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DESIGN OF MANAGEMENT INFORMATION SYSTEM FOR DAM SAFETY AND FLOOD CONTROL OF CTG

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ABSTRACT

China Three Gorges Corporation (CTG) currently owns 57 large dams all over the world. These dams are operated by different entities independently. To better share information and to provide efficient technical support for these dams, it's necessary to establish a management information system for safety and flood control, as a standardized operation platform, to collect real-time data, and to provide auxiliary safety analysis as well as functions such as expert consulting and emergency response for their operators. This paper describes the positioning, modules, system integration as well as innovative features of the system.

1. SUMMARY

China Three Gorges Corporation (CTG) currently owns 57 large dams all over the world, including 28 in China, 17 in South America, 3 in Africa and 9 in Asia (except China), which are operated and managed by 7 secondary companies respectively. Due to wide distribution of these dams, complex meteorological conditions and different technical and management levels of each operator, it is necessary to establish a unified flood control and safety management information system for better management, information sharing and necessary technical support, to realize real-time grasp of overall situation of flood control and safety management of each dam, and to provide a standardized operation platform together with featured functions such as auxiliary dam safety performance analysis, expert consulting and emergency command for the operator of each dam.

To achieve the above objectives, a system covering all business units in various levels of CTG and all dam safety managing tasks has been established. The system composition and major functional modules are shown in Fig 1. This paper mainly discusses the planning and design of three basic functions required for dam safety management and flood control in the system, namely, mastering overall situation of dam safety, standardized management in plant and station operation, and auxiliary command system.

2. MASTERING OVERALL SITUATION ON DAM SAFETY

Overall situation of dam safety is mastered by the large screen system, which integrates and displays safety monitoring information, safety management information and statistical information of each dam. Fig. 1

2.1 Basic situation display

Based on high-definition image, river basin, river and other geographic information data, the system displays basic distribution and overall dam situation through two-dimensional maps. At the same time, on the macro level, all registration and filing information, basic engineering information, safety appraisal information and other safety management information of all reservoirs and dams are summarized.

Basic Information mainly displays the overall situation of dams in the system, including number of dams, total storage capacity, total installed capacity as well as the number of dams in each category over the years in the form of histogram. It also shows the characteristics of each dam project, make statistics and query on the dam according to the classification of storage capacity, installed capacity, dam height, project level, dam level, dam type, etc., display the statistical results in the form of pie chart, histogram, table, etc., and jointly display the classified statistical results on the map.

