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Disease Analysis on Hydraulic Concrete Structure of Reservoir Works in Jiangxi Province

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Abstract. In recent years, a large proportion of reservoir works in Jiangxi province have emerged different kinds of new diseases, which not only hold back the benefit but also affect the safety of these projects, to some extent. Based on investigating the present situation of dams in Jiangxi province and analyzing the reasons for deterioration condition in reservoir works, the main disease for hydraulic concrete structure of ill-dangerous dams is divided into several typical types and the characteristics of the existing problems are given as well as some control measures.

Introduction

As one of the important foundation establishments of economic society, reservoirs play a significant role in Jiangxi province's economy. For years, reservoirs make huge benefits in many ways such as flood control, irrigation, water supply, electricity generation and ecosystem protection. However, for some reasons, reservoir works in Jiangxi province have many problems existed in general. For example, the flood control standard can't meet the request of criterion, the construction quality is not good enough, aging phenomenon is serious, and management drops behind, etc. In latest decades of years, *Jiangxi Provincial Water Conservancy Department* has paid great attention to the harnessing of diseased reservoirs. Especially after the year of 1998, the government of Jiangxi province has increased invests in repairing large-scale diseased reservoirs and important middle-scale ones. However, some new diseases have emerged in some projects during the harnessing due to the improper measures or construction techniques, or quality problems, which has even worse impacts on the safety of the reservoirs.

General Situation of Reservoir Works in Jiangxi Province

According to statistics, there are 9268 dams with total capacity of 28.016 billions m^3 in Jiangxi province by the end of 2002.The number of reservoirs of this province ranks the second in China, which accounting for about 1/9 of all the reservoirs in our country. And there are 7690 small-scale (II) dams, 1329 small-scale (I) dams, 224 medium-scale dams and 25 large-scale dams. 25 large-scale dams have been listed as key reservoir, in which the total reservoir capacity of Zhelin reservoir with capacity of 7.92 billions m^3 is the maximum. In the existing 249 large and medium-scale reservoirs, the number of earth-filled dam and earth-rock-filled mixed dam is 191 which accounting for 77% of the total; and the number of masonry dam, concrete gravity dam and arch dam is 58 which accounting for 23% of the total.

But, due to historical reasons, a high ratio of reservoirs has all kinds of diseases. It is estimated that there exists 3488 ill-dangerous dams that would impact the security of the life of people, public facilities and the reservoir benefit in Jiangxi province. In terms of the safe operation of hydraulic structures, monitoring and testing facilities of various types of hydraulic structures is not good enough, and the defect detection technology for hydraulic structures is not advanced. The lack of a reliable method to assess the safe operation of large hydraulic structures, and the lack of timely

treatment and rehabilitation for diseases in buildings all caused functional failure and other issues in the reservoir works.

Harnessing of Diseased Reservoir Works

Based on this fact, *the opinions of ill-dangerous dam reinforce in Jiangxi province* were announced by the office of the people's government of Jiangxi province. It put forward the goal: the task of reinforce on dangerous dams must be finished in 5 years. First of all, the government worked out the ill-dangerous dams reinforce plans in Jiangxi province through analyzing the present situation of ill-dangerous dams, the reasons of bringing into the ill and danger, the benefits resulting from reinforce, the factors of fund resources and the assortment proportion. Then the measures such as organization, policy, technology and fund were established to finish the goal by the end of 2007 and direct the work of reinforce under the consideration of the water resources condition in each region. Since 2003, Jiangxi Province began to carry out the reinforcement for the large-scale dam. Then, the reinforcement plans of 3488 dams basically completed by the year of 2007. In 2007, 668 dangerous reservoir works in Jiangxi province were included in the national dam reinforcement special plan. Up to December 28, 2010, the 668 dam reinforcement works in Jiangxi Provincial Special Plan have been completed and put into use at the final acceptance or acceptance.

