DISCHARGE-STORAGE METHOD OF FLOOD ROUTING

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1. INTRODUCTION

All the hydrologic flood routing procedures through river channels, make use of the continuity equation which can be written as :

$$I(t)-Q(t)=ds/dt \qquad (1)$$

In descrete form,

$$1/2[(I_1+I_2)-(Q_1+Q_2)]=(S_2-S_1)/\ t \qquad (2)$$

where I is the rate of inflow, Q the rate of outflow and S the storage. Since eq.1 has two unknowns, namely Q and S, so one more equation is required for the solution of eq.1. In this paper different discharge-storage models are tried and used with varying degrees of success for solving eq.1.

2. DESCRIPTION OF MODELS

2.1 MUSKINGUM MODEL

Writing Muskingum storage equation :

$$S=K[xI+(1-x)Q]+\sigma \qquad (3)$$

where x is a dimensionless constant and K the slope of storage-weighted discharge relation and has the dimension of time. Eq.1 and 2 can be combined into

$$Q_2=\frac{Kx-0.5\Delta t}{K-Kx+.5\Delta t}I_2+\frac{Kx+0.5\Delta t}{K-Kx+.5\Delta t}I_1+\frac{K-Kx-0.5\Delta t}{K-Kx+0.5\Delta t}Q_1 \qquad (4)$$

or

$$Q_2 = C_0I_2+C_1I_1+C_2Q_1 \qquad (5)$$

The preceeding method is now applied to a example taken from Wilson(1974) . However it is apparent from the Fig.1 that the actual data seem to lie on a curve rather than a straight line. So a nonlinear equation was fitted to the data as given by the Gill(1978)

$$S=\alpha[xI+(1-x)Q]^m +\sigma \qquad (6)$$

where m is an exponent and α is a coefficient. The empirically fitted curve is shown in Fig.1.

2.2 FUJITA MODEL

For convenience, the following equation was also fitted to the data

$$S=KQ^P \qquad (7)$$

where K and P are the model parameters. Combining eqs.7 and 1,

$$\frac{dz}{dt}=\frac{I-z^{1/P}}{K} \quad ; \quad z=Q^P \qquad (8)$$

Runge-Kutta-Gill method was used for the solution of eq.8.

2.3 PRASAD MODEL

Considering unsteady flow effect(hysteresis effect), which was neglected in the development of eq.7, the storage-discharge relationship expressed by Prasad(1967) is :

$$S=K_1Q^P+K_2dQ/dt \qquad (9)$$

In which K is a constant for a particular hydrograph. Combining eqs.9 and 1, the following system of equations were obtained

$$\frac{dx_1}{dt} = x_2$$

$$\frac{dx_2}{dt} = -\frac{K_1P_1}{K_2}x_2x_1^{P-1} - \frac{x_1}{K_2}+\frac{I}{K_2} \quad ; \quad x_1= Q \qquad (10)$$

Runge-Kutta-Gill method was used for the solution of eqs.10.

2.4 HOSHI MODEL

Hoshi(1982) mathematically proved that K is a function of discharge, not a constant as considered by Prasad(1967). He gave the following relationship

$$S= K_1Q^{P_1} + K_2dQ^{P_2}/dt \qquad (11)$$

Combining eqs.11 and 1, the following system of equations were obtained

$$\frac{dx_1}{dt} = x_2$$

$$\frac{dx_2}{dt} = -\frac{K_1 P_1}{K_2 P_2} x_2 x_1^{P_1/P_2 - 1} - \frac{x_1^{1/P_2}}{K_2} + \frac{I}{K_2} \quad ; \quad x_1 = Q^{P_2} \qquad (12)$$

Runge-Kutta-Gill method was used for the solution.

3. NUMERICAL EXAMPLE ON FLOOD ROUTING

The direct search method was used for obtaining the optimized model parameters for the first example of Wilson(1974). Using these optimized parameters, the flood from Wilson's second example was routed. The computations were performed on the FACOM M382 computer system at the Kyoto University.

4. RESULTS AND DISCUSSIONS

The calculated optimum values of model parameters and the numerical values of sum of square errors for all the models are shown in Table 1. For comparison, the same flood of Wilson's first example, from which optimum values of model parameters were obtained, is routed by using the five models. The results are plotted in Fig.2. The sum of square errors is found to be minimum for Hoshi model. Fig.2 shows that the calculated values by Hoshi model best fit the observed data. The routed flood hydrographs of Wilson's second example are plotted in Fig.3. It is expected that Hoshi model with the optimum parameters determined from historical flood data would function satisfactorily for the routing of flood in a channel. These results can at best be regarded as approximate results.

5. ACKNOWLEDGEMENT

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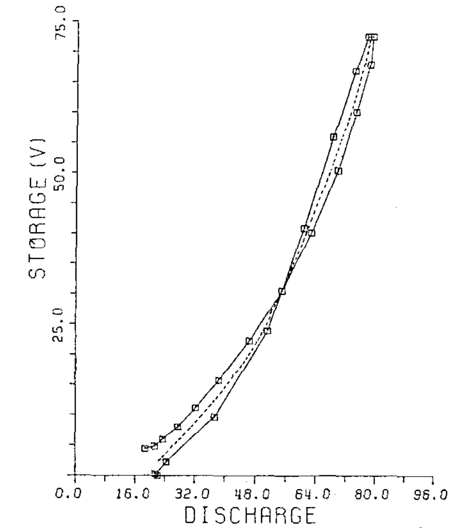

Fig.1 : Plot of storage vs weighted discharge

TABLE 1.
Comparison of sum of square errors by various methods :

Model	Sum of Square errors	Optimized parameters values
1. Muskingum	637.5	x=0.25; K=1.154
2. Eq.6	-	x=0.25; α=0.010; m=2.0415
3. Fujita	1029.3705	K=31.5; P=0.975
4. Prasad	139.3048	K=65.8; P=0.8; K=231.0
5. Hoshi	76.2048	K=60.9; P=0.814; K=53.8; P=1.30

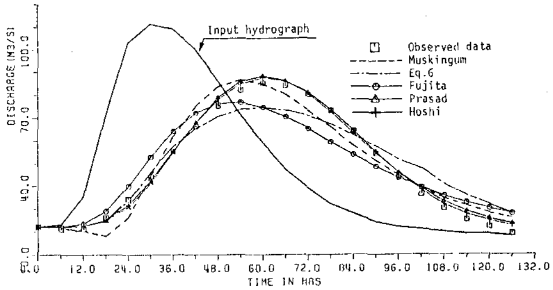

Fig.2 : Routing of flood from Wilson's first example

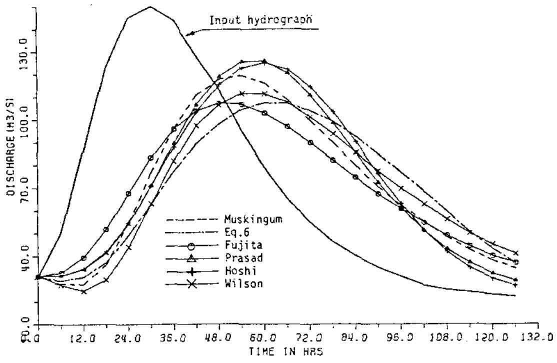

Fig.3 : Routing of flood from Wilson's second example