow rates. The study concentrates only on the Kanhan river valley.

1.1 General Philosophy of the Modelling System

HEC-RAS is an integrated system of software, designed for interactive use in a multi-tasking environment.

The HEC-RAS system contains four one-dimensional river analysis components for:

(1) steady flow simulations;

(2) unsteady flow simulation;

(3) sediment transport computations; and

User Interface

The user interacts with HEC-RAS through a graphical user interface (GUI). The main focus in the design of the interface was to make it easy to use the software, while still maintaining a high level of efficiency for the user. The interface provides for the following • File management

• Data entry and editing

• River analyses

• Tabulation and graphical displays of input and output data • Reporting facilities

• On-line help

1.2 River Analysis Components

<u>Steady Flow Water Surface Profiles</u>. The modelling system has a component that calculates water surface profiles for steady gradually varied flow. It can handle a full network of channels, a dendritic system, or a single river reach. The component can model subcritical, supercritical, and mixed flow regime water surface profiles. The computational procedure is based on the solution of the one-dimensional energy equation, and energy losses are evaluated by friction and contraction/expansion. The momentum equation is used for rapidly varied water surface profiles, such as those found in hydraulic jumps, bridges, and river confluences. The system can also consider the effects of obstructions such as bridges, culverts, dams, weirs, and other structures in the flood plain.

<u>Unsteady Flow Simulation.</u>

The HEC-RAS modelling system incorporates a component that can simulate one-dimensional unsteady flow through a complete network of open channels. The unsteady flow equation solver is based on Dr. Robert L. Barkau's UNET model (Barkau, 1992 and HEC, 1997). This component was initially developed for subcritical flow regime calculations but can now perform mixed flow regime calculations, including subcritical, supercritical, and hydraulic jumps, with the release of Version 3.1. The unsteady flow module includes hydraulic calculations for cross-sections, bridges, culverts, and other hydraulic structures, similar to the steady flow component. The unsteady flow component features dam break analysis, levee breaching and overtopping, pumping stations, navigation dam operations, and pressurized pipe systems.

<u>Sediment Transport/Movable Boundary Computations.</u>

The modelling system's specific component is created for simulating sediment transport and movable boundary calculations that occur due to scour and deposition over moderate time periods. It calculates sediment transport potential by grain size fraction, which allows the simulation of hydraulic sorting and armoring. The system has the capability of modelling a complete network of streams, channel dredging, various levee and encroachment alternatives, and using different equations for sediment transport computations. Its purpose is to simulate long-term trends of scour and deposition in a stream channel, caused by modifying water discharge frequency and duration or channel geometry modification. This system is useful for evaluating deposition in reservoirs, designing channel contractions required to maintain navigation depths, and predicting the impact of dredging on the deposition rate, as well as estimating the maximum possible scour.

Water Quality Analysis.

This component of the modelling system is intended to allow the user to perform riverine water quality analyses. The current version of HEC-RAS can perform detailed temperature analysis and transport of a limited number of water quality constituents (Algae, Dissolved Oxygen, Carbonaceous Biological Oxygen Demand, Dissolved Orthophosphate, Dissolved Organic Phosphorus, Dissolved Ammonium Nitrate, Dissolved Nitrite Nitrogen, Dissolved Nitrate Nitrogen, and Dissolved Organic Nitrogen). Future versions of the software will include the ability to perform the transport of several additional water quality constituents.

1.3 Graphics and Reporting

The graphics offered comprise of X-Y plots of the river system schematic, cross-sections, profiles, rating curves, hydrographs, and other hydraulic variables. A 3D plot of multiple cross-sections is also available. User can access tabular output, choosing from pre-defined tables or creating their own customized tables. All graphical and tabular output can be viewed on the screen, printed directly, or shared with other software, such as a word-processor or spreadsheet. The reporting function allows for customized printing of input and output data with the option to select the required amount and information.

