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Dominant Discharge in the Kor River, Upstream of Doroodzan Dam, Fars Province, Iran

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Abstract: Estimation of the frequency of dominant discharge in the rivers is necessary for flood plain management. The determination of the dominant discharge is also very important for flood mitigation and estimation of flood damage. In this study the frequency of dominant discharge of the Kor River, upstream of Doroodzan Dam in the Fars Province is investigated and the rate of flow for dominant discharge was also determined. The flood discharge of 36 years at Chamriz station, upstream of the Doroodzan dam was collected and analyzed. The flood frequency analysis was used to find the ARI of the dominant discharge in the Kor River, upstream of Doroodzan Dam. It was found that the dominant discharge in the Kor River at Chamriz station has an ARI of 1.11 years on partial series analysis. The dominant discharge was found to be 552.75 m^3 sec^{-1} for the Kor River, upstream of Doroodzan Dam.

Key words: Dominant discharge, Kor River, Doroodzan Dam, Iran

INTRODUCTION

Determining the dominant discharge is very important for sedimentation problem in the river and it is very useful for river stabilization. The dominant discharge is a discharge which forms the river shape and morphology. It is also very important for the riverine stabilization and fish habitats. Despite the importance of the dominant discharge, it is not yet completely determined for the existing rivers. Inglis (1949) defined that the dominant discharge in a natural stream is a discharge, representative of a whole range of discharges that pass through the channel and forms the channel morphology. The dominant discharge is usually defined as; i) The most effective discharge for sediment transport. To define the dominant discharge, Benson and Thomas (1966) defined the dominant discharge as the discharge which transports the most sediment transport in suspended load. Pickup and Warner (1976) have also defined the dominant discharge as the effective discharge which transports the sediment particles as the bed load and they found that it is a discharge with 1.15-1.4 annual recurrence interval for the upstream of natural stream in Australia. However, Keshavarzi and Erskine (1995) and Erskine and Keshavarzi (1996) found that the dominant discharge on downstream of South Creek and Eastern Creek in New South Wales, Eastern Australia has an Annual Recurrence Interval (ARI) of 1.89 to 2.40 years on the partial series analysis. Andrews (1980) defined the dominant discharge as the discharge with 1.2-1.4 annual recurrence interval and it is effective for the transport of the most sediment particles as total load. ii) The natural bankfull discharge or the discharge in a river which just fills the main channel and not over banking the flood plains. Riley (1972) reported that the bankfull discharge has an annual recurrence interval of 1.58 for Eastern Australia. Dury (1965) reported the discharge with 1.58 years annual recurrence interval for bankfull discharge in USA Rivers. Hey (1975) reported the

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bankfull discharge with 1.5 years annual recurrence interval for UK Rivers. Bary (1975) reported a bankfull discharge with 2 years annual recurrence interval for western Canada. iii) The dominant discharge is also defined as the discharge or a flood of fixed frequency such as 1-2 years flood. iv) It is defined as the discharge which exhibits the best statistical correlation with various channel morphological characteristics. In some studies for example by Williams (1978), Doyle *et al*. (1999) and Valentine *et al*. (2001), it was attempted to define dominant discharge as a bankfull discharge or effective discharge which overtopping the flood plains. However, the design of stable channel for flood plain management and estimation of flood damage in the rivers is still a major concern of the engineers. In this study, the frequency of dominant discharge in the Kor River, upstream part of Doroodzan dam was determined using 36 years of recorded flood discharge. The stage discharge curve method for determination of bankfull discharge and meander wavelength method were used to find the dominant discharge in the Kor River. Also to find the frequency of dominant discharge, some flood frequency distributions were also applied to the flood data.

MATERIALS AND METHODS

Study Site

The Kor River is one of the most important rivers in Fars with a catchments basin area of 9650 km^2 which branch off from elevation of Palangy and Baraftab mountains and it drains into the Kamfiroz, Ramjerd and Korbal plains and finally enters into the Bakhtegan lake. Figure 1 shows an aerial view of the Kor River upstream of Doroodzan Dam. The Kor River is very important for urban water supply, agricultural and industrial purposes.

