NUMERICAL SIMULATION OF A DAM BREAK FLOW USING FINITE DIFFERENCE APPROACH

Thesis Submitted In Partial Fulfillment of the Prerequisites for the Degree Of Masters of Technology

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BY

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CERTIFICATE

This is to affirm that the thesis entitled, "**Numerical Simulation of a dam break flow using the finite difference approach** " set up together by **Ms. Saudamini Naik** in partial fulfillment of the essentials for the reward of Master of Technology Degree in **CIVIL ENGINEERING** with specialization in "**WATER RESOURCE ENGINEERING**" at the National Institute of Technology, Rourkela is a genuine work did by her under my supervision and heading.

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ABSTRACT

Each and every phenomenon that occurs in this world is governed by some mathematical equations or functions, that means every incident can be represented in terms of mathematical functions of some independent variables. Likewise the flow that occurs after the break of a dam is represented by a set of some non-linear hyperbolic mathematical equations known as shallow water equations those are obtained from the profundity incorporating the Navier-Stokes equations where the horizontal dimensions are greater than the vertical dimensions. Investigation of dam break stream numerically is a fundamental piece of water driven designing practice. Estimation of peak flood profundity, its time of occurrence at a predefined area, wave fronts and evaluation of its fetch can be possible better through numerical models than that of physically-based models. In this present research work this system of shallow water equations are discretised by finite difference method (mainly using Mac Cormack method) for preparing the codes for programming in both MATLAB and FORTRAN to prepare a numerical model with all the required boundary conditions that used happen during a dam break. The numerical method used here for analysing the above governing mathematical statements are upgraded by utilizing the technique for fragmentary strides for rearranging application, treating the grinding slant, a hardened source term, point-certainly, for numerical swaying control and security. This prepared model is again validated with some documented results to know the accuracy and stability of the numerical discritisation and compared with a practical dam break case study analysed with HEC-RAS software so as to compare the different aspects of the model and the software. The present numerical examination has the capacity for resolution stuns, complex bed geometry including the impact of bed inclines and unpleasantness. So the above scheme is much effective in analysing the set of SWES than the former ones.

Key words: Finite difference method, MacCormack method, SWE, Numerical analysis

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LIST OF NOTATION USED

Notation	Description of the notation
C_n	Courant number
f(x)	Any Function of x
f'(x)	Derivative of f(x)
f	Roughness coefficient in Darcy weisbach equation
g	Acceleration due to gravity
h	Depth of water
k	Roughness coefficient in Mannige's equation
n	Present time level
u	Velocity of flow along horizontal direction
v	Velocity of flow alon vertical direction
Q	Discharge in m^3/s
S_{0x}	Slope of the bed along x(horizontal direction)
S_{fx}	Friction term along x(horizontal direction)
S_{0y}	Slope of the bed along y(vertical direction)
S_{fy}	Friction term along y(vertical direction)
x	Horizontal dimension
y	Vertical dimension
t	Representation of time
Δx	Grid or mesh size along the space axis
Δt	Grid or mesh size along the time axis
U_x	Derivative of U with respect to x
U_t	Derivative of U with respect to t
U	Vectors of primitive variables
F &G	Flux vectors along x and y direction respectively
q_x	Discharge along x direction
q_y	Discharge along x direction
z	Datum surface of water

CHAPTER-1

INTRODUCTION

1.1. OVERVIEW

A dam is characterized as a block or a hindrance fabricated over a stream or a waterway to limit and use the stream of water for human purposes, for example subdue flood/surges, make water supply for various requirement include storage of water, irrigation, industrial use, human consumption, navigability, aquaculture and generation of hydroelectricity, watering system and era of hydropower. All water impoundment speaks to a potential danger to life and property. The examination of dam-break stream is a piece of dam outline and wellbeing investigation and is viewed as an essential organ in water driven designing practice. A specialist is keen on the estimation of top surge stream, comparing most extreme stream profundity and now is the right time of event at a predefined area in the way of surge wave. One is additionally inspired by knowing the profundity of stream at the dam site coming about because of the dam-break as identified with upstream and downstream stream profundities preceding the disappointment. Amid this century there have been more than 200 disappointments of dams more prominent than 15 m high. Dam disappointments are relatively uncommon yet dam break streams can bring about monstrous harm and misfortune to the downstream regions as uncontrolled arrival of water at a high speed happens abruptly with no time. Because of the capability of high danger it postures to the downstream territory, a dam break examination is viewed as exceptionally key. Since there is no unmistakable system for keeping a dam disappointment as potential for loadings surpassing outline points of confinement can never be wiped out, another key piece of danger relief is recreating potential disappointments and arranging. The relief of the effects to the best conceivable degree obliges demonstrating of the surge with adequate detail in order to catch both the spatial and transient/temporal advancements of the surge occasion, too of the speed field. The determination of a fitting model to accurately reenact dam-break surge steering is accordingly a vital step.

Scientifically the "Dam break stream" is usually depicted by the shallow water comparisons (likewise named the Saint-Venant comparison for the 1D case). The shallow water comparisons (SWEs) are traditionally used to depict the unstable open channel stream, for example, dam break. These comparisons are named as Saint-Venant mathematical statements for one-dimensional (1D) issue furthermore incorporate the congruity and energy mathematical statements for two dimensional (2D) studies .Basically, the Navier–Stokes comparisons and the shallow water comparisons (the Saint Venant comparisons) can be utilized as the numerical definition to model dam break streams. Dam break streams are described by a very transcritical conduct including blended stream administrations, in which the stream can change with either space or time along the reenacted span from supercritical to subcritical, or alternately. Generally, one and two-dimensional models have been utilized to model dam break flooding, however these models are restricted in their capacity to catch the surge spatial degree, as far as stream profundity and speed and timing of surge landing and subsidence, with any level of point of interest. Since the cooperation between the fundamental channel stream and the floodplain stream obliges an entire two-dimensional model which mimics the drying and wetting procedure. In numerous handy issues streams could change suddenly in time, for example, the event of stun waves when opening floodgate doors, or in a dam break, or a rupture of a levee. The moderate type of the overseeing mathematical statements are more suitable for issues containing discontinuities in the arrangement. There are strategies for the arrangement of frameworks of protection laws for issues which include intermittent arrangements. In this way, the nature of dam break stream expectation predominantly relies on upon the fittingness of scientific plan and the precision of numerical reenactment models basing on the above arrangement of mathematical statement

1.2. HISTORICAL BACKGROUND

There square measure thousands of dams are made over several centuries round the world for the above mentioned various purposes, etc. But also, many dams have unsuccessful and each year several dikes breach attributable to high flows within the rivers, ocean storm surges, etc. usually resulting in ruinous consequences.

The worst dam disaster in India occurred in Machhu II(Irrigation scheme) Dam, Gujurat(1972-1979). attributable to abnormal flood, inadequate spill capability and overtopping of water from the mound the dam unsuccessful on Lammas,1979 inflicting a loss of 2000 lives. In August 1958 Kaddam dam Project , province unsuccessful and therefore the prime reason of failure is overtopping of water crest by 46cm that cause development of breach of 137.2m within the locality. associate degree earth crammed dam, Kalia Dam, Gujurat(1955-59) of a height of twenty three.08m on top of the watercourse bed and acrest length of 213.36m. the explanation behind the failure of this dam was breaking of mound attributable to weak foundation bed product of sedimentary rock in 1959. Then within the year 1977 Kodanagar dam , Tamil Nadu unsuccessful attributable to overtopping by flood waters. The on top of square measure a couple of samples of ruinous dam failure in India, however there square measure numbers of samples of dam break in alternative countries or throughout the globe. until currently the world’s worst dam failure “ Baniqiao Dam and therefore the Shimantan Dam” occurred attributable to overtopping caused by torrential rains in august 1975, in China, that cause death of eighty five,000 people. within the year 1975 a concrete dam, Malpasset dam in France unsuccessful inflicting loss of lives of 433 individuals. Vaiont reservoir in Italia fails in Gregorian calendar month, 1963 attributable to land slide that created a flood wave of some 100m high that overtopped the dam and flooded in to the downstream natural depression inflicting loss of 2000 lives.

All the a lot of as lately, in could 1999, a dam fizzled in Southern Federal Republic of Germany transferral on four passings and over one billion monetary unit of damage. In Espana 1997, disappointment of a dam on the Guadalquivir. Waterway, created large biological damage from the arrival of contaminated residue into the stream natural depression. As we have a tendency to in all probability am aware atmosphere is persistently dynamic and that has given instability in stream within the life compass of dams. various dams already thought to be safe square measure presently show vulnerability in greatest streams that cause overtopping amid high surge occasions prompting security considerations. On the off likelihood that a dam falls flat, toll and financial damage square measure direct results of such a happening, contingent upon the dimensions of water profundity and speed, cautioning time, and neighbourhood of people at the season of the occasion. Early cautioning is polar for economical lives in surge inclined zones. the event of dams persuades that the surges square measure fully controlled, associate degreed thus an enlarged urban and mechanical advancement within the floodplains typically happens. Thus, if the structure comes up short, the damage brought on by flooding could also be way more outstanding than it might are while not the neighbourhood of it. Having the authentic disappointments of structures as a main priority as talked regarding over, one could supply the voice communication starter what might be doable to diminish the danger postured from a dam disappointment occasion.

Although safety criteria have been considered in design, construction and operation of dams, dams may fail due to any unpredictable events i.e. Due to both external forces and internal erosion. There are various factors responsible for failure of dams, such as earthquake, landslides, extreme storm, piping, structural damage, foundation failure, sabotage, piping etc. Regardless of the reason, almost all failures begin with a breach formation. Basically, breach is defined as an opening formed in the dam body that leads concentrated water behind the dam to propagate towards downstream regions causing failure of the dam. So considering all the factors responsible for failure of dam main modes are identified as overtopping and breaching due to piping. Whatever may be the reason “dam break” is our concern and the investigation of dam break stream is a piece of dam configuration and security examination and is viewed as a key errand in water powered designing practice as surge brought on because of dam break causes huge loss of both living creatures and properties along downstream.We are occupied with the estimation of crest surge stream, comparing most extreme stream profundity and now is the ideal time of event at aspecified area in the way of surge wave and its get. There are mainly two types of models for analyzing dam break, physical models and numerical models.

Recreation of dam break events and the consequent surges are noteworthy to depicting and diminishing risks in light of potential dam dissatisfactions. For the Bureau of (Reclamation), the growing usage of the risk assessment change as a masterminding and decision making instrument has highlighted the necessity for upgraded barrier crack examination mechanical assemblies. Danger assessment examinations of Reclamation dams consider each possible stacking and dissatisfaction circumstances for a dam, the probability of those loadings and groupings of events anticipated that would realize frustration (i.e., event trees), and the results of disillusionment. Key request related to bank break that must be anwered over the compass of a peril examination are: Will dam disillusionment happen? What are the stacking furthest reaches that cause frustration, and what is the probability of dissatisfaction given a particular stacking? • What are the results of frustration with respect to loss of life and property hurts? To answer the second question, low down information about the failure is needed, for instance, the measure of alert time, and submersion levels and paces at downstream territories. The change of effective emergency action orchestrates and setup of right on time forewarning structures that may reduce or abstain from consequences of frustration moreover require such information. Dismembering the failure of a bank dam can be seen as a two-stage process. At first, the certifiable break of the dam must be inspected, and second, the surge from the crack must be guided through the downstream valley to center the resulting surge at masses centers. In case the masses at threat is discovered well downstream from a dam, purposes of enthusiasm of the breaking methodology have little effect on the result; travel time, debilitating, and other coordinating effects win. The National Weather Service (NWS) DAMBRK model and its successor FLDWAV are suitable instruments for such an examination. Regardless, in a creating number of cases, the region of masses concentrates near to a dam makes exact desire of crack parameters (e.g., break width, significance, dispatch time, and rate of change) fundamental to the examination. In the occasion that crack parameters can't be foreseen with sensible exactness, extended conservatism with related extended costs may be required. Shockingly, break reenactment and crack parameter conjecture contain the best defenselessness of all parts of dam-break surge suspecting (Wurbs, 1987). Most philosophies depend either on logical investigation data from past dam dissatisfactions or numerical models that don't reenact the crumbling frameworks and stream organizations that are noteworthy to a dam break. Contextual investigation information give just constrained data (i.e., extreme profundity, width, and shape; top release; greatest overtopping profundity; aggregate time to completely come up short bank or channel store), in view of a moderately little database of dam disappointments, fundamentally of little dams. Contextual investigation information are particularly powerless for setting aside a few minutes expected to launch a break, the rate of rupture development, and the aggregate time needed for disappointment. This is because of the trouble of characterizing the careful purpose of disappointment and the varieties in elucidation of disappointment by the layman who frequently is the main onlooker to a dam disappointment.

Physically-based numerical models (e.g., NWS-BREACH) offer the possibility to give more nitty gritty data yet as of now are perceived as having constrained precision. Right now accessible models depend on dregs transport relations that are not material or are untested in the administration of stream conditions relevant to a dam rupture. Moreover, large portions of the accessible models basically don't recreate the disappointment mechanics saw on the off chance that studies and research center tests. Therefore, Reclamation has started an agreeable examination exertion with the target of adding to another, physically-based, best in class numerical model for mimicking the methodology of dike dam rupture. The new model ought to be material to dike dams broke by overtopping or funneling. This model will advance enhanced examination of dam-break surges that will prompt better portrayal of dam dangers and more practical arrangement of dam security issues. Early cooperators in this exertion incorporate the Department of Interior/Reclamation Dam Safety Program, the National Weather Service, and the Pacific Gas & Electric Company (PG&E). The Agricultural Research Service is additionally seeking after comparable targets and has as of now been a specialized accomplice in this exertion. The initial phase in this exploration exertion was to direct a review of the current writing to distinguish momentum break forecast systems, case histories, and related advancements, and to center the future examination endeavors for most extreme advantage. This report exhibits the aftereffects of the writing overview. The report starts by looking at dam-break surge estimating all in all and the significance of dam rupture parameter forecast. The report then surveys beforehand recorded dam disappointment contextual investigations, new contextual investigations, and the break parameter forecast routines in view of those information. Essential instruments in rupture development and advancement are distinguished from the archived contextual investigations and past research facility testing, and existing physically-based dam break models are investigated in this connection. At long last, a structure is plot for another dam break model, parts of the model are distinguished, and research needs are compresse.