2. Literature Review

2.1.One Dimensional Steady Flow Analysis Using HEC- RAS – A case of River Jhelum, Jammu and Kashmir - The study area has experienced repeated flooding, which occurs due to heavy precipitation at the end of the summer season, often accompanied by sudden cloudbursts. As a result, the catchment area of the river becomes saturated, leading to rivers swelling beyond their capacity. To study this phenomenon, the HEC RAS Model was applied to the river Jhelum Kashmir valley. Peak flood records were used as inputs to the model to predict expected flood levels. The model shows that for a return period of 50 years or more, there will be overflow at most locations of the river under study. This information can assist policy makers, planners, and insurers in developing effective strategies for flood mitigation measures and plans to minimize losses associated with the disaster in the study area.

2.2.Flood Modelling Of River Godavari Using Hec-Ras - A lot of cities and towns are situated downstream of dams or on the banks of rivers. During monsoon season, when the dam is full and surplus floods are approaching, maximum discharge is released to avoid overtopping. Unfortunately, this often results in floods downstream and can lead to disasters in cities or towns located on river banks. To prevent this from happening, flood plains need to be modelled to enable effective flood mitigation measures to be taken in advance. The use of advanced software in flood modelling has made it possible to accurately predict the extent of flood submergence. This paper examines the case of Godavari river flood modelling using HEC-RAS software, with a focus on the flood released for the Gangapur dam, which is located 14 km upstream of Nashik city. The flood discharge is based on the worst discharge of 1969 flood. The river, 14 bridges across the river and the flood plain are modelled. The model facilitates to locate the flood plain and its extent for effective flood mitigation measures.

2.3.Flood management by using HEC-RAS software- Due to the changing climate conditions in the world , our country has experienced more frequent instances of floods and droughts . In order to make decisions related to flood protection and disaster management, mathematical modeling of the river is necessary to predict its stage during floods. During monsoon in Pune City, Maharashtra, there are often issues with floods and damages, with many bridges over rivers getting submerged, causing communication failures and inundation of the surrounding areas. Extreme weather conditions such as excessive rainfall can result in debris flow, river overflow, and urban flooding, which pose a significant threat to the community. The project discusses the use of HEC-RAS to predict floods in the Mula-Mutha river, which can aid in the development of a Flood Mitigation Plan for Pune City as a curative measure for flood control. r. Thus, this present project describes the setting up of hydraulic model. In HEC-RAS 5.0.1 for Mula-Mutha River in Study reach. HEC-RAS 2D is a hydraulic model which is used to simulate water flowing through rivers and open channels.

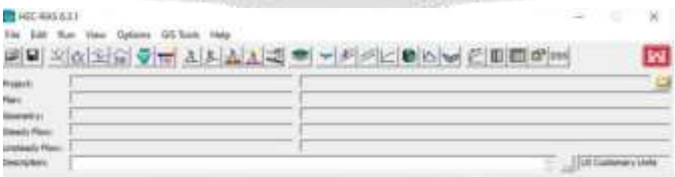
2.4.Applicability of HEC-RAS & GFMS tool for 1D water surface elevation/flood modelling of the river: a Case Study of River Yamuna at Allahabad (Sangam), India- Floods always have been a natural disaster and it is very difficult to stop flood destruction and apply required preventive measures without any preprediction. Remote sensing and GIS tool like Global flood monitoring system (GFMS) and HEC-RAS model provide the idea to analyse the flood analysis and their potential. The purpose of this study was to model the water surface elevation (WSE) of river Yamuna at district Allahabad near Sangam area, Uttar Pradesh, India by using the one of the latest flood monitoring tools (GFMS) which provides near real time discharge value of various streams of the world. In this study three stations were selected for calibration of the model, at present these stations are also being used by various government organisations of India for river stage monitoring. HEC-RAS modelling was carried out for determine flood events or WSE/ HFL (High Flood Level) of the year 1978 and 2001–2014. After that, the modelled output data was compared with real observed data and no significance difference in most of the cases was observed. The findings of HEC-RAS modeling indicate that applicability of this model can play the effective role to predict flood potential and identify the WSE in future for making the plan for any city situated near the river. In this regard, WSE level for upcoming 100, 500 and 1000 years was estimated by Gumbel's distribution method and found maximum stage 89.367, 90.568 and 92.268 m, respectively, above from mean sea level. Further, this study indicates that a larger area nearby the study area falls in highly risky zone and plan for safety management is needed.

