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An Interpretation of Reversed Flow Curve In Hec-RAS 2D Time Based Cross Section

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Abstract---*Modelling software is important nowadays, especially in a country which troubled with a flood. Flood can be happened from various cautions from the Dam failure, heavy rain, tidal and etc. HEC RAS is one of modelling software that often used by an engineer to create a flood model. It even can calculate an unsteady flow in 2D simulation and use a discharge calculation as an initial boundary data and use a Digital Elevation Model as flow areas. The modelling results is a flood plain area, a flow in cross section area, velocity and etc. Some of flow results that shown in graphic area is reversed and sometime make a miss interpretation. The reversed graphic is caused by negative value of Velocity which is a part of flow equation. Based the velocity equation the possible negative value is come from the Slope value which can be read negative by the system. To interpret it, we need to see how the long section is and change the value to positif.*

Keywords---*HEC-RAS, Flood, Discharge*

I. Introduction

HEC-RAS is a modelling software that gives us a freedom to create a flood modelling in a various ways. It capable to create a modelling in 1D steady flow, 1D unsteady flow, 1D/2D combined steady flow, 1D/2D combined unsteady flow and also 2D steady flow and 2D unsteady flow[1]. Another HECRAS capabilities are :

+ **HECRAS Can Perform 1D Flood Modelling, 2D Flood Modelling and combined 1D/2D Flood modelling.**

  HEC-RAS is able to create a flood modelling in 1D modelling, such as a flood modelling in vertical way. The equation for 1D modelling are :

  Continuity Equation

- Inflow rate

$$Q - \frac{\partial Q}{\partial x}\frac{\Delta x}{2} = 0$$

- Outflow rate

$$Q + \frac{\partial Q}{\partial x}\frac{\Delta x}{2} = 0$$

Momentum Equation

- Upstream

$$Fp - \frac{\partial Fp}{\partial x}\frac{\Delta x}{2} = 0$$

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- Downstream

$$Fp + \frac{\partial Fp}{\partial x}\frac{\Delta x}{2} = 0$$

Furthermore the equation for 2D unsteady modelling are :

mass conservation

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -g\frac{\partial H}{\partial x} + v_t\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) - c_f u + f_v$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} = -g\frac{\partial H}{\partial y} + v_t\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) - c_f u + f_u$$

H : Depth Of Water
u and v : kinematic velocity x and y ways
g : gravity
vt : viscosity coefficient
cf : friction coefficient
f : Coriolis force

+ **Two modelling choice, Saint-Venant Equation Set or Diffusion Wave Equations set in 2D.**

Saint Venant equation can help your model works accurately, unfortunately it also works slower, unstable and have a wider problem. Saint venant equation can be seen below :

$$\frac{\partial A}{\partial t} + \frac{\partial (A\mu)}{\partial x} = 0$$

And

$$\frac{\partial \mu}{\partial t} + \frac{\partial \mu}{\partial x} + \frac{\partial \zeta}{\partial x} = -\frac{P}{A}\frac{\tau}{\rho}$$

Where :

x : space coordinate
t : denotes time
A(x,t) : Area
u : velocity
ξ(x,t) : free surface elevation
T(x,t) : shear stress
P(x,t) : wetted perimeter

Diffusion Wave can help your model works faster, unfortunately it isn't as accurate as Saint Venant equation. The formula can be seen below [4] :

$$\frac{\partial Q}{\partial t} = Dh\frac{\partial^2 Q}{\partial x^2}$$

+ **Regular or Irregular Shaped of Meshes**

  The software can do a computational in many shapes of meshes, it doesn't have to be a square. It can handles triangles, square, rectangles, five and six sided elements. The smaller the meshes, the shape of meshes will be more regular, it will take a rectangular shaped.

  .

+ **Multi-Processor Based Solution Algorithm (Parallel Computing).**

  The 2D flow computation will accelerate it works with your computer. The higher specification of your processor the faster it works. Recent processor came with multiple processor, it will help the model done faster than a single processor.

+ **Flexible Computational Engines.**

  HEC-RAS now become more flexible, it doesn't need a special engine to run. It can run both in a good performance for 32 bit engine and 64 bit engine. So it can works great in your computer.

The software usually used to create a flood modelling in a channel or in a plain area. However there is an anomaly when the curve show reversed graphic in output cross section. Here we will analyse how it could possibly happened and how to interpret it.

