Remote safety monitoring management information system for dam group

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ABSTRACT: Dam safety monitoring is an important measure to ensure the safety of a dam. It is also an important and indispensable activity in the operation and management of the dam. Computer software play a vital role in dam safety monitoring. As a result, many dam owners have developed so-called dam safety monitoring management information systems to facilitate data management and analysis. At present, almost all these management information systems run in a single computer near dam sites. For an electric power company, it may own tens of dams which belong to different dam types and scatter in different areas. For example, Fujian Electric Power Company in east China owns 27 dams which types range from gravity dam, arch dam to earth and rock-fill dam. All these dams locate in remote rural areas. As a result, it is difficult to manage the safety monitoring information of the scattered dams. So it is urgent to develop a remote safety monitoring management system information system to collect and transfer dam safety monitoring data so that all this information can be processed, analyzed and evaluated to judge the state of dam safety. Fortunately, such a remote safety monitoring management information system has be successfully developed through the efforts of all the parts involved. It has been applied to the dam group owned by Fujian Electric Power Company. Engineering personnel can use the system to analyze and evaluate monitoring data.

1 INTRODUCTION

Dam safety monitoring is an important measure to ensure the safety of a dam. It is also an important and indispensable activity in the operation and management of the dam. Computer software plays a vital role in this activity. This role ranges from data acquisition, data transmission to data analysis. Using computer software can result in some benefits. The benefits include the following: increased data reliability, a reduction in the labor required to collect and evaluate data, timely results allowing efforts to be focused on the evaluation of the data rather than the process of data collection, and a better understanding of the structure's performance so that changes can be identified in a timely manner and corrective actions can be taken. As a result, many dam owners have developed dam safety monitoring management information systems to facilitate data management and analysis in China. However, almost all these management information systems run on stand-along architecture, and it is not convenient to manage information coming from a dam group.

For an electric power company, it may own a group of dams that belong to different dam types and that scatter in different areas. For example, Fujian Electric Power Company in East China owns 27 dams whose types range from gravity dam, arch dam to earth and rock-fill dam. All these dams are located in remote rural areas. As a result, it is difficult to manage the safety monitoring information of these scattered dams. So it is urgent to develop a remote safety monitoring management information system (RSMMIS) to collect the dam safety monitoring data in the company headquarters so that all this information can be processed, analyzed and evaluated in time.

Fortunately, such a remote safety monitoring management information system (RSMMIS) has been successfully developed through the efforts of all the parts involved. It has been applied to the dam group owned by Fujian Electric Power Company. This paper presents the architecture and main functions of the system.

2 NETWORK ARCHITECTURE OF THE RSMMIS

The monitoring network of the RSMMIS consists of two levels of monitoring center. One is the local monitoring center near each dam site. The other is the remote monitoring center in the company headquarters in Fuzhou city, Fujian Province. A local network with architecture client/server (C/S) is set up for each local monitoring center. A network is also established in the remote monitoring center, but it is based on a mixed architecture of client/server (C/S) and browser/server (B/S). The two levels of monitoring center are connected through Internet. A diagram of the overall system architecture is presented in Fig. 1.

