

Sediment ejection of “the bed scour by hyper-concentrated flow” flood under different operation modes of Sanmenxia Reservoir

Q. Wan^{1,2,a*}, E.H. Jiang^{1,2}

¹Yellow River Institute of Hydraulic Research, YRCCZhengzhou, Henan, 450003, China,

²Key Laboratory of Yellow River Sediment Research, MWR, Zhengzhou, Henan, 450003, China

^a wanqiangmail@163.com

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Abstracts: From the historical data of “the bed scour by hyper-concentrated flow” flood the whole sediment and middle size coarse sediment discharge ratio of SanMenxiareservoir is smaller in the stage of flood detention and open discharge. The flood peak is inharmonious with the sediment peak and the carrying capacity of flood peak is small when flood is passing over the dam. Under the harmonious water and sediment condition, the sediment is transported by flood easier in the lower channel.

Introduction

“The bed scour by hyper-concentrated flow” is a typical sediment movement phenomenon which happen mainly in the XiaoBei master stream of Yellow River and Wei river .When it occurs the river bed scours sharply in a short time and the sediment is raised into pieces from the bed. This kind of scour would reduce the bed from 1~2meter to near 10metres in several hours[1]. “the bed scour by hyper-concentrated flow” flood scour the river channel the XiaoBei master stream at the same time the kind of flood influence the Sanmenxia and Xiaolangdi reservoir obviously; If dispatch deviation, the reservoir may be deposited clearly and the effective storage would not be kept. So the shape of the channel of LYR would be destroyed.it is studied that this special kind of flood sediment and flood discharge characteristic on different operation stages of Sanmenxia reservoir and suggestion is put forward to hyper-concentrated flood management of reservoir .

Sanmenxia reservoir is located at the edge of the ShanXiShanXi and HeNan province 113.5km below Tongguan section, chart 1. It is the first large-size controlling multipurpose project built on the Yellow River. The basin area is 688000 km² which controls the two main flood source area (HeKouzhen~LongMenandLongMen~SanMenxia). The reservoir controls the flood of SanMenxia~HuaYuankou and Ice flood control, irrigation, power generation effectiveness is clearly.

The reservoir started in 1957 and store water in September 1960. The serious siltation happened On the first operation stage of “water storage and silt detention”. The second stage of “flood detention andopen discharge” was carried out in march 1962. in the term, the reservoir actualized open water and sediment discharge and adopted flood detention operation only in term of flood. On the stage, the project was rebuilt in 1965~1969 and 1969~1973 to amplify the discharge. The third stage of “storage rinsing and discharge muddy” has begun since December 1973[2].



Chart 1 The schematic diagram of the relative hydrological stations' location of Sanmenxia Reservoir

Analysis on sediment discharge of SanMenxiareservior

The sediment discharge ratio is contrasted in 4 typical “the bed scour by hyper-concentrated flow” floods on “flood detention and open discharge” and “storage rinsing and discharge muddy” stage to analyze hyper-concentrated flood sediment discharge situation of SanMenxia reservoir. The sediment volume and gradation is similar in these floods and the boundary situation is identical, table 1. The 1969.7” and “1970.8” flood total coarse and middle size size sediment discharge ratio is smaller than “1977.7” “1977.8” flood. The sediment discharge ratio of “1977.7” “1977.8” flood is bigger.

