RESEARCH ON MONITORING TECHNOLOGY OF DIGITAL RESERVOIR

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Abstract: Firstly, the concept of digital reservoir is proposed and discussed in the paper, then the method how to monitor dam's state by digital means and how to transmit the monitoring data by GPRS technology is presented, and the method can monitor the dam's state in real time and its advantages such as real-time, visibility, visualization are analyzed later. The indicators reflecting the safety of dam are selected, and the method how to build mathematical model to real time monitor the safety and the procedure of modeling in engineering are given. At last, the above proposed method is demonstrated in Xueye reservoir, Lai Wu, Shandong Province. As a result, it is prove that the monitoring technology of the dam is effective.

Keywords: digital Reservoir, monitoring technology of the dam, data collection

1. INTRODUCTION

Reservoirs are important water conservancy facilities and water resources protection bases. They are key facilities which ensure industrial and agricultural production and urban people's life. Also, they are foreland of the rapid response to flood prevention, drought control and flood warning. The management level of reservoir is directly related to the normal design efficiency and people's life and property's safety. As the main contents of the reservoir modernization, reservoir automatic monitoring system can

realize the automatic collection and delivery of hydrological factors such as rainfall, water level and water scheduling, directly serve the flood forecasting and scheduling and the water resources management, achieve the optimal allocation of water resources, provide the scientific basis for decision-making on the efficient use of water resources, comprehensively upgrade the management level of the reservoir, and is an important means to realize reservoir management modernization (Liang, et al., 2005).

The digital reservoir is usually understood as describing the whole reservoir with digital information technology to make it serve the human existence and development furthest (Liu, 2004). Strictly speaking, the digital reservoir is referred to describing vast information of the reservoir in different dimension and space-time by RS, GPS, GIS, telemetry, remote-control and virtual reality technology based on computer, multi-media, large-scale memory and wide-band networks technology for the human existence, development and daily work, life and entertainment. The core of digital reservoir is to realize the intelligence and visibility of vast information of the reservoir through computers and networks. The dam is main building of reservoir, whose safety concerns reservoir and people's safety. Safety monitoring is important way guaranteeing the dam's safety, which controls the dam's running through collecting the dam's information concerned and developing trend. Safety monitoring of the dam is the process from collection and processing of initial safety information to forming safety concept in the brain. The paper mainly researches information collection and processing of the dam by digital means.

2. COLLECTION OF THE DAM INFORMATION

Affected by complicated factors, the dam's press condition will real time changes and the flaw hiding the dam's structure and harm brought by the flaw both have the characteristic of gradation. The particularity determines that, on one hand, safety monitoring system of the dam has long-term stability and high precision, on the other hand, the primitive data collected and transmitted must be exact, reliable and timely, especially under the bad condition such as rainstorm and earthquake etc (Su, et al., 2004; Xin, 2004). Digital technology changes traditional way of information collection and processing and provides technical support for raising the safe monitoring level of the dam (Zhang, et al., 2004; Xu, et al., 2003).

2.1 Indicators of data collection

It can be known from statistical data, that the cause of the dam accidents can be classified into three kinds: One is caused by design, construction and natural factors, such as selecting too high water level, too low concrete grate, not considering earthquake load etc. The factors are determined since the dam is built, this do not exists the course from quantitative change to qualitative change. The second is formed in the course of running and management of the dam, this exists the course from quantitative change to qualitative change such as washing, eroding, aging of concrete, rusting of metal etc. The third is blend of the first and second case, that is, flaw in the design and construction is not corrected in the running of the dam, with time goes and imperfect management the flaw will be developed into destruction. At present, safety monitoring of the dam mainly aims at the last two cases.

Information collection indicators should be selected on the base of analyzing primitive observed data and running data. Observe the dam from both time and space, collect the information and find sensitive part of the dam and corresponding observing items to grasp safety information rapidly and exactly.

