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Numerical Analysis of Hydraulic Performance of negative surge on Earth Dam Discharge

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Abstract :

The dynamic effects of the flood wave resulting from the failure of the dam have a high destructive power and a large volume of water accumulated in the reservoir in a short time suddenly empties and floods occur. The purpose of this research Performance of negative surge on Earth Dam Discharge. Simulation of gradual breakdown of the dam and expansion of the gap by modeling the software of HEC RAS software based on discontinuity of De St. Venant equations by numerical method of finite cross-sectional difference of four prism points and solving current flow equations due to gradual failure of the dam gradually There have been. Also, in the study of this phenomenon, the numerical method of the explicit boundary of McCormack's explicit differences has been used to break the St. Vincent equation. Examination of the dam's hydrographic failure of the dam in both case patterns indicates that in the case of dam failure in the hydrograph entry conditions into the reservoir, the volume of flood inflow into the reservoir moves like a wave on the negative wave in the reservoir and changes its shape. Due to the movement of the released current in the tank downwards, these changes gradually and over time spread to all areas of the tank and downstream, and increase the depth at all points in the tank, although the negative wave to the end The water level is not expected to decrease due to flooding at the reservoir at the beginning of the canal. However, the upward movement of the negative wave upwards can affect the expansion of the inflow flood flow in the reservoir and to some extent delay the discharge of the flood. Therefore, the results of comparing the flow hydrographic comparison of dam failure in HEC RAS model and explicit numerical model in dam failure mode and in the conditions of hydrographic entry into the reservoir indicate that the current prism model in HEC RAS model analysis has similar advantages and approximate results. McCormack is for solving the De St. Venant equations

Key Words: *Explicit, supercritical, subcritical, Negative surges, Preissmann, peak breach discharge, De St. Venant.*

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I. Introduction :

Dam failure is a hydraulic problem in which a large amount of water accumulated in the reservoir in a short period of time is unintentionally discharged and a huge flood flows downstream of the dam, in which case large flood waves cause huge damage in the downstream areas. These waves cause a lot of loss of life and property, erosion of the earth and adverse environmental effects. Accurate hydrographic forecasting and maximum discharge rate due to dam failure play an important role in assessing safety and emergency measures in dams. The failure of earthen dams in different years has been studied by various methods around the world. These studies have been conducted in the form of laboratory studies or the use of real dam failure information. Many mathematical models and theoretical studies have been conducted on the expansion of fissures in earthen dams and their outflow rates. The modeling of the dam failure phenomenon is modeled primarily to calculate the approximate peak output discharge of the failure, to provide predictions for its inhibition or measures to prevent the risks arising from it. In this study, the numerical model of the failure phenomenon includes the calculation of the discharge flow from the tank and the hydraulic modeling of the flow at the bottom of the dam body. To model gradual erosion, the dam is provided by creating an initial gap at the bottom of the body to initiate erosion. By modeling, the gradual increase of the dimensions of this gap, the increase of the flow rate through it and as a result the destruction of the dam and the discharge of the reservoir water behind the dam are analyzed. In this study, the flow at the site of the dam fracture based on the dismantling of De St. Venant equations has been investigated using studies of the Takestan River Reorganization Project at various stages. In order to perform non-permanent analysis of flow and dam failure from river system analysis using hydraulic models based on reservoir modeling using the ability to model dam failure in HEC RAS model environment and apply the method of dam failure and maximum flow flooded And the failure analysis of the dam has been removed. Therefore, in order to perform analysis of dam failure and determine hydraulic parameters along the river and at different stages of this model as a model for failure analysis by simulating non-permanent currents in the canal and at the fracture site of the dam based on dissociation of the De St. Venant equations. Four points are analyzed. This model has the ability to model all types of dams, both concrete and soil, by considering transverse structures, and in the case of soil dam, it has the ability to simulate both models of permeable and permeable failure of the cavity. Therefore, this model is the basis of calculations. The study of the phenomenon of gradual dam failure in this study includes two general sections. In the first part of the process of gradual breakdown of the dam and expansion of the gap, it is done to simulate the development of the time gap created in the breakdown of the dam due to the Piping, using the modeling of HEC RAS software, in which the dissociation of traditional and quantitative equations is limited. In addition, four prism points are performed. The second part involved solving the equations of the flow caused by the gradual failure of the dam simultaneously in the upstream reservoir of the dam and the river downstream. In the study of this phenomenon, the numerical method of McCormack's explicit boundary differences has been used. Considering that the prismatic numerical model is used to categorize the equations, due to the inability of this model to model supercritical currents, an approximate method has been used. This method has good accuracy when the flow rate is low, but in supercritical currents, due to ignoring the inertial sentences in the equation of motion, it suffers an unavoidable error. Therefore, due to the explicitness of McCormack's model, the necessary precautions have been taken in applying the boundary condition of gradual failure as an internal boundary condition. Advantage of case of De St. Venant formulas