3.Methodology

3.1 **STEPS FOR SIMULATION**

3.1.1Installing HEC-RAS

Working with HEC HEC-RAS is an integrated package of hydraulic analysis programs, in which the user interacts with the system through the use of a Graphical User Interface. The system is capable of performing Steady and Unsteady Flow simulation, water surface profile calculations, Sediment Transport/movable boundary computations, water quality analysis The data files for a project are categorized as follows: plan data, geometric data, steady flow data, unsteady flow data, quasi-steady flow data, sediment data, water quality data, and hydraulic design data. During the course of a study the modeler may want to formulate several different Plans. Each plan represents a specific set of geometric data and flow. Once the basic data are entered into the HEC-RAS, the modeler can easily formulate new plans. After simulations are made for the various plans, the results can be compared simultaneously in both tabular and graphical form.



3.1 <u>3.1.2 Entering geometric data:</u>

The step is to enter the necessary geometric data, which consist of connectivity information for the stream system, cross-section data, and hydraulic structure data . Geometric data are entered by selecting Geometric Data from the Edit menu on the main HEC-RAS window. Once this option is selected, the geometric data window will appear as show in Figure 3-5 (except yours will be blank when you first bring this screen up for a new project).

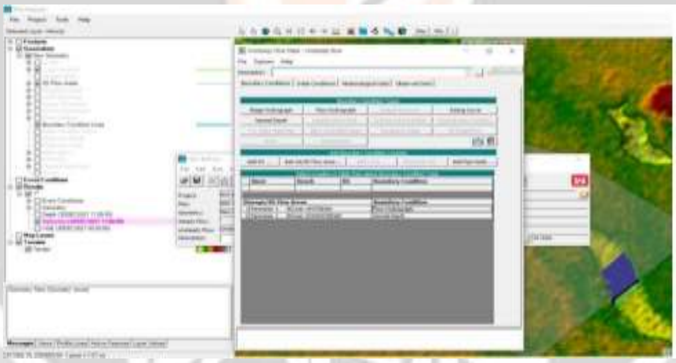
FIG.No-3.1.2 HEC-RAS Geometric Data Interface

After geometric data are entered, the data should be saved.

3.1 <u>3.1.3 Entering Flow Data and Boundary Conditions</u>

After the geometric data is entered, the user can then enter either steady flow or unsteady flow data. The type of flow data entered depends upon the type of analysis which is to be performed The data entry form for steady flow data is available under the Edit menu bar option on the HEC-RAS main window.

An example of the steady flow data entry form is shown in figure below, which is the Steady Flow Data Editor. As shown in Figure, steady flow data consist of the number of profiles to be computed; the flow data; and the river system boundary conditions. At least one flow must be entered for every reach within the system Additionally, flow can be changed at any location within the river system. Flow values must be entered for all profiles.



Boundary conditions are required in order to perform the simulation. If a subcritical flow analysis is going to be performed, them only the downstream boundary conditions are required. If a supercritical flow analysis is going to be performed, then only the upstream boundary conditions are required. If the user is going to perform a mixed flow regime calculation, then both upstream and downstream boundary conditions are required. The Boundary Conditions data entry form can be brought up by pressing the Reach Boundary Conditions button from the Steady Flow Data entry form.

Once all of the steady flow data and boundary conditions are entered, the modeler should save the data.

FIG. No. 3.1.4 Flow Data Interface

3.2 Selecting the area which is to be analyzed

There are various sources for selecting the areas like ARC-GIS & ASF Data search.. The above figure shows the selection of area from the ASF Data base.

