Seasonal Limited Water Level Control of Reservoir Based on Flood Utilization

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Abstract. The development of the transit of flood resources utilization, increase of surface storage capacity, is the strategic measures to alleviate the shortage of water resources and flood multiple contradictions. Shilianghe reservoir is a large reservoir of Jiangsu Province, Lianyungang City, is also the key of flood resources utilization in Lianyungang City, through the study of the limited water level by stage has important significance to the utilization of flood resources. In this paper, on the basis of flood control operation mode and conditions in Shilianghe reservoir, according to the specific situation of the reservoir and then take into consideration all the factors related to the reservoir flood regulation, considering the flood resources utilization in flood season, which is based on the flood season staging situation of present situation of reservoir, and inquire into the various stages of reservoir design flood, flood routing, determine the limit water level by stage of the staging of Shilianghe reservoir, and calculate the efficiency of controlling the limited water level by stage, on this basis ,analysis of the influence of water level adjustment of reservoir flood control. The research results can provide a reference for the large reservoir flood resources utilization in china.

Introduction

Lianyungang City is located in the northeast of Jiangsu Province, east of the Yellow Sea, undertakes the task of releasing flood waters about nearly 80000 km^2 upstream drainage area, is the famous "flood passage". On the one hand crossing water is rich, but the basic is not available water. On the other hand, the local freshwater resources are deficient; the water supply capacity is insufficient. The contradiction of water shortage comes seriously. To carry out the transit of flood resources utilization, increase of surface storage capacity, is the strategic measures to alleviate the shortage of water resources and flood multiple contradictions in Lianyungang city. Therefore, it has important significance to study about Shilianghe reservoir flood with water level control.

Shilianghe reservoir, located in Lianyungang City, is one of the east and south control projects in the YiShuSi, is the first large reservoir of Jiangsu Province, undertakes the task of releasing flood waters of Xinshu River upstream and Yihe river, Shuhe river interval inflow, the catchment area of 15365km^2, the total capacity of 531 million m^3, reservoir was built in 1958, a hydroelectric power station was built in 1970, installed capacity l120 kW. Reservoir is designed to meet every 100 years, checked to meet every 2000 years, design flood level is 26.81 m, flood water level is 27.95 m, the maximum discharge flow is 10131 m^3/s. Shilianghe reservoir is mainly for flood control, with the comprehensive benefit of city water supply, irrigation, hydropower generation, aquaculture, etc.

Shilianghe reservoir scheduling rules

The scheduling of Shilianghe reservoir fully considers the scheduling relationship between watershed, reservoir itself and the downstream, scheduling rules are as follows:

(1) When the local without rainfall but upstream floods, Shilianghe reservoir can be pre fall, try to control the discharge not more than 3000 m^3/s, to ensure that the new Shuhe River dyke safety;
(2) When the local and the upper reaches of the same frequency exceeding standard flood and the local waterlogging will be very serious, Shilianghe reservoir should be based on the amount of upstream and weather forecasts, proper control of runoff in order to take care of Qiangwei River, discharge, Fan River and the City and farmland drainage, alleviate downstream disaster. And as far as possible to take a large flow release flood waters, shorten the time of release flood waters, stagger drainage with downstream river, cede the river to care downstream flood exclusion;
(3) When the local and upstream at the same frequency standard in flood, in order to make full use of the time difference formed by the upstream and downstream peak, the implementation of peak load shifting, give full play to the function of reservoir regulation, make time for the Rose River, Moshanhe River, Fan River and urban and drainage, in order to reduce the downstream disaster, at the same time to make full use of flood resources, variable harm into benefit.
The stage of reservoir control and application shows: when the reservoir water level is 23.5 m-24.0 m, take care of the confluence of the region downstream , controlling discharge not more than 5000 m^3/s, the new and old gate of the control is not more than 2500 m^3/s; when the reservoir water level is 24.0 m-26.3 m, controlling discharge 6000 m^3/s, the new gate is 3500 m^3/s, the old gate is 2500 m^3/s; the reservoir water level 26.3 m-27.0 m, of which the new gate is 4000 m^3/s, the old the gate is 3000 m^3/s; when the reservoir water level exceeds 27.0m, all the gate open to release flood waters.

Research on the limited water level of Shilinghe reservoir by stage

The limited water level of Shilinghe reservoir by stage is based on basin flood season staging calculation, and calculate the various stages of reservoir design flood process, then conduct staging flood regulating calculation according to the operating rules of reservoirs, according to the flood regulating calculation results to determine reservoir seasonal flood control water level. Shilianghe reservoir was built in 1958, was listed as the second batch of national key dangerous reservoirs by the Ministry of water resources, has since been lowered water level to operate, the original design features of reservoir water level and current characteristics of water level are shown in Table 1.