The flood frequency analysis was applied to the 36 recorded flood data at Chamriz station, upstream of Doroodzan dam. The stage discharge curve of flood discharge at the above station was also used to find the bankfull discharge. The bankfull stage is that discharge which just fills the channel without overtopping the banks and inundating the flood plain at the specified location. While a number objective definitions of bankfull have been proposed (Riley, 1972), they are no more reliable than subjectively determined assessments (Williams, 1978). Thus, in this study a definition of the dominant discharge is used. It is defined as the discharge at which the rating curve exhibits an abrupt flattening of slope. The Dury's method (1965) for definition for the dominant discharge from meander wavelength was also used in this study. Wavelength meanders were measured on 1:25000 topographic maps.

Fig. 1: Aerial view of the Kor River

RESULTS AND DISCUSSION

Stage-Discharge Curve

As mentioned earlier, a definition of dominant discharge was equal to the bankfull discharge and in the stage discharge curve is the point at which the rating curve exhibits an abrupt flattening in slope.

Knight and Demetriou (1983) concluded that there is a linear relationship for the in-bank flow and out-bank flow. It is represented in Eq. 1 with a hinge point at the bankfull level.

$$\log H = \gamma . \log Q + \delta \quad (1)$$

where γ and δ are constants whose values are determined by linear regression, Q is the flow depth in mm and Q is the flow discharge in L sec^{-1}.

Sellin (1964) pointed out that the presence of some interactions along the vertical interface between the shallow and deep sections of compound channel results the transfer of momentum between the main channel and the flood plain. Bankfull discharge can be derived from the point of abrupt change in the rating curve. The slope of the rating curve for flow in simple channel is steeper than that for channel with over bank flow. Figure 2 shows the stage discharge curve for the above station. From the rating curve in logarithmic scale for Kor River at Chamriz station, upstream of Doroodzan dam, the flow for bankfull level was found to be 552.75 m^3 sec^{-1}.

Meander Wavelength

Meander wavelength varies with the square root of bankfull discharge and any empirical relationship between wavelength (L) and bankfull discharge (Q_{bf}) may be statistical rather than causal (Dury, 1965). Wolman and Leopold (1957) concluded that the bed width is determined directly by discharge, whereas wavelength depends directly on width and thus only indirectly on discharge. Then;

$$L = K.q^b \quad (2)$$

Where, L is the meander wavelength, q is the dominant discharge, K is the coefficient and b is an exponent. The above parameters are in English system unit (FPS). Inglis (1949) found a relationship between width (W) and discharge (q):

$$L = 36_q^{0.5} \quad (3)$$

Dury (1965) used a very large data set and found that

$$L = 30_q^{0.5} \quad (4)$$

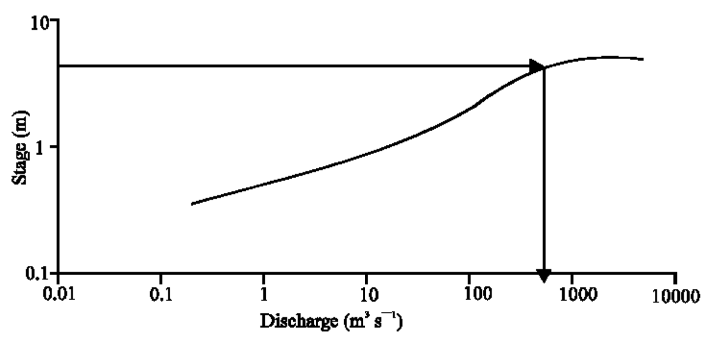

Fig. 2: Rating curve for Kor River at Chamriz station

Table 1: Number and meander wavelength

No.	Meander (m)
1	2100
2	900
3	1350
4	2300
5	1600
6	1200
7	1550
8	800
9	900
10	1200
11	1750
12	850
13	800
14	900
15	1600
16	1200
17	900
18	1050
19	1200

