Innovative Methodology for Developing Analytical Hydraulic Model of Bridge

[1]Swati Pachpande,[1]Yogini Goswami,[1]VaibhavRajnor, [1]ShubhamShirsath, [1]Meghali Gangurde
[2]Shri. Kuldeep Malik, [3]Dr. Prof. Shantini Bokil

[1]Civil Engineering, SavitribaiPhule Pune University,
MIT College Of Engineering Pune, Maharashtra, India
swatipachpande2808@gmail.com

[2]Bridge Engineering, CWPRS, Pune,
Maharashtra, India
kuldeep.cwprs@gmail.com

[3]Civil Engineering, Head of Department,
MIT College Of Engineering Pune, Maharashtra, India
shantini.bokil@mitcoe.edu.in

Abstract: Bridge construction requires careful planning and designing study as no undue risk should be taken in its design and construction. Hydraulic considerations in the bridge design comprises several aspects such as selection of site, determination of waterway, assessment of scour for design of foundation of piers and abutments, design of guide banks and approach banks, protection works etc. Undermining of piers due to excessive scour could become a common cause for bridge failure. So it is necessary to study and analyze the hydraulic design of bridge to reduce the structural damage and make the structure safe by considering all the natural conditions. This research paper highlights an innovative methodology for hydraulic design of bridge using software i.e. HEC-RAS. As this modelling system can give an insight about hydraulic behavior of bridge and assist to plan infrastructure improvements, develop operational maintenance strategies.

Keywords- *Mathematical modelling, HEC-RAS, Hydraulic analysis, Hydraulic behavior*

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1. Introduction

A bridge is a structure built to span physical obstacles such as a body of water, valley, or road having length above 6 m between the inner faces of the dirt wall for carrying traffic across obstruction.A bridge is a structure built over a river so that movement of people or vehicles are done across safely. Bridges are classified as minor and major bridge. A minor bridge has a total length up to 60m whereas a major bridge's length is above 60m. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available it . Hydraulic analysis is necessity for any hydraulic project that involves construction of structure across river. Thesuitable hydraulicapproach is of crucial importance in terms ofthe safety and cost-effectiveness of the project, the approach to hydraulic analysis determines the extent of uncertainty which will be incorporated into the designtherefore the level of residual risk is reduced.

So this research paper "Innovative Methodology for Developing Analytical Hydraulic model of Bridge"emphasizes on-

- Preparing and analyzing mathematical model using hydraulic calculations.
- Study the effects of different components and make predictions about behavior.

1.1 Mathematical Modelling and Hydraulic Analysis

A mathematical model can be used to describe any system with the help of mathematical ideas and language. A 4model could facilitate to clarify system and check the results of various elements and form predictions regarding the behavior. This could help in estimating the uncertainties in observed data.
Hydraulic analysis is a prerequisite tool for any project work that compares the existing and future probabilities of structure. One can relate mathematical modelling and hydraulic analysis by using one dimensional software HEC-RAS.

1.2 HEC-RAS One Dimensional Software

HEC-RAS is software that allows you to perform one-dimensional steady and unsteady flow river hydraulics calculations, sediment transport-mobile bed modeling, and water temperature analysis. It was developed at the Hydraulic Engineering Center (HEC) by

Mr. Gary W. Brunner. HEC-RAS permits you to perform one-dimensional steady flow, unsteady flow calculations, sediment transport bed computations and water temperature modelling.HEC-RAS is associateintegrated system of software package, designed for interactive use in very multi-tasking surroundings.

