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APPLICATION OF MUSKINGUM FLOOD ROUTING METHOD FOR THE DHALEGAON-BABLI REACH OF THE GODAVARI

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Flood routing is an important aspect of hydrology which progressively determines the timing and magnitude of a flood wave along a river stream. For issuing a forecast to the down-stream areas of a river, flood routing is necessary. The present paper presents the results of a study of the Dhalegaon-Babli reach (237km) of the river Godavari. The Muskingum method of flood routing has been adopted. The constants for the entire reach were $K = 37$ Hr and $X = 0.4$. The result helps in forecasting of passage of a flood wave at Purna and Babli on the main river Godavari, with the help of observed flood hydrograph at Dhalegaon.

Key Words : Flood Routing; Streamflow Routing; Floodwave Forecasting; Godavari River

INTRODUCTION

FLOOD routing is the process of determining progressively the timing and shape of a flood wave at successive points along a river and is basic for flood forecasting, It plays an important role in the design and management of many environmental and water resource projects. This communication presents some results of flood routing studies of the Dhalegaon-Babli reach of the river Godavari.

In the calibration of medium and major river basins using digital hydrologic models, one has to divide them into several sub-basins depending upon the areal extent, stream pattern and other morphological characteristics. For instance, for estimating probable maximum flood (PMF) at Navagam dam site using the OPSET model,[1] Ramanamurthy *et al.*[2] have divided the Narmada basin into twenty sub-basins on the basis of morphological characteristics, raingauge and gauge-discharge network in the basin. The FORTRAN version of the Stanford Watershed Model—IV (SWM—IV)[3] has been modified by Liou[1] in such a way that the model becomes a selfcalibrating one and determines an *optimum set* of watershed parameter values. It is named as OPSET. The basic approach to this model is to match the observed flows with synthesized flows by adjusting the initially assigned parameter values. A majority of digital models, including OPSET, do not have

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the capability to route the flows of the main river and tributary flows in proper time phase. In this way, the streamflow routing plays an important role in digital modelling, apart from its conventional applications.

DATA

Data on daily stage, discharge and hourly stage at three sites. namely, Dhalegaon, Purna and Babli (60km downstream of Nanded) for the period 1971-75 have been utilized in the study (Fig. 1). The observed daily stage and discharge values have been plotted on graph papers showing the relation between them for the above three places and for all the five years separately. The best fit curves have been obtained by the least squares and they are named the rating curves. Occasionally very high stages will be observed at which discharge measurements are very difficult or not possible. Consequently to obtain discharge values corresponding to these high stages during high flood periods, the above rating curves have been extended using a logarithmic method of extension by Linsley *et al.*[4] From these curves hourly discharge values corresponding to the stages during selected major flood events have been obtained and utilized.

METHOD

As a flood wave passes along a natural channel, some of the water is stored temporarily. The amount depends on the dimension and variability of the channel and flood plain. Storage in the channel increases as long as the inflow exceeds the outflow. All methods of flood routing are based on the law of continuity. This implies that the volume of water discharged from a reach during an interval must equal the inflow minus the change in storage.

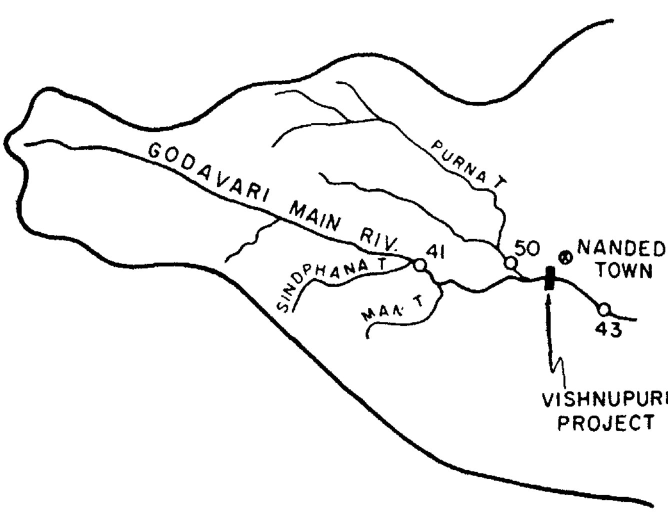

FIG 1 Location map of gauge and discharge measurement sites. 41—Dhalegaon, 50—Purna, 43—Babli

