

Forecast and Prediction of Flood Circumstances of River Basin

Rajvardhan S. Patil¹ & Mukund P. Chougale²

¹ Assistant Professor in Civil Engineering, D.Y. Patil College of Engg. Akurdi, Pune-44 INDIA

² Assistant Professor in Civil Engineering, D.Y. Patil College of Engg. Akurdi, Pune-44 INDIA

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ABSTRACT

The Godavari is India's second longest river after the Ganga. Its source is in Triambakeshwar, Maharashtra. Hydraulic model can be used to predict the consequences of flooding events. In this project, the hydraulic model of Godavari river near Bhadrachalam was constructed using the software Hydrologic Engineering Center-River Analysis System (HEC-RAS). The model include (i) a 1-dimensional (1D) model, where river and floodplain flow is modelled in 1D, and (ii) a pure 2D model, where river and floodplain flow is modelled in 2D. Important differences between data requirements, pre-processing, model set-up and results were highlighted and summarized, and a rough guide that may be used when deciding the appropriate type of model for a project, was presented. In addition, the sub-grid technique used in 2D HEC-RAS modeling was studied by investigating the influence of computational mesh structure and coupling between 1D and 2D areas. The results showed that a model could successfully reproduce a historic flooding event. The 2D model could also provide more detailed information regarding flood propagation and velocities on the floodplain. The results obtained from HEC-RAS are then used for providing various mitigation measures such as modifying the cross-section, design of flood embankments, for various river training works etc.

Keywords: Hydraulic model, flood modeling, HEC-RAS, flood propagation, mitigation measures.

Introduction:-

The **Godavari** is India's second longest river after the Ganga. Its source is in Triambakeshwar, Maharashtra. It flows east for 1,465 kilometres (910 mi) draining the states of Maharashtra (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal through its extensive network of tributaries. Measuring up to 312,812 km² (120,777 sq mi), it forms one of the largest river basins in the Indian subcontinent, with only the Ganges and Indus rivers having a larger drainage basin. In terms of length, catchment area and discharge, the Godavari river is the largest in peninsular India, and had been dubbed as the Dakshina Ganga – Ganges of the South.

The river has been revered in Hindu scriptures for many millennia and continues to harbour and nourish a rich cultural heritage. In the past few decades, the river has been barricaded by a number of barrages and dams, restricting its flow. The river delta supports 729 persons/km², and has been categorized as having substantial to greater risk of flooding with rising sea levels.

Godavari enters into Telangana in Nizamabad district at Kandakurthy where Manjira, Haridra Rivers joins Godavari and forms Triveni Sangamam. The river flows along the border between Nirmal and Mancherial districts in the north and Nizamabad, Jagityal, Peddapalli Ramagundam districts to its south. About 12 km (7.5 mi) after entering Telangana it merges with the backwaters of the Sriram Sagar Dam. The river after emerging through the dam gates enjoys a wide river bed, often splitting to encase sandy islands. The river further swells after receiving a minor tributary Kinnerasani River and exits into Andhra Pradesh.

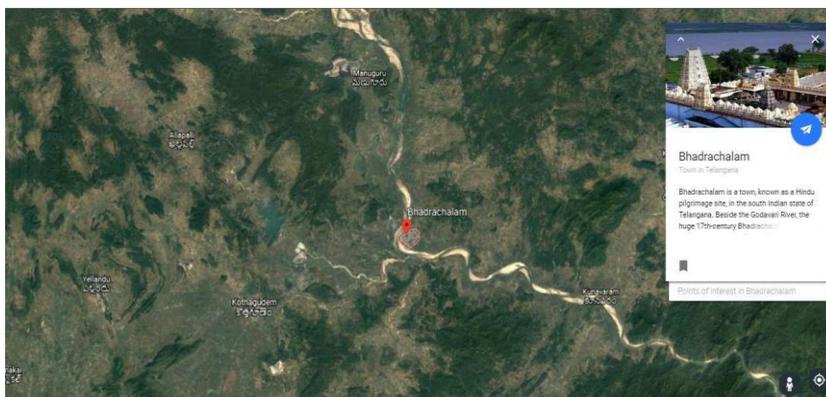


Fig :-1 Godavari River In Bhadrachalam

Objective:-

To develop Digital Elevation Model using Global Mapper and integrate with HEC-RAS to create 2D flood model.

To delineate natural flow routes and flow accumulation with the help of Digital Elevation Model (DEM).

To suggest measures to reduce floods.