The above relationship was applied to the meander wavelength in the Kor River at Chamriz station. Wavelength meanders were also measured on 1:25000 topographic maps. The numbers of recognized meanders (n) were found to be 19 and the average meander wavelength (L) was found to be 1271.053 m (Table 1). Therefore, bankfull discharge for the Kor River at the above station calculated using Dury's method (Eq. 3) and it was found to be about 547.141 $m^3\ sec^{-1}$. The calculated discharge from the above method agrees with the discharge which was determined from stage discharge curve.

Flood Frequency Analysis

Wolman and Leopold (1957) recommended that bankfull discharge has an Annual Recurrence Interval (ARI) of 1-2 years ($Q_{bf} = Q_{1\text{-}2years}$) on the annual series. Dury (1965) suggested that bankfull discharge is a discharge with ARI of 1.58 years or $Q_{bf} = 0.97Q_{1.58}$. If the annual maximum flood series confirms to the theory of extreme values, the mean annual flood has a return period of 2.33 years and the most probable annual flood has a return period of 1.58 years (Pickup and Warner, 1976).

In the present study the partial series was selected for flood frequency analysis, then the maximum peak discharge per month were considered. The number of floods (K) normally differs from the number of years of record (N) and depends on the selected threshold flood. The variable (K) is assumed to be equal to (2N) (Pilgrim and Doran, 1987). Therefore, the 76 largest floods were selected for the flood frequency analysis in the present study. Flood frequency analysis is a statistical method for analysis of recorded floods. It can estimate annual exceedance probability from the peak instantaneous discharge. Flood frequency analysis may be done analytically or graphically. For the analytical method a probability distribution is fitted mathematically to the recorded data. For the graphical method the recorded data is plotted on appropriate probability paper and a frequency curve is drawn. Here the following probability distributions were used to determine of best probability frequency to the data.

- Normal distribution
- Log normal distribution
    - -log normal (2 parameter) distribution
    - -log normal (3 parameter) distribution
- Pearson Type III distribution
- Log Pearson Type III distribution
- Gumbel Extremal Type I distribution

Table 2: Root mean square error for all distributions

No.	Type of distribution	RMSE
1	Normal	13.44635
2	2 parameter Log normal	7.720215
3	3 parameter Log normal	8.40056
4	Pearson Type III	6.974963
5	Log Pearson Type III	6.550569
6	Gumbel Extremal Type I	8.11607

Table 3: Results of flood frequency analysis with some distribution

No.	Type of distribution	AEP	ARI (years)
1	Normal	0.92	1.087
2	2 parameter Log normal	0.90	1.111
3	3 parameter Log normal	0.90	1.111
4	Pearson Type III	0.93	1.075
5	Log Pearson Type III	0.88	1.136
6	Gumbel Extremal Type I	0.91	1.099

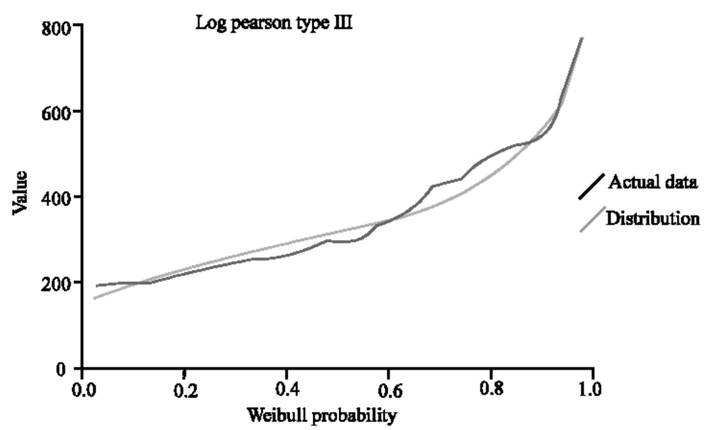

Fig. 3: Flood frequency analysis curve for Log-Pearson III

The root mean square error with equation is compute using

$$\mathrm{RMSE} = \left[\frac{1}{n}\sum_{i=1}^{i=n}(M_i - S_i)^2\right]^{0.5} \times \frac{100}{\overline{M}} \tag{5}$$