Table 1 different size sediment ejection of SanmenxiaReservior

Operation mode	Flood time	SanMenxia Sediment volume (billion)	Different size sediment ratio%			Sediment ejection ratio %			
			fine sediment	Middle size sediment	Coarse sediment	Total sediment	fine sediment	Middle size sediment	Coarse sediment
flood detention and open discharge	1969.7	0.6535	53	22	25	0.90	0.39	0.09	0.05
	1970.8	0.7612	45	25	31	0.88	0.51	0.14	0.03
storage rinsing and discharge muddy	1977.7	0.796	48	26	25	1.008	0.54	0.40	0.22
	1977.8	0.784	45	22	33	1.011	0.40	0.34	0.14

Deposit and sediment transport characteristic in the LYR

Contrast the deposit ratio in 4 typical “the bed scour by hyper-concentrated flow” floods in the LYR, table 2. It is clear that the sediment whole deposition and deposition in upstream of GaoCun of flood of 1970.8 in the stage of flood detention and open discharge is close to the flood of 1977.8 in the stage of storage rinsing and discharge muddy. but from the gradation of sediment proportion to sediment capacity, the fine sediment deposit ratio of 1977.8 flood is larger than 1970.8 flood; but in the stage of storage rinsing and discharge muddy, the coarse sediment deposit ratio is larger than the other stage. The deposit ratio of another group of 1969.7 flood and 1977.7 flood is in line with the trend. So for “the bed scour by hyper-concentrated flow” floods, the fine sediment deposit ratio is larger and the middle size or coarse sediment sediment ratio is smaller.

Table 2 gradation sediment deposit “the bed scour by hyper-concentrated flow” floods in the LYR

Operation mode	Flood time	Sediment reach	The deposit ratio of the whole sediment capacity (%)	The deposit ratio of the whole sediment capacity(%)					
				< 0.01	0.01 ~ 0.025	~ 0.025 ~ 0.05	~ 0.05 ~ 0.1	~ 0.1 ~ 0.1	> 0.1
flood detention and open discharge	1969.7	Whole down stream	72.30	43.3	73.4	89.1	93.4	97.8	
		Upperstream of GaoCun	60.02	27.3	56.8	82.6	84	98	
	1970.8	Whole down stream	68.46	26	59.1	81.9	93.8	99.6	
		Upperstream of GaoCun	57.33	21	49.7	64	79.8	96.4	
storage rinsing and discharge muddy	1977.7.	Whole down stream	55.54	39.2	48.7	57.4	74.2	94.8	
		Whole down stream	46.61	39.8	44.5	48.7	52.3	90	
	1977.8	Whole down stream	64.78	59.8	48	62.4	79.1	99.1	
		Upperstream of GaoCun	54.18	43.2	30.4	51.9	75.1	91.3	

Reason of the sediment discharge characteristic in the reservoir and the LYR

Why the gradation sediment discharge ratio of reservoir in the condition of the similar sediment and water condition? analysis from the water and sediment discharge out of XiaoLangdi reservoir, the water and sediment discharge from SanMenxia reservoir is in chart 2. The max sediment concentration is 450 kg/m^3 and the correspondent sediment concentration of the flood peak is only 220 kg/m^3 . it is the typical phenomenon of sediment peak delay in flood. In The flood of 1977.7, the flood peak is $7900 \text{ m}^3/\text{s}$ and the correspondent sediment concentration is 589 kg/m^3 . The sediment and water peak is matching very good, chart 3. The water and sediment peak is better matching so the whole sediment and middle size coarse sediment discharge ratio of reservoir is larger; on the other hand, the water and sediment peak is bad matching so the whole sediment and middle size coarse sediment discharge ratio is smaller.