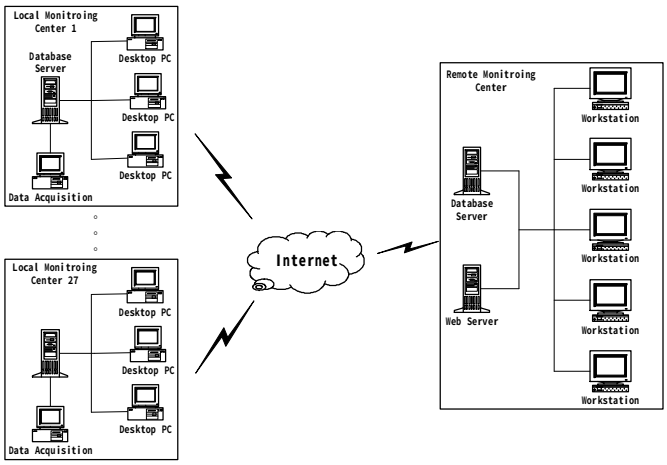

Fig. 1 The safety monitoring system architecture for the dam group

The two levels of center undertake different tasks. The local monitoring centers are responsible for data collection and data transfer. The remote monitoring center receives data from the local monitoring centers periodically or in real time and stores them into the corresponding databases. Engineering personnel in the remote monitoring center can use various functions of the RSMMIS to handle and evaluate the data, including statistics of characteristic values (averages, maxima, minima, etc.), analysis by use of statistical models (Bao 2004), deterministic models (Bonaldi et al. 1977), hybrid models and combined models(Wu 2003), structural behavior analysis of dam foundations, and comprehensive assessment of dam safety. The analysis results and monitoring data can be viewed as graphical representations. In addition, through network system the remote monitoring center publishes all the analysis results on its website so that engineering personnel in the local monitoring centers and other authorized users can browse them. The remote monitoring center also provides reports and graphs for remote clients to download from its website. The remote monitoring center is responsible for the management and maintenance of the RSMMIS, including communication management, database management, authorization of database access, incremental data update, security management of the website, access authorization, account management, etc. an interface of the remote safety monitoring management information system for dam group is presented in Fig. 2.

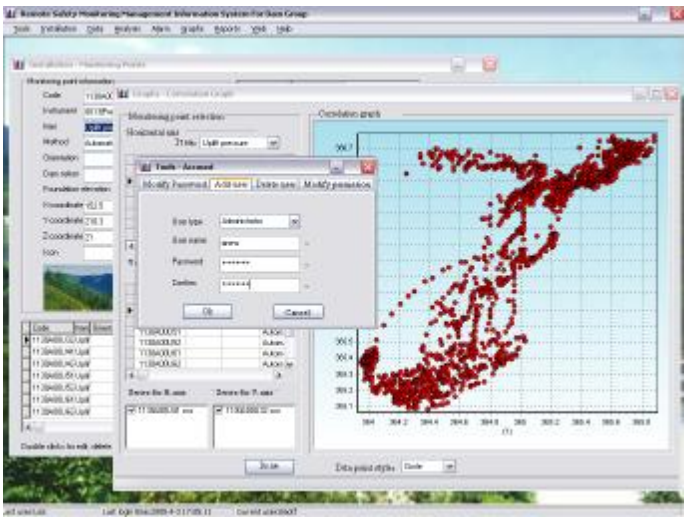

Fig. 2 Interface of the remote safety monitoring management information system for dam group

3 MAIN FUNCTIONS OF THE RSMMIS

The RSMMIS consists of nine modules: tools, installation, data, analysis, alarm, graphs, reports, web, and help modules. Their functions are given as follows.

3.1 *Tools*

The tools module includes the following options: logon, account, database backup, database restore, and system log. The system provides a logon interface for authorized users to enter the system. Before logon, a database concerning a dam, which the users wish to connect, should first be selected and connection parameters should be set. The function of the account option is to add and delete users, and to grant different permission to system operators. The permission falls into four levels. The first level users can only browse data. Besides browsing data, the second level users can also edit data, and the permission of editing system information (e.g. add and delete monitoring points) is added to the third level users. The fourth level users, also the highest level users, not only have the permission of the proceeding three levels of users, but also own the permission of adding and deleting users, and of modifying the permission of other users. The fourth level is also called administrator level. For the sake of safety, the system provides the

function of database backup. Once databases fail, they can be restored from their backups through the database restore option. The system log is another measure to guarantee the safety of the system. The log file records users who have logged on the system, their logon time, corresponding operations, and logoff time, which protects the system from vandalism.

3.2 *Installation*

The installation module provides the following options: monitoring points, instruments, monitoring items, monitoring profiles, and engineering archive. The option of monitoring points provides an interface for management of all monitoring points. Monitoring points are codified and grouped according to instruments used, monitoring items, and observation method. The detailed locations are defined, including x, y and z coordinates. The status of instruments (malfunction or not) is also indicated. In general, monitoring items include displacement, strain, stress, temperature, uplift pressure, seepage, etc. Various items have their corresponding notations and units, and different instruments are used. The notation (e.g. s for stress), unit (e.g. MPa for stress), and instrument for a given item are defined through the monitoring items option. In addition, the notations and units of raw data (e.g. R and Ω for resistance respectively) can also specified. In the instrument interface, various instruments, their parameters and converting formulae can be defined. The engineering archive option is used to record and save characteristics of the works, characteristics of the quantities, safety manual, important technical materials, design results, layout of monitoring system, monitoring point information, etc.