Problem statement:-

The main object of this project is to create 2-Dimensional (2D) flood model using Hydrologic Engineering Center- River Analysis System (HEC-RAS) and complementary multimedia interactive devices, as tools for the comprehensive evaluation of floodplain management policies taking into account the dynamics of growth in developing areas. In fact, dissemination of relevant flood information using HEC-RAS, or other computer graphic devices, can help support individual and institutional decision-making processes, either for preventive flood management or for dealing with emergency situations. In both cases, public involvement is a major issue for better decision making and policy effectiveness. Therefore, HEC-RAS provides an appropriate working environment for the participatory evaluation of flood hazard management policies. HEC-RAS have been recognized as a powerful means to integrate and analyse data. Adequate information and prediction capability is vital to improve decision making processes. Therefore, emphasis is put on flood risk mapping based on hydrologic and hydraulic simulation of flood hazards, and a GIS based comparison of different scenarios for urban growth, improving the possibility simulating the consequences of the alternative scenarios for urban development and for flood mitigation strategies.

Scope of the project:-

The unique capabilities of satellites to provide comprehensive, synoptic and multi-temporal coverage of very large areas at regular interval and with quick turnaround time have been very valuable in monitoring and managing flood dynamics by using 2-D flood modelling. In fact, it is only space technology, which has for the first time provided the basic information needed in the space, time and frequency domain. In order that the appropriate flood control and anti-erosion works are scientifically planned, executed, monitored and maintained as per the best standards, it is necessary to acquire timely and reliable information about the flooded areas, watershed areas, river behaviour and configurations, etc. prior to floods, during floods, and after floods. Such information is difficult to acquire in time for decision making from conventional ground survey methods in vogue, which are arduous, time consuming and beset with various limitations, especially while studying floods of large river basins. The earth Observation satellites provide comprehensive, synoptic and multi-temporal coverage of large areas in real time and at frequent intervals and, thus, have become valuable for continuous monitoring of atmospheric as well as surface parameters related to flood. They are also useful in delineating the boundaries of flood prone zones. Digital analysis of satellite data can detect changes on the sections of the inundated flood plains as well as in water quality. The multi temporal data from satellites are proved to be very valuable in the identification of the site ideal for taking up structural measures to control floods.

Mathematical modeling:-

Various 2D modeling software are available such as **MIKE-11, CHARIMA, HEC-6, HEC-RAS** forces simulation. We are using HEC-RAS beta 5.0.3 version for the computation of water level in Godavari River.

HEC-RAS is capable of handling one dimensional steady and two dimensional unsteady flow in detail. Description about various governing equation used and the assumptions in the equation and model formulation are given below:

Governing equations of water flow:-

One dimensional unsteady water flow is represented by "Saint Venant" equation as follows

Continuity Equation:

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} = 0$$

Momentum Equation:

$$\frac{\partial Q}{\partial t} + \frac{\partial(\alpha Q^2/A)}{\partial x} + gA(\frac{\partial h}{\partial x} - S_o + S_f) = 0$$

Where:

Q = Flow (water discharge)

α

= velocity distribution coefficient A = cross-sectional flow area

t = time

x = distance in the flow direction

h = depth

S_o = bed slope

S_f = friction slope, from Manning's equation

v = flow velocity

These equations are nonlinear partial differential equations with Q and y as dependent variables and x and t as independent variables. The exact solutions of these equations are not possible since these equations are not in standard forms.

2- D Flood modeling:-

2-D hydraulic model is the application of fluid mechanics to simulate the movement of water. It is also used to determine the extents of a floodplain and the probability of flood plain occurring. We use this model to simulate what will happen if a dam fails and with this information we can determine how far a flood in a particular direction goes, and with what velocity, so we can make evacuation maps in emergency actions. 2-D models are very useful in a region where flow patterns are very irregular.

In contrast to 2-D models need continuous topographical data, covering the whole area that is to be modeled in 2D.

For unsteady flow, HEC-RAS solves the full, dynamic, 1-D Saint Venant Equation using an implicit, finite difference method. The unsteady flow equation solver was adapted from Dr. Robert, L. Barkau's UNET package.

Software used:-

Global Mapper is a geographic information system (GIS) software package currently developed by Blue Marble Geographic that runs on Microsoft Windows. Global Mapper handles vector, raster, and elevation data, and provides viewing, conversion, and other general GIS features¹. Global Mapper has an active user community with a mailing list and online forums.