Many less complicated methods have been developed for flood routing problems and have been found satisfactory in many practical applications. The Muskingum method, which was suggested by the U.S. Corps of Engineers for the study of the Muskingum River basin in Ohio, U.S.A., is one of the most frequently used.[5] After much research,[6–10] even today the method is widely used by scientists and engineers, as it is simple and sufficiently accurate.

In the present study, the Muskingum linear method has been adopted. The storage equation is:

$$S = K[X \cdot I + (I - X) O],$$

where

S = storage within the routing reach at a given time in m^3,

K = slope of storage-weighted discharge relation with the dimension of time,

X = dimensionless constant which weights the inflow and outflow

I = rate of inflow at the upstream end in $m^3\ sec^{-1}$

and

O = rate of outflow from the downstream end in $m^3\ sec^{-1}$.

The procedure for determining the constants K and X with examples are given in many text books.[11–12]

To derive the values of K and X for the Godavari river reach Dhalegaon-Babli, several flood hydrographs during 1971–75 were plotted and examined. From a preliminary examination of these twelve events were found suitable for further analysis. The suitability was judged on the basis of the steadiness of the flood hydrograph and its symmetry around the peak. Based on the hydrographs at upstream and downstream points corresponding to these twelve events, a tentative set of constants was taken and a couple of events were routed. The synthesized hydrographs were then derived by routing at the downstream end at Babli. They were compared with the observed hydrographs. The constants were then altered by examining the differences between the observed and routed flows. The process was continued four or five times until the best match between observed and routed was obtained. These constants were taken as the approximate Muskingum constants. Two cases are shown in Figs. 2 and 3. In a similar way, routing for the other events was performed and an average set of constants was obtained. There were widely varying situations in the twelve selected events. For instance, in Sept.-Oct., 1971 (Fig. 2), the runoff contribution from the region between Dalegaon to Babli was considerably less, but an opposite situation prevailed in the event of July–Aug., 1974. (Fig. 3).

In routing streamflows of any main river, the usual procedure is to route the first section of the main river and then adding the gauged tributary flows, local flows, if any, are added in proper time phase utilise these combined flows to route the next section and so on. If any two or more consecutive