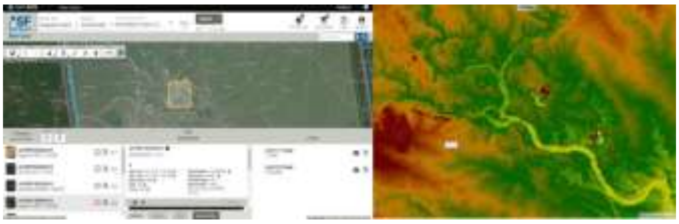
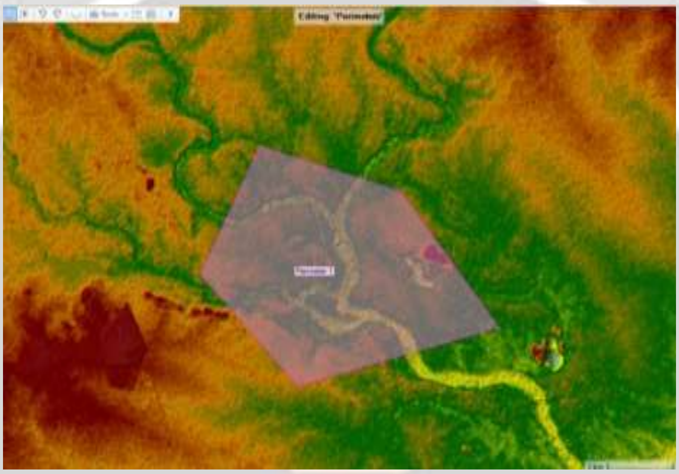


Fig 3.2 Selecting The Area

3.3 Entering the boundary condition

The below figure shows the boundary condition of the selected area.



3.4 Defining upstream and downstream region

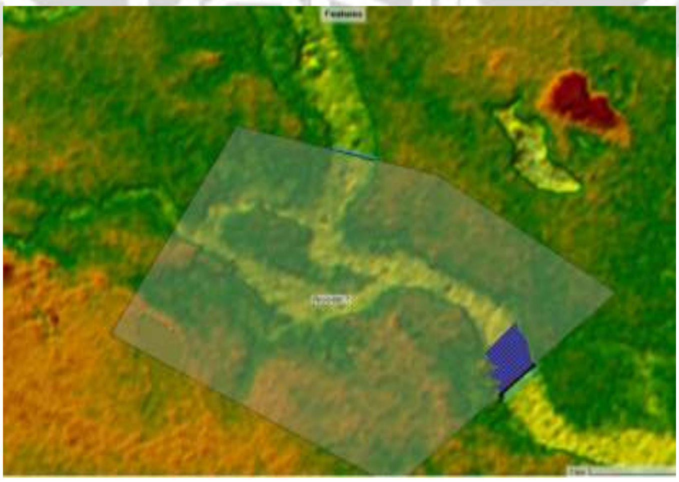


Fig 3.4 Setting upstream and downstream region

Above figure shows upstream region(in the directon opposite to flow) and downstream region(in the direction of flow)

3.5 Entering flow data for upstream and downstream

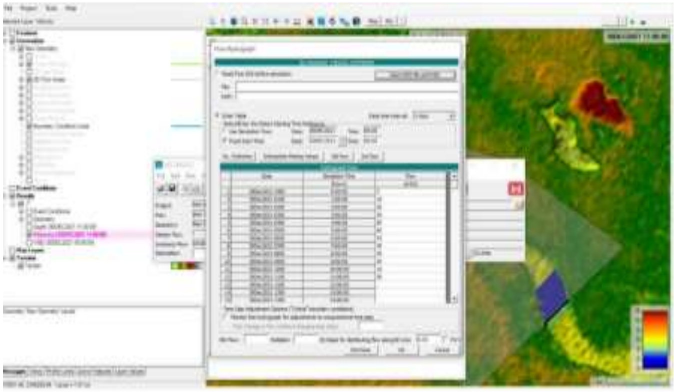


Fig 3.5 Entering flow data

Entering the flow condition for one hour interval till the date which is to be analysed.

3.6 Running the analysis

Fig 3.6 Analysis Interface

Running the data with different trials and errors and reducing the overall error

4. Result and Discussion

4.1 Depth

According to our river analysis in the selected region it is observed that along the right direction depth is decreasing because from right direction the width of river is increasing and in the left direction, the width of river is decreasing that's why the depth is increasing.