- 1) Low-cost and easy-to-use GIS.
- 2) Supports over 250 spatial data formats.
- 3) Optional LiDAR Module for powerful point cloud processing.
- 4) Advanced projection management using GeoCalc library.
- 5) Unmatched and complimentary technical support.

HEC-RAS

The basic computational procedure of HEC-RAS for steady flow is based on the solution of the one-dimensional energy equation. Energy losses are evaluated by friction and contraction / expansion. The momentum equation may be used in situations where the water surface profile is rapidly varied. These situations include hydraulic jumps, hydraulics of bridges, and evaluating profiles at river confluences.

Unsteady Flow Simulation :-

This component of the HEC-RAS modelling system is capable of simulating one-dimensional; two-dimensional; and combined one/two-dimensional unsteady flow through a full network of open channels, floodplains, and alluvial fans.

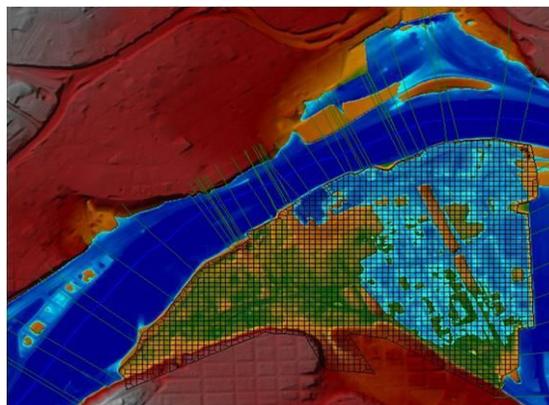


Fig 2. Unsteady flow simulation

The unsteady flow component can be used to performed subcritical, supercritical, and mixed flow regime (subcritical, supercritical, hydraulic jumps, and draw downs) calculations in the unsteady flow computations module.

Graphics and Reporting :-

Graphics include X-Y plots of the river system schematic, cross-sections, profiles, rating curves, hydrographs, and inundation mapping. A three-dimensional plot of multiple cross-sections is also provided. Inundation mapping is accomplished in the HEC-RAS Mapper portion of the software. Inundation maps can also be animated, and contain multiple background layers (terrain, aerial photography, etc...). Tabular output is available. Users can select from pre-defined tables or develop their own customized tables. All graphical and tabular output can be displayed on the screen, sent directly to a printer (or plotter), or passed through the Windows Clipboard to other software, such as a word-processor or spreadsheet.

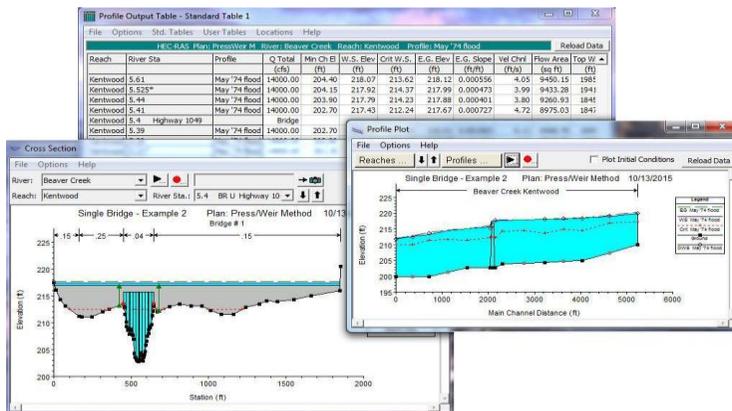
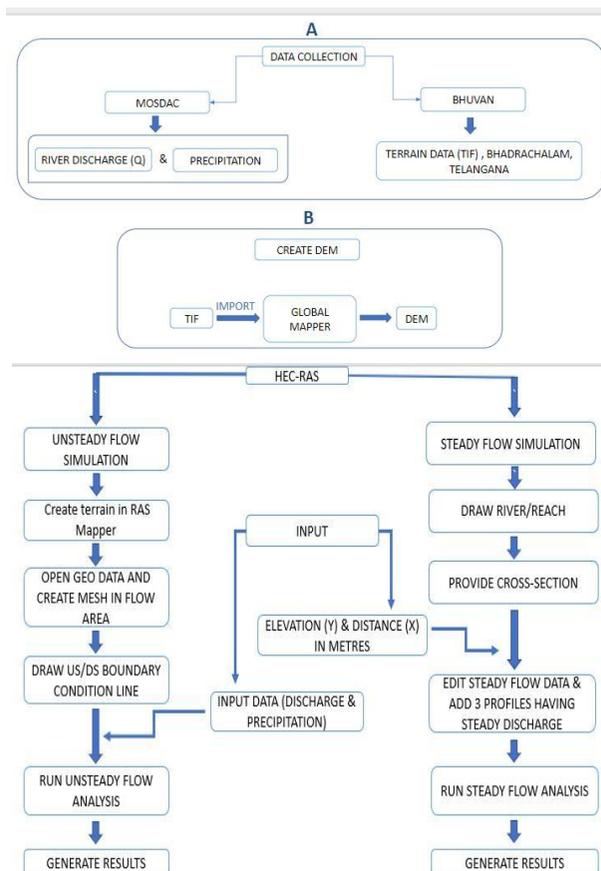