Since there is no definite programme for preventing a dam failure as potential for loadings surpassing configuration cutoff points can never be killed, another key piece of danger alleviation is recreating potential disappointments and arranging. The relief of the effects to the best conceivable degree obliges displaying of the surge with adequate detail to catch both the spatial and fleeting advancements of the surge occasion, also of the speed field. The determination of a suitable model to effectively reenact dam-break surge steering is subsequently a vital step.Amusement of bank dam burst events and the ensuing surges are critical to depicting and diminishing perils on account of potential dam disillusionments. For the Bureau of (Reclamation), the extending use of the threat assessment change as a masterminding and decision making instrument has highlighted the prerequisite for upgraded barrier burst examination devices. Peril assessment examinations of Reclamation dams consider each possible stacking and disillusionment circumstances for a dam, the probability of those loadings and groupings of events anticipated that would achieve frustration (i.e., event trees), and the results of dissatisfaction. Key request related to bank break that must be anwered over the compass of a peril evaluation are: Will dam frustration happen? What are the stacking furthest reaches that bring about frustration, and what is the probability of disillusionment given a particular stacking? • What are the results of frustration with respect to loss of life and property hurts? To answer the second question, low down information about the mistake is needed, for instance, the gauge of alert time, and inundation levels and paces at downstream ranges. The change of effective emergency movement orchestrates and setup of right on time advised systems that may diminish or forgo consequences of dissatisfaction similarly require such information. Dismembering the failure of a bank dam can be seen as a two-stage process. At first, the authentic break of the dam must be analyzed, and second, the surge from the burst must be coordinated through the downstream valley to center the ensuing surge at people centers. If the people at peril is discovered well downstream from a dam, purposes of enthusiasm of the breaking method have little effect on the result; travel time, debilitating, and other coordinating effects win. The National Weather Service (NWS) DAMBRK model and its successor FLDWAV are suitable instruments for such an examination. Regardless, in a creating number of cases, the zone of people concentrates near to a dam makes exact desire of burst parameters (e.g., break width, significance, dispatch time, and rate of change) key to the examination. In the occasion that crack parameters can't be expected with sensible exactness, extended conservatism with related extended costs may be required. Shockingly, break reenactment and burst parameter gauge contain the best defenselessness of all parts of dam-break surge reckoning (Wurbs, 1987). Most techniques depend either on logical examination data from past dam disillusionments or numerical models that don't reenact the crumbling frameworks and stream organizations that are noteworthy to a dam break. Logical examination data give simply obliged information (i.e., compelling significance, width, and shape; top discharge; most noteworthy overtopping significance; total time to totally miss the mark bank or channel store), in perspective of a respectably little database of dam dissatisfactions, on a very basic level of little dams. Relevant examination data are especially frail for putting aside a couple of minutes anticipated that would dispatch a break, the rate of burst improvement, and the total time required for dissatisfaction. This is a result of the inconvenience of describing the cautious motivation behind frustration and the mixed bags in illustration of disillusionment by the layman who often is the fundamental spectator to a dam dissatisfaction.

Physically-based numerical models (e.g., NWS-BREACH) offer the likelihood to give more bare essential information yet starting now are seen as having obliged accuracy. At this moment open models rely on upon leftovers transport relations that are not material or are untested in the organization of stream conditions pertinent to a dam crack. Also, substantial bits of the available models fundamentally don't reproduce the failure mechanics saw in case studies and examination focus tests. Accordingly, Reclamation has begun a pleasing examination effort with the objective of adding to another, physically-based, best in class numerical model for mirroring the strategy of dam crack. The new model should be material to embankment dams broke by overtopping or channeling. This model will progress upgraded examination of dam-break surges that will provoke better depiction of dam perils and more commonsense plan of dam security issues. Early cooperators in this effort join the Department of Interior/Reclamation Dam Safety Program, the National Weather Service, and the Pacific Gas & Electric Company (PG&E). The Agricultural Research Service is furthermore looking for after equivalent targets and has starting now been a specific assistant in this effort. The beginning stage in this investigation effort was to direct an audit of the present written work to recognize energy break figure frameworks, case histories, and related progressions, and to focus the future examination tries for most compelling favorable position. This report shows the delayed consequences of the written work review. The report begins by taking a gander at dam-break surge evaluating all things considered and the importance of dam crack parameter gauge. The report then overviews in advance recorded dam frustration relevant examinations, new logical examinations, and the break parameter estimate schedules in perspective of those data. Vital instruments in burst improvement and progression are recognized from the chronicled context oriented examinations and past examination office testing, and existing physically-based dam break models are researched in this association. Finally, a structure is plot for another dam break model, parts of the model are recognized, and research needs are compresse.

Since there is no distinct system for keeping a dam disappointment as potential for loadings surpassing configuration points of confinement can never be wiped out, another crucial piece of danger alleviation is recreating potential disappointments and arranging. The relief of the effects to the best conceivable degree obliges displaying of the surge with adequate detail to catch both the spatial and worldly advancements of the surge occasion, too of the speed field. The determination of a fitting model to accurately mimic dam-break surge directing is consequently a key statement.

1.2.1. REASONS FOR FAILURE OF DAMS

- Sub-standard development materials/methods (Gleno Dam)
- Spillway plan slip (South Fork Dam, close disappointment of Glen Canyon Dam)
- Topographical unsteadiness created by changes to water levels amid filling or poor looking over (Malpasset Dam).
- Sliding of a mountain into the store (Vajont Dam – not precisely a dam disappointment, but rather brought on almost the whole volume of said supply to be dislodged and overtop the dam)
- Poor upkeep, particularly of outlet funnels (Lawn Lake Dam, Val di Stava dam breakdown)
- Great inflow (Shakidor Dam)
- Human, PC or plan slip (Buffalo Creek Flood, Dale Dike Reservoir, Taum Sauk pumped capacity plant)
- Interior disintegration, particularly in earthen dams (Teton Dam)
- Seismic tremo

Some images of dam failure are given below.

Fig-1

Fig-2

1.3. SOFTWARES USED

During the research work the different types of softwares used are MATLAB and FORTRAN for numerical analysis and programming and another software HEC-RAS f or comparision between the results and the mathematical equations used in all cases.

1.3.1. MATLAB

Matlab known as framework research center is fourth-era programming dialect with multi-ideal model numerical registering environment, grew by math lives up to expectations. This product can do all the numerical capacity like controls of framework, plotting of limits and data, execution of computations, development of customers interfaces, and interfacing with ventures written in diverse vernaculars, including c,c++, java, fortran and python. Notwithstanding the way that matlab is proposed primairily for numerical handling, an optional toolbox uses the MuPAD ordinary engine, allowing access to run of the mill engine, allowing access to normal enrolling capacities. An additional pack, simulink, incorporates graphical multi-space diversion and model-based arrangement for dynamic and embedded system.

1.3.2. FORTRAN

Fortran (already FORTRAN, got from Formula Translating System) is a universally useful, basic programming dialect that is particularly suited to numeric processing and exploratory registering. Initially grew by IBM in the 1950s for investigative and building applications, Fortran came to command this region of programming at an early stage and has been in ceaseless utilization for over a large portion of a century in computationally concentrated regions, for example, numerical climate expectation, limited component analysis,computational liquid flow, computational material science and computational science. It is a standout amongst the most prominent dialects in the region of elite processing and is the vernacular used for activities that benchmark and rank the world's speediest supercomputers.Fortran includes a genealogy of variants, each of which advanced to add expansions to the dialect while normally holding similarity with past renditions.

1.3.3. HEC-RAS SOFTWARE

HEC-RAS stands for Hydrologic Engineering Cente-river Analysis System which is has an executable code and documentation created with U.S. central Government assets and is accordingly in the general population space. This product permits you to perform enduring stream, flimsy stream figuring, silt transport/versatile bed calculation and water temperature modeling.

HEC-RAS is to help water driven specialists in channel stream examination and floodplain determination. The consequences of the model can be connected in floodplain administration and surge protection studies. The essential method utilized by this product is to process water surface profiles accepting an unfaltering, progressively changed stream situation, and is known as the immediate step system. The fundamental computational system is taking into account an iterative arrangement of the vitality mathematical statement: , which expresses that the aggregate vitality (H) at any given area along the stream is the total of potential vitality (Z + Y) and dynamic vitality (mV2/2g). The adjustment in vitality between two cross-areas is called head misfortune (hL). Given the stream and water surface rise at one cross-segment, the objective of the immediate step system is to figure the water surface height at the neighboring cross-area. Whether the reckonings continue from upstream to downstream or the other way around, relies on upon the stream administration.

1.4. OBJECTIVES OF THE RESEARCH

From the literature survey it is inferred that there is less work involved in numerical solution of shallow water equation that represents a dam break flow, so this research includes the writing up a code language for simulation of a shallow water flow. My research includes

- Discretization of shallow water equation using MacCormak’s predictor-corrector method by application CFD tool.
- Using this absolute advanced aberration adjustment to a accustomed river access i.e. to authenticate the abeyant of the methods acclimated in this research, models are activated to simulate a practical case.
- Applying MATLAB and fortran for writing the coded programs for getting the outputs and resultsof a dam break flow.

- Comparison of this aftereffect acquired from present access with HEC-RAS Computer model by considering a practical case of a dam break flow.

1.5. THESIS OUTLINE & RESEARCH METHODOLOGY

The whole thesis comprises of total seven numbers of chapters. Mainly chapter 1 consists of general introduction, chapter 2 comprised of literature survey about the past works.The research methodologyis described in chapter 3 and model validation, outputs, result comparison among the softwares, practical case analysis are described in Chapter 4. In chapter 5 the discussion of results are done with the future scope of work and chapter 6 consists of references used during the research work and writing of thesis.

In this thesis, I have researched about the numerical methods for analyzing the water flow due to dam break. When a dam breaks how the water flows, its behavior, the types of waves formed are analyzed by taking the partial differential equation that represents the type of flow that occurs after the above phenomena. The PDE that represents this type of flow is known as Shallow water equation that is derived from the N-S equation with some assumptions. By discretising the systems of equation of SWE with required and proper boundary conditions and initial conditions a numerical analysis is done. By the help of finite difference method with different time and space steps the discretised systems of equations are converted into the programming language.

Then this numerical model or programming is validated with a benchmark problem of dam break, of which analytical solution is available. Then the results are validated. After that the outputs of a practical dam break case is considered, which are analysed by the software HEC-RAS then the mathematical equations used behind both the solutions are compared with each other. The different governing equations for both the cases, method of solution like conservative and non-conservative, thn the numerical methods used for the solution are compared and discussed. Mainly the type of time steps, spacing and stability of the outputs, detailed output at different intervals etc are compared and analysed with the othr software used.

The numerical method used is The finite difference approximations for derivatives which is one of the simplest and of the oldest methods to solve differential equations.

It embodies in approximating the differential head by supplanting the subordinates in the scientific explanation using differential leftovers. The region is allocated in space and in time and close estimations of the plan are handled at the space or time centers. The slip between the numerical game plan and the precise course of action is controlled by the oversight that is commited by going from a differential overseer to a qualification head. This slip is known as the discretization bumble or truncation error. The term truncation failure reflects the way that a restricted bit of a Taylor plan is used as a piece of the appraisal.

$$f'(x)_{h} = \lim 0 \frac{f(x+h)-f(x)}{h} \quad (1.1)$$

$$\frac{f(x+h)-f(x)}{h} = f'(x)+\frac{hf'(x)}{2!}+h^2\frac{f''(x)}{3!}+\ldots = f'(x)+o(h') \quad (1.2)$$

$$f'(x) = \frac{f(x+h)-f(x)}{h} \quad (1.3)$$

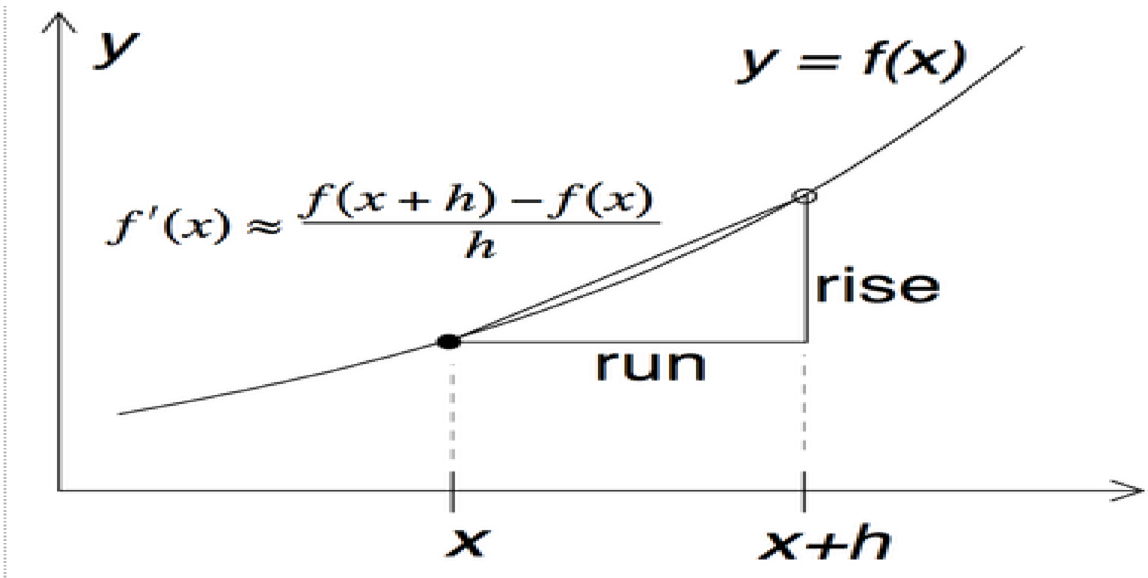


Figure 1: Illustration of the approximation $f'(x) \approx \frac{\text{rise}}{\text{run}} = \frac{f(x+h)-f(x)}{h}$, increasingly accurate as $h \to 0$.

Fig-3

Then MacCormak method from the finite difference method is used to discretised the shallow water equation for formulating the program in matlab and fortran coding language. Then validation of the model is done using a bench mark problem then a practical case is analysed using all the softwares and the results, outputs are discussed with comparison. MacCormack method is multistep method and good for solving nonlinear equations. Elaborate description about the above method is presented inside the thesis.

CHAPTER-2

LITERATURE REVIEW

2.1. OVERVIEW

Researcher and specialists are doing and drawing nearer a wide range of courses for understanding numerical strategy in water assets designing. The systems are all that much complex on account of examination of a dam break stream. Yet, among them some are straightforward and foresee the surge wave by reproduction process. Researchers and analysts are drawing closer a superior created strategy step by step by adjusting the past one. In computational liquid motion, the comparison used to speak to the stream of water after dam break is known as Shallow water mathematical statement that is determined type of N-S mathematical statement. A percentage of the works and investigation of dam break stream utilizing numerical mehods done by distinctive researchers are talked about beneath.

2.2 . PREVIOUS WORK ON NUMERICAL SIMULATION OF DAM BREAK

Tsang-Jung Chang, Hong-Ming Kao, Kao-Hua Chang, Ming-Hsi Hsu(2014) taken a shot at numerical reproduction of shallow water dam tear streams in open channels utilizing smoothed molecule hydrodynamics . a work less numerical model is proposed to research shallow water dam tear streams in 1d open channels. The numerical model is to comprehend the shallow water euations (SWE) in light of smoothed particle hydrodynamics(SPH). The numerical affectability investigation is initially performed to study the proper SWP number and variable smoothing length through dam break streams in an admired 1D channel with dry/wet beds.

Hamid Reza Vosoughifar, Azam Dolatshah and Seyed Kazem Sadat Shokouhi (2013) recreated both wet and dry bed dam break issues. A high determination limited volume system (FVM) was utilized to unravel the one dimensional (1D) and two-dimensional (2D) shallow water mathematical statements (SWEs) utilizing an unstructured Voroni network lattice. Numerical Flux at cell interfaces are figured by the strong nearby Lax- Friedrichs (LLxF) METHOD.

Jafar Bagheri1 and Samir K Das(2013) taken a shot at insecure two-dimensional (2D) non-straight shallow-water comparisons (SWE) in preservation law structure to catch the liquid stream on the move. Numerical reproductions of dam-break surge wave in channel moves have been performed for inviscid and incompressible stream by utilizing two new understood higher-request minimal (HOC) plans. The calculation is second request exact in time and fourth request precise in space, on the nine-point stencil utilizing third request non-focused distinction at the divider limits. To understand the arithmetical framework, bi-conjugate slope balanced out method(BiCGStab) with preconditioning has been utilized. Albeit, both the plans have the capacity to catch both transient and relentless state arrangement of shallow water mathematical statements, the plan communicated in progressive law structure is unequivocally steady. The model results have been approved for dam break issue and contrasted and the test information for dry and wet bed conditions.