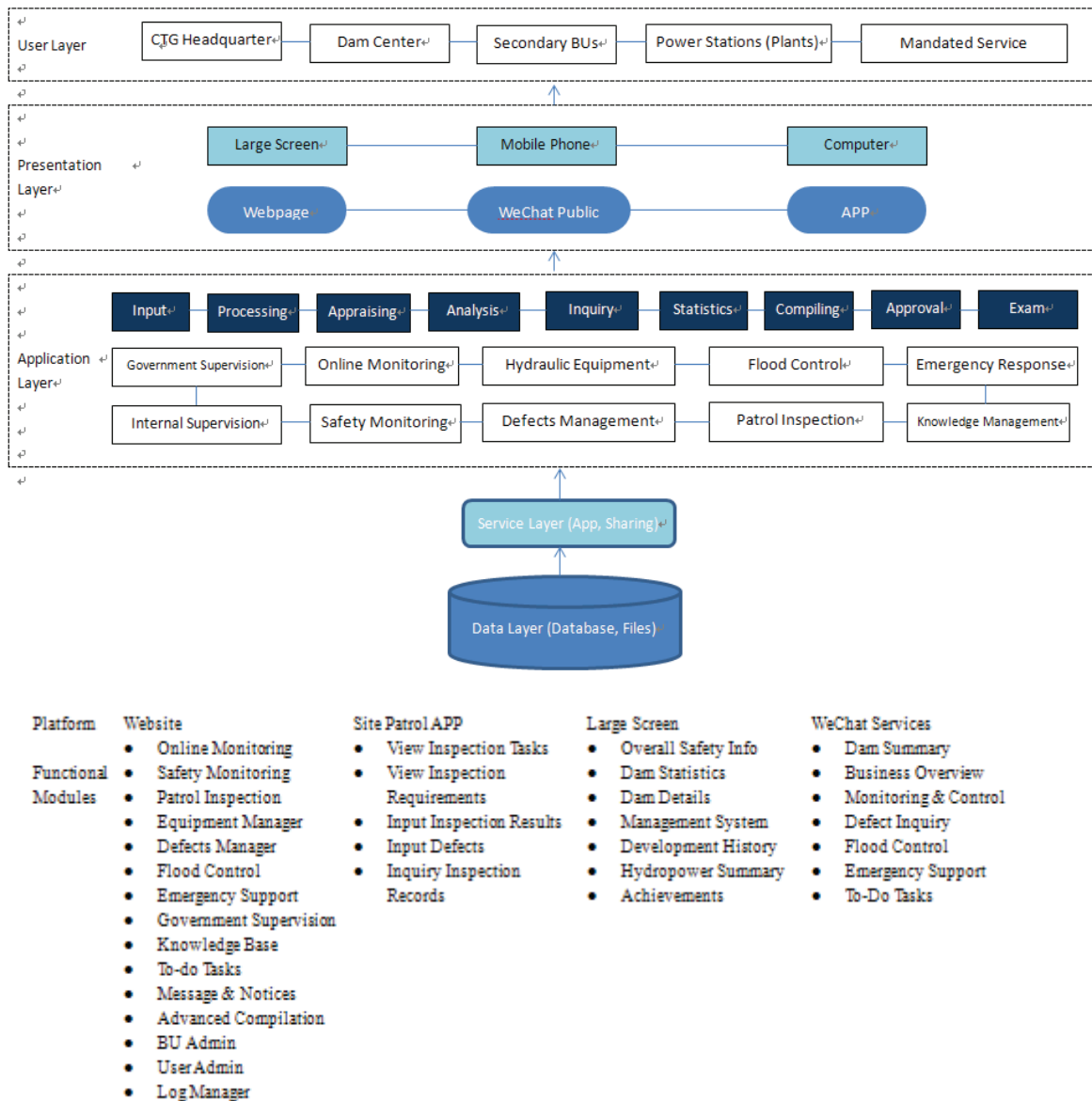


Fig 1 : Composition and Functional Modules of the System

Safety management mainly displays registration and filing records, safety appraisals, safety monitoring, information submission, as well as danger elimination and reinforcement information. The registration and filing module is the default prompt interface of the basic situation subsystem, which embodies the responsibilities and tasks of the Dam Management Center of CTG. The safety appraisals module classifies and counts the safety appraisal information of the dams. Statistical chart is presented in the form of pie chart, and the results of classified statistics are displayed in different types of icons on the map.

Safety monitoring module makes statistics on the general situation of the safety monitoring as well as the operation and management status of the monitoring system for registered dams. The information submission module makes statistics on information submission of registered dams, showing the information transmission mode, network connection status, the integrity of submitted information and other information of each dam. The danger elimination and reinforcement module makes statistics on the occurrence of dangerous situations, which is arranged on the sub screen in the form of a list, and the scheme, progress, reports and other information to deal with dangerous situations are arranged on other sub screens in a rolling way.

On national map of the main screen, dam with reservoir exceeds the flood limit level is indicated in the hydrological information module. This module also displays real-time water level (including time), characteristic water level, as well as level change trend of the dam.

Disaster information module mainly displays all disasters happened in recent period, including natural and man-made disasters.

2.2 Display of monitoring information

Support the introduction of regional, river basin, provincial dam overview, regional dam operation information, etc. By taking digital earth as the carrier, high-definition image data, digital elevation model data as the basis, and three-dimensional visualization as the way of information expression, a three-dimensional virtual scene of the global real geographical environment, together with three-dimensional visualized display for typical dams is constructed. It also displays the basic information and registration information, regular inspections of the dams, general situation of the power station, dam safety monitoring and related reports.