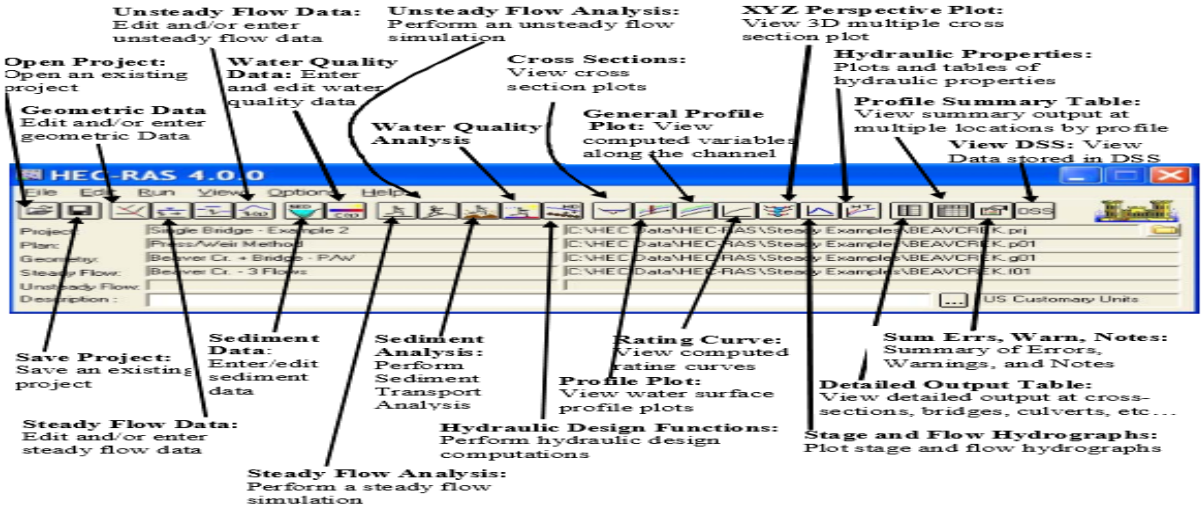

Figure 1. HEC-RAS main window Button ba

2. Objectives

The following objectives were set to carry out this work in systematic work:

1. Evaluate various flow properties of river.
2. To interpretand utilize 1-D modelling software.
3. Analysis of hydraulic calculation using mathematical modelling.
4. To predict the behavior of different components explaining a model system.
5. To plan, design, calculate and construct a modelof a bridge.

3. Necessity of Developing Model

Whenever any structure is designed by considering all the loading conditions, it is safe in loading aspects. But, The hydraulic behavior of any structure is unpredictable in case of any changes in the flow conditions. So, it is to work on mathematical modelling of a structure to reduce the structural damage caused due to natural Calamities in future. By modeling a system we will gain a full understanding about hydraulic behavior of bridge, model as a tool to plan infrastructure improvements, develop operational maintenance strategies.

4. Literature Survey

Hydraulic modeling of flow impact on bridge structures: A case study on Citarum Bridge concludes that the role of hydraulic modelling in the design of the bridge across the river is on the aspect bridge safety against the flood stream in the river. The bridge over structure should be sufficient high so that pier and deck protected from flood. The base, the pillar, and the foundation of the bridge should be safe against the risk of scouring.

Role of hydraulic model studies in bridge design by B.U. Nayak and V.K.Appukuttan overviews that Hydraulic aspects of bridge design consists of selection of site, Optimum orientation and waterway, location of abutments, design of guide banks, approach embankments and design of bridge piers. For scour observations during floods, it is very much essential to install automatic recording type instrument. Such instrument should be compatible for installing at the bridge pier. It should give a clear indication of the depth of scour under all flow conditions. The System should record the onset of scour, maximum depth of scour.

Bridge hydraulic analysis with HEC-RAS by Vernon R. Bonner, Gary W. Brunner, (April 1996) concludescertain situations, such as highly skewed bridge crossings and bridges at locations of sharp curvature in the floodplain were not addressed by the study. The evaluation of contraction and expansion coefficient should ideally be substantiated by site-specific calibration data, such as stage-discharge measurement upstream of the bridge.This paper provides an overview of HEC-RAS representation of bridge hydraulics and the results of several bridge hydraulics investigations.

5. Methodology

Background investigation is a necessary whenever a hydraulic report is required for a bridge, the first process is to review any previous investigations that have been carried out on this bridge. The first analysis process in the hydraulic design for a bridge is

the hydrology, or the calculation of design flood discharges and sometimes discharges for historical floods Records of Highest Flood Level and also gauge discharge are required in hydraulic analysis.Also flood hydrographs are calculated from rainfall using different software packages.