M.F. Ahmada, M. Mamat, W.B. Wan Nika and A. Kartonoc(2013)described about a numerical scheme in order to overcome the problem of shock wave for the test case of dam break. This method is based on the Godunov approach of finite volume method to solve the shallow water equation. In order to expedite and improve the solution an approximate Roe's Riemann solver associated with Monotone Upstream-centered Scheme for Conservation Laws(MUSCL) was applied. The results were presented in one and two dimensional and verifications were made with analytical solution. The results are comparable and a good agreement is achieved between numerical and analytical.

M S Lariyah, M Vikneswaran, B Hidayah, Z C Muda, S Thiruchelvam, A K Abd Isham, H Rohan(2012) have done research on most extreme release from the dam amid the likely greatest flood(PMF). The Spillway is worked to keep the dam from disappointment because of overtopping, which can prompt dam disappointment and that may bring about a broad harm to downstream region with loss of human life and properties inside of a brief time of time.

Szu-Hsien Peng(2012) worked on 1D and 2D numerical displaying for tackling dam break stream issues utilizing limited volume system which purposed to model the stream development in a romanticized dam break design. One dimensional and two-dimensional movement of a shallow stream more than an unbending slanted bed is considered. The reproductions are accepted by the correlation with flume tests. Unstable dam-break stream development is discovered to be sensibly very much caught by the model. This idea can be further created to the numerical estimation of non-Newtonian liquid or multilayer liquid stream.

Sun Guangacai Wei Wenli Y.L. Liu(2010) inquired about on numerical plan for reproduction of 2D surge waves concerned with a scientific model for numerical reenactment of 2D surge waves because of complete or halfway dam-break. The administering water comparisons are understood by an implied bi-askew numerical plan, in view of the MacCormack's indicator corrector system. The scientific model is utilized to numerically process the water surface from supercrtitical one in arectngular open channel; and the numerical results are contrasted and the hypothetical results.

C. Biscarini,S. Di Francesco and P. Manciola(2010) have taken a shot at numerical recreations of free surface streams prompted by a dam break contrasting the shallow water approach with completely three- dimensional reproductions. The arrangements are taking into account the arrangement of the complete arrangement of Reynolds-Averaged Navier-Stokes (RANS) mathematical statements coupled to the volume of fluid(VOF) system.

Changhong Hu and Makoto Sueyoshi(2009) presented two novel numerical reckoning systems coming about because of numerical reenactment of dam break test for firmly nonlinear wave body cooperation issues, for example, boat movements in unpleasant oceans and coming about green water affect on deck taking into account Cartesian matrix strategy.

Dongfang Liang, Binliang Lin and Roger A. Falconer(2006) presented a proficient numerical plan for comprehending the SWEs(shallow water mathematical statements) in ecological stream; which incorporates the expansion of five-point symmetric aggregate variety diminishing(TVD) term to the corrector venture of the standard MacCormak plan. The discretisation of the moderate and non-traditionalist types of the SWEs prompts the same limited distinction plan when the source term is discretised in a certain manner. The bed grinding is incorporated by neighborhood water profundity either expressly or certainly with reproduction of wetting and drying process all the while.

S.Farzin, M. Alizadeh and Y. Hassanzadeh(2002) considered about numerical reenactment of precarious one-dimensional dam break stream utilizing TVD MacCormack Scheme. Dam break sensation is still of vital essential issue in the field of water powered designing. Anticipating the basic conditions because of dam-break streams shows more field studies prerequisite. The MacCormack numerical plan is a traditional second request unequivocal plan for the recreation of flimsy dam-break streams. It is no doubt understood that traditional second request plans show oscillatory conduct close discontinuities and can produce or keep up a stun in the arrangement.

J.S. Wang, H.G. Ni and Y.S. He(2000) depicted around a second-crossover kind of aggregate variety reducing (TVD) limited contrast plan is examined for understanding dam-break issues. The plan is based upon the first-arrange upwind plan and the second-arrange Lax-Wendroff plan, together with the one-parameter limiter or two-parameter limiter. A similar investigation of the plan with diverse limiters connected to the Saint Venant euations for 1D dam break waves in wet overnight boardinghouse bed cases demonstrate a few distinctions in numerical execution. An ideal chose limiter is gotten. The present plan is stretched out to the 2D shallow water comparisons by utilizing an administrator part procedure, which is approved by contrasting the present

C.Zoppu and S. Roberts(1999) depicted around a numerical model for the arrangement of the two-dimensional dam–break issue. This model is in light of a second-request surmised Riemann solver with a van Leer sort limiter is utilized to unravel the shallow water wave mathematical statement on a Cartesian network. The shallow water comparisons incorporate source terms which represent imperviousness to the stream and the impact of the bed slant or slope.

P. Brufau and P. Garcia-Navarro(1993) taken a shot at numerical demonstrating of shallow water stream in two measurements that is broke down through dam break tests. Free surface stream in channels can be portrayed scientifically by the shallow water frameworks of mathematical statements. These euations have been discretised utilizing a methodology in light of unstructured Delaunay triangles and connected to the recreation of two-dimensional dam break streams.

C.V. Beiios, J.V. Soulis and J.G. Sakkas(1991) depicted around a second-half and half kind of aggregate variety lessening (TVD) limited contrast chipped away at two dimensional development of water on a dry bed because of immediate dam break. They inspected it numerically and likewise relentless state stream arrangements are analyzed to accept the precision of proposed numerical plan.

CHAPTER-3

RESEARCH METHODOLOGY

3.1. OVERVIEW

There are a wide mixed bag of physical phenomena which are administered by numerical models of supposed Shallow water sort. A cluster of issues of viable interest includes water streams with the free surface because of gravity. Displaying of sea tides, breaking of waves on shallow shorelines, move waves in open channels, surges in stream, surges and breaking of a dam wave incorporates that critical class of issues. Shallow water mathematical statements have been generally used to model waves in streams, lakes, seas and environment. This SWE can be utilized to model gravity waves in a littler area, i.e surface waves in a shower. Dam break is characterized as a disastrous disappointment of dam prompting uncontrolled arrival of water creating surge along the downstream. The examination of the above wonder is essential to catch spatial and transient advancement of surge occasion and wellbeing investigation. Utilizing SWE the sort of stream that is created because of dam break can be examined. Since the wavelength of the water discharged because of dam break is much higher than the vertical measurements of the bowl identified with the wonder. Particularly Shallow water sort models are suitable to depict and clarify tides which have extensive length scales (over several kilometer).

3.2. SHALLOW WATER EQUATION

This Shallow water equations or Saint-Venant system are derived from the three dimensional incompressible Navier-stokes equations with some simplifying assumptions. The main operation giving SWEs from N-S is an average over the vertical, however the existence of non linear terms require some assumptions and approximations. Firstly it is assumed that the pressure is hydrostatic, means the acceleration due to the pressure balances gravity. And the second assumption is the water depth is much smaller than the characteristic horizontal size of the field of study. Third, it is supposed that the vertical velocity is negligible and thus has no equation. After all the above assumptions the N-S equations with mass constant volume and hydrostatic pressure wiil be averaged on the vertical by integration from the bottom to surface. In two dimensional system, the shallow water equations can be written as follows.

$$\frac{\partial h}{\partial t} + \frac{\partial}{\partial x} hu + \frac{\partial}{\partial y} hv = S \qquad (3.1)$$

$\frac{\partial}{\partial t}hu+\frac{\partial}{\partial x}\left(hu^2+\frac{gh^2}{2}\right)+\frac{\partial}{\partial y}huv$ = $-gh(S_{ox}-S_{fx})$ (3.2)

$\frac{\partial}{\partial t}hv+\frac{\partial}{\partial x}huv+\frac{\partial}{\partial y}\left(hv^2+\frac{gh^2}{2}\right)$ = $-gh(S_{oy}-S_{fy})$ (3.3)

In the first seconds of after the breaking of a dam even turbulence, viscous effects in the fluid and friction at the bottom can be neglected. Thus the above system of equations in 1D form can be represented as below.

$$\frac{\partial h}{\partial t}+\frac{\partial}{\partial x}hu=0 \quad (3.4)$$

$$\frac{\partial}{\partial t}hu+\frac{\partial}{\partial x}\left(hu^2+\frac{gh^2}{2}\right) = -gh(S_{ox}) \quad (3.5)$$

Where t is time, x and y are the space coordinates, h is the nearby vertical profundity of water, u and v are the profundity normal speeds along x and y bearings. S_0 the bed slant and g the gravitational steady. The source S relates to the volume of water accessible, in particular the contrast between the precipitation rate and the penetration rate. S_0 the bed inclines are figured straightforwardly with ground surface height z.

$$S_{0x} = \frac{\partial z}{\partial x} \quad S_{0y} = \frac{\partial z}{\partial y} \quad (3.6)$$

In the above system of shallow water equations the terms S_{fx} and S_{fy} which represents the friction terms; can be calculated by Manning's formula and Darcy-Weisbach's law from empirical considerations.

$$S_{fx} = K^2\frac{u\sqrt{u^2+v^2}}{h^{4/3}} S_{fy} = K^2\frac{v\sqrt{u^2+v^2}}{h^{4/3}} \quad (3.7)$$

$$S_{fx} = \frac{fu\sqrt{u^2+v^2}}{8gh} \qquad S_{fy} = \frac{fv\sqrt{u^2+v^2}}{8gh} \quad (3.8)$$

Where K and f are individually Manning's and Darcy-Weisbach's unpleasantness coefficient which rely on upon physical and normal properties, evaluated from alignment. The coefficients should be steady in time amid the thought.

The shallow water equations do not necessarily have to describe the flow of water. They can describe the behaviour of other fluids under certain situations. For example we can think of the atmosphere as a fluid. The equations governing its behaviour are the Navier-Stokes equations;

however, these are notoriously difficult to solve. Where K and f are individually Manning's and Darcy-Weisbach's unpleasantness coefficient which rely on upon physical and normal properties, evaluated from alignment. The coefficients should be steady in time amid the thought. The SWE have been applied to

Tsunamis prediction Atmospheric flows

Storm surges Flows around structures (pier)

Planetary flows

Fig-4

Fig-5

Fig-6

3.3 VARIOUS NUMERICAL METHODS

To solve this type of partial differential equations we have different types of numerical methods available with us. The methods are maintioned below.

1) Method of characteristics

2) Finite element method

3) Finite difference methods

4) Finite volume method

5) Spectral method

The numerical integration of nonlinear hyperbolic partial differential equations are solved mainly by FDM, FVM, FEM. For the analysis of shallow water equation representing a dam break flow in present research finite difference method is applied. So the detail study about the used method is given below.

3.3.1. METHOD OF CHARACTERSTICS

Method of characteristicsSystem for attributes grew by Monge (1789) is a graphical strategy for the answer for halfway differential comparisons . It is utilized for investigating open channels streams by Massau (1889) and Criya (1946) . In precarious stream issues and in addition in open channel stream issues this system is utilized to break down the engendering of surge waves in upstream and downstream. Often all are utilizing limited distinction conspired as a strategy to unravel shallow water comparisons for stream in open channels. The idea of attributes bends is for the most part connected in exploration field. It can be useful in comprehension the wave proliferation at upstream and along the stream. It is utilized for the unequivocal limited contrast strategies.

3.3.2. FINITE DIFFERENCE METHOD

The method for traits is used for both Finite difference methodology and Finite part framework. Finite difference method is the first technique for delivering for approximating standard differential numerical explanation. It is in light of performing Taylor course of action improvement and substituting the announcements into the differential numerical articulation. It in like manner exhibits the issue through a movement of characteristics at a particular point. It is the minimum complex methodology for realize in any routine differential numerical articulation where the inquiries are found by supplanting the auxiliary terms. As there is no fascinating course of action in numerical method, if the data (basic data and cutoff condition) are not known then it demonstrates a severely acted plan. With the objective that one will be sure about the poor result or can understand that the course of action will miss the mark.

3.4. GRID GENERATION

Before producing framework for limited distinction plan it is an imperative element to center that there are two systems in limited contrast plan. They are unequivocal and certain limited distinction plan.

3.4.1. EXPLICIT METHOD

Explicit method is a way in computational liquid motion utilized as a part of numerical examination for acquiring arrangements of time-ward conventional and in addition incomplete differential mathematical statements. It is needed in reproductions of physical process in surge steering, working issue. Explicit methods ascertain the questions at a later time interim from the known qualities at a present time arrangement. In the event that the n level stream parameters are known then express strategy figures for n+1 time level.

3.4.2. IMPLICIT METHOD

Implicit method is a way to deal with discover an answer by explaining one mathematical statement or a no of comparisons all the while including both the parameters of present time level and the following one. This systems require an additional calculation which is much harder to execute in the computation process.

Mesh formation for an explicit method applies little time ventures to minimize the blunder in the outcome limit. By considering numerical stability the consistent lattices are utilized as a part of space and time. Unfeasibly for such issues, unequivocal routines take a great deal less computational time to accomplish given precision yet bigger time steps utilized as a part of a verifiable technique. Unequivocal or understood system ought to be utilized relies on the issue which arrangement is to establish. To take suitable consistent framework size, it is obliged to check the solidness of finite difference plan.

3.5. STABILITY

The robustness or solidness of the unequivocal arrangement is controlled by the Courant-Fred riches Lewy (or Courant) condition. The Courant number (CFL), which is the extent of the physical speed of the wave to the rate of the numerical sign. It ought to be not exactly unity so the structure size will be found from that condition. Redesigned processings of the water stage is used to evaluate the celerity of the wave, c and for the water speed u, the discharge quality is used. Accordingly CFL condition is associated at each time step. This condition is executed at each time dare to survey the estimation of stream at the pushed time step. Numerically by this framework the time step must be kept adequately little so information will be by and large exact.

Mathematically

Courant no $=C_n=\frac{u\Delta t}{\Delta x}$ (3.9)

Where $0 \le C_n \le 1$ and

u is the velocity

Δx is the space interval

Δt is the time space

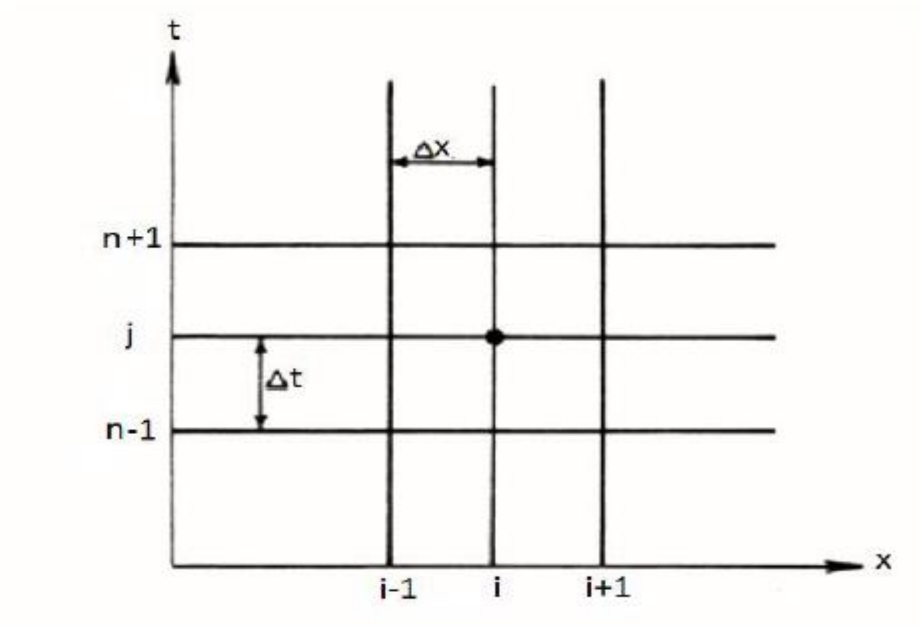


Fig-7

After era of consistent matrices in both space and time i.e. Δx and Δt the principle element for the estimate of the arrangement is to take after the standard of limited distinction technique. That is the subordinates in the fractional differential comparison are directly tackled by approximating the qualities for each lattice focuses with mixes of capacity qualities. In the event that u is the subordinate variable and x and t autonomous variables then approximating the first request subordinates for the space variables there are three techniques for express plan talked about below.