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based on explicit numerical method compared to HEC RAS model. The purpose of this study was to investigate the interaction of sudden flood inflow on the reservoir and the simultaneous failure of the dam and the effect of the negative wave resulting from the failure of the dam, so due to the short time of destruction, the effect of the negative wave on the output discharge dam was investigated. Is. Using wave simulation by explicit numerical method that simultaneously simulates the negative wave son in the dam reservoir and the positive wave progression of the downstream river and the maximum amount of downstream flow that can be lost on the rate of casualties, especially in areas It is a densely populated and developed city. The dam break phenomenon is essentially a problem of safety by both the engineering profession and the public at large. This topic has attracted in the world a large number of hydraulic engineers, researches and, more recently, of members of the computational hydraulic community. The published theoretical studies in Colombia on dam break are not many. Cataño et al. (2005), and Pacheco et al. (2005), presented three different scheme models for solving the problem of the submersion wave immediately after the sudden dam failure in a channel of rectangular section with no valley water and with horizontal or steep sloping bottom Escobar et al. (2007), have adopted the same numerical scheme proposed by Pacheco et al. (2005), and have developed a mathematical model that includes the convection terms in the momentum equations. The numerical solution of this model uses the finite difference method and solves the set of equations by an iterative process that reduces the error generated by variations of the water depth as proposed from Molinaro et al. (1998).

Jiménez et al. (2010), with the support of the PIS – Polo Idraulico Structural di Milano, presented a quasi-analytical solution of dam break problem for laminar mud flows and debris flows based on a Herschel-Bulkley law. The perturbation technique is used to obtain first-order solution for unsteady gradually varied flows. The solution proposed here includes as particular cases the approximate analytical or quasi-analytical solutions presented by B. Hunt (1983, 1994) for laminar high viscosity fluids and more recently by Huang and Garcia (2004) for Bingham plastic mud flows.

Different codes 1-D are used in Colombia for numerical simulations of floods caused by dam failures: the most know being the DAMBRK code developed by Dr. D. Fread in the National Weather Service of U.S.A, Fread D.L. (2011). Moreover in Colombia the Dam-Break problems normally are two-dimensional, in particular in urban areas.

The importance and necessity of research is that the construction of dam structures is considered as a vital structure in river engineering. The more economical and efficient the structure of a hydraulic design can be to save as much financial resources as possible during operation. Of course, examining non-risk conditions to avoid potential risks should also be on the agenda of designers. On the one hand, by presenting the results of precise hydraulic analysis, the project risk can be reduced and on the other hand, it can help make the project more economical. Its volumes are involved. Expressing the problem of analyzing the accuracy of hydrographic forecasting and the maximum flow rate resulting from dam failure plays an important role in assessing safety and emergency measures in dams. The flood resulting from the failure of the dam, both in terms of its dimensions and in terms of the dynamic effects of the flood wave, therefore has a high destructive power. In addition, in most cases, the river canal below the dam does not experience such flooding and is therefore unable to contain it in its main canal. Therefore, it is necessary for all dams to

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analyze the failure of the dam and evaluate the consequences. In addition to assessing the damage and the level of risk at the bottom of the dam, this analysis also enables the planning of rescue operations and the relief of the disaster caused by the failure of the dam. .

according to the aim of this paper which surveys the Parametric Models for the estimation of dam breach parameters .Breach outflow hydrographs were computed using Numerical models and Parametric Models .according to that Dam break flood models for Partial Failure. So The modeling included the breach was simulated as a piping failure.