In spatial, the information collection indicators emphasize outer character of the dam such as transmogrification and seepage. An outer behavior of the dam is general reflection of the dam's character. For concrete hidden trouble and danger degree, inner trouble detecting apparatus is needed. Monitoring data collected can be analyzed through building monitoring model to know the dam's safety situation and developing trend. In addition, the conditions of the reservoirs upstream and downstream, rainfall, floodwater regulation, dam, base, counterfeit, drainage structure, power station and the flood discharge construction should be included in the indicators of information collection. So the indicators can be classified into three kinds: transmogrification information, seepage information, hydrology information and meteorological information. Transmogrification information included dam surface transmogrification, inner transmogrification, crack and joint etc. Seepage information includes dam-body seepage、dam-radix seepage and the amount of seepage. Hydrology information and meteorological information mainly includes the water level of the reservoir、the water level of the drainage building、the amount of the precipitation、the temperature of the water、the temperature of the atmosphere etc.

The dam safety state change is a gradual course. Discontinuous observing data can't provide effective information for safety judgment, even brings completely wrong result. So information collection should follow the principle of continuity.

2.2 Technology of data collection

It is the purpose of collecting the big dam information that understanding the safe condition in the whole and the each part of safe levels, controlling the change of the condition of dam, eliminating the hidden trouble of the big dam, servicing safe running of reservoir. In the recent years, with the development of the RS technology, the GPS technology, the sensor technology and the geographic information system ,the technology is developing along all-in-one, automatization, numeralization and intelligentization.

The RS is the detecting technology which can collect information without touching the target directly. The RS obtains and deals with the information of the earth's surface, shows the datum on the photos and digital images. The digital images can be used by farther processed which is called Image processing. The Image processing includes the operations such as image compression , image storage , image enhancement, image quantification and so on. Recently, the RS has been the valuable tools. It not only can obtain the visible information, such as sinking size, but also can process the invisible information, the temperature of water, gas and so on.

The sensor technology is the base of the collection of dam information. By reasonable disposal, the information such as the condition of rain, water, working, disaster, water quality can be converted into electronic signal through the sensor and carried to the controlling center.

The location technology of GPS is adopted in the collection of the dam information. The GPS receiver has small volume, higher measurement precision. The receiver can work at open country and carry on normally at the abominable condition filled with lightning storm, mill dust, hot or chilliness. The GPS technology which has the advantage of round-the clock, automatization and real time can be used to collect the displacement at real time.

The distortion questions of the dam such as the coast and sinking of upstream face and downstream face, the glide of the big dam base are concerned with the water pressure among the gaps closely. The distortion questions are caused due to the seepage distortion. So the collection of seepage information is the emphases of the whole collection. At present, the well-rounded technology is the sensor and has been used in the many special engineering fields.

The chromatography imaging technology has been used widely in the seepage information collection. It is the chromatography imaging technology that using the mathematical method to compute and rebuild the two or three dimensional images on the special lever of the target according to the one dimensional image datum which are caught from the object circumference

without destroy. Because the distributing condition and rejected region of the lining material can be reflected quantificational, the complexity of devices is reduced and the safety of big dam is increased, at the same time the important reference is provided to the internal state detection of big dam, the bug searching and the aging evaluation.

Seeing from the current actual circumstance, although monitoring facilities and technology has been modified significantly, the operation, analysis and use of observational data is still one kind of passive processing mode. The experts think that the key is that explaining these data by numerical method and not by only experience. According to the theoretical model and the foundation behavior, the working condition of the big dam should be valuated. At first, the theoretical model should be built for the key of monitoring data of the object, secondly, prognosticating the safe condition of the big dam, during the period if the difference between influencing quantity and the predicted value is in the allowed range ,the big dam are considered under the safe condition, otherwise, the big dam are considered under the dangerous condition, certainly all the operations are according to the influencing quantity(sinking, displacement) of the given time, environment(water level, temperature, pressure). The method introduced is called real time and quantificational detecting method.