- Forward difference method

$$u_x \approx \frac{\partial u}{\partial x} \approx \frac{u_{i+1} - u_i}{\Delta x} \quad (3.10)$$

$$u_t \approx \frac{\partial u}{\partial t} \approx \frac{u^{n+1} - u^n}{\Delta t} \quad (3.11)$$

- Backward difference method

$$u_x \approx \frac{\partial u}{\partial x} \approx \frac{u_i - u_{i-1}}{\Delta x} \quad (3.12)$$

$$u_t \approx \frac{\partial u}{\partial t} \approx \frac{u^n - u^{n-1}}{\Delta t}$$ (3.13)

- Central difference method

$$u_x \approx \frac{\partial u}{\partial x} \approx \frac{u_{i+1} - u_{i-1}}{2\Delta x}$$ (3.14)

$$u_t \approx \frac{\partial u}{\partial t} \approx \frac{u^{n+1} - u^{n-1}}{\Delta t}$$ (3.15)

Where i and n are utilized as documentation of variables for the present space and time level separately and for the forward or next space and time level here we are utilizing i+1 and n+1. Essentially i-1, n-1 are the documentations for the past space and time level separately.

Approximating second request subordinates there is stand out system to be specific.

- central difference method.

$$u_{xx} \approx \frac{\partial^2 u}{\partial x^2} \approx \frac{u_{i+1} - 2u_i + u_{i-1}}{(\Delta x)^2}$$ (3.16)

$$u_{tt} \approx \frac{\partial^2 u}{\partial t^2} \approx \frac{u^{n+1} - 2u^n + u^{n-1}}{(\Delta t)^2}$$ (3.17)

3.6. MODELLING OF SHALLOW WATER EQUATION

To model the shallow water mathematical statement different numerical techniques, for example, express and verifiable limited distinction systems with higher-request minimized plan have been utilized by various specialists. The overseeing mathematical statements from 3.1-3.3 can be composed in progressive structure or non-moderate means disparity shape as

$$\frac{\partial U}{\partial t} + \frac{\partial F}{\partial x} + \frac{\partial G}{\partial y} = S$$ (3.18)

Where U ,F and G can be represented in vector form are

$$U = \begin{bmatrix} h \\ hu \\ hv \end{bmatrix} \quad F = \begin{bmatrix} uh \\ u^2h + gh^2/2 \\ uvh \end{bmatrix} \quad G = \begin{bmatrix} vh \\ uvh \\ vh^2 + gh^2/2 \end{bmatrix} \quad S = \begin{bmatrix} 0 \\ gh(S_{0x} - S_{fx}) \\ gh(S_{0y} - S_{fy}) \end{bmatrix} \qquad (3.19)$$

Here U denotes vectors containing the primitive variables h,u,v; F ang G are vectors written in flux form and are functions of U ; S is the source term. Here the system of SWE is solved by using MacCormack method.

3.6.1. MACCORMACK METHOD

Computational dependability, union, and exactness may be enhanced utilizing multistep (middle stride in the middle of n and n + 1) plans, for example, Richtmyer, Lax-Wendroff, also, McCormack routines. In computational fluid dynamics;the MacCormack system is a generally utilized discretization plan for the numerical arrangement of hyperbolic incomplete differential mathematical statements. This second-arrange limited contrast system was presented by Robert W. MacCormack in 1969.The MacCormack technique is rich and straightforward and program. The MacCormack system is a modification of the two-step Lax–Wendroff scheme yet is much less complex in application. This numerical method has accuracy of 2^{nd} order both in time and space.

This method consists of two steps one is predictor method and another is corrector method.

Here we consider U_i^* which is an intermediate step which is related to $U_i^{n+1/2}$

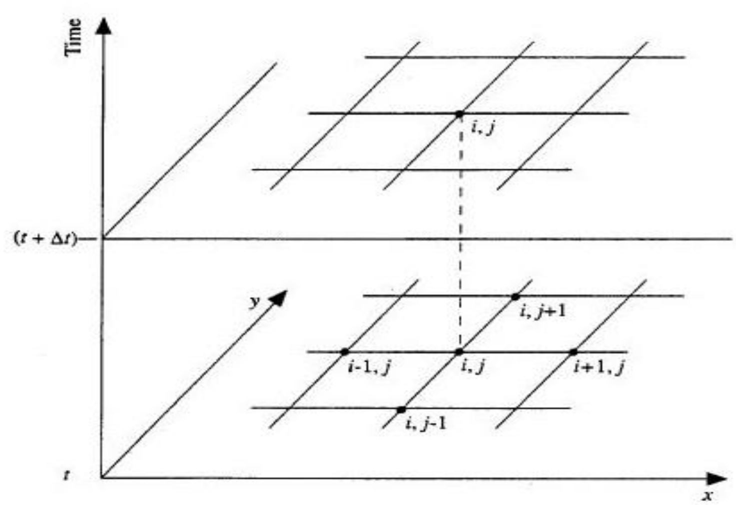


Fig-8

$U_i^{n+1/2} = ½(U_i^n+U_i^*)$ (3.20)

Step-1

$$\frac{U_i^*-U_i^n}{\Delta t} = -a\left(\frac{U_{i+1}^n-U_i^n}{\Delta x}\right) \quad (3.21)$$

Step-2

$$\frac{U_i^{n+1}-U_i^{n+1/2}}{\Delta t/2} = -a\left(\frac{U_i^*-U_{i-1}^*}{\Delta x}\right) \quad (3.22)$$

Substituting3.20 in to 3.22 yields predictor step

$$U_i^* = U_i^n - C(U_{i+1}^n - U_i^n) \quad (3.23)$$

Corrector step

$$U_{i+1}^n = ½[(U_i^* + U_i^n) - (U_i^* - U_{i-1}^*)] \quad 0(\Delta t^2, \Delta x^2) \quad (3.24)$$

C = stability correction factor criterion, c≤1

Finally MacCormack scheme is

Step-1 called predictor step

$$U_i^* = U_i^n - a\frac{\Delta t}{\Delta x}(U_{i+1}^n - U_i^n) + \frac{v\Delta t}{\Delta x^2}(U_{i+1}^n - 2U_i^n + U_{i-1}^n) \quad (3.25)$$

Step-2 called corrector step

$$U_{i+1}^n = ½\left[U_i^n + U_i^* - a\frac{\Delta t}{\Delta x}(U_i^* - U_{i-1}^*) + \frac{v\Delta t}{\Delta x^2}(U_{i+1}^* - 2U_i^* + U_{i-1}^*)\right] (3.26)$$

2nd order accurate with the stability requirement

$$\Delta t \le \frac{1}{\frac{a}{\Delta x}+\frac{2v}{\Delta x^2}} \quad (3.27)$$

$$\frac{\partial U}{\partial t} + \frac{\partial F}{\partial x} + \frac{\partial G}{\partial y} = S$$

The above equation (3.18) can be written in the following differential form

$$\frac{\partial U}{\partial t} = S - \frac{\partial F}{\partial x} - \frac{\partial G}{\partial y} \quad (3.28)$$

Now the above equation is discretised in its conservative format

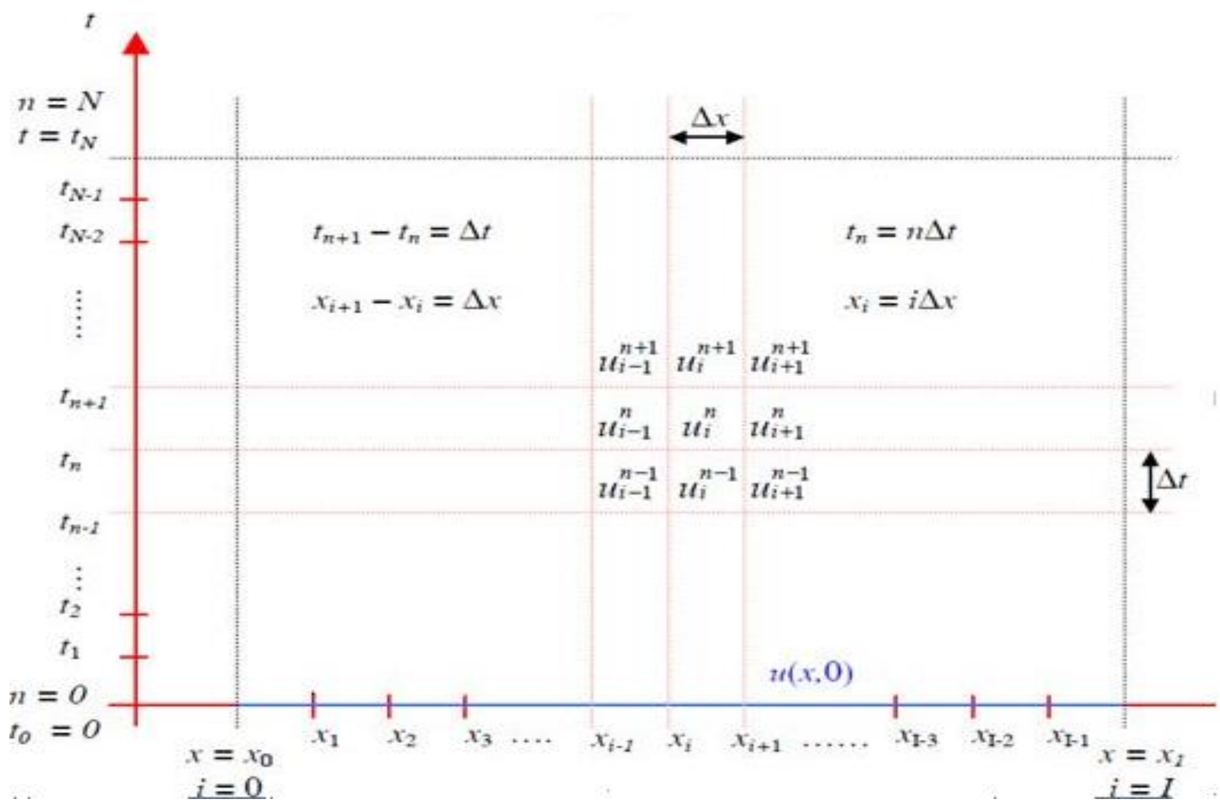


Fig-9

The above method is used to differentiate shallow water equation in the following steps.

- Predictor step:

Here we will calculate U at time t+Δt using known values at time t and forward differences.

$[U^{n+1}_{i,j}]_p = U^n_{i,j} + \Delta t(S(U^n_{i,j}) - [F(U^n_{i,j}) - F(U^n_{i,j})]/\Delta x - [G(U^n_{i,j}) - G(U^n_{i,j})]/\Delta y)$ (3.29)

- Corrector step:

$(\partial U_{i,j}/\partial t)^{n+1}_{cor} = S([U^{n+1}_{i,j}]_p) - [F([U^{n+1}_{i,j}]_p) - F([U^{n+1}_{i-1,j}]_p)]/\Delta x - [G([U^{n+1}_{i,j}]_p) - G([U^{n+1}_{i,j-1}]_p)]/\Delta y)$

(3.30)

Then, we have the solution at time step n + 1 with an average between the

predictor and corrector step

$U^{n+1}_{i,j}=\{U^{n}_{i,j}+[U^{n+1}_{i,j}]p\}/2+\Delta t/2(\partial U_{i,j}/\partial t)^{n+1}_{cor}$ (3.31)

Being second order accurate in space and time, it offers good resolution and has a great conceptual simplicity.

Before talking about the different numerical methodologies for approximating the SWE , we must characterize the cross section and after that take a gander at the numerical limit conditions needed to actualize the numerical methodologies accurately. We will utilize a settled work over the limited district $x_o \leq x \leq x_I$ and $0 \leq t \leq t_N$, Here, the numerical arrangement is meant by uin =u(i∆x, n∆t) where $\Delta x = x_i - x_{i-1}$ and $\Delta t = t_n - t_{n-1}$ for all i and n.

The computational space is discretized as xt =i∆ x and t n = n∆t , where x is the extent of a uniform lattice, andt is the time increase. The traditional limited contrast plan suitable for the discretization of Saint-Venant Eqs with source terms, is the unequivocal two stage indicator corrector MacCormack

SOLUTION ALGORITHM

- Initialize the height and velocity fields
- Evaluate the values of ∂F/∂x and ∂G/∂y by using forward and backward difference method at nth level or known value satisfying courant condition
- Evaluate the intermediate values at n+1/2 level by predictor method.
- Evaluate the new value for both ∂F/∂x and ∂G/∂y at n+1 level using the intermediate value got from predictor method,take the average of predictor and corrector value to get the new value.
- Take the new time step and proceed with repeating all the steps again.

CHAPTER-4

VALIDATION OF MODEL AND PRACTICAL CASE STUDY

4.1. MODEL VALIDATION

Acceptance and viability of the numerical model is tried utilizing the illustration of dam break for which a logical arrangement is available.For this relevant examination, a 2D midway dam break issue with unbalanced crack was considered. The computational space was described in a direct with 200m long and 200m in width. The break is 75m long and the dam is 15m in stature. The beginning upstream water significance is 10 m. The downstream water significance is 5m in a wet overnight boardinghouse in a dry bed. The brutality coefficient was acknowledged zero surmising a frictionless surface. In this example, a territory with 200 × 200 center centers, it was proposed and a time of 12was considered as the total time for the reckoning system

Schematic representation of the model

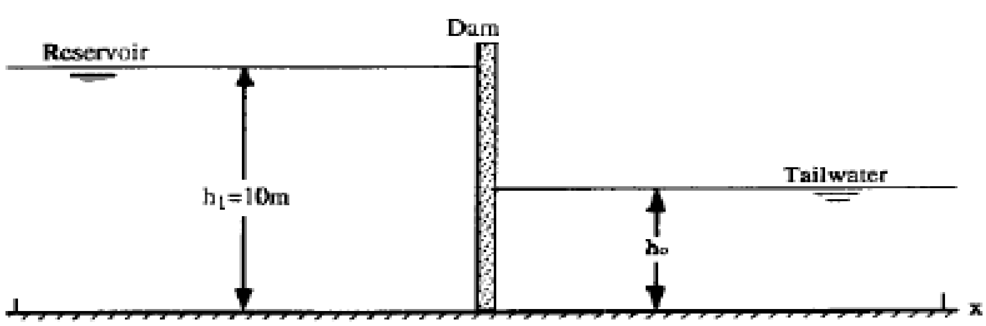


Fig-10

4.1.1 INITIAL AND BOUNDARY CONDITIONS

At time t = 0, the introductory conditions are given as followed

$h(x, y)\big|\ t=0 = h_0(x, y)$ (3.32)

$q_x (x, y)\ \big|t=0 = q_{x0} (x, y);\ \ q_y(x, y)\ \big|\ t=0 = q_{y0} (x, y)$ (3.33)

For a 2D dam-break issue, the basic water significance h_0 is by and large the irregular limit of bearings (i.e., it has a water rise contrast from the upstream to the downstream). The basic discharge fragments q_{x0} and q_{y0} are given as zero here as there is no stream before the dam break. For a general shallow water issue, the points of confinement of the computational zone have solid breaking points and open cutoff points. Because of solid confines, the managing numerical articulations do prohibit the turbulent thickness, however the base contact, free-slip conditions may be considered, and the regular discharge to the divider is arranged to zero in order to identify with no flux through as far as possible. Taking Δx=1m, Δy=1m, Δt=0.05.