As a result, based on the safety investigation and analysis of 7690 small-scale (II) dams, 1329 small-scale (I) dams, 224 medium-scale dams and 25 large-scale dams, the evaluation principle of ill-dangerous dams is established. There are 3488 ill and dangerous dams that accounted for 37.6 percent of the total quantity of dams in Jiangxi province until Dec.31 in 2002(11 large-scale dams, 44.0 percent; 153 medium-scale dams, 68.3 percent;775 small-scale (I)dams, 58.3 percent; and 2549 small-scale (II) dams, 58.3 percent; respectability). Moreover, there are 80 reservoirs in which have been identified as the third level dam, including 24 reservoirs being lack of flood safety, 43 reservoirs with flood safety deficiencies; 73 reservoirs with seepage safety deficiencies, 77 reservoirs being lack the structural safety of the dam, 47 dams being lack of slope stability, and 70 reservoirs with discharge structural safety deficiencies.

Diseases Statistics on Hydraulic Concrete Structure of Reservoir Works in Jiangxi Province

Due to the role of various loads and natural factors, the working conditions of hydraulic structures in reservoir works are changing. There are lots of reservoirs in Jiangxi Province, however, most reservoirs were built from 1950 to 1970. With the prevalence of low standard, and poor construction quality, reservoir facilities generally became aging, and dams exist many security risks.

In the process of implementation of the reinforcement plans in Jiangxi province, the offices of the government have detailed records on reservoirs under deterioration conditions over the years. As the registration policy on dams has been carried out in recent years, the management of dangerous reservoirs becomes more normative. In this study, we finished with statistics from 1963 to 2005 between 100 typical reservoirs, including the basic situation of diseased hydraulic structures in different types and in different parts. According to the name of reservoir, the category of the diseased building, the occurrence time of danger, the class of danger, the site of danger, and the level of danger, all these factors are taken to accounted(shown in Table 1 and Table 2).

Table 1. Disease classification based on 100 reservoirs in Jiangxi province

Types	Description of deterioration conditions	Frequency(times)
Buildings which have been under deterioration conditions	Dam	142
	Culvert	86
	Tunnel	22
	Spillway	47
Name of deterioration conditions	crack	21
	Leakage	62
	Piping	6
	Dam-break	1
	Slope sliding	13
	Collapse	9
	Damage of spillway	6
Times of dangerous events	1963 year－1999 year	521
	2000 year－2005 year	63
Total	Total times of dangerous events	584

Table 2. Detail statistics information for typical diseased reservoir in Jiangxi province*

Name of reservoir	Buildings and sites under deterioration conditions	Name of deterioration condition	Class of deterioration condition	Frequency (times)
Dafeng reservoir	culvert for water distribution	crack, surface voids	fatal danger	32
Fengchan reservoir	dam slope	seepage	fatal danger	23
Matou reservoir	discharge channel	collapse	fatal danger	12
Huangjin reservoir	dam	seepage	relatively high danger	13
Wucheng reservoir	dam	crack	relatively high danger	43
Ganghe reservoir	dam	seepage, crack	relatively high danger	11
Humaoshan reservoir	dam toe	seepage	relatively high danger	10
Gaofang reservoir	dam toe	crack, leakage	relatively high danger	12
Majie reservoir	diversion tunnel	seepage	relatively high danger	87
Xingfu reservoir	main dam	seepage	general danger	51
Shantian reservoir	main dam	termite harm	general danger	42
Guanyintang reservoir	main dam	termite harm	general danger	32
Dongtang reservoir	discharge culvert	crack	general danger	18

* Note: (only listed the number of reservoir in dangerous condition for more than 10 times)

Diseases Classification on Reservoir Works in Jiangxi Province

The Reasons Leading to Diseases of Reservoir Works

According to a large amount of analysis, the reasons causing diseases in reservoirs include:

(1)*Low design criteria*. With expend of hydro sequence, especially with the increase of observed record flood, the flood control criterion was checked and reformulated. That is one of the important reasons why design criteria of most existing reservoir works is lower than that used today. Another reason is that people's requirement to safety is increasing with the development of economy and technology, which has reflected in new criterion. For example, the crest elevation of dam does not meet regulatory requirements.