II. Model Introduction:

Information has been obtained from the studies of two rivers, Abharrud and Khorud, in Qazvin province. In this regard, current simulation at the dam fracture site has been analyzed based on dissociation of De St. Venant equations with two different models. In order to perform non-permanent analysis of flow and dam failure from river system analysis using hydraulic models based on reservoir modeling using the ability to model dam failure in HEC RAS model environment and applying how to prevent dam and maximum flood flow in the affected conditions And the failure analysis of the dam has been removed. Therefore, in order to perform analysis of dam failure and determine hydraulic parameters along the river and at different stages of this model as a model for failure analysis by simulating non-permanent currents in the canal and at the fracture site of the dam based on dissociation of De St. Venant equations. Four points are analyzed.

In this research, the numerical model of the failure phenomenon includes the calculation of the discharge flow from the reservoir and the hydraulic modeling of the flow at the bottom of the dam body. To model gradual erosion, the dam is provided by creating an initial gap at the bottom of the body to initiate erosion. By modeling, the gradual increase of the dimensions of this gap, the increase of the flow rate through it and as a result the destruction of the dam and the discharge of the reservoir water behind the dam are analyzed. Therefore, traditional and constant equations have been used for hydraulic modeling of non-permanent currents, which have been prismatic and discrete with the explicit numerical model of McCormack. Finally, using wave simulation and numerical analysis based on McCormack's explicit numerical method, it simultaneously simulated the negative wave in the dam reservoir and the positive wave in the downstream river. Finally, in order to ensure the results of the maximum transient flow at the moment of failure of the resulting dam by HEC RAS and explicit numerical model methods, due to the simplicity and accuracy of the second order, the flow and hydraulic characteristics of the failure phenomenon should be investigated.

III. Analysis Method:

The simulation of the flow at the dam fracture site has been analyzed based on the dissociation of De St. Venant equations. In order to perform non-permanent analysis of flow and dam failure from river system analysis using hydraulic models based on reservoir modeling using the ability to model dam failure in HEC RAS model environment and apply the method of dam failure and maximum flow flooded And the failure analysis of the dam has been removed. Therefore, in order to perform analysis of dam failure and

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determine hydraulic parameters along the river and at different stages of this model as a model for failure analysis by simulating non-permanent currents in the canal and at the fracture site of the dam based on dissociation of De St. Venant equations. Four points are analyzed.

In this study, the simultaneous effect of flood hydrograph entry with negative wave effect from failure on the output flow has been investigated. In modeling the gradual failure of the dam, it is possible to use wave simulation and numerical analysis based on McCormack's explicit method. Has been. Therefore, the negative wave in the form of a Backward in the dam reservoir and the positive wave of the river in the form of downstream progress should be simulated simultaneously. For this purpose, it is necessary to introduce the characteristic lines of the dam as a middle boundary condition to the model using the method of lines. Inhomogeneous currents follow the equations of St. Vincent, these equations are in the form of the equation of the dynamic motion of non-permanent currents, and are known as De St. Venant equations, which are a side current for a prismatic period. Thus, a surge analysis is carried out by using control volume forms of the momentum and continuity equations across the surge, and the De St. Venant equations are used for all other portions of the flow [1].

.**Matrix form of equations:**

$$\frac{\partial U}{\partial t}+\frac{\partial F}{\partial x}=S \;\rightarrow\; Ut+Fx+S=0 \tag{1}$$

$$F=\begin{bmatrix} VA \\ V^2A+gA\bar{y} \end{bmatrix} \tag{2}$$

$$S=\begin{bmatrix} 0 \\ -gA(S_o-S_f) \end{bmatrix} \tag{3}$$

$$U=\begin{bmatrix} A \\ VA \end{bmatrix} \tag{4}$$

$$S_f=\frac{u^2n^2}{R^{\frac{4}{3}}} \tag{5}$$

in which A = flow area, B = surface width, t = time, U = mean velocity, R = the hydraulic radius, g = gravitational constant, x = horizontal distance, Sc = bed slope, S_f = friction slope, y flow depth .The friction slope can be evaluated from Manning's equation for uniform, stead Flow.

3.1. Dam Breach Analysis Model Development :

Several ways were developed to calculate the reservoir outflow hydrograph caused by a dam failure. Velocities and depths within the reservoir were calculated by applying boundary conditions at the upstream end of the reservoir and at the dam breach. Thus, it was necessary to specify both the geometry and time history of the breach development together with the reservoir inflow, controlled outflow and reservoir geometry.