For upstream stream profundity is equivalent to the stream profundity in the upstream supply. In any case, for downstream of the dam there are two sorts of conditions at the d/s of the dam.

(i)wet bed condition: where the genuine profundity existing at (t)=0 is determined as the starting condition.

(ii)dry bed condition: Zero stream profundity can't be utilized because of peculiarity issues. In this manner a little non-zero worth for stream profundity is indicated as the starting condition.

After discretization of the Shallow water comparison by utilizing MacCormak system matlab codes are composed for the reproduction of the above speculative dam break stream. The accompanying yields for water surface profiles are discovered with diverse time interims. From the yields it is realized that wave proliferation is all that much dependant on the proportion between tail water and store water.

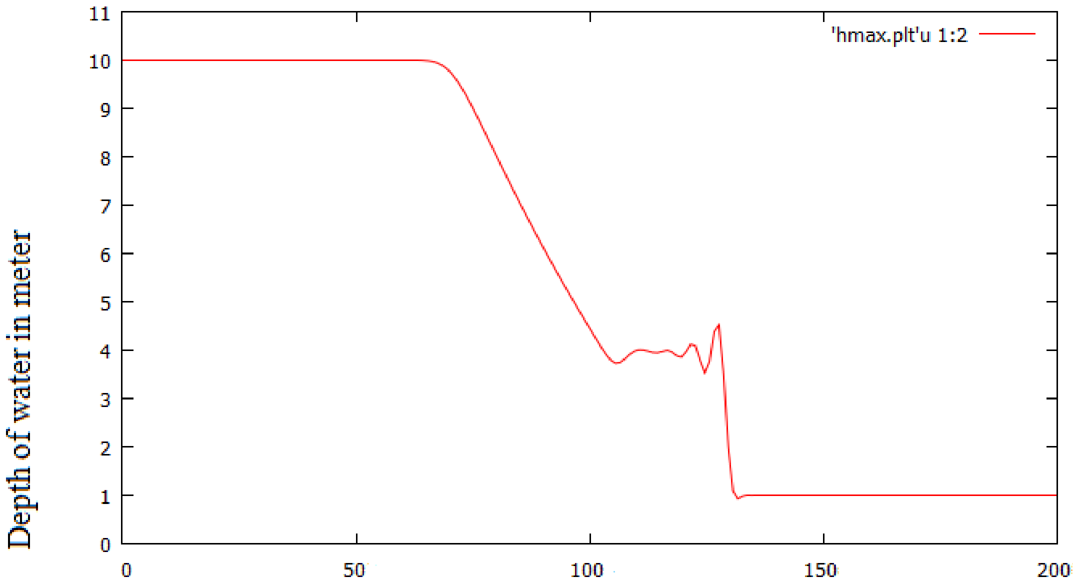
(iii) Wetting/drying Algorithm: now and again the mind boggling wetting/drying wonder is mimicked by forcing a meager layer of water crosswise over dry cells. Thusly, the calculation is constantly done all around paying little heed to the wet/dry condition. Notwithstanding, this straightforward treatment is not suitable for uneven ground circumstances, where the dry range must be perceived and rejected from the typical limited contrast calculation. Something else, water level slopes over moderately soak dry grounds will prompt preposterously huge speeds.

Toward the start of every stride, all the matrix focuses whose profundities are littler than an endorsed quality, Hmin, are viewed as being dry. The speeds are situated to zero at dry framework focuses. This drying procedure is trailed by wetting procedure, where the neighboring framework focuses around every dry matrix point are inspected.

The limit conditions at the downstream end are the same as the introductory conditions as far as profundity and speeds. The symmetry limits are dealt with at side walls.

4.1.2. OUTPUTS

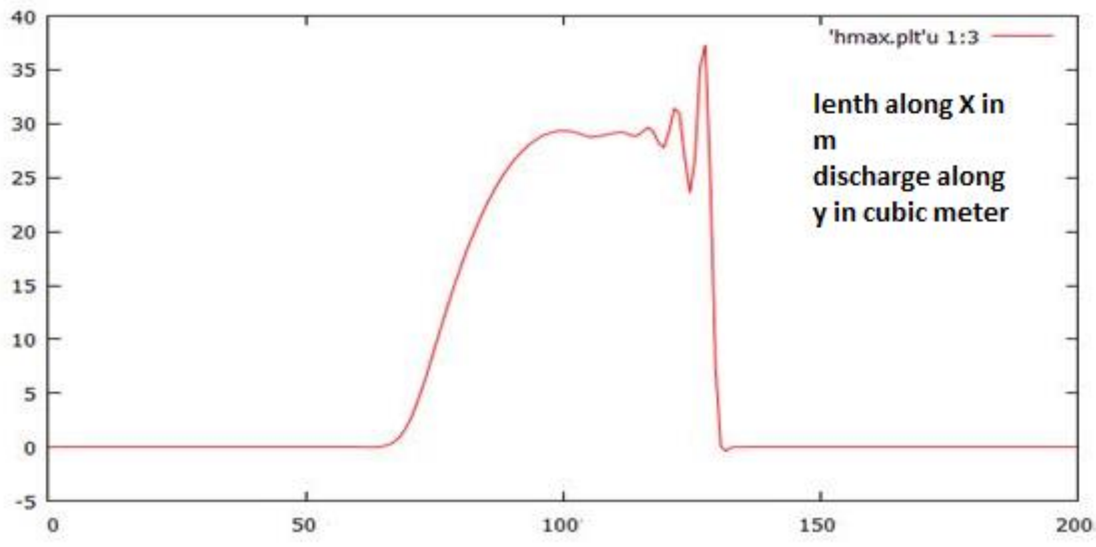
Water depth at different time along x direction from Fortran



Distance along the x direction

Fig-11

Discharge at different time along x



Distance along the x direction

Fig-12

Outputs from matlab

Water surface profiles at different time(3.5,s 8s,12s respectively)

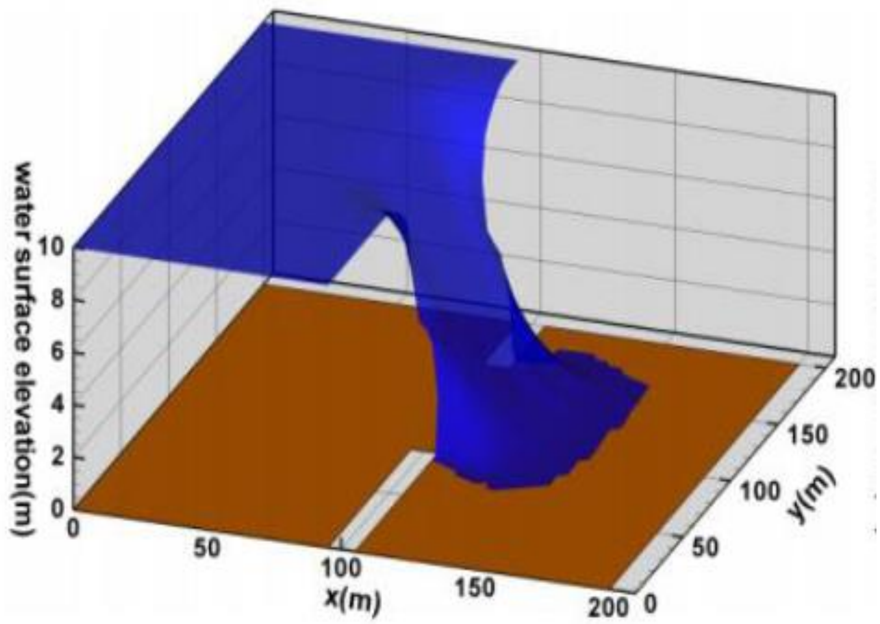


Fig-13

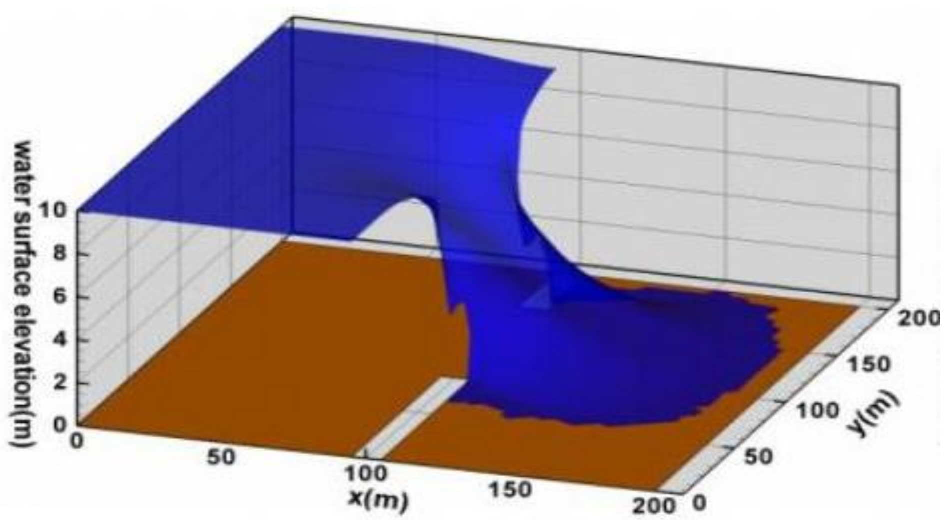


Fig-14

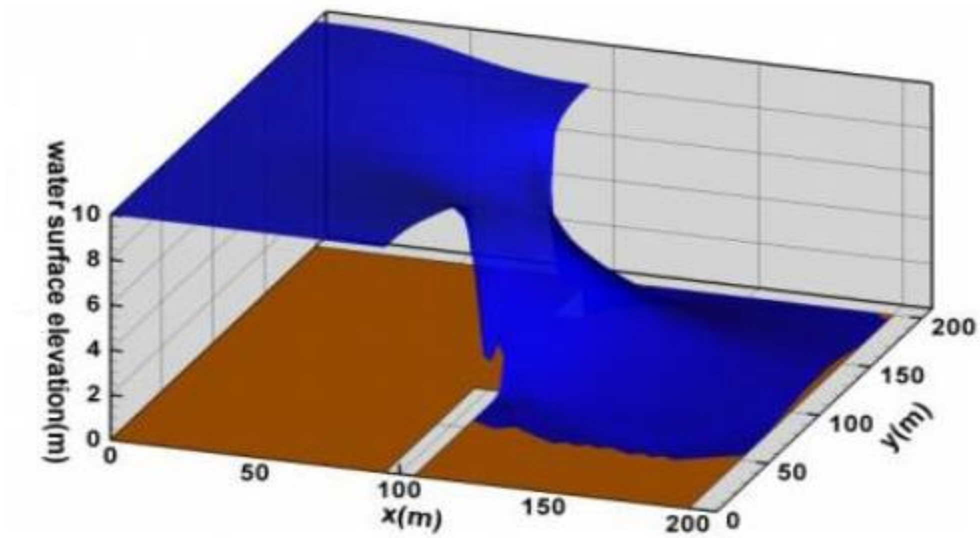


Fig-15

Water depth contours at different interval time

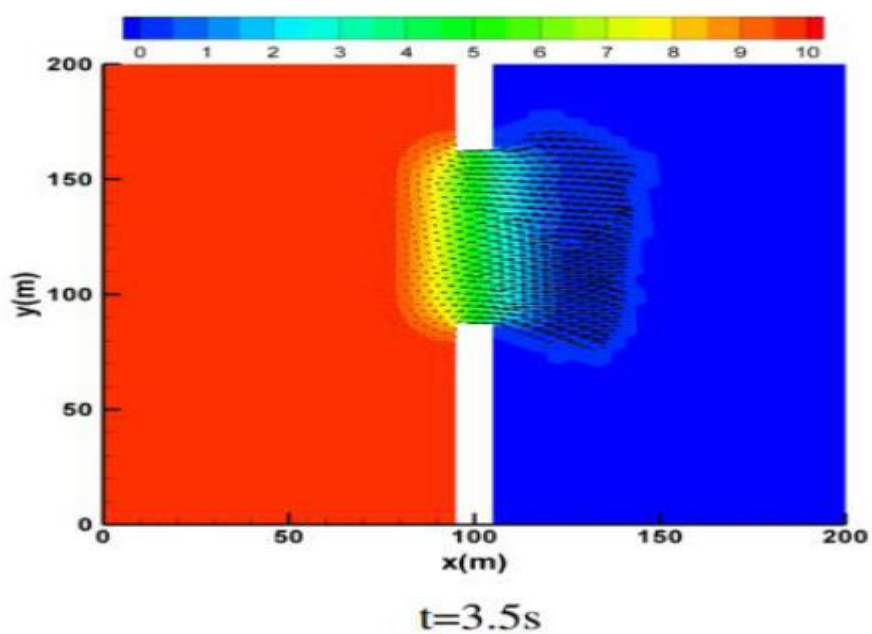
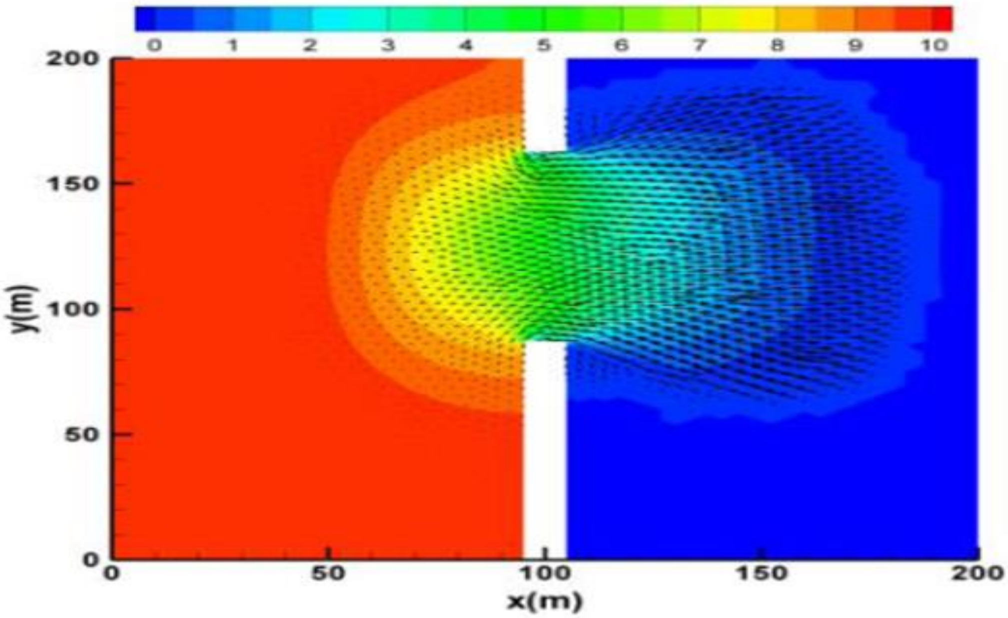
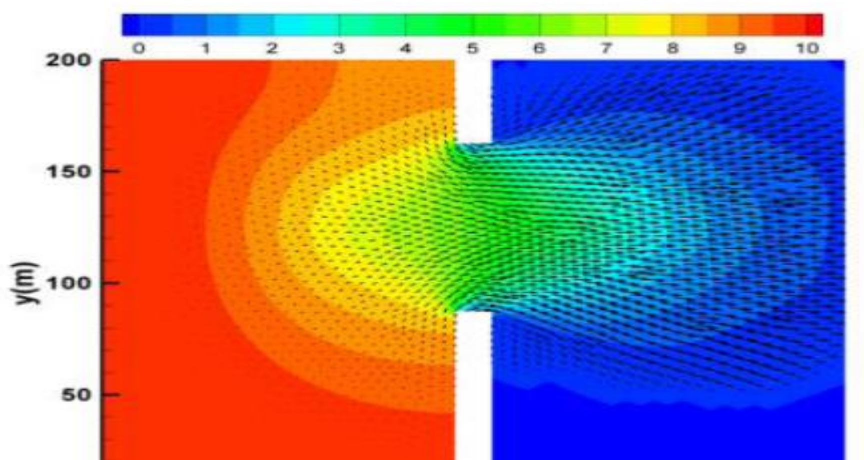