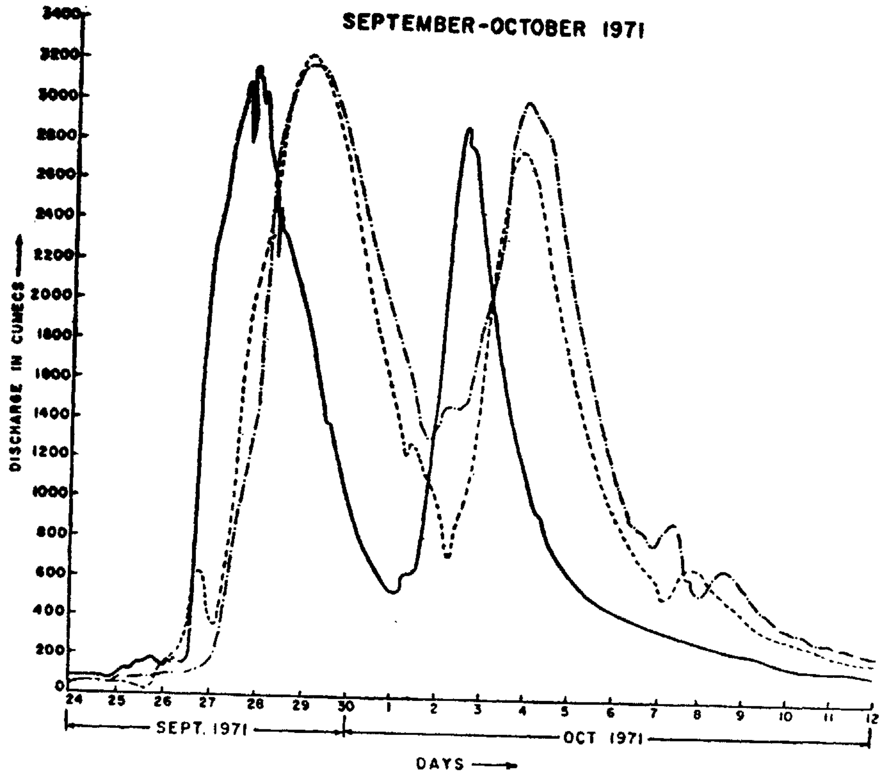

FIG 2 Observed and Routed flood hodrographs during 1971. Solid line—Inflow hydrograph at Dhalegaon; Broken line—Routed hydrograph at Babli; Broken and dotted line—Observed hydrograph at Babli

sections have the same or almost equal X values, the constants can be adjusted for the combined section. Otherwise, different Muskingum constants will be computed for different sections. The same value of X for different reaches indicates similar channel characteristics.

In the above procedure, the observed flows at Dhalegaon were first routed upto the confluence of Purna (147km). The observed tributary flows of Purna were added to them in a proper time phase to obtain the combined flows. In the second step, the combined flows were routed from Purna confluence to Babli (90km).

RESULTS AND DISCUSSION

An average value of the constants for the first portion of the reach from Dhalegaon to Purna were found to be $K = 23$Hr and $X = 0.4$. For the second portion, that is the Purna-Babli reach, they were $K = 14$Hr and $X = 0.4$. Hence, for the entire reach from Dhalegaon to Babli, the constants were $K = 37$Hr and $X = 0.4$. This implies that a flood wave at Dhalegaon would take about 23 hours to reach Purna confluence and 37 hours to reach Babli. This result will be useful to engineers for taking remedial action at the downstream points, as and when necessary.

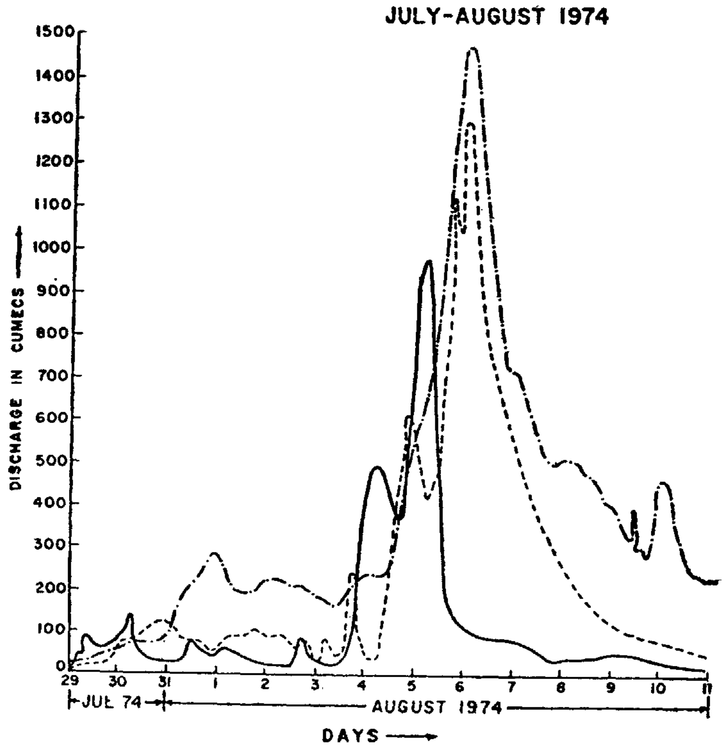

FIG 3 Observed and Routed flood hydrograph during 1974. Solid line—Inflow hydrograph at Dhalegaon; Broken line—Routed hydrograph at Babli; Broken and dotted line—Observed hydrograph at Babli.

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