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3.1.1. Dam Breach Mechanisms To Estimate:

The reservoir outflow hydrograph is governed largely by the geometry of the breach and the development of the breach with time. Overtopping and internal piping are the main causes of failure for earth-darns .A piping failure occurs when initial breach formation takes place some point below the top of the darn, and, as the erosion proceeds, a larger and larger opening is formed until the structure above the pipe collapses. There are four critical elements of any breach analysis: 1- breach parameter estimation (breach size/shape and time of failure), 2- breach peak discharge and breach hydrograph estimation, 3-breach flood routing, and 4-estimation of the hydraulic conditions at critical locations. The most commonly used approaches for the required elements of the analysis are described briefly such as: Parametric Models, Comparative Analysis, Physically-Based Models, Numerical models.

3.1. 1.1. Numerical Models:

The simulation of the flow at the dam fracture site has been analyzed based on the dissociation of De St. Venant equations. In order to perform non-permanent analysis of flow and dam failure from river system analysis using hydraulic models based on reservoir modeling using the ability to model dam failure in HEC RAS model environment and apply the method of dam failure and maximum flow flooded And the failure analysis of the dam has been removed. Therefore, in order to perform analysis of dam failure and determine hydraulic parameters along the river and at different stages of this model as a model for failure analysis by simulating non-permanent currents in the canal and at the fracture site of the dam based on dissociation of De St. Venant equations. Four points are analyzed.

Therefore, this model is the basis of calculations. The study of the phenomenon of gradual dam failure in this study includes two general sections. In the first part of the process of gradual failure of the dam and expansion of the gap, it is done that to simulate the development of the time gap created in the failure of the dam due to the Piping; the modeling of HEC RAS software has been used. The second part involved solving the equations of the flow caused by the gradual failure of the dam simultaneously in the upstream reservoir of the dam and the river downstream. In the study of this phenomenon, the numerical method of McCormack's explicit boundary differences has been used. In this study, the simultaneous effect of flood hydrograph entry with negative wave effect from failure on the output flow has been investigated. In modeling the gradual failure of the dam, it is possible to use wave simulation and numerical analysis based on McCormack's explicit method. So simultaneously simulate the negative wave as a Backward in the dam reservoir and the positive wave in the river as a downstream advance

3.1.1.1.1. The Explicit Method Of Characteristics:

The phenomenon of dam failure is a non-rapid variable current flow, and the equations governing this flow are of the hyperbolic equation type. Based on this, McCormack's explicit discretion of St. and Nantes' formulas has been programmed by software in the Fortran 90 software, where McCormack's numerical method is capable of modeling failure and simulating the advancement of sharp waves due to dam failure at the bottom of the balloon. Has it. This method is possible in the application of internal boundary conditions such as gradual failure of the dam, with the accuracy of the second order in time and place. Because the dissociation of equations has a two-step accuracy in time and space, it includes two stages of

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prediction and correction, the main advantage of this method of dissociation is its ability to simultaneously calculate the gradual and rapid variable flow. Disconnected form of De St. Venant. An equation with this method is as follows in the two sections of prediction and correction.

In this case was used software Fortran 90 and write code to solve The Explicit McCormack model. McCormack use Predictor and Corrector stages to solve the partial differential equations [1].

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According to Predictor stage:

$$\frac{\partial U}{\partial t} = \frac{U_i^* - U_i^k}{\Delta t} \tag{6}$$

$$\frac{\partial F}{\partial x} = \frac{F_i^k - F_{i-1}^k}{\Delta x} \tag{7}$$

$$U_i^* = U_i^k - \frac{\Delta t}{\Delta x}\left(F_i^k - F_{i-1}^k\right) - \Delta t S_i^k \tag{8}$$

According to Corrector stage:

$$\frac{\partial U}{\partial t} = \frac{U_i^{**} - U_i^k}{\Delta t} \tag{9}$$

$$\frac{\partial F}{\partial x} = \frac{F_{i+1}^* - F_i^*}{\Delta x} \tag{10}$$

$$U_i^{**} = U_i^k - \frac{\Delta t}{\Delta x}(F_{i+1}^* - F_i^*) - \Delta t S_i^k \tag{11}$$

$$U_i^{k+1} = \frac{1}{2}(U_i^* + U_i^{**}) \tag{12}$$

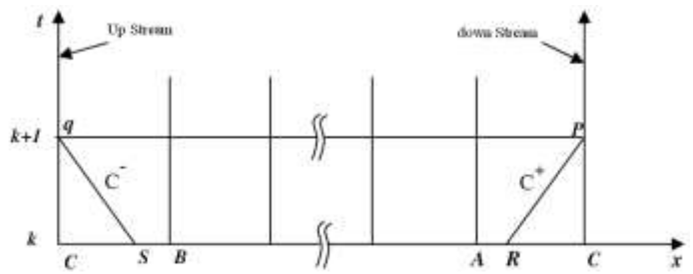

Fig1. Dam break Characteristics in the neighborhood of the surge [1].