Fig-16



0
1
2
3
4
5
6
7
8
9
10
200
150
100
50
0
y(m)
0
50
100
150
200
x(m)

Fig-17



0
1
2
3
4
5
6
7
8
9
10
200
150
100
50
0
y(m)
0
50
100
150
200
x(m)

Fig-18

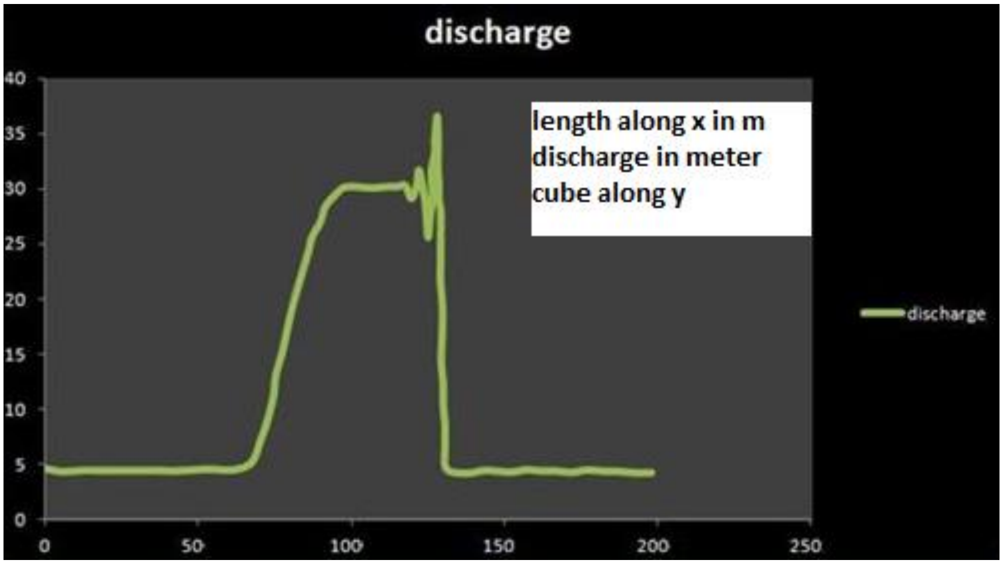


Fig-19

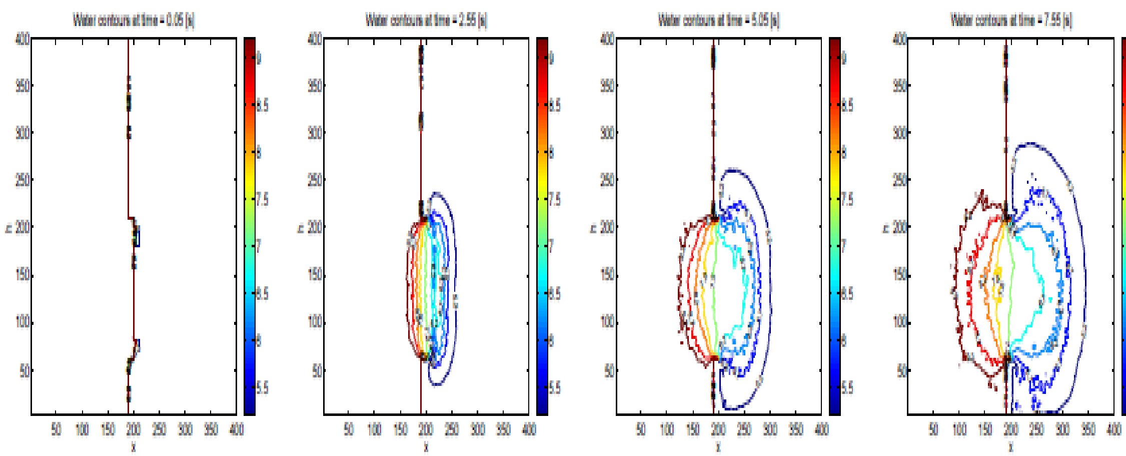


Fig-20

4.2. DISCUSSION OF THE RESULTS

From the outputs it is watched that at both closures of the break, the water profundities are littler than that at the focal point of the rupture. Stream isolates from the truncated dam dividers only downstream of the break and structures shape turning swirls. Water profundity profiles for wet overnight boardinghouse bed conditions are same till mid position of the upstream area and in this way water profundity profile of wet bed increments continuously towards d/s. surge wave ventures speedier with a reduction in the downstream water profundity. The wave front is seen to be more extreme when the d/s water profundity is bigger. Shape plots demonstrate that the wave engendering on a wet bed is speedier than on a dry bed. Then again, the wave front is seen to be more extreme when the downstream water profundity is bigger. What's more, the contact coefficient gets to be immaterial in a wet bed case. This is because of the way that the sorrows that are ordinarily filled by the surge wave as it goes by are presently officially loaded with water when the processing starts. In genuine applications, the erosion coefficient is a great deal more critical, particularly for the proliferation times. The impact of grinding on the greatest free surface is little, regardless of the fact that it is realized that the bring down the grating coefficient, the higher the rises. Because of this break a surge is framed and proliferates over the surge plain. At the same time, an in number gloom wave happens in the store and reasons the water surface close to the break to dive radically. In light of the impacts of limit reflection, water surface in the store sways fundamentally in the introductory stage. Nevertheless, corresponding rise in the downstream water levels is due to the imposition of higher water level during initial condition or wet bed.

4.3. ANALYSIS WITH HEC-RAS

This hypothetical case is solved by using hecras software for analyzing the results. The result are also given below. All the geometrical cross-sectional data are given. Then providing all the flow data, initial and boundary condition unsteady flow analysis is done.

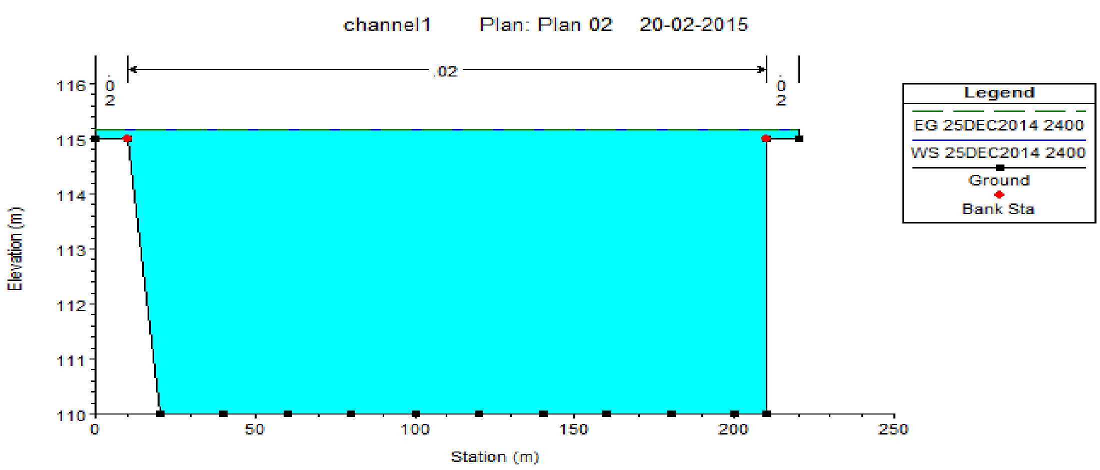


Fig-21

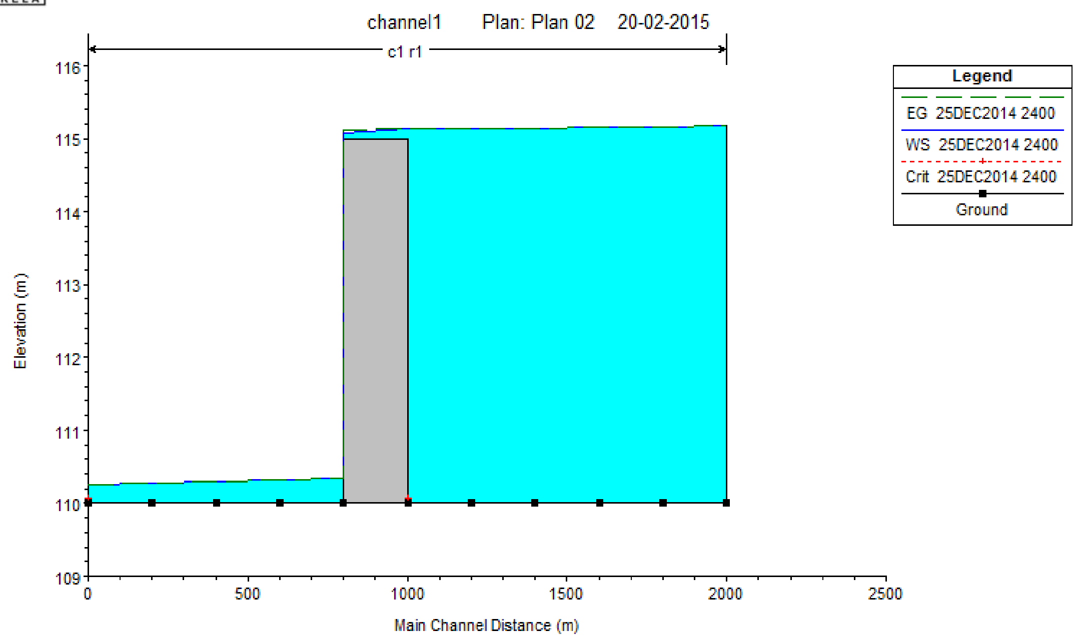


Fig-22

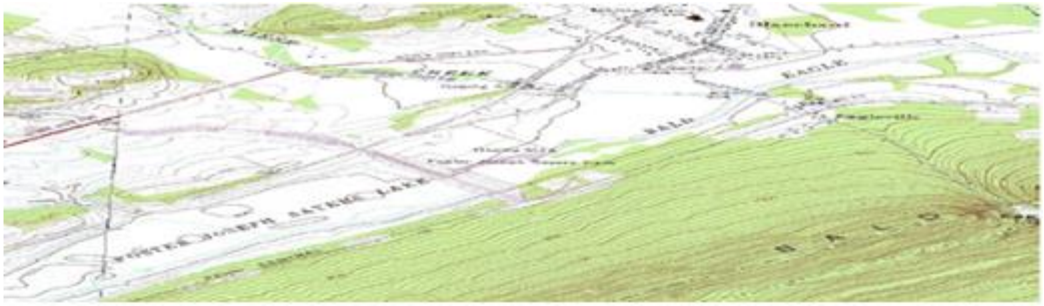
In this taking after issue, breaking happens rapidly with game plan of full break. As the basic conditions are broken a couple impediment are there for getting the marvel. The made estimation for understanding shallow water numerical proclamation in this investigation is second demand exact in both time and space. Introduction has been performed along y course while plotting. Results for both wet and dry bed conditions for downstream of the dam are demonstrated. The genuine water criticalness at t=0 is shown as the essential condition in the downstream.In the middle of this time the wave because of dam-break has not went to quite far. It can be seen that the water criticalness profiles for wet overnight boardinghouse bed condition stays same till mid zone of the upstream partition and thusly water hugeness profile of wet bed increases always towards downstream course. The wave front plainly demonstrates the impact of dam break closer to quite far for wet bed condition. It can be seen that water surface profiles show smooth move even with less number of structure center hobbies. At time t=0.5 s, the surge wave is yet to achieve the downstream range and in this manner water level stays at 0.0025 m. after t=1.0 s, the surge wave fundamentally reach downstream district beside couple of matrix facilitates close toward the most extreme. At time t=1.5 s, the surge wave achieves the downstream totally and drop in water level in quite far is seen. We consider four cases to blueprint the impact of surge wave for wet bed conditions for time t=0.5 s, 1.0 s, 1.5 s and 2.5 s and the taking a gander at water surface profiles are indicated freely. Like the dry bed conditions, the surge wave does not perform the downstream totally at time t=0.5 s and 1.0 s as indicated in Figures solely. Notwithstanding, relating move in the downstream water levels is a consequence of the injury of higher water level amidst starting condition (wet bed). Figures show that the wave because of dam-break has touch base at upstream end with massive diminishment in stream centrality and the change of wave front through numerical expansion.The results got from the above softwares are compared with each other. In numerical method we are discretising the conservative form of SWE by using MacCormack method. But the software HEC-RAS uses one dimensional Saint – Venant equation in non-conservative form. So the accuracy of theresults we got from matlab and fortran coding are better than hecras software.

4.4. PRACTICAL CASE STUDY

After this hypothetical case now we will go for practical dam break case study to exhibit the capability of the techniques utilized as a part of this examination, models are connected to simulate which will be analysed by both matlab and hecras software so that we can discuss the positive aspects of this numerical model and software. Foster Joseph Sayers Dam is arranged on Route 150 in Center County, PA, on Bald Eagle Creek around 1mile upstream from Blanchard and 14 miles over the mouth at Lock Haven. This 100-foot high and 1.3 mile long dam structures Foster Joseph Sayers Reservoir. The dam is a unit of a broad surge control wander for the security of gatherings in the West Branch Susquehanna River Subbasin.

This includes the study zone Reservoir framed by an earthfill dam with ungaged solid ogee weir at height 657.00 ft with adjoining solid gravity dividers and incompletely cleared way out channel. Capacity started in March 1971. Limit at height 657.00 ft is 99,100 section of land ft. Dead stockpiling is 25 section of land ft. Normal least (preservation) pool height is 610.00 ft limit, 6,300 section of land ft. Supply utilized for surge control and amusement. Regulation is proficient by two doors.

The above practical case is analysed through hecras model. In hecras for dam break analysis the data required are given as input and then computations are carried out. All the geometrical cross-section data of the river then dam are given step by step procedure. Then breaching data were given to breach the dam with a piping failure. Then unsteady flow analysis is carried out by giving all the initial and boundary conditions as inflow hydrograph, normal depth. After this computation procedure is carried out for the outputs. i.e. outflow hydrograph at d/s, rating curve, stage hydrograph, water surface profiles etc.



