Stage discharge curve for Guillemard Bridge streamflow sation based on rating curve method using historical flood event data.

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Abstract The purpose of the stage-discharge curves varies from water quality study, flood modelling study, can be used to project climate change scenarios and so on. As the bed of the river often changes due to the annual monsoon seasons that sometimes cause by massive floods, the capacity of the river will changed causing shifting controlled to happen. This study proposes to use the historical flood event data from 1960 to 2009 in calculating the stage-discharge curve of Guillemard Bridge located in Sg. Kelantan. Regression analysis was done to check the quality of the data and examine the correlation between the two variables, Q and H. The mean values of the two variables then were adopted to find the value of difference between zero gauge height and the level of zero flow, “a”, K and “n” to fit into rating curve equation and finally plotting the stage-discharge rating curve. Regression analysis of the historical flood data indicate that 91 percent of the original uncertainty has been explained by the analysis with the standard error of 0.085.

1. Introduction
Both the stage and the discharge of a stream vary most of the time and in order to obtain a continuous record of discharge, the stage is recorded and the discharge computed from correlation of stage and discharge. [1] This correlation or calibration is known as the stage discharge relationship. The stage-discharge relationship is very important in surface hydrology, as quality discharge data is highly dependent on a satisfactory head – discharge relationship at the gauging station [2]. For establishing this relationship, the rating curve method is the most widespread technique and has been applied on thousands of gauging stations worldwide for decades. [3]

It is known that in natural river, the stage-discharge relationship does change. Usually it is called shifting controlled. Shifting controlled is usually due to erosion, deposition of sediment at the site or after a big flood. [4]

This paper discusses the result of stage discharge rating curve calculated based on flood historical event for Guillemard Bridge Station of Sg. Kelantan. The data were regressed using the least square method technique and then the stage-discharge rating is plotted based on rating curve method.

2. Theory
The functional relationship between stage and discharge can be established by field measurement of stage and discharge and thereafter can be expressed as a rating curve. Idyllically, a rating curves can...
be describes as a unique functional relationship between stage and discharge and therefore it is obtained as a smooth and continuous curve with reasonable degree of sensitivity. [4] The stage-discharge relationship may be expressed by

$$Q = K(H - a)^n$$ (1)

Where $Q$ is the discharge in cubic metres per second, $K$ is a constant, $H$ is the gauge height, “$a$” is the gauge height for a zero flow and $n$ is an exponent. [4]

Usually the value of “$a$”, i.e. the difference between zero gauge height and the level of zero flow is not zero and its magnitude is unknown. In order to solve this, we need to plot $Q$ against $H$ on logarithmic plot. This will show when “$a$” is not zero will produce a curve. The graph will produce a straight line when the correct “$a$” is known. Taking the logarithm of both sides of the general equation will give us:

$$\log Q = \log K + n \log(H - a)$$ (2)

3. Case Study

Historical flood data from 1960 until 2009 were used to predict the stage-discharge curve for Guillemand Bridge streamflow station in Sg. Kelantan. Based on the historical event shown in Figure 1, it is noted that some major flood event happened in 1965, 1967, 1969, 1972, and 1973. The capacity of the river also decreased over the time especially in between 1967 and 1972 where a huge difference can be seen in the graph. It is believe that the major flood occurred in 1965, 1967 and 1969 causing this shift controls to happen.

![Figure 1. Flood event data of Guillemand Bridge streamflow station for year 1960 until 2009.](image)
3. Analysis and Result

Based from the historical flood event data in Figure 1, power regression type was plotted as shown in Figure 2. The black line representing the mean value of the two variables involved. The logarithm graph then was plotted to find the standard error deviation, coefficient of determination and correlation coefficient of the data as shown in Figure 3.

![Figure 2. Regression graph of water level vs. discharge for Guillemard Bridge streamflow station.](image)

The mean values of the two variables then were adopted to find the value of difference between zero gauge height and the level of zero flow, “a” and to calculate the rating curve for Guillemard Bridge streamflow station of Sg. Kelantan. Various values of “a” were assumed until the data fit with the mean value of regression analysis. To validate the “a” value, logarithmic graph of Q against (H-a) is plotted until the guessing value gives a straight line as shown in Figure 4. By solving the simultaneous equations, the value of n and K can be found. Figure 5 shows the stage-storage curve derived from the equation (1).

![Figure 3. Linear least square regression method to determine the standard error and correlation coefficient.](image)

![Figure 4. Log Q vs. Log H shows a straight line when a=0.5 is applied to selected random data (1970) for validation process.](image)

![Figure 5. Graph of stage-discharge rating curve (red-line).](image)

4. Discussions

Regression analysis of the data historical flood event data was conducted to find stage-storage rating curve. Based from the statistical calculation, the standard error is 0.085 with coefficient of determination equal to 0.91 and coefficient correlation equals to 0.96 has been obtained. These results indicate that 91 percent of the original uncertainty has been explained by the analysis. This result supports the conclusion that the equation represents an excellent fit.
Once the data for mean values of the two variables has been obtained, stage-discharge rating curve need to be plot in the form of equation (1). After several trial and error and validation process, the value of “a” is 0.5m thus will give the equation of the rating curve equals to:

\[ Q = 0.027(H - 0.5)^{4.443} \]  \hspace{1cm} (2)

![Stage Discharge Curve of Guillemard Bridge Streamflow Station](image)

**Figure 6.** The new stage discharge rating curve for Guillemard Bridge using the historical flood event data.

5. Conclusions

Stage discharge rating curve for Guillemard Bridge streamflow station was calculated based on general rating curve equation using the historical flood event data. Regression analysis of the historical flood data indicate that 91 percent of the original uncertainty has been explained by the analysis with the standard error of 0.085. The “a” value for the difference between zero gauge height and the level of zero flow also has been determined by using trial and error until it fits the regression data. By solving the simultaneous equations the value of n and K were obtained. Hence the equation for stage discharge rating curve \( Q = 0.027(H-0.5)^{4.443} \) was obtained using the rating curve method.

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