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$$V_p = C_m - C_a y_p \quad , V_q = C_n + C_B y_q \tag{13}$$

$$C_m = V_R + \frac{g}{c_R} y_R + g\Delta t (S_0 - S_f)_R \quad , \quad C_n = V_s - \frac{g}{c_s} y_s + g\Delta t (S_0 - S_f)_s \tag{14}$$

$$V_R = \frac{V_C - \frac{\Delta t}{\Delta x}(c_A V_C - c_C V_A)}{1 + \frac{\Delta t}{\Delta x}(V_C - V_A + c_C - c_A)} \quad V_S = \frac{V_C - \frac{\Delta t}{\Delta x}(c_B V_C - c_C V_B)}{1 - \frac{\Delta t}{\Delta x}(V_C - V_B + c_C - c_B)} \tag{15}$$

$$C_S = \frac{c_C + V_S \frac{\Delta t}{\Delta x}(c_C - c_B)}{1 + \frac{\Delta t}{\Delta x}(c_C - c_B)} \quad C_R = \frac{c_C - V_R \frac{\Delta t}{\Delta x}(c_A - c_A)}{1 + \frac{\Delta t}{\Delta x}(c_C - c_A)} \tag{16}$$

$$y_S = y_C + \frac{\Delta t}{\Delta x}(V_s - c_s)(y_c - y_B) \quad y_R = y_C - \frac{\Delta t}{\Delta x}(V_R + c_R)(y_c - y_A) \tag{17}$$

In which $C = \sqrt{gA/B}$ is the celerity of a small-amplitude wave in still water. along the forward and backward C characteristic $C^{\pm}$

3.1.1.1.2. Implicit Finite-Difference Model [1]:

At any given time, we write about McCormack's model equations in all parts of the network. This equation cannot be written for the nodes at the beginning and end of the interval. Therefore, we need two other equations to calculate the flow parameters at the boundaries. These equations are called characteristic.

Of the various implicit methods of finite differences that have been developed, the Preissmann [14] -type schemes (the weighted four-point schemes) .According to Preissmann, the case of dependent variables and its derivatives are :

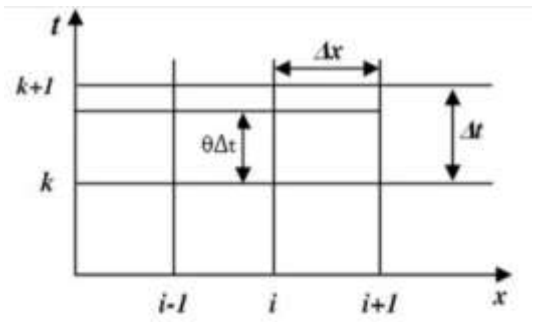

Fig2. the Preissmann schemes (the weighted four-point schemes) [1]

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$$\frac{\partial f}{\partial x} = \frac{\theta}{\Delta x}(f_{j+1}^{k+1} - f_j^{k+1}) + \frac{1-\theta}{\Delta x}(f_{j+1}^{k} - f_j^{k}) \tag{18}$$

$$\frac{\partial f}{\partial t} = \frac{f_{j+1}^{k+1} + f_j^{k+1}}{\Delta x} - \frac{f_{j+1}^{k} + f_j^{k}}{\Delta x} \tag{19}$$

$$f = \frac{\theta(f_{j+1}^{k+1} + f_j^{k+1}) + (1-\theta)(f_{j+1}^{k} - f_j^{k})}{2} \tag{20}$$

Matrix form of equations:

$$\begin{aligned} &U_1^{k+1} + U_{i+1}^{k+1} + 2\frac{\Delta t}{\Delta x}(\theta(F_{i+1}^{k+1} - F_i^{k+1}) + (1-\theta) \\ &(F_{i+1}^{k} - F_i^{k})) + \Delta t(\theta(S_1^{k+1} + S_{i+1}^{k+1}) + (1-\theta)(S_{i+1}^{k} + S_i^{k})) \\ &= U_i^{k} + U_i^{k+1} \end{aligned} \tag{21}$$