Topo map of sayers dam and vicinity area

Sayers dam in google map

F ig-23

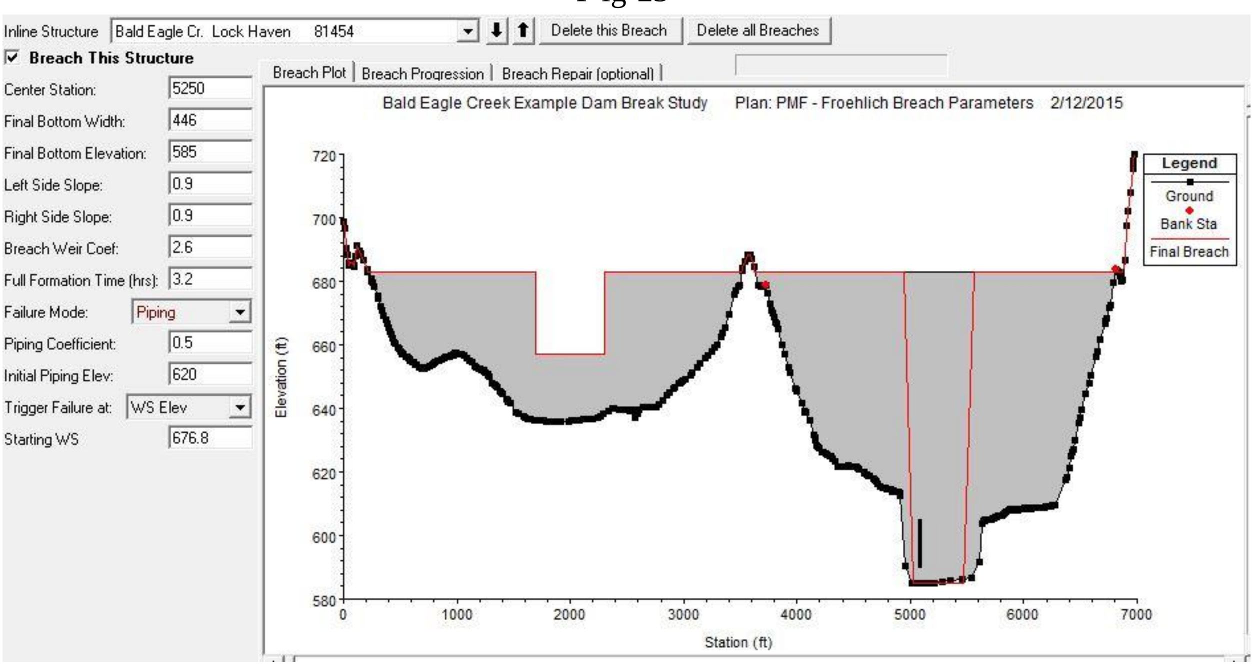


Fig-24

4.4.1. OUTPUTS

The outputs got from the HECRAS software are given below.

Cross-section

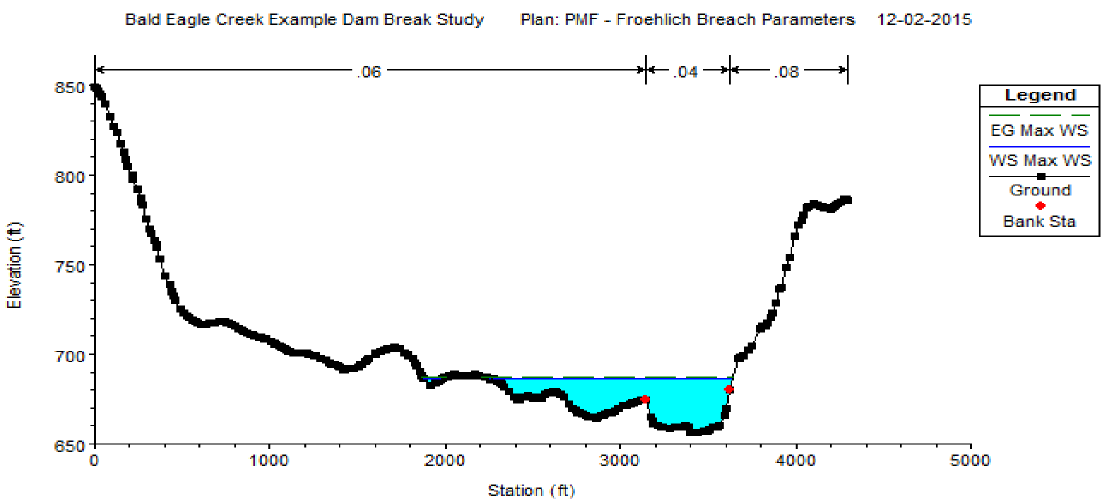


Fig-25

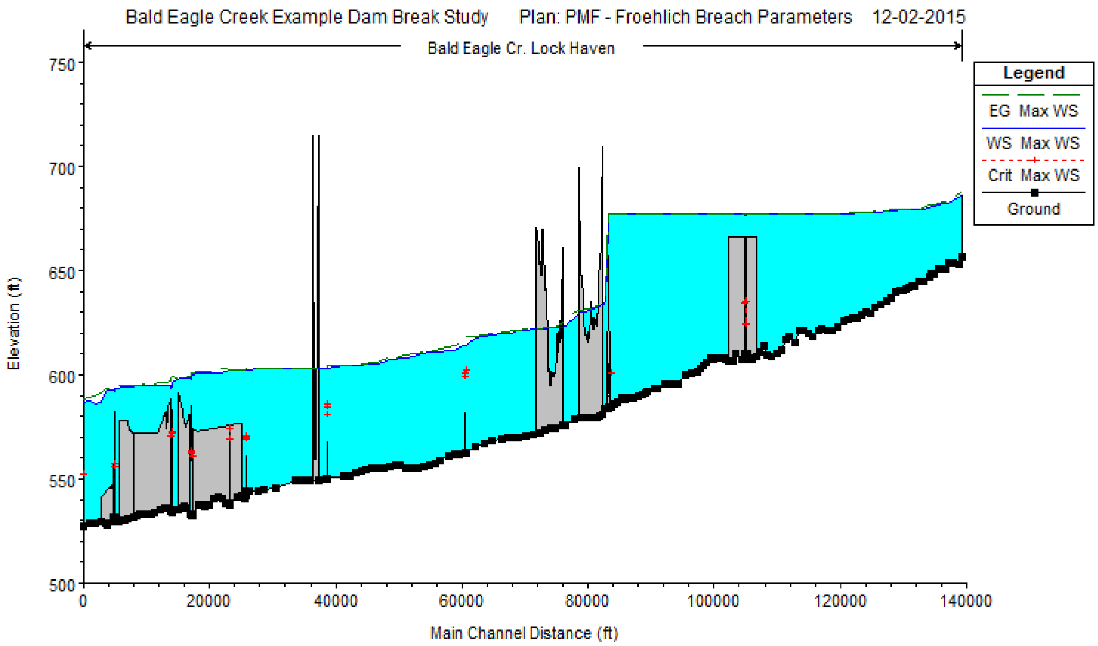

Bald Eagle Creek Example Dam Break Study   Plan: PMF - Froehlich Breach Parameters   12-02-2015
Bald Eagle Cr. Lock Haven
Legend
EG Max WS
WS Max WS
Crit Max WS
Ground
Elevation (ft)
750
700
650
600
550
500
0
20000
40000
60000
80000
100000
120000
140000
Main Channel Distance (ft)

Fig-26

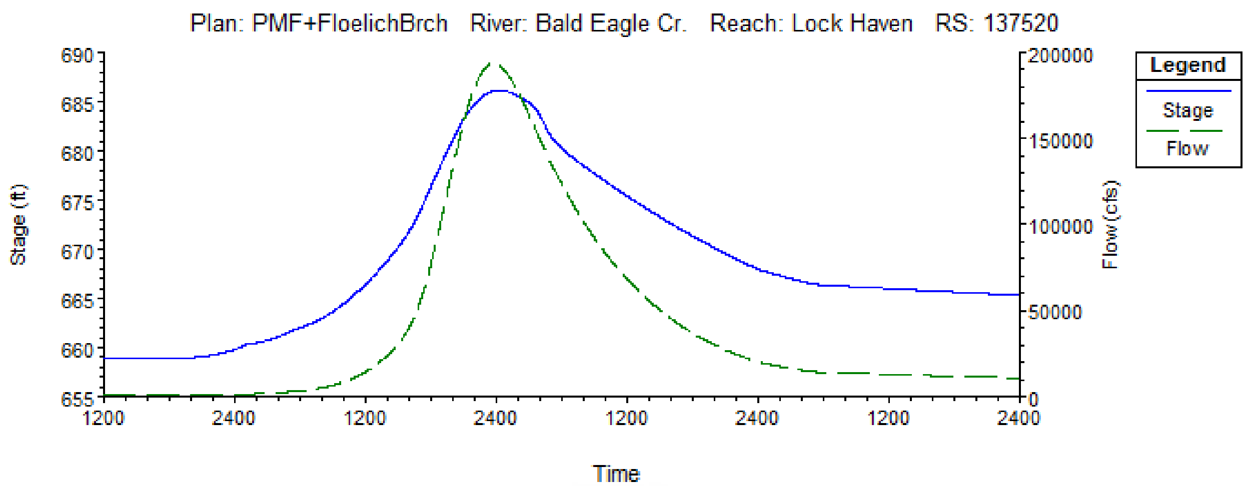

Plan: PMF+FloelichBrch   River: Bald Eagle Cr.   Reach: Lock Haven   RS: 137520
Legend
Stage
Flow
Stage (ft)
690
685
680
675
670
665
660
655
Flow (cfs)
200000
150000
100000
50000
0
1200
2400
1200
2400
1200
2400
1200
2400
Time

Fig-27

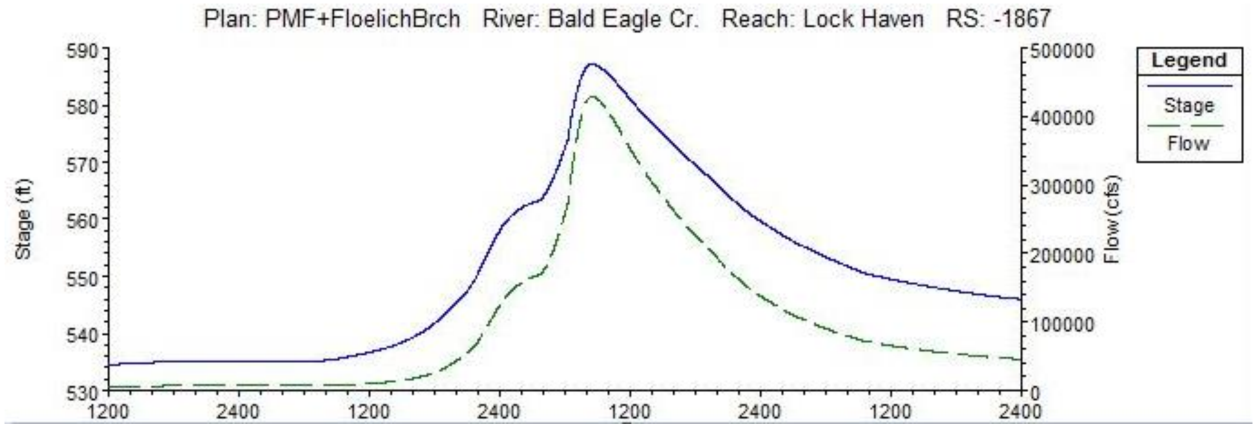


Fig-28

4.5. NUMERICAL ANALYSIS

After analysis of the above case in HEC-RAS software we will go for solving this in MATLAB software by the numerical method that is described above.

Data being available, both as measurements or bench simulations on a reducedscale model, they can be compared with the numerical results. Indeed, electric transformers have been shut down by the flood, giving a good estimate of the height and arrival time of the water at certain given points. Moreover, several points of given coordinates have been measured by the police to determine the water height. Finally, nine points (gauge points) have been measured thanks to a reduced-scale physical model. The coordinates of these particular points can be found. We base the comparisons on the gauge points in the present section.

4.5.1 MESH GENERATION

It is apportioned the x-t plane into amounts of grids that the grid break along the x-turn is and the system between time along the t-center point is . Despite the way that it is excess yet rather for less requesting estimation it is normal that, the lattice size is uniform along every center. For the space j level a subscript (i,j),(i+1,j), (i+2,j),(i+3,j), (i+4,j), (i+5,j), are used for various grids for space. For the time turn i level a subscript (i,j) ,(i,j+1), (i,j+2),(i,j+3), (i,j+4), (i,j+5), are used for particular lattices for time. To insinuate unmistakable variables at these cross section centers, the amount of the spatial system as a subscript and that of the time lattice as a superscript are used. The known time level is meant by superscript j and the dark time level is demonstrated by j + 1.

The soundness and security of numerical arrangement is ensured by the courant condition. For a settled spatial system ,the estimation of Δt satisfying the courant condition is determined. The networks are delivered by the courant's law i.e. $C_n = \frac{u\Delta t}{\Delta x}$ and the $0 \le C_n \le 1$ Where u is the velocity of the stream; Δx is network evaluate along the length, Δt is the time step.

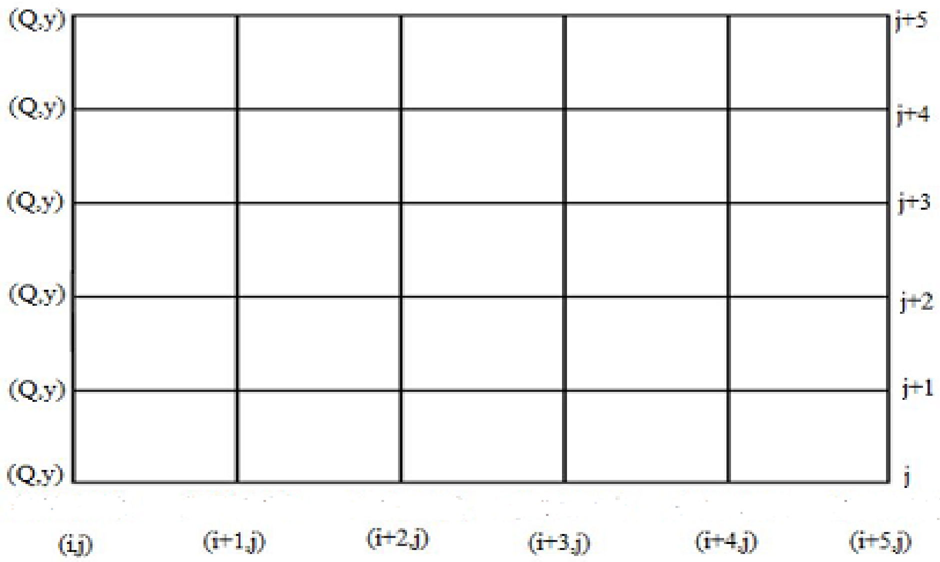


Fig-29

The processing procedure for the arrangements of the representing comparisons of movement is restricted to assessing them at a limited number of focuses along the channel. The two methodologies are here for processing inexact answers for these mathematical statements. To start with the qualities, at area of the focuses along the direct ahead of time level at upstream segment are settled. At that point the qualities are altered at those networks, that balanced as beginning condition required for the arrangement.

At that point the wide scope of the system for attributes are incorporated at upstream limit as it is expressly settles the arrangement. The trademark comparisons are tackled at the same time by the mathematical statements given for the upstream and downstream limit. Positive trademark structure is utilized at downstream limit and negative trademark type of the mathematical statements is utilized for upstream stream qualities as a part of unequivocal techniques, following in entire or to a limited extent on the x-t plane. In the technique for qualities, the areas and timesat which streams and rises are processed are unpredictable and differ as the stream is temperamental. This strategy is worthwhile with extraordinary precision.

4.6. INITIAL AND BOUNDARY CONDITIONS

BOUNDARY CONDITION

Definition of boundary condition is the assignation in a certain section of known values for which proceed in the calculus of the unknown is a critical passage of the analysis. The given discharge hydrograph at upstream site as afunction of time is taken as initial upstream boundary condition. Here the abscissa shows the time in hour and the flow values in series are indexed by the ordinate y.