Table 4.1.1

Along the right direction(m)	Depth(m)
767.6	11.35
397.8	9.01
412.2	7.10

Table 4.1.2

Along the left direction(m)	Depth(m)
956.8	0.956
907.4	6.43
271.7	9.15

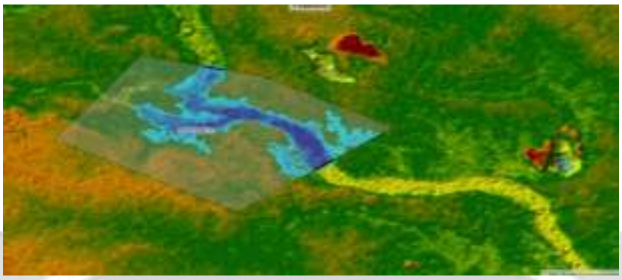


Fig No. 4.1.1 Final Depth Analysis

4.2 Velocity

As per as per the analysis through HEC-RAS software along with the right direction the river is getting wild therefore the velocity all flow is decreasing similarly the river is getting narrower therefore the velocity of flow is increasing

Table 4.2.1

Along the right direction(m)	Velocity(m/s)
785.4	1.29
619.4	1.35
170.8	0.81

Table 4.2.2

Along the left direction(m)	Velocity(m/s)
748.6	0.21
627.5	0.10
548.7	0.07

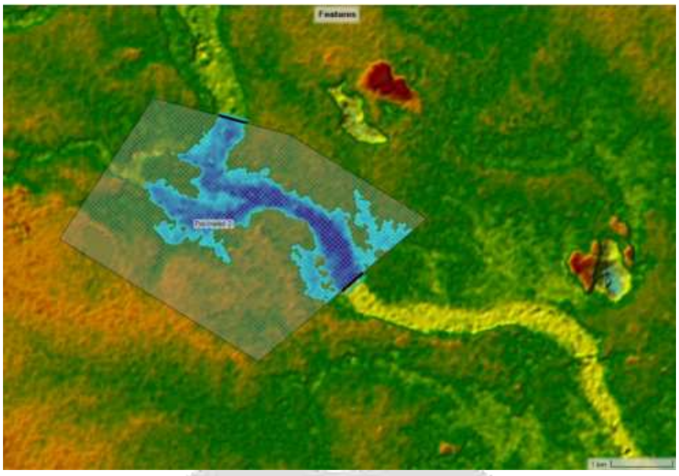


Fig no. 4.2.1 Velocity Distribution

4.3 Water Surface Elevation

As per the analysis along the centre line at point 1149.5, the water surface elevation is 220.91 and similarly at point 870.1 m the water surface elevation is 220.81.Similarly we can optimize the water surface elevation at any point.

Table 4.3.1

Along the centre line	WSE(m)
1149.5	220.91
870.1	220.81
916.4	219.50

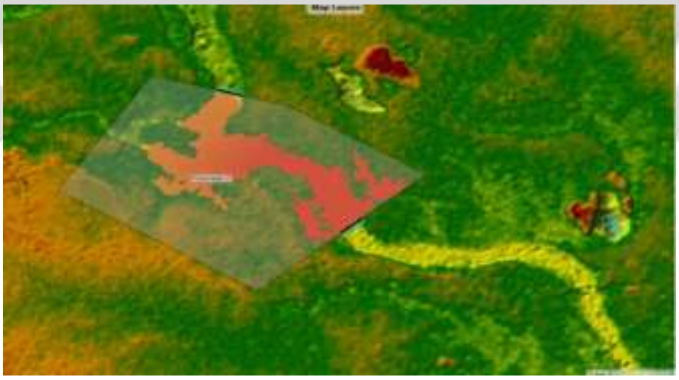


Fig No. 4.3.1 Water Surface Elevation

4. CONCLUSIONS

The aim of this study is to show that the HEC-RAS model is able to simulate the surface profiles formed in different recurrent flows of the Kanhan river, as well as that the boundaries in a public area can be easily obtained by using the HECRAS package program. We can optimize the values of velocity, depth and water surface elevation at any section. When the results of the analysis made with the HEC-RAS program are examined, it is seen that the velocity decreases with increase in width. It is of course difficult to make a suitable analysis in natural rivers with such floodplain width and low slope. However, the current maps to be obtained and the suitability of these maps to the land, the precise hydrological data obtained from the study area, and the accuracy of the acquired data as a result of the observations made in the field are very important. In addition to gathering all these data through an effective user, the flood analysis studies will be much suitable by ensuring the compatible between land and computer.

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