3.2.Basic Variable Definition:

In this case determined certain variables that were importance. Lo : The length of the water behind the dam reservoir. Data entry in Hec-Ras for Predicting dam failure parameters was shown in below. Then Results from the simulation by using Hec-Ras was given as The maximum depth of the dam discharge

$H_w = h_o = 5.6$ m

H = 6.9 m

$V_w = 0.4x10e^6m^3 < 1.23\ x10e^6m^3$

Failure Models :The characteristics of this failed earth dam was given Piping

In which:

H_w or h_o :Hydraulic height of water directly at the reservoir before breach

H: Height of the dam

V_w: Total quantity of stored water at failure

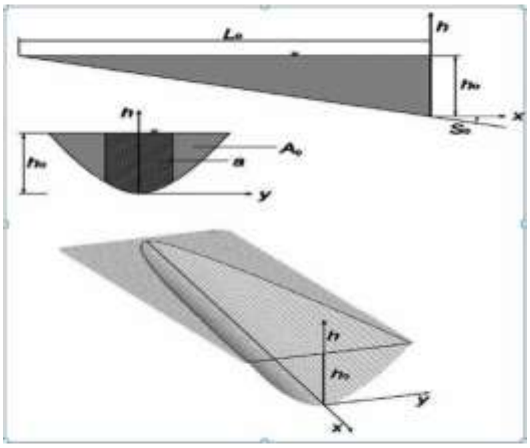

Fig3. Schematic Reservoir Bathymetry

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3.3. Parametric Models For Predicting Peak Outflows:

In this study, the maximum discharge results obtained from the modeling of dam failure phenomenon by HEC RAS model have been evaluated by comparing with the results obtained from analytical methods and explicit numerical model. The results of the maximum cleavage overflow derby have been validated by HEC RAS model with analytical methods and explicit numerical model by considering the negative wave effect, so by reviewing the sources, it can be inferred that The time frame is broken. Dam Breach parameters are also estimated using experimental formulas based on old dam failure information.

There are many analytical methods for estimating dam failure parameters have been estimated in below. Using Average height of water behind the dam reservoir Hw ,V_w and B, we obtain the average value for the dam breach peak flow Q_p . So Using analytical methods using parametric relationships to estimate the maximum output flow and failure time range as a table number 1. The breach outflows are computed as follows that summarizes the results In this case:

Table 1- Summary Of The Peak Outflows Results

Method	Equation Parameter	Value
The SCS Method	$Q_P = 0.000421(\frac{VwHw}{BH})^{1.35}$	200.75 m^3/s
MacDonald Method	$Q_P = 1.175\ V_w\ 0.41\ H_w^{\ 0.41}$	470.78 m^3/s
Costa Method	$Q_P = 0.763\ V_w^{\ 0.42}\ H_w^{\ 0.42}$	353.8 m^3/s
Froehlich (1995) Method	$Q_P = 0.607\ V_w^{\ 0.295}\ H_w^{\ 1.24}$	230.65 m^3/s

In which:

B: Breach Width

H_w :Hydraulic height of water directly at the reservoir before breach

H: Height of the dam

V_w: Total quantity of stored water at failure

3.4. Dam Break Simulation With Hec-Ras:

In this study, the maximum discharge results obtained from the modeling of dam failure phenomenon by HEC RAS model have been evaluated by comparing with the results obtained from analytical methods and explicit numerical model. The modeling of the reservoir is the introduction of the characteristics of the dam and how to destroy it, and finally the process of finding the resulting flood in the

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downstream using data related to the geometry and roughness of the river. In order to model the tank, its geometric characteristics and the reservoir curve are required. Using this information, the Hec-Ras model will be able to model the Dam Storage. In this study, the hydraulic parameters of the dam failure are as follows and enter the Hec-Ras model. In this study, the numerical model of the failure phenomenon includes the calculation of the discharge flow from the tank and the hydraulic modeling of the flow at the bottom of the dam body. To model the gradual erosion of the dam, it is provided by creating an initial gap below the body to start erosion.