HEC-RAS 2D needs an elevation data that called DEM which stand for Digital elevation Model which is a 3D representation of terrain's surface that collected by a satellite mapping, digital mapping through a theodolite, digital mapping through a drone, or even echo sounding through a plane. Indonesia has a BIG or Badan Informasi Geospasial which provide us with a 1:7500 accuracy DEM. It means the minimal accuracy is 7.5 m. There are several source of free DEM data in the world such SRTM from NASA, USGS from USA and DEMNAS from Indonesia.

Based on Widyanto[3] 2019, the value of viscosity coefficient can be influenced by land changing and temperature which push the climate to become warmer and decrease the value of viscosity.

From the equation above we can see that there is a velocity variable for each way equation (u way and v way). For sure we know that the formula of velocity is shown below :

$$V = 1/n\ R^{2/3}\ S^{1/2}$$

V : velocity

n : manning number

R : Hydraulic Radius

S : Slope

Meanwhile the formula of Slope is :

$$\frac{h - h1}{d}$$

h : initial height

h1 : next height

d : distance

II. Analysis and Discussion

To obtain the HEC-RAS Result we have to prepare the model first. This model use a case study of Pengasinan reservoir in Depok, West Java. The model preparation is based on several steps :

+ Rainfall Data

Rainfall data for this model is from several Rainfall station. The rainfall design data can be shown below.

Periode	Rainfall Design (mm)
2	116
5	140
10	157
20	170
25	177
50	193
100	208
500	230
1000	258

To acquire maximum result, we use a 1000 years Period of rainfall such as around 258 mm.

From data above here are the hourly rainfall design through Mononobe Formula[3].

$$I = \left[\frac{R_{24}}{24}\right]\left[\frac{24}{t}\right]^{\frac{2}{3}}$$

I = Rainfall Intensity (mm/hour)

t = Length of hour

R_{24} = Max rainfall in 24 Hour (mm)

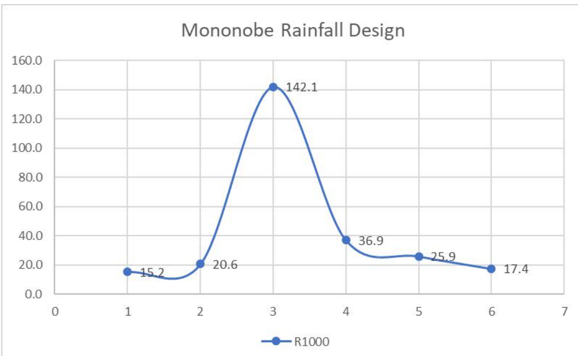
The time percentage use a bell shape where the percentage of rainfall can be seen below

Hour	Percentage
1	5.9%
2	8.0%
3	55.0%
4	14.3%
5	10.0%
6	6.7%

The hourly rainfall from Mononobe can can be shown below

Hour	R1000
1	15.2
2	20.6
3	142.1
4	36.9
5	25.9
6	17.4

The Graph can be seen below

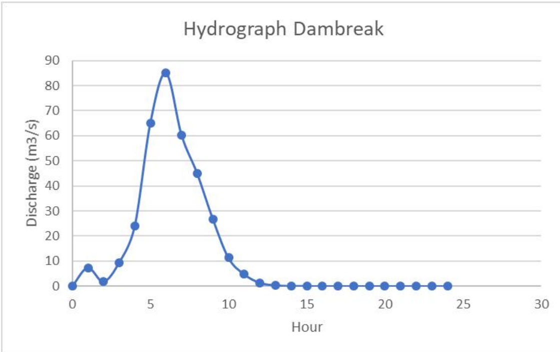


From data above we can create a Dambreak model through HEC HMS software with the result below :

Jam Ke	Q1000
0	0
1	7.4
2	1.9
3	9.4
4	23.9
5	65.1
6	85
7	60.2
8	44.9
9	26.8
10	11.3
11	4.8
12	1.4

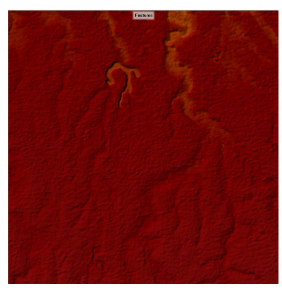
Jam Ke	Q1000
13	0.4
14	0.1
15	0.1
16	0
17	0
18	0
19	0
20	0
21	0
22	0
23	0
24	0