Table 1 Different operating characteristics of Shilianghe reservoir water level gauge

Condition	The normal water level (m)	Design flood level (m)	Check flood level (m)	The limited water level(m)		
				Pre flood season	The main flood season	Latter flood season
Present situation	24.5	26.81	27.95	24.5	23.5	24.5
Design	Recent25.0 Forward26.0	27.65	28.0	23.5		

During 1999-2001 Shilianghe reservoir implemented reinforcement engineering, by the end of 2008, the treatment project of Xinshuhe river officially started, when completed, the flood control standards in the middle and lower reaches of Yishusi river and Xinshuhe River area flood capacity will be increased to the level of meeting every 50 years, creating conditions for the future to restore the normal use of Shilianghe reservoir. Therefore, the purpose of this study was to restore Shilianghe reservoir constant storage level to the original design goals for 26 m, the design flood level and check flood level were restored to 27.65 m, 28.0 m, and on this basis, to research on controlling the limited Water Level of Shilianghe Reservoir by stage. In the premise to guarantee the reservoir flood control safety, to further tap the potential of reservoir, making full use of pre flood and late flood season passing flood, enhance the ability of utilization of rain resources in Lianyungang city.

3.1 Flood season staging

At present, the domestic flood season staging has some research results; flood season staging belongs to the clustering problem of high dimensional time series, currently the main way to handle such problems including fuzzy set analysis method, system clustering method, the fractal method, change point analysis, dynamic clustering method [1-3]. Based on comprehensive analysis of Shilianghe reservoir upstream, local rainfall, climate and extreme weather and other factors, combined with the actual situation of the work for flood control basin and area, put the flood season from June 1st to September 30th as the research object, selects the flood daily maximum flow series for many years of Shilianghe reservoir from 1980 to 2009 as series of samples for analysis, Shilianghe reservoir flood season can be divided into pre flood season, the main flood season and latter flood season.

3.2 Stage design flood

In a survey of 1980-2009 Shilianghe reservoir inflow flood, according to different stages to select maximum flow of storage year after year, to constitute the peak flow series, using curve fitting method to compute the stage flood frequency curve, obtain the design peak corresponding to the design standard. Considering the abnormal changes of Shilianghe reservoir upstream and basin weather significantly, leading to exist a certain chance of its flood occurrence time in years, based on the possibility of advancing and pushing back, using "step sampling method", which on the basis of the original time period on installments, flood sampling extends forward and backward five days each at the same time. The stage design flood peak discharge of Shilianghe reservoir is shown in Table 2.

Table 2 Stage design flood calculation results

Staging	Q_m (m^3/s)	Cv	Cs/Cv	The peak flowQ_p (m^3/s)		7 days flood W_p (billion m^3)	
				1%	0.05%	1%	0.05%
Pre flood season	2391.9	1.03	1.0	8029.6	11264.7	27.55	29.28
The main flood season	——	——	——	10017	15799	34.36	41.07
Latter flood season	2493.8	0.96	1.0	8026.2	11247.2	27.53	29.31

3.3 The limited water level by stage

The People's Republic of China Ministry of water conservancy "general of the comprehensive utilization of reservoirs " provisions: staging flood limited water level should be based on the design flood by stages, by not less than the engineering safety standard, undertake the downstream flood control standard and the principle of reservoir safety standards, and the corresponding discharge method for flood regulating calculation. The calculation method of the limited water level of reservoir by stage is: in the condition of the stage design flood, design flood level, flood water level has been established; flood is calculated according to the principle of reservoir operation, then experiment flood limit water level. The flood regulating calculation results of design flood by stages and check flood of Shilianghe reservoir are shown in Table 3 and Table 4.

Table 3 Flood regulating calculation results of stage design flood （P=1%）

Staging	Adjust the water level（m）	The highest water level（m）	The maximum flow（m^3/s）	The maximum discharge（m^3/s）	The maximum storage capacity（10^4m^3）
Pre flood season	26.02	27.65	8029.6	7000	50044
The main flood season	24.65	27.65	10017	7000	50053
Latter flood season	25.83	27.65	8026.2	7000	50053

Table 4 Flood regulating calculation results of stage check flood（P=0.05%）

Staging	Adjust the water level（m）	The highest water level（m）	The maximum flow（m^3/s）	The maximum discharge（m^3/s）	The maximum storage capacity（10^4m^3）
Pre flood season	26.14	28.00	11264.7	10131	53137
Main flood season	24.52	28.00	15799	10131	53103
Latter flood season	25.87	28.00	11247.2	10131	53081

According to the above regulating calculation results of design flood by stages and staging check flood, the limited water level by stage are shown in Table 5.