3. DATA TRANSMISSION NETWORK

According to the availability of current domestic communication resources and the actual situation and also taking the operational management facilities of the system into account, a mixed-mode network is designed with the use of wireless mobile communications as the main channel and the cable communications (PSTN) as a backup channel. Equipped with the "double channel", the communication can be automatically switched to the backup channel in case of the main channel failure, and return to the main channel to transmit data after the main channel is normal again(Guo, et al., 2007; Liu, et al., 2006). Because all the stations are situated in the coverage areas of China Mobile's signal, the wireless mobile communications are taken as the main channel. Data are packaged into TCP / IP data packets in the GPRS modules of data collection terminals and are sent to the data-processing and control center through the GPRS wireless network (Li, et al., 2004; Cui, 2004). Transmission network is shown in figure 1.Transmission network is made up of automatic sending end, data communication net, central workstation of data and computer network. These parts are used to gather dam information data sent by several terminals automatically and join them to the centre process system.

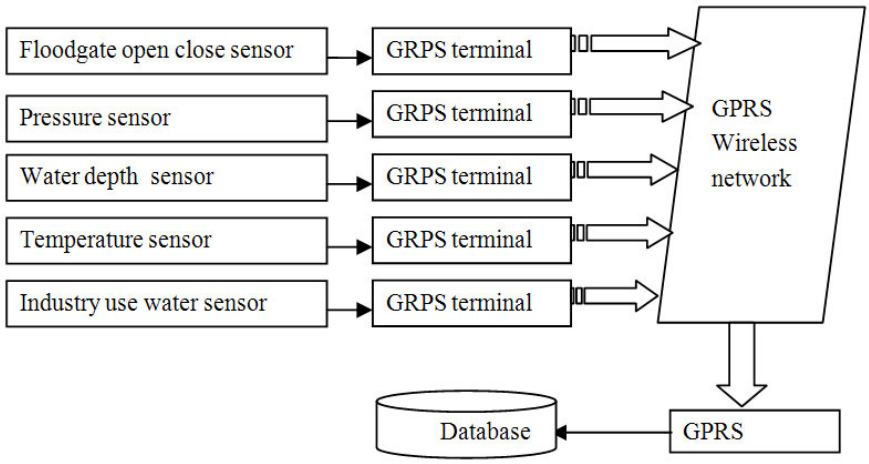

Figure.1 Transmission Network

Automatic sending end that is formed with units of sensor and single-chip system is installed at each observation station as terminals of the system. The single-chip in wired sending station transmits dam data got by sensors to computer through serial communication. Then, the computer sends processed data to the central business station which has fixed IP through internet. The central business station should have corresponding server data and software to receive and save data.

The wireless automatic sending end is mainly formed with units of sensor, single-chip system and units of GPRS data terminal. GPRS wireless data terminal (DTU) adopts GPRS wireless DDN data terminal in the system. Each module needs to install SIM card while using and each SIM card has unique ID in moving networks. GPRS DTU module also has user data interface, in order to supply power and carry on data interchange to the module. After all connections of terminal station are finished, GPRS data terminals can be managed through the setting of built-in establishment, management and debugging tools. GPRS modules adopted H7000 produced by Hongdian Company in Shenzhen. The unified mobile SIM cards are required to install in each module of collection points, and has the only ID in the mobile network just as the mobile phone. Specialized APN distributed by China Mobile is adopted by GPRS wireless data terminals and control center to access the wireless network. There are four modes for H7000 GPRS wireless DDN System, and different stations can choose arbitrary one mode according to the actual situation (Wu, et al., 2007).

The wireless data transmission of automatic dam monitor network adopts the way that one central point to several points. Many types of equipment are allocated in the automatic data collection system, and they pack data into IP packets with their own GPRS data terminals. These data are connected into

wireless GPRS network by the interface of aerial GPRS and then connected into Internet by ISP subsequently. The data at last reach unified data processing unit in the central work station through various kinds of gateways and routers.

The central management part of the network system of data processing is made up of one main server and several data processing servers. All data came from automatic hydrometric station of the terminal station enter the main server with fixed IP address at first through the network, the data processing server comes to finish the data processing task that the main server distribute.