3.3 *Data*

Data module includes transmit/receive, convert, edit, export, and import options. The transmit/receive module consists of two sub-modules: data listening and transfer sub-module, and data receiving sub-module. The transmitting ends are located in the local monitoring centers. They are responsible for sending data to the remote monitoring center periodically or in real time. The receiving end in the remote monitoring center receives the data from each dam in real time and stores them in the corresponding database. Edit interface enables users to view, enter and print data. Historical data can be viewed as graphical representations. Double clicks of a data point in the graph can pop up a data editing box for convenient editing. Convert option facilitates users to convert raw data to their corresponding engineering units by applying formulae specified in instrument interface. Export and import facility for exchanging data (ASCII format or Microsoft Excel format) is also available in data module.

3.4 *Analysis*

For interpretation of the behavior of structures, statistic models, deterministic models, hybrid models, and combined models can be established. For a modeled quantity, the hydrostatic, thermal, irreversible components due to water level variations, temperature variations, and the imperfect elasticity of the dam and foundation or any time-dependent phenomenon respectively can be separated and displayed as graphical representations. The short term changes (anomalies) and long term changes (slow drift) in the behavior and condition of the dams and reservoirs can be detected. Once the long term changes are detected, comprehensive assessment of dam safety is resorted.

3.5 *Alarm*

The system performs routine check of measurements after new measurements are received. New measurements are compared with alarm thresholds. If alarm thresholds have been exceeded, the measurements are especially marked in the databases. At the meantime, signals are sent to the remote monitoring center and local monitoring centers. Engineering personnel shall verify the proper function of the signaled instruments, perform a visual inspection of the corresponding locations, and request intervention for in-depth analysis in the case of anomalous situation. Alarms not only can be displayed to the users through a graphical interface, but also can be sent by mobile phone message or by E-mail.

The thresholds fall into two levels indicating the degree of abnormity. The pre-set thresholds are calculated on the basis of physical features of each quality, the measured behavior collected in the previous period, or the various models.

3.6 *Graphs*

The system provides several types of graphs: evolution of measurements over time, one quantity versus any other, distribution (e.g. uplift pressure along a dam section), components separated by the various models, etc. Every graph can be viewed on the screen and be saved in the hard disks as bitmap, metafile, gif, or jpeg format. Every graph can also be exported into Microsoft Word for further processing.

3.7 *Reports*

Monthly, quarterly and annual reports can be prepared throng the system. Data can be raw data or converted data from single instruments or grouped instrument. The graphical representations of the data can also be included in the report. The reports can be printed or be exported in Microsoft Excel or Word format for further processing. Besides the default style, the reports can be customized whenever they are necessary.

3.8 *Web*

Analysis results, monitoring data and their characteristic values (averages, maxima, minima, annual variation, etc.) are published in the form of sheets or graphs on the website of the remote canter. Authorized users can search, browse and download them.

3.9 *Help*

The system provides detailed Windows-style on-line help to guide users to complete various operations. The help system provides contents, index and search options. Users can readily find their needed information.

4 SYSTEM REQUIREMENT

The RSMMIS is a kind of Windows-based software. The following software is required for the system:

- Windows 2000 server or higher;
- Windows 98/2000/XP;
- IIS 5.0 or higher;
- SQL sever 2000 or higher;
- Windows 98/2000/XP;
- Internet Explorer 5.5 or higher.

5 CONCLUSION

Monitoring is an important activity in managing the safety of dams. A management information system enables support to assist engineering personnel in this activity. The RSMMIS has significantly reduced the labor effort required for monitoring the performance of the various types of the dams which scatter in different areas. Engineering personnel can now utilize it to collect and evaluate data in a timely manner to continually monitor the performance of the many dams that they are responsible for.

The RSMMIS is a user-friendly program. It obtains very rapid acceptance by the users. The program is being improved to meet the increasing needs in the field of dam safety monitoring and to keep up with the extraordinary progression of the information technologies.

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