3.4.1.Estimation of Breach Width B[2]:

Breach characteristics can be estimated in several ways which is describe the physical characteristics of a dam breach, use of those parameters within the unsteady flow routing model Hec-Ras, and the computation breach out flow hydrograph. So In this paper using Von Thun [12] and Gillette Method was better to estimating than the other model that they developed. They suggested that: Bave = 2.5 hw + Cb

Breach description input data about this case: Cb = 6.1 because Vw= 0.4x10 e6 m3 < 1.23 x10 e6 m3,Average breach bottom width : $\overline{B}$ = 20.1 m , Ultimate breach bottom elevation : B bot =18 m

3.4.2. Estimation of Side Slope Horizontal Factor Z[2]:

Most of the methods that suggest the Z factor. So In this paper using Froehlich [9] (2008) Method was better to estimating than the other model that they developed. In this Case: Z= 0.7 because the characteristics of this failed dam was given Piping

3.4.3.Estimation Of Failure Time[2] :

Several researchers have estimated the failure time. So In this paper using Von Thun and Gillette Method was better to estimating than the other model that they developed. Von Thun and Gillette Method suggested that t_f calculation depends on the materials 'resistance for erosion .they have suggested other equations that estimate the time of failure using the average lateral erosion rate (the ratio of the final breach width to breach formation time) and depth of water above the breach invert. So $t_f = \overline{B}/4h_w$

In this case: For not easily eroded materials, Breach development time was estimated : tf = 1hr

IV. Research Results:

4.1. Dam-Break Outflow Hydrographs:

Analytical methods of fissure parameters have also been estimated using experimental formulas based on old dam failure information. Modeling of the dam failure phenomenon is mostly done for the approximate calculation of the output peak of the failure peak, so that predictions are made to control it or measures are taken to prevent the risks arising from it.

In this study, the simultaneous effect of flood hydrograph entry with negative wave effect from failure on the output flow has been investigated. In line with the objectives of this research, in modeling the gradual failure of the dam, it is possible to use wave simulation and numerical analysis based on the explicit McCormack method. The failure of the dam has been investigated. Calculating the discharge flow from the

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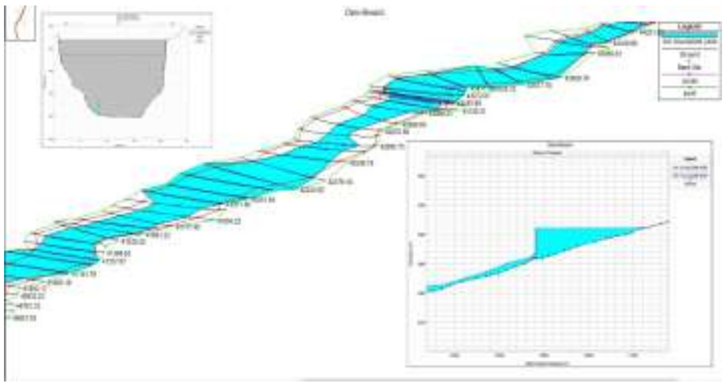
tank and hydraulic modeling is the flow at the bottom of the dam body, and to model the gradual erosion of the dam by providing an initial gap at the bottom of the body to begin erosion. By modeling, the gradual increase of the dimensions of this gap, the increase of the flow rate through it and as a result the destruction of the dam and the discharge of the reservoir water behind the dam are analyzed.

Comparing the process of calculating the time of destruction resulting from analytical methods shows that Von Thun and Gillette method for calculating the time of destruction due to failure width and considering the relationship based on the percentage of erosion of materials forming the body of the dam and the average intensity of lateral erosion. The wall achieves more reliable and accurate results while creating a breaking width. Comparison of maximum dam failure rate, resulting from analytical methods, shows that in SCS analytical method compared to other analytical methods, the effect of several parameters such as: average failure width which depends on the time of destruction, dam reservoir volume and height of water behind the dam at the moment. Failure to estimate the maximum flow rate is considered a dam failure. Therefore, the results are estimated more accurately.