Fig 3. Graphics and reporting

Methodology :- Flow chart



Unsteady Flow Analysis :-

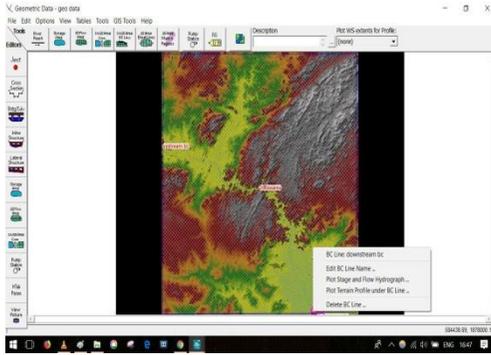


Fig. 4

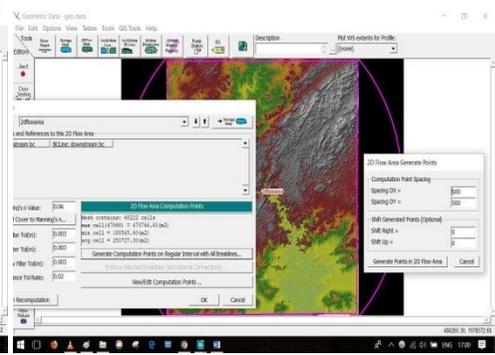


Fig. 5

Result Analysis:-

Steady Flow simulation

Channel Cross-section provided by HEC-RAS:

Deepening of Bed Profile:-

Flow is obstructed by uneven bed profile, hence discharge decreases. Water level increases where bed slope is uneven resulting in floods. Smoothing and Deepening of Bed profile helps in reducing the water level.