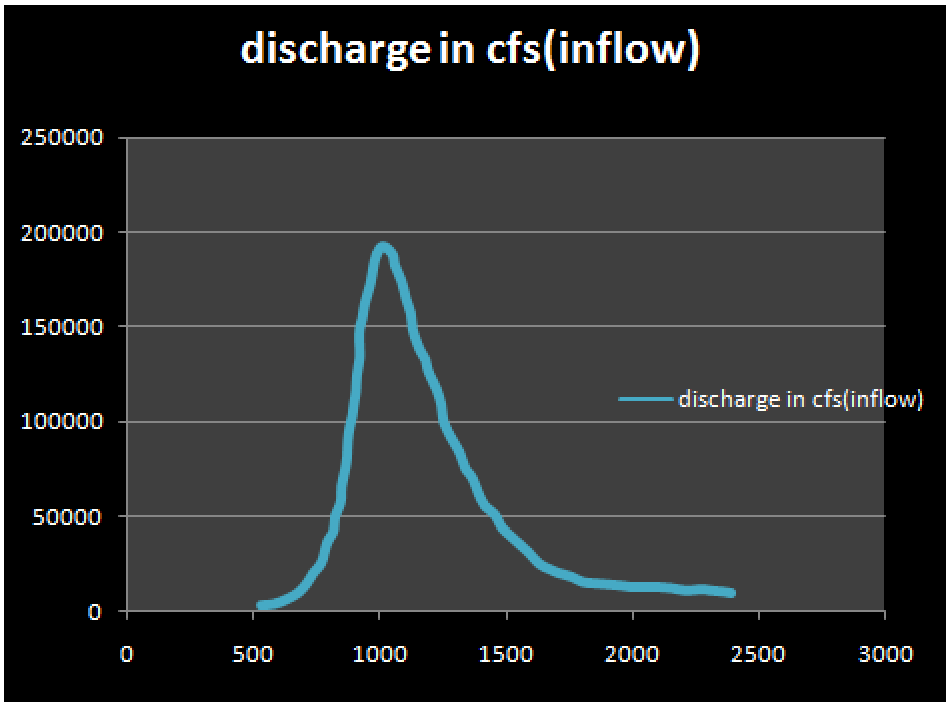


Fig-30

DOWNSTREAM BOUNDARY CONDITIONS

In this method at the end section or downstream where x=L, the normal flow depth is considered as the downstream end condition or downstream boundary condition.Normal flow depth is defined as the depth of stream or flow in a channel or river when the slope of water surface and channel bottom is constant or same and the water profundity remains steady. It occurs when gravitational force of the water is equivalent to the erosion drag along the course and there is noincrease in velocity or accelerationof the stream.

NUMERICAL SOLUTION

This practical case is scaled in to a domain of 25000ft in length and 13500ft in width taking and deltax=1000ft and delta t=200seconds. The remaining piece of the base of the area is dry. At time t = 0, the dam is totally and quickly evacuated; the water subsequently streams down the valley. The quality of the channel release is situated to zero, despite the fact that this quality is not known precisely. No-slip limit conditions are authorized on the base geography (dissimilar to distributed results we don't adjust any friction coefficient). Then all the required initial data are given, i.e. initial water depth in reservoir, and all the above boundary conditions the numerical equations are written for each grid point to solve the next grid value as we are following the explicit Mac Cormack scheme. Then the output at the downstream e.g. flow hydrograph and stage hydrographs are computed. Aftere the computation process the outputs are given in the following pages along with the comparison and coclusion.

CHAPTER-5

CONCLUSION AND SCOPE FOR FUTURE STUDY

5.1. COMPARISON OF STAGE HYDROGRAPHS OBTAINED FROM MATLAB AND HECRAS

In this research the flow and stage values at two sites, upstream and downstream station, obtained from the numerical analysis of MacCormack method are compared with the hec-ras software. The fig represents the comparison of stage values at upstream and downstream of the river respectively.

Stage at upstream

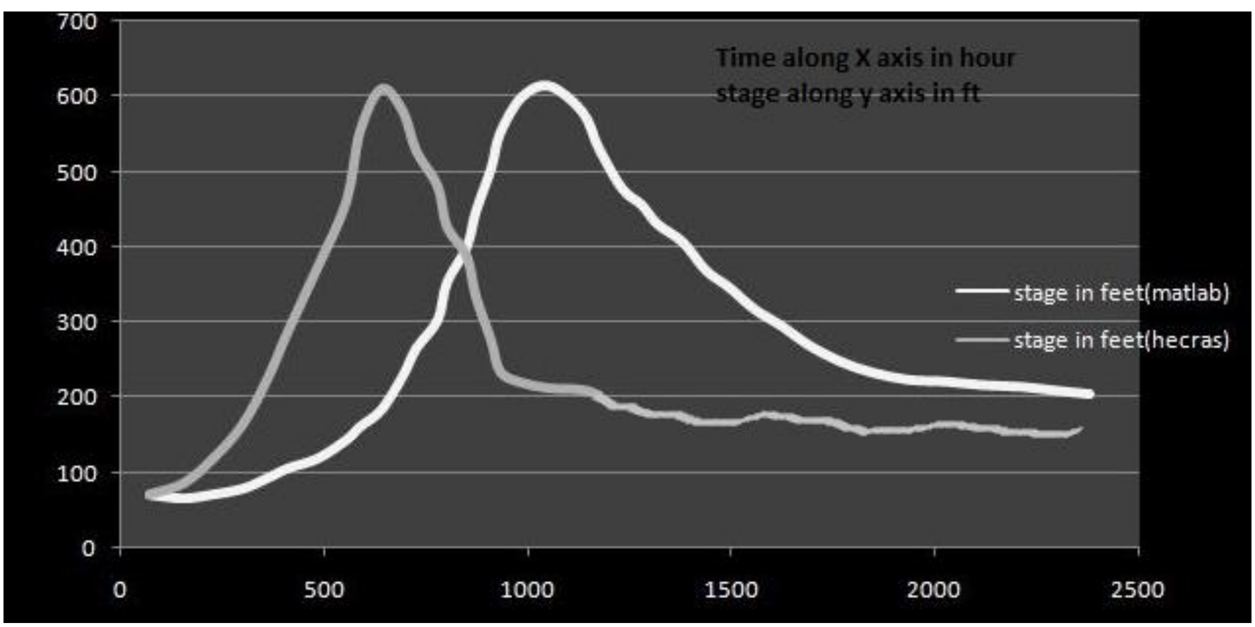


Fig-31

Stage at downstream

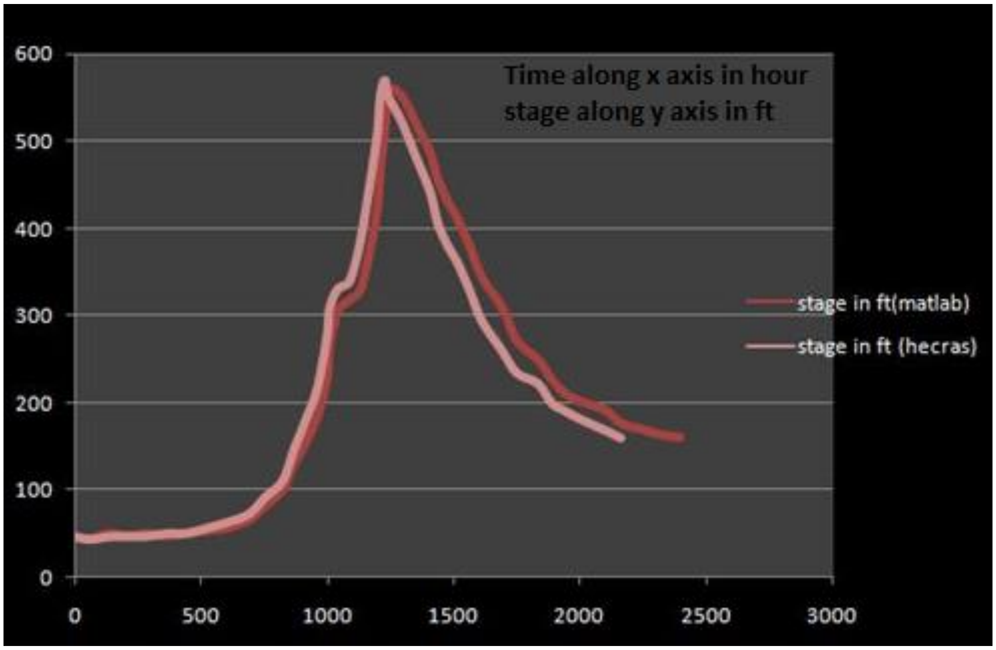


Fig-32

5.1.1. COMPARISON OF FLOW HYDROGRAPHS OBTAINED FROM MATLAB AND HECRAS

Like the stage comparison the flow values at two sites upstream and downstream both the outputs are compared.

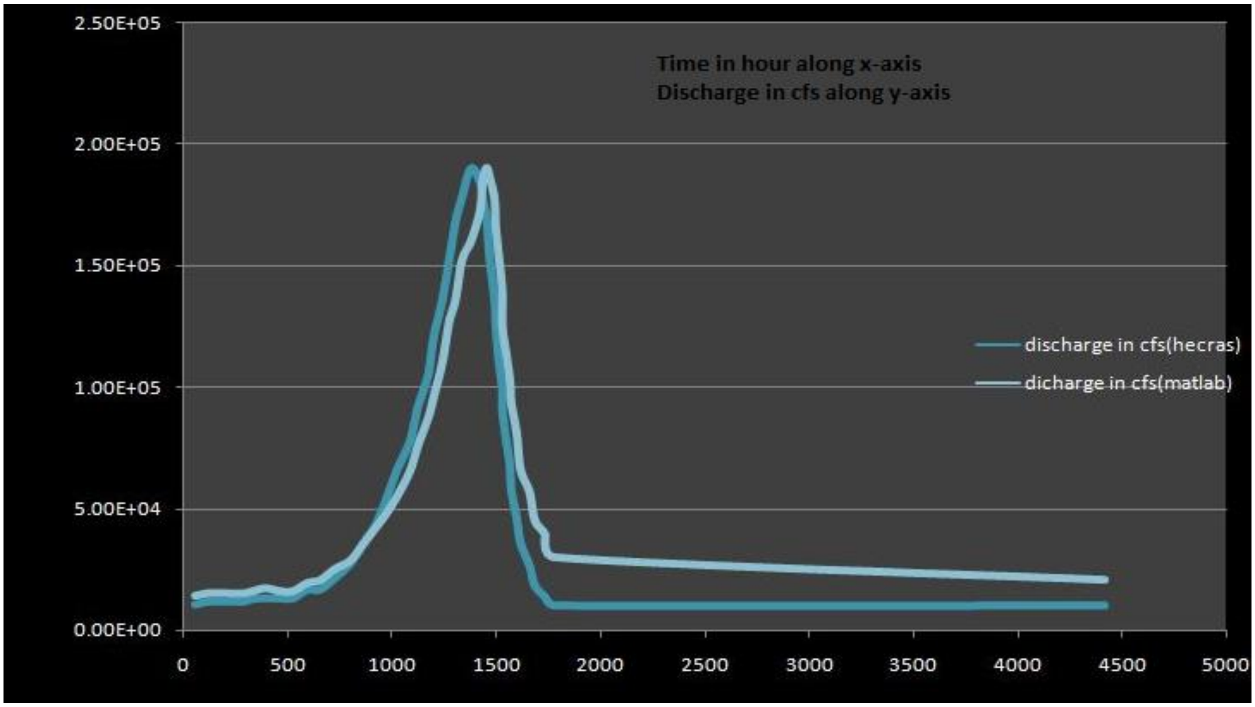


Fig-33

Here the numerical methods used are explicit in nature, that is why we are getting different types of results in different cases and software. The type of mesh generation , time stepping, changing the step size in space, means both in x and y direction we can come with various or different and better results.

Again if we will analyze the above case with implicit methods then the output will be coming a bit different than what we have got now in this research.

Method of analysis is an important factor in numerical analysis, with minute change in grid generation or meshing technique it will lead to a different and improved results.

Flow at downstream

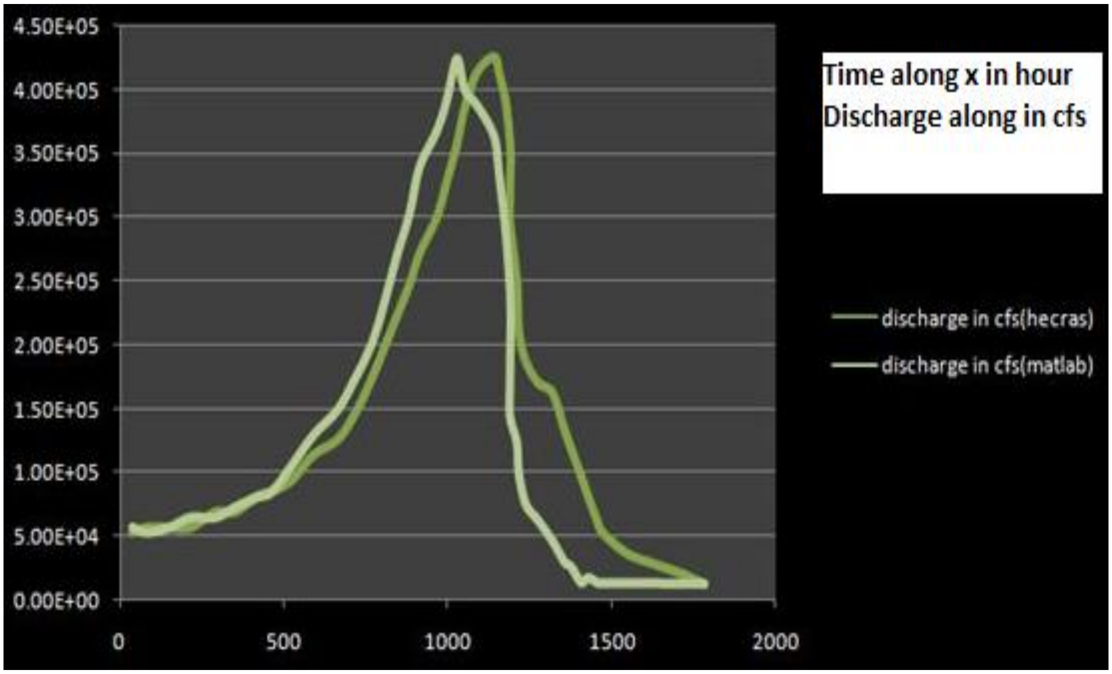


Fig-34

CONCLUSIONS AND SCOPE OF FUTURE STUDY

5.2. CONCLUSION

Both the software are giving almost same results with minor differences. All the results got from both matlab and hecras are compared with each other. From the comparison it is clearly visible that the results got from the present numerical scheme are much better than the results got from hecras model. In both the cases the governing equation is shallow water equation only. But the methods used to solve this system of equation mathematically are different in both the cases that is causing the minute differences in outputs.

In the present numerical scheme the shallow water equations are discretised in their conservative forms in 3-dimensions. But the software hecras is a one dimensional software that uses one dimensional SWE in non conservative form. Means there is a chance of instability problems during mixed flow regimes and flow discontinuities during flow transition at the time of computation, which is not suitable or bearable during dam break analysis using hecras.

This software doesnot contain any consideration regarding the wet-dry fronts or flow discontinuities that is considered in the present numerical method. Any flow discontinuities are completely smeared or ignored. Due to these short comings the unsteady flow option of hecras may be subjected to numerical instability.

The difference in the result we get are in existence due to the numerical methods used behind the solution. The different approach of discretisation, stepping, mesh generation are the main reason for the minute differences among the results. The better and finer the mesh generation better the degree of accuracy of result will come. Here the MacCormack method used in this research gives better result than the software.

5.3. SCOPE OF FUTURE STUDY

The above project or research work is an approach towards simulation of a flow due to dam break for better understanding the temporal and spatial evolution of the water wave fronts so that we can estimate peak flood flow, corresponding maximum flow depth and its time of occurrence at a specified location in the path of surge wave.

- By using different numerical method we can simulate the dam break flow, as well as flood routing successfully in practical field.
- For natural cases of dam break and flood routing, we can further develop the above method in different ways like implicit scheme.
- Numerical models are the better methods for providing better results than physical based models. Using this strategies we can develop softwares for producing better results.
- Using implicit methods for the above analysis may lead to better aspects and results for analysis of a dam disappointment.

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