Dambreak hydrograph can be seen below with a peak discharge around 65.1 m3/s



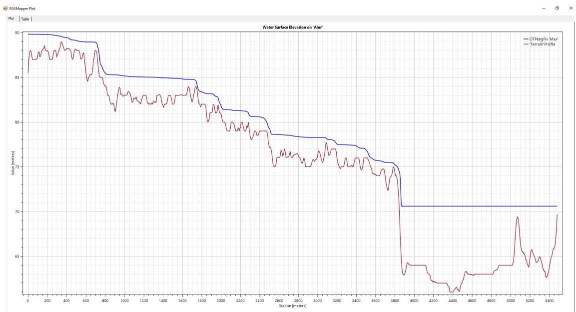
+ DEM Data

DEM data for the modelling location have to be suitable with satellite data, the datum can be seen below :



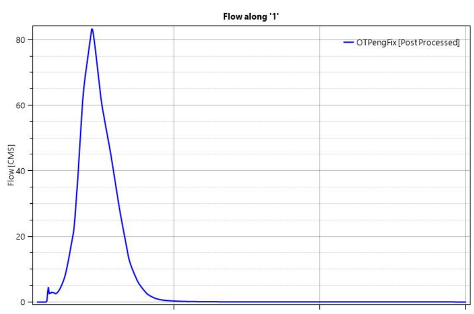
Blue box is the location of reservoir location, and flood model can be seen below :

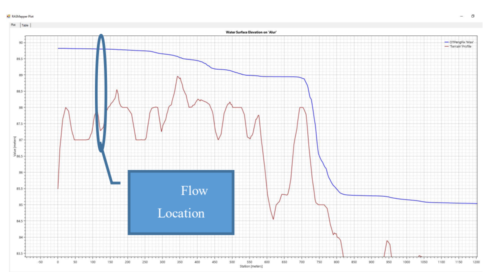
From the model we can create a long section of flood that shown below.



Based on the flood area, we can create the cross section of flood area. For Example here are the cross sample and flow graphics in several cross.

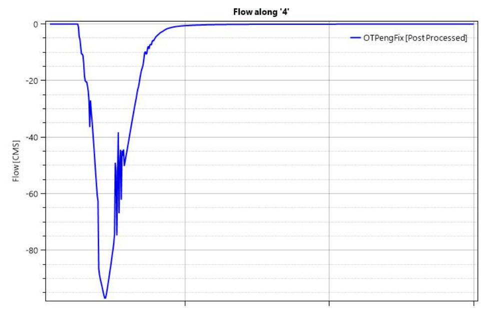
- Cross 1 (Sta 0+200)

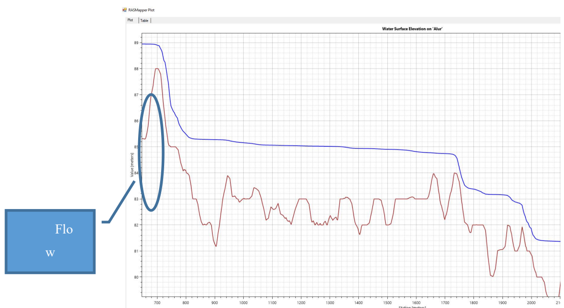




The graphic above is a normal graphic where the discharge flow is increasing normally, but in several condition the graphic will not shown normally like shown below.

- Cross 4 (Sta 0+800)





III. Results

From two condition above we can see that the shape of long section create a huge different on form of graphic shape. The initial head of water create a huge impact in this condition. For sample number one we can see that even the steep is negative but the height of flow is much higher from the elevation of downstream. It different with the second case where the head of initial flow isn't much bigger with the downstream, it even the elevation is increase in several ways. It can cause a negative value in HECRAS calculation. To interpret the calculation of flow, we just need to change the negative value of flow. Based on the velocity equation the negative value is in Slope value (S) and the rest of calculation is valid.

IV. Conclusion

The result from the research is that we have to see how the long section is, and we just need to adjust whether we just need to change the negative value to positive or we need to re run the program. Commonly we just need to change the negative value to Positive.

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