Where RMSE is the Root Mean Square Error, M_i is the discharge measurement, S_i is the discharge of output model, $\overline{M}$ is mean discharge measurement and n is the number of years. The Root Mean Square Error for all distributions is shown in Table 2. With the comparison of the errors it was found that the best fitted frequency distribution to the data was log-Pearson III. Therefore, the Annual Exceedance Probability (AEP) of dominant discharge in Kor River was found using log-Pearson III. The log-Pearson III distribution is shown in Fig. 3. The Annual Exceedance Probability (AEP) is inversely related to the Average Recurrence Interval (ARI). Table 3 shows both AEP and ARI of bankfull discharge for the 547 m^3 sec^{-1} for all distributions. The AEP's for the bankfull discharge were derived from flood frequency curves with five distributions and six methods and the results are shown in Table 3. Also Annual Recurrence Interval (ARI) was computed using

$$\mathrm{ARI} = \frac{1}{\mathrm{AEP}} \tag{6}$$

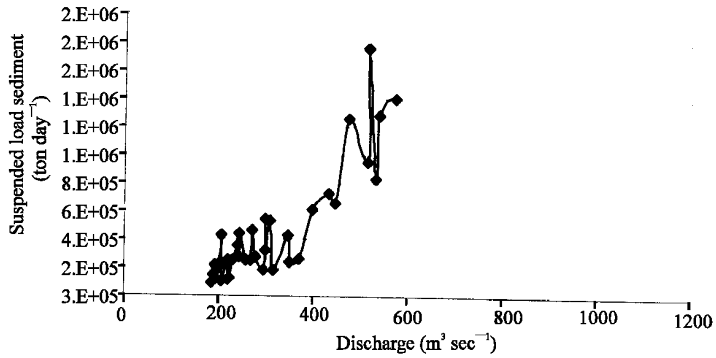

Fig. 4: Suspended sediment load discharge vs. flow discharge

Where ARI is Annual Recurrence Interval (ARI) and AEP is Annual Exceedance Probability (AEP). From the rating curve the value of bankfull discharge is found to be 552.75 (m^3 sec^{-1}). This agrees with the characteristic discharge which is determined from the meander wavelength method (552.75 m^3 sec^{-1}). Therefore the ARI of dominant discharge for the Kor River upstream of Doroodzan Dam was found from the log-Pearson III distribution and it was found to be 1.11 years. This dominant discharge is also called the effective discharge for sediment transport.

Also the suspended sediment of the flow was measured and recorded during 36 years of flood monitoring at Chamriz station. Figure 4 shows analysis of measured suspended sediment concentration. From the measured suspended sediment load it was found that the maximum sediment transport occurred in dominant discharge or bankfull discharge at bankfull stage. When flow overtopping the flood plain, the velocity of flow increases usually due to the roughness at bed of flood plain and also the momentum transfers between flood plain and main channel and dissipate the energy of flow.

CONCLUSIONS

In the present study, the rating curve method and meander wavelength method were used to determine bankfull and dominant discharge in the Kor River upstream of Doroodzan dam Fars Province, Iran. Also the flood frequency analysis of the flood data is shown that the Log-Pearson III was fitted to the data best. From the earlier analysis, it was found that the dominant discharge of Kor River at Chamriz station, upstream of Doroodzan Dam was about 552.75 m^3 sec^{-1} with an ARI of 1.11 year.

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