Steps for developing Model:

1. Inputthe geometric data
2. Assignthe flow data and boundary conditions
3. Simulate the hydraulic calculations
4. Asses the output

5.1 Prerequisite for New Project

The first step in developing a hydraulic model with HEC-RAS is to determine that directory you would like to work in and to enter a title for the new project.To start a new project, move to the File menu on the main HEC-RAS window and choose New Project.This will show a new Project window as shown in figure 2.

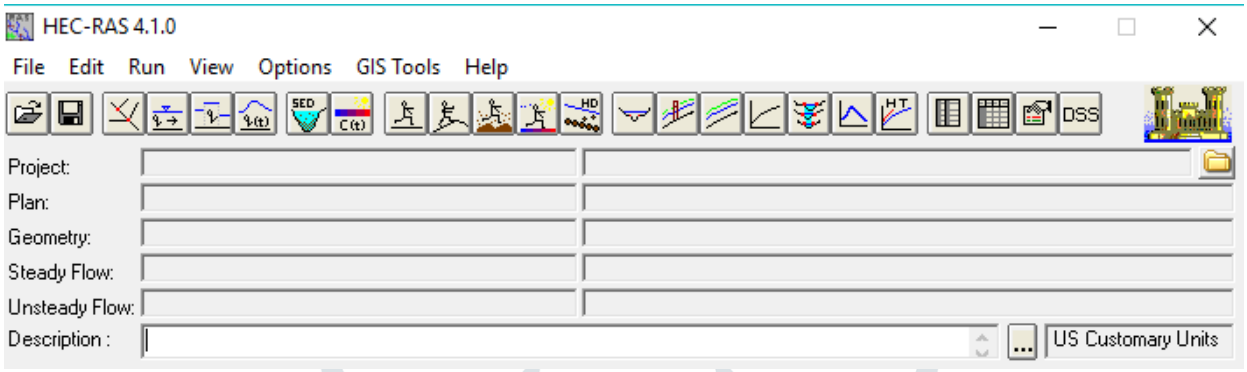

Figure 2. Main Windowof HEC-RAS

5.2 Input the Geometric Data

In this step, enter the necessary geometric data, which consist of connectivity information for the cross-section data, hydraulic structure data and stream system.