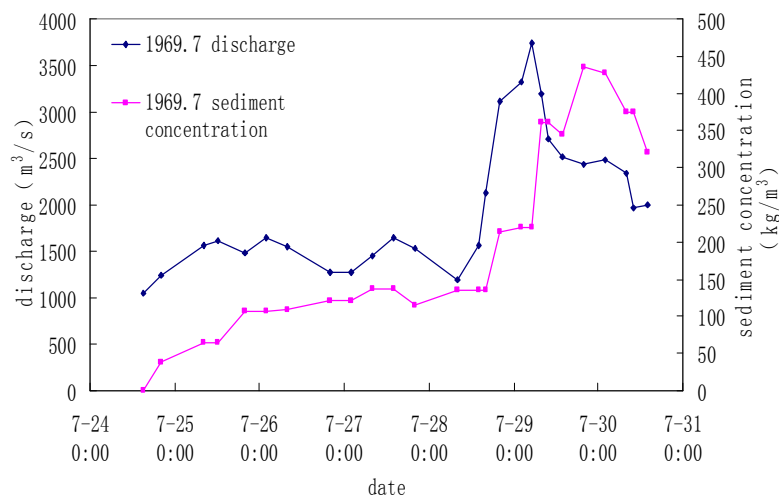


Chart 2 the water and sediment discharge in the flood of 1969.7 in the stage of the flood detention and open discharge of Sanmenxia

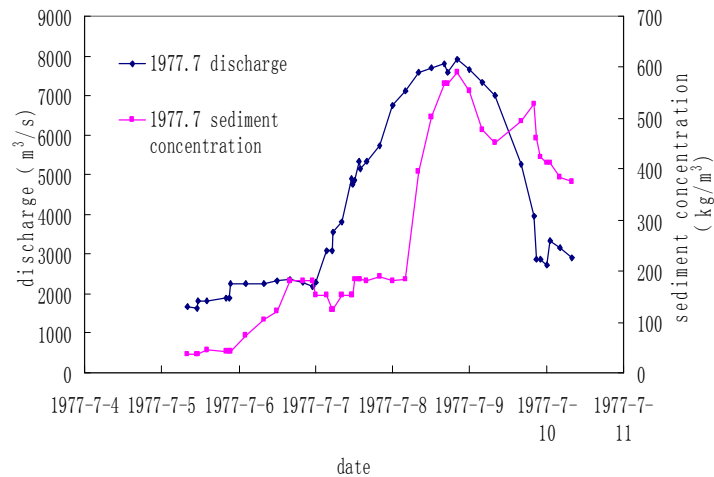


Chart 3 the water and sediment discharge in the flood of 1977.7 in the stage of storage rinsing and discharge muddy

In the stage of flood detention and open discharge, because the sediment structure was unperfect the SanMenxia dam has effect of flood detention. The high water level condition makes the sediment low concentration of the flood discharge. When the water level reduces, the sediment concentration increases rapidly which makes the sediment peak and water peak is mismatching. The sediment carrying capacity of the flood peak is small. But when the water level reduces the sediment ejection of the reservoir begins and the sediment peak delay flood peak situation is made. In the stage of storage rinsing and discharge muddy, because the control water level of the SanMenxia reservoir is low and the sediment structure was perfect the effect of flood detention is not obvious and the water and sediment ratio is more close to the nature. Under the coordinate water and sediment condition the middle size and coarse sediment transportation in the river channel is easier. So the “the bed scour by hyper-concentrated flow” flood whole sediment or middle size coarse sediment discharge ratio in the stage of storage rinsing and discharge muddy is higher than In the stage of flood detention and open discharge.

Conclusion

(1) From the historical data of “the bed scour by hyper-concentrated flow” flood the whole sediment and middle size coarse sediment discharge ratio of SanMenxiareservoir is smaller in the stage of flood detention and open discharge. But the sediment discharge ratio in the stage of storage rinsing and discharge muddy is larger.

(2) In the Lower Yellow River channel, the whole sediment middle size and coarse sediment deposit ratio in the stage of the storage rinsing and discharge muddy is smaller than in the stage of the flood detention and open discharge and fine sediment deposit ratio is larger.

(3) In the stage of flood detention and open discharge, the flood peak is inharmonious with the sediment peak and the carrying capacity of flood peak is small when flood is passing over the dam. When the water level decreases the sediment ejection of the reservoir begins. So the large volume sediment with small flow makes the sediment peak delay flood peak situation. In the stage of the storage rinsing and discharge muddy, the flood sediment and water condition which passes over the dam is more harmonious. Under the harmonious water and sediment condition, the sediment is transported by flood easier in the lower channel.

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