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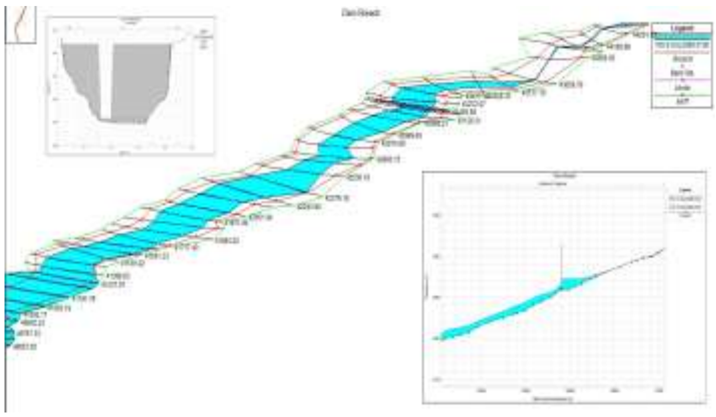

(b

Fig4. Longitudinal profile of Dam breach At ,a) 0.00hr. ,b) 1:36hr.

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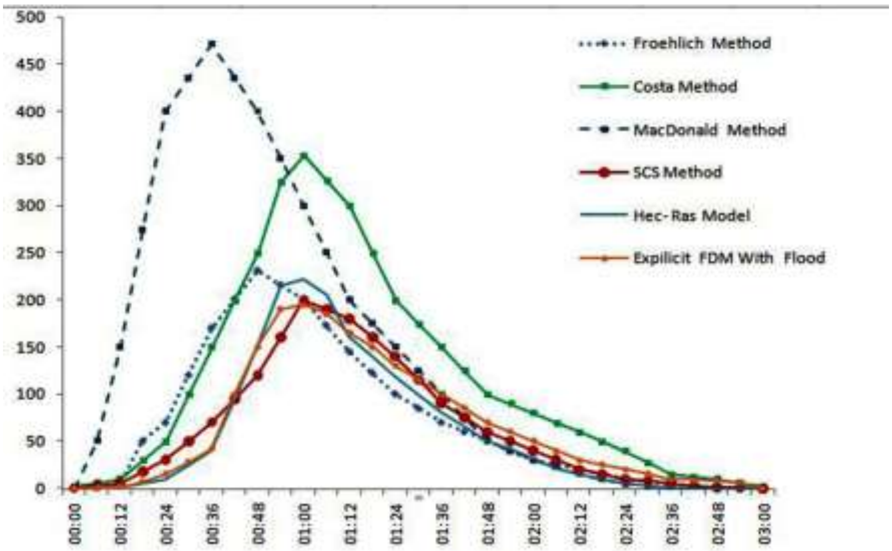

Fig6. Total Discharge Hydrograph Comparison(Peak Outflow)

Table 2, presents a comparison of the percent error in peak discharge calculated using :

$$\%\ \text{error} = \frac{\text{Calculated peak discharge} - \text{Observedpeak discharge}}{\text{Observedpeak discharge}} \text{ x } 100$$

Table 2- Comparison of peak discharge error (%) for the various models

Method	error (%)	Value
Mc Cormack	0	185 m3/s
Hec-Ras Computed	4.51	177 m3/s
The SCS Method	7.5	200.75 m^3/s
MacDonald Method	60.72	470.78 m^3/s
Costa Method	47.74	353.8 m^3/s
Froehlich (1995) Method	19.91	230.65 m^3/s

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V. Conclusion:

In the present study, for the explicit numerical model, the flow rate due to dam failure was used by McCormack's explicit boundary difference method due to the simplicity of calculations and having a two-step accuracy. The HEC RAS dam breakdown hydrograph in the HEC RAS model with explicit numerical model in the case of dam failure in the case of hydrographic entry into the reservoir, shows that in the numerical model the volume of flood inflow into the reservoir moves like a wave on the negative wave in the reservoir and in the hydrograph It has made a difference. These changes are gradual and gradually spread to all parts of the reservoir and downstream as the released current in the reservoir moves, and there is an increase in depth at all points in the reservoir, despite the negative wave reaching the end of the channel. As expected, it will not decrease at the beginning of the channel due to flooding into the reservoir. However, the upward movement of the negative wave upwards can affect the expansion of the inlet flood flow in the reservoir and to some extent delay the discharge of the flood.

In discharge, the HEC RAS dam failure is delayed compared to the explicit numerical model, and when the negative wave reaches the end of the channel, the water level decreases at the beginning of the channel. Failure has been observed.

Hydrographs entering the reservoir in case of failure can add to the destructive effects. However, the speed of the negative wave moving upwards can affect the expansion of the inflow flood flow in the reservoir, to some extent the delay in the discharge of the flood.

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