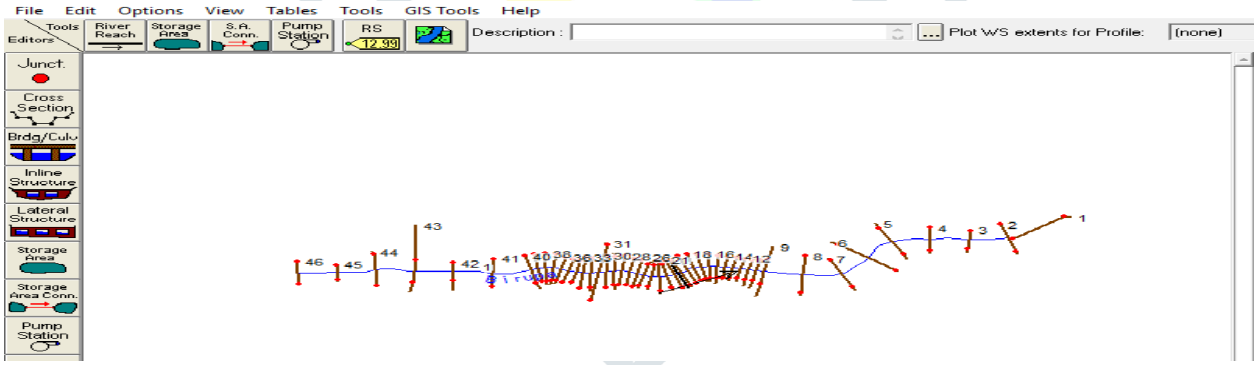

Figure 3. River reach along with cross-sections

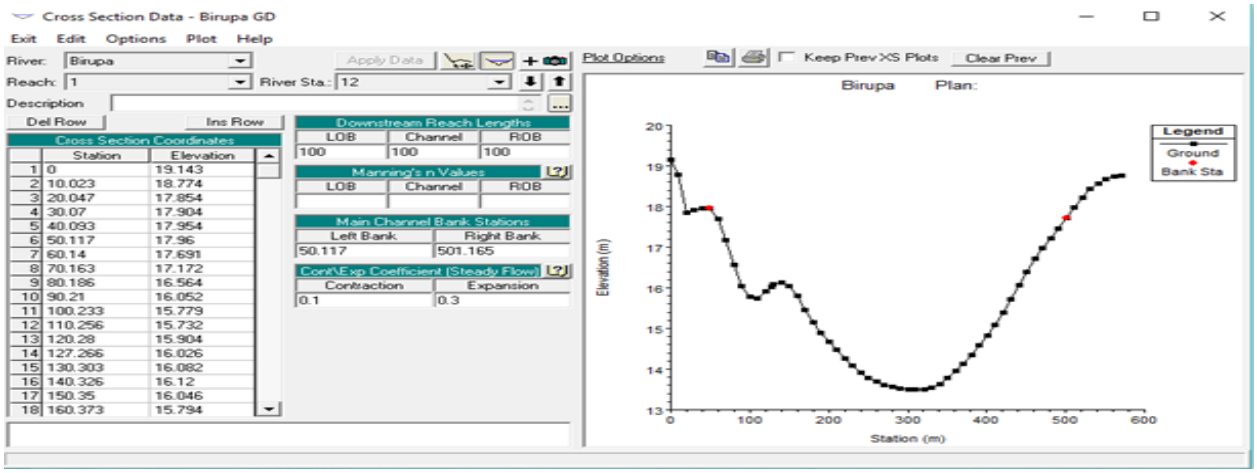

Figure 4. Geometric cross-section data editor

After the river system schematic is drawn, enter cross-section and hydraulic structure data. Pressing the Cross Section button causes the cross section editor to start up. Each cross section has a Reach name, River name, River Station, and a Description. The River, Reach and River Station identifiers are used to describe where the cross section is located in the river system and details about every cross-section. Once the cross-section data are entered, the modeler can then add any hydraulic structures such as weirs, bridges, dams, culverts and spillways.

5.3 Assign Flow Data and Boundary Conditions

After entering geometric data, the modeler can then enter either steady flow or unsteady flow data. The type of flow data depends upon the type of analyses to be performed. Boundary conditions are required for performing the calculations. Enter normal depth and critical depth to stimulate the model.

5.4 Simulate the Hydraulic Calculations

The modeler can begin to perform the hydraulic calculations once all of the geometric data and flow data are entered. The modeler has selected the plan and all steady flow computations are done. The system runs the steady flow model.