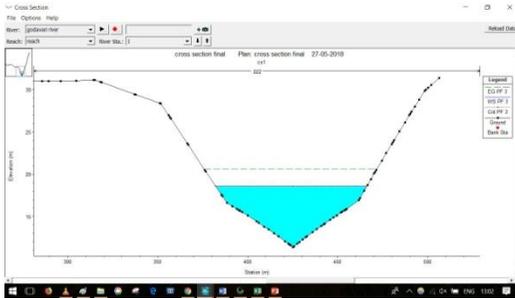


Fig. 6

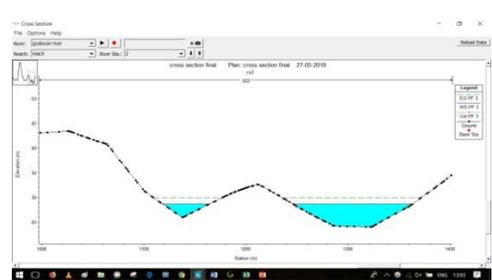


Fig. 7

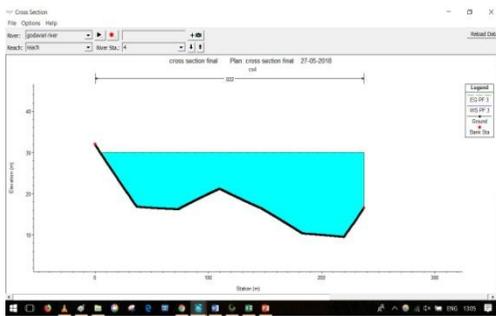


Fig. 8

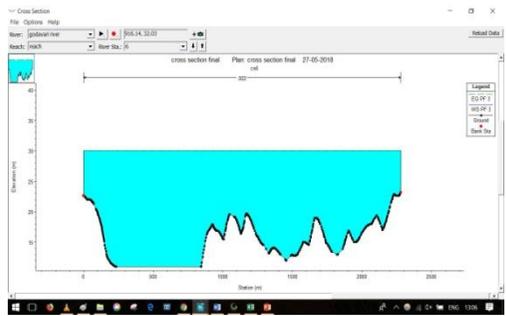


Fig. 9

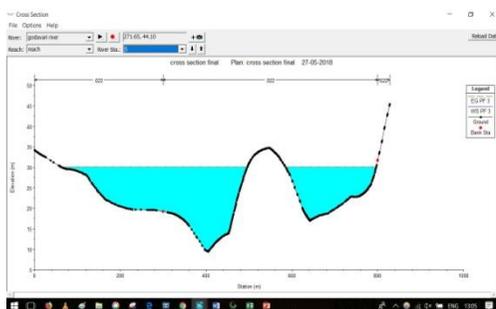


Fig. 10

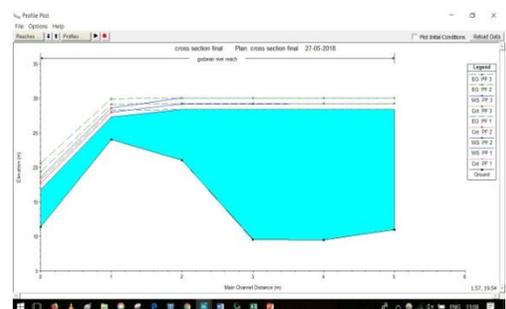


Fig. 11

Channelization / cross section alteration :-

Channelization involves changes in channel plan form and gradient (usually straightening); channel cross profile form and flow resistance (usually channel enlargement and removal of morphological and vegetation roughness elements); and in some cases it involves the introduction of artificial materials to reinforce the modified channel form (e.g. concrete, metal, stone, bricks). Construction of flood embankments at Various river training works. River training" is a term used to the measures used to stabilize the river channel along a certain alignment with certain cross-sections.

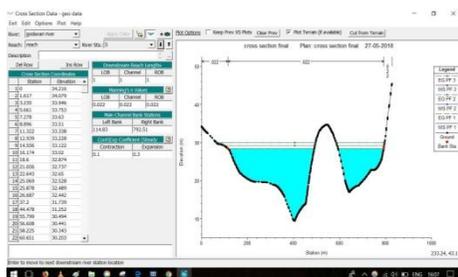


Fig. 22

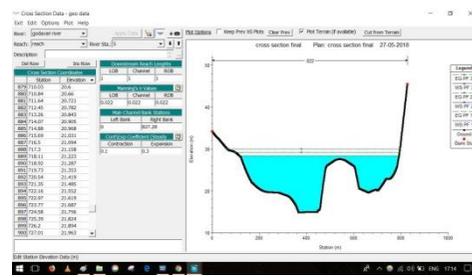


Fig. 23

Conclusions:-

Following were the probable reasons for the floods in Bhadrachalam, Telangana:

- 1) Large urban development in floodplains- roads, railways, canals.
- 2) Incomplete protection works- embankment and sluice gates.
- 3) Encroachments within and along Godavari

Following are the probable measures which can be provided to mitigate the flood:

- a) Construction of water flow resistant concrete riverside road on top of the embankment would be desirable with similar protection on both side slopes. This will further strengthen the flood embankment.
 - b) Provision of appropriate launching apron and bank slope protection with stones in crates and synthetic filter below as per the design suggested.
 - c) Appropriate storm water drainage arrangement for the low lying areas behind the embankment on countryside along with suitable drain along the toe of embankment be provided.
 - d) In order to increase stability of embankment and provide some protection against marginal flood sleeps over top the embankment, it may be worthwhile to construct 2 to 4 Lane Riverside concrete roads with 1.5 m high concrete parapet wall on Riverside and appropriate embankment slope protection on city side may be provided. This may be taken as a part of riverfront development.
 - e) Except for Riverside Road on embankment as suggested above, no permanent development or structures be allowed within embankments. Only activity such as development of open garden without any structures may be allowed with embankments.
 - f) Permanent water level gauges maybe installed and maintain. During flood period continuous water level observation be taken to generate useful data.
- Necessity of making legislative for imposing restrictions on development in the flood plains. Especially no permanent structures are allowed with an embankment.
- g) Extension of flood embankment to provide partial protection against appropriate flood discharge.
 - h) Embankment constructed or raised subsequent to past floods should be maintained as per the guidelines of Indian Standards mentioned. Regular inspection of embankment slope, apron and embankment top level should be carried out after monsoon season and damages noticed, if any, should be rectified.

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