(2)*Poor construction quality.* According to historical reasons, construction of these reservoirs was carried out at the same time with exploration and design, which leads to poor construction quality and a lot of potential safety problems.

(3)*Serious aging and disrepair.* Most of reservoir works in Jiangxi province has functioned for several decades of years and aging phenomenon is quite common. Some structures and equipments need repairing and updating. However, most reservoirs have main function of flood control and irrigation, so maintenance expense is often not enough and they can hardly get maintained and repaired in time. Nearly all of large-scale reservoirs, middle-scale reservoirs and small-scale reservoirs were built about during the period of 1958 to 1976. More than 80% medium-scale reservoirs in Jiangxi province are earth dams and most dams had no observation facilities for a long time. For example, spillway facilities are not reliable and floods can not be safely discharged.

(4)*Improper management.* Management is disregarded in many reservoir works, especially the small ones. In such projects, there is no special road for flood prevention or communication and lighting equipment, or monitoring system and early warning system are not perfect. Now, for some reservoir works, monitoring installation is aging badly so that displacement of dam can not be monitored properly. And for some reservoirs, even no monitoring equipment installed so that managers have no way to discovery diseases or resolve them.

Classification of Diseases in Hydraulic Concrete Structures

Based on investigating and analyzing the present situation of dams in Jiangxi province, the main disease for hydraulic concrete structure of ill-dangerous dams in Jiangxi province is divided into several typical types and the cause is given (shown in Table 3).

From the statistical data, it shows that cracks and seepage are the most two common diseases in hydraulic structures. Cracks exist in many aspects of hydraulic structures, and the seepage is the most large risk in dams. The corrosion of steels is also a very common phenomenon. Since most hydraulic structures in Jiangxi province having running for a long time, many hydraulic structures have problems such as aging and disrepair, in which including exposed steels and corrosion.

Table 3. Types and causes of diseases for hydraulic concrete structure in Jiangxi province

types of diseases and defects	cause
crack	Temperature stress, low concrete strength, poor uniformity, uneven foundation settlement, cracks caused by improper structure design, alkali-aggregate reaction, the improper initial curing of concrete, steel corrosion
seepage	Seepage in retaining structure, water level variation, holes, penetrating cracks, poor quality of construction, failure in expansion joint and sealing structure, foundation curtain damage
erosion and cavitation	Erosion damage, water medium influence, poor concrete quality
corrosion of the reinforcing bar	Concrete subjected to erosion of CO_2 in the air and the formation of carbonation, chloride ion permeability

Another critical thing is that small reservoirs are entering a period of high danger. Many small reservoirs have been running for more than 40 years. The aging dam, seepage in dam, culvert corrosion damage are emerging gradually. In the future, these diseases will further exacerbate the risk of dam failure. Once experienced the standard of rainstorm in 50 years, the small-scale (Ⅱ) reservoir will not escape from danger or even collapse.

Conclusions

Reservoir works are playing an important role in ensuring safety of people's life and properties and the development of economy. However, ratio of diseased reservoirs is very high because of low design criteria, poor construction quality, serious aging and disrepair and improper management, which badly impacts the safety and benefits producing. In recent years, Jiangxi Province government has invested huge funds to harness diseases and has achieved considerable effects. Most of hydraulic concrete structures in Jiangxi province are now going into ageing status. As a consequence, it is necessary to remedy and repair these old concrete structures. Only can they be safe by inspected regularly, maintened and repaired carefully.As we have mentioned, a lot of diseases have emerged in hydraulic structures due to improper measures or quality problems. Therefore, proper management should be made according to the specific environment and operation conditions so as to ensure the safety and quality of the project. Another critical thing is that small reservoirs in Jiangxi province are entering a period of high danger. Once experienced the standard of rainstorm in 50 years, the small-scale (Ⅱ) reservoir will not escape from danger or even collapse. Moreover, with the development and application of high-performance concrete in hydraulic concrete structures, these new materials can slow down the ageing rate and eliminate some defects in diseases.Only in these ways can we ensure that the diseases harnessing project will perform in safety.

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