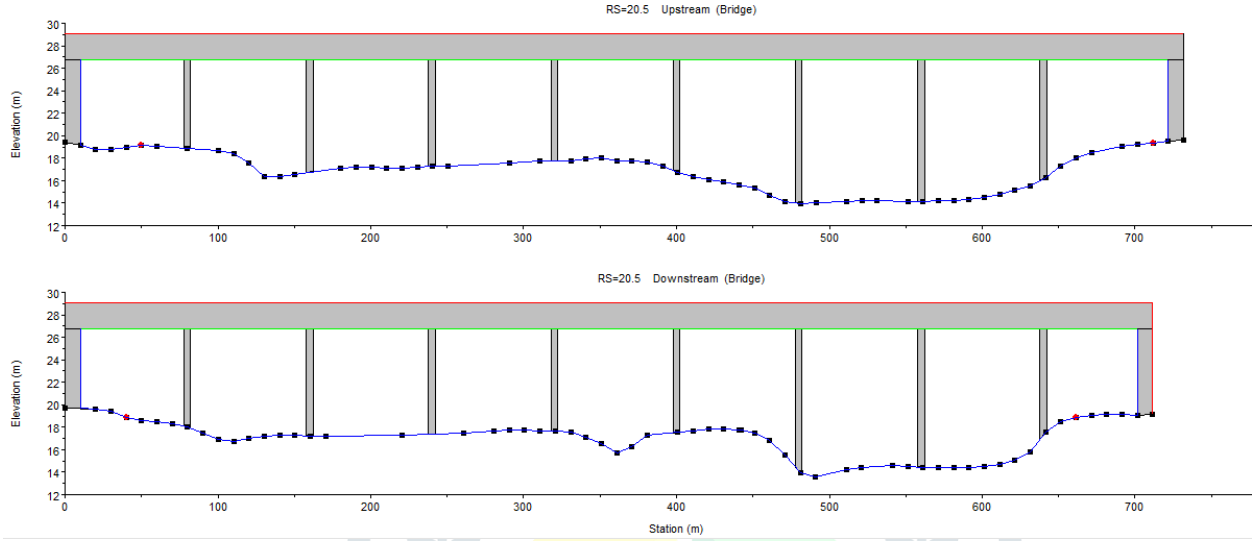

Figure 5. Upstream and downstream side of Bridge

5.5 Assess the Output

Once the model has finished all of the computations, the modeler can begin viewing the results. Several output features are available under the View option from the main window.

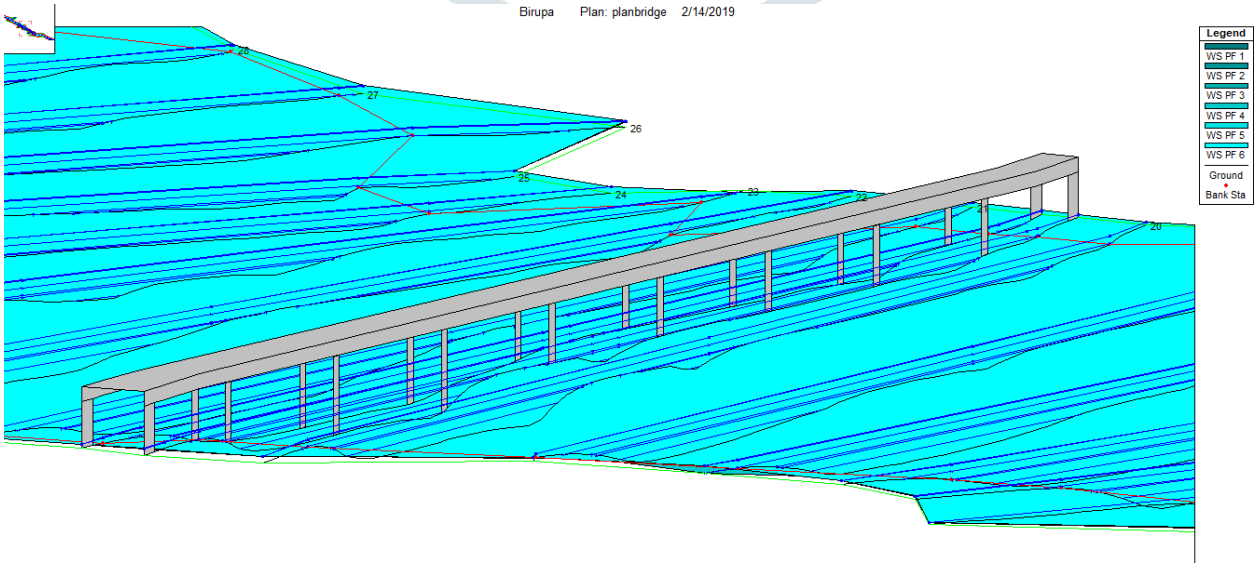

Figure 6. X-Y-Z Perspective Plot of River Reach with a Bridge

CONCLUSION

The application of HEC-RAS to analyze the various aspects in design of bridge is highlighted in this study. The excessive scour in the piers of the bridge is reduced. The hydraulic model can give instant decisions to work on the preventive measures to reduce the damages.The research paper highlights on this aspects, the innovative methodology can be used in the planning, designing and laying at the structural design of the bridge. The development and the operational strategies for maintenance of structural component of bridge up to its pier foundation are highlighted. The research study thus concludes that the lifecycle planning and the cost structure of a bridge structural can be effectively sketched with the strategic planning using mathematical modelling with the help of HEC-RAS. Also one can further use advanced modelling like recording type instrument installed around pier to record maximum scour depth, can also install instrument to quantify the flow impact on structures. Piers can be protected by garlanding and pitching.

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