Table 5 The comparison of limited water level by stage

Frequency P	Pre flood season (m)	The main flood season (m)	Latter flood season (m)
1%	26.02	24.65	25.83
0.05%	26.14	24.52	25.87

A comprehensive analysis and comparison of the regulating calculation results of design flood by stages and staging check flood, the limited water level of Shilianghe Reservoir by stage chose a smaller value of the two and rounding, in order to ensure the safety of reservoir flood control and the convenience of its own dispatching control, thereby determining the limited water level of Shilianghe reservoir by stage.

3.4 The benefit calculation of limited water level by stage

The benefit calculation principle of limited water level of Shilianghe reservoir by stage is as follows: To investigate the previous abandoned water data over years of Shilianghe reservoir from 1991 to 2009, calculated that the adjustment of limited level corresponding to the storage capacity increment. When the various stages of abandoned water less than the increase of storage capacity due to limited water level, the increasable water storage of the reservoir that is equal to the abandoned water; when the staging of abandoned water is larger than the increase of storage capacity due to limited water level, increase storage is equal to the increase of storage capacity due to limited water level [4]. Thus, to calculate the benefit of limited water level of Shilianghe reservoir by stage, see Table 6. According to the results of benefit, after using limited water level by stage, Shilianghe reservoir average annual can retain more water storage about 111.24 million m^3.

Table 6 The benefit calculation of limited water level of Shilianghe reservoir by stage

Project	non flood season	Pre flood season	The main flood season	Latter flood season	Total
Present flood control level（m）	——	24.5	23.5	24.5	——
After adjusting the flood control level（m）	——	26.0	24.5	25.80	——
The normal water level（m）	24.5	——	——	——	——
After the adjustment of normal water level（m）	26.0	——	——	——	——
Increasing storage capacity	10084	10084	5761	8685	——
Cumulative increase water storage capacity（10^4m^3）	47407	15167	69934	78860	211368
Average annual increase in the volume（10^4m^3）	2495	798	3681	4151	11124

Impact analysis

(1) After Shilianghe reservoir takes the implementation of stage flood control level, the overall flood risk of the Shilianghe reservoir downstream in Lianyungang City increases. Despite after the implementation of controlling the limited water level of reservoir by stage, Lianyungang City and reservoir dam risk relative increase, but overall is still in the controllable range[5]. Shilianghe reservoir downstream Xinshuhe River after comprehensive treatment, river flood control capacity has reached the level of meeting every 50 years, flood carrying capacity up to 7000 m^3/s, solves the sluggish problem of Shilianghe reservoir exports, the reservoir can flight capacity for flood control in a relatively short period, ensure the Lianyungang city and dam flood control safety.

(2) After Shilianghe reservoir recovers the original design water level operation and takes implementation of staged limited water level control, the average annual can retain more water storage about 111.24 million m^3, in non-flood season the average annual retains about 24.95 million m^3, in flood season the average annual can retain more water storage about 86.29 million, which will greatly improve the efficiency of utilization of flood resources in Lianyungang City, and effectively ease the contradiction of industry and agricultural water utilization of its surrounding area.

(3) After Shilianghe reservoir recovers the original design water level operation and takes implementation of staged limited water level control, the normal water level is increased from 24.5 m to 26 m, at the same time limit water level in flood season and the design flood level reservoir level are improved, which will cause the increase of the reservoir waters area and the reservoir submerged area, easy to cause the reservoir immigrants move again and other social problems, also produce certain effect on the reservoir ecological, environment, climate and other local.

Summary

In order to promote the work of Shilianghe reservoir flood resources utilization, Lianyungang City should strengthen coordination work with watershed management mechanism, upstream of the reservoir area and the reservoir area within the scope of influence of the masses, and properly handle all kinds of contradictions and problems, at the same time, the integrated use of scientific and technological means of reservoir safety monitoring, flood forecast, flood optimization dispatching etc, improve the management level of reservoir, under flood control security, gradually carry out the stage control of Shilianghe reservoir, bring into play the benefit of reservoir flood resources sufficiently.

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References

[1] Wang J L, Gao Y. The Dongfeng reservoir flood limit water level dynamic control [J]. Central China Electric Power, 2006, 19 (6):41- 43.

[2] Shao D G, Li W, Liu B J, et al. Study on the utilization of flood water resources of reservoir flood limit water level elevation [J]. Chinese Rural Water and Hydropower, 2004(9): 26-29.

[3] Shang Z H, Wan F Q. Study on flood resources in city [J]. Water Economy, 2006, 24(5):7-8.

[4] Feng P, Han S, Li J. Comprehensive analysis of risk and benefit of adjusting the flood control level of reservoir [J]. Journal of Hydraulic Engineering, 2006, 4:451-456.

[5] Zhang G H, Zhou H C, Wang B D. Study and risk analysis of reservoir about real-time dynamic control of limited water level [J]. Journal of Hydroelectric Power, 2009, 2:51-55.