The multi-source information fusion technology based on rule base is applied to real-time diagnosis of dam safety conditions, which is based on the analysis of dam safety monitoring data and the records of equipment defects found in patrol inspections.

In this system, users can see the safety situation of hydraulic structures at a glance through 3D virtual scene, such as whether there is an abnormal situation and where is it.

2.3 Events monitoring

Events monitoring is realized by large screen duty and WeChat public account. WeChat public account mainly provides some lightweight data query functions, most operations are of query types, which are used to meet the needs of users who focus on results release and have no complex interface interaction. User can inquire safety monitoring data and flood data of the power station, as well as comprehensive information such as documents, news, system operation and important information by follow the WeChat public account. User can also timely push the concerned contents such as alarm information and missing information of safety monitoring data to help user grasp the latest dam operation status. Some relatively complex and highly interactive services can be realized by WeChat applet.

3. STANDARDIZED MANAGEMENT OF PLANT AND STATION OPERATION

Standardized management of plant and station operation involves dam safety monitoring, patrol inspection of equipment and facilities, equipment maintenance management three functions, which are carried out through customized operation process for quality control.

3.1 Dam safety monitoring

Dam safety monitoring includes management of dam embedded safety monitoring instruments and secondary monitoring equipment, monitoring activities, data management, result analysis, abnormal feedback, monitoring work assessment, etc

Instrument and equipment management is furnished with monitoring instrument and equipment account, unified storage of equipment verification information, tracking of instrument working status (damage, storage, shutdown, etc.) as well as inspection, calibration, update and renovation records.

By comparing the acquired data results with the monitoring plan, the completion rate of monitoring plan can be obtained to check whether the monitoring operation activities are carried out as planned.

The visualization of monitoring data includes drawing of process line, distribution map, cloud map, etc. Monitoring data analysis function is provided to analyze and judge whether the measured value is abnormal by using functions such as statistical extreme value, calculation of mean value, change rate, analysis of lows in variations, establishment of statistical model, etc.

Based on digitalization, visualization and automatic analysis of monitoring results, integrated reports can be generated. By customizing the report template (or using the system built-in template), integrated report with both pictures and texts and standard format can be generated through a single key touch, which greatly improve the efficiency and quality of dam monitoring data analysis and save human resources by eliminating a large number of mechanical and repetitive data listing, map reading, text entry and typesetting.

Abnormal alarm is provided to judge whether the measured value is abnormal according to the set rules, and to push the alarms or prompt information to relevant personnel. Based on the analysis, inspection and judgment of relevant personnel, the source of abnormality can be traced, and to determine whether there is an abnormality in the observation instrument, observation method, automatic observation equipment and/or hydraulic equipment.

3.2 Advanced compilation

According to the digital trace of relevant works, the maintenance performance, the quality of monitoring data and the analysis and compilation can be assessed and compared so as to improve the work quality.

3.3 Patrol inspection of equipment and facilities

A digital patrol inspection solution is provided for inspectors to carry out patrol inspection through mobile App. Inspection records (text, picture, video) are created and saved in real time in the cloud, which can be viewed through

web page, mobile phone, the large screen and other terminals. The inspection records created by digital patrol inspection are standard, detailed and rich in quantity, which can be viewed remotely in real time and used for online structural safety diagnosis. In addition, digital traces of patrol inspections can be used for performance management, and effectively improve the quality of work.

Inspection plan of equipment and facilities includes inspection route, inspection cycle, inspection contents and key points. With inspection plan customized in advance, on-site inspectors can carry out their inspections under the intelligent guidance of mobile App, which can effectively avoid missing inspection, better describe the on-site situation, and enrich the inspection results with graphs and texts.

Inspection results can be remotely viewed through web, large screen, mobile phone and other terminals, which is convenient for superior units to understand site conditions, and provide required materials for remote technical support of experts. Rich visual presentation and statistical analysis technology enables users to quickly grasp the overall situation and locate defects. Detailed and standardized records enable users to deeply understand the problems and track their development process.