4. TECHNOLOGY OF PROCESS DATA

4.1 Seepage monitoring model based on regression analysis

The regression analysis is to make the statistical analysis to fits questions. It measures the quantity changes between two or more variables that have general relations. After establishing a corresponding mathematical expression formula, it calculates another unknown quantity from a known quantity and provides the basis for estimation. Because of the complexity interrelation among diversified factors of the reservoir, the relation among the factors is difficult to show in function form. To find out the relation between them by statistical method needs a large number of data got through experiments or observations. The regression analysis confirms expression formula between y and x1, x2, xp mainly according to the statistical data.

The regression analysis can be divided into four styles, namely unitary linear regression, multiple-linear regression, unitary nonlinear regression and multiple-nonlinear regression. The relations between the variables are not always linearity; it is presented nonlinear relation sometimes. To confirm the curve regression equation, observation materials should be compared and be analyzed, especially the curve presented by the picture should be observed through pursuing a diffused dot diagram. The function of known figure should also be considered to choose the proper mathematics expression formula. While confirming the equation, values of unknown parameters in it need to be calculated. It is the least squares method that be commonly used in the calculating of parameters. The following step is proposed in this paper, combing the actual conditions in practical application:

(1) Gather and store the data surveyed on the spot or utilize history data, analyze these data synchronously; (2) doing calculation about curve of related quantity to calculate and set up regression model; Calculate the

correlative variables (3) Adjust the models through comparing the calculating value with the monitoring value; (4) Revise the model when necessary; (5) Store models after revising; (6) Determine the sequential movements according to whether the dispersion between the calculating value and the surveying value is within the range when manipulating in practice.

4.2 Experiment Result

Experiment is explored in Xueye reservoir, Lai Wu, Shandong Province. Xueye reservoir lies on Yingwen River, a branch of Dawen River. It is a large reservoir and constructed in 1959. The main project consists of dams, off lets, a spillway and a water power plant. The dam is composed of a primary dam and a secondary dam. The primary dam is a composite structure with grit hull and clay core below 230.5m and a homogenous clay dam above 230.5m. The length and height of it are 1200m and 239.5m respectively. The secondary dam is a homogenous dam with a length of 552m. The spillway lies on the eastern side of the secondary dam, on which there is a steel flashboard with a dimension of 10m times by 6m. There are two off lets, that is, the eastern off let and the western one. The power plant is at the back of the primary dam, whose main functions are irrigation and floodwater regulation.

The water level data got from April to August, 2006, shown in table 1. The results of regression analysis are presented in figure 2. The comparison between these results and the subsequent data showed that the distribution of error is quite even.

5. CONCLUSIONS

Comparing with the traditional technology, this method of displacement information collecting and processing can combine the safety evaluation and the indexes of design standard and parameter such as safety factor and reliability. At the same time, this approach can also make full use of the successful experiences and methods of safety inspection so that it can be comprehended, mastered and applied into practice more easily. Transmitting the observation data by means of GPRS technology has obvious advantages in several aspects such as real-time and reliability.

Table 1. Water level data

No.	1	2	3	4	5	6	7
Value	216.783	216.843	216.943	216.733	216.123	216.933	217.083
No.	8	9	10	11	12	13	14
Value	217.213	217.033	217.013	217.113	217.203	216.993	216.833

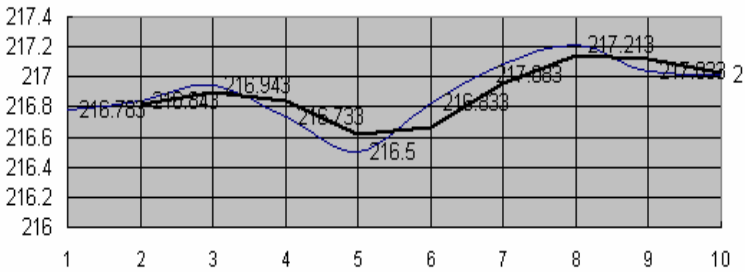

Figure.2 Regression analysis result

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