Online patrol management provides task management function, which can issue patrol inspection tasks online with task reminders push out by the system accordingly. In addition, the progress of task completion can also be checked with inspection results reviewed online.

3.4 Equipment maintenance management

Equipment maintenance management mainly includes equipment defect handling and regular maintenance of equipment. It manages the information generated by each task, and displays it in the form of graphics and forms, so that users can track and view information on the whole process of defects and various business processes.

Equipment defect handling is capable to handle all related management online from defect discovery to elimination, including defect registration, defect governance progress update and defect information change. Equipment defects found in the process of safety monitoring data analysis and patrol inspection can be automatically transferred to the equipment defect register.

According to the preset maintenance cycle or time, reminder information on regular maintenance will be pushed to relevant responsible person(s) through WeChat or website in time with implementation process records registered.

4. AUXILIARY COMMAND SYSTEM

The auxiliary command system is comprised of required supporting or information as well as the integration of relevant information in the disposal process of emergencies such as flood control, geological disaster, etc

4.1 Flood Control module

Flood control module mainly includes two functions: information reporting and information integration display. Information reporting is divided into pre flood, flood season and post flood reporting. Pre flood reporting is mainly of flood control information reporting (including the structure of flood control organization). Pre flood, flood season and post flood inspections are implemented in equipment inspection module. This module provides inspection results query; flood season reporting, includes daily flood situation report and gate operation report; after flood reporting is to submit summary report after flood. Information integration display includes hydrological information, summary display of today's events (including information summary and display generated by real-time tasks such as flood control inspection, access to flood, encounter flood, overrun operation, gate operation, etc.).

Based on information provided by the above function modules, two kinds of display pages are designed for River basin (region) management, group level users and operation users, to facilitate their inquiry and to provide reference for decision-making in flood control. The page viewed by operation user includes information collected by the above functions related to their own project. The river basin (region) management and group level user page mainly displays the overall view of projects under their jurisdiction, including the completion of flood control inspection, overall situation of overrun operation, overall situation of flood encountered and the reservoir operation information of each power station. It's also provided with the query entry for flood control info of each power station.

4.2 Emergency response module

Emergency response module provides alarm push of abnormal events. In case of earthquake, rainstorm, flood or geological disaster, the system can push alarm information of dams in the nearby of affected area to the operator, competent unit and relevant staff of the group through SMS, WeChat and other means.

In case of emergency, it will gather and integrate the information required by emergency response of hydropower stations for convenient inquiry of related users in the group, and provide reference for decision-making, communication and coordination. The information involved includes:

- (1) Event information: location (GIS display), intensity, etc;

- (2) Dam safety information: monitoring, monitoring, on-site inspection results and defects;
- (3) Relevant emergency plans and on-site disposal plans;
- (4) Information of emergency organizations at all levels and emergency responsible person: name and contact information;
- (5) Emergency force and material information;
- (6) Engineering basic technical data: Engineering BIM system, completion safety appraisal report, layout, section, photo, etc;
- (7) Other emergency related data: dam break analysis report, seismic analysis report, etc;
- (8) List of experts;
- (9) Access of on-site monitoring video.

5. CURRENT SYSTEM IMPLEMENTATION PROGRESS

Development of the system started in April 2019. In July 2019, real data from three large dams of Qingjiang River was switched to the system for trial operation. So far, major contents planned in this paper have been realized. The first version of the system has been online for CTG domestic users. Large monitoring screens are furnished both in Beijing and Shanghai (See Fig 2). Real time monitoring data from the automatic monitoring system of 9 large dams has been connected to the system. For the rest of dams, manual monitoring data are uploaded periodically, with artificial equipment inspection results uploaded through mobile App in real-time.



Fig. 2 : Photo of Large Screen Presentations

The system provides the means of dam safety supervision and technical support both in the group level and its secondary units. It provides a standardized operation platform for the dam operators worldwide. With the automatic data analysis as well as its data integration and reporting, station operation personnel can focus on the reliability and safety status of the equipment itself through the system reminders. The use of the system improves the overall dam safety management and control level of CTG.