Discussion of Qingfengling Small Hydropower Monitoring Training Base Construction

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Abstract. Qingfengling Small Hydropower Training Base is a base under planning and construction of Sichuan Electric Power Company. The training is based on the relevant requirements of Technical Specification for Concrete Dam Safety Monitoring (DL/T5178-2003), Technical Specification for Earth-Rockfill Dam Safety Monitoring (SL 551-2011) and Technical Specification for Dam Safety Monitoring Automation (DL/T5211-2005) as well as the guidance of some laws and regulations such as Detailed Rules for Dam Safety Inspection of Hydropower Station and Regulations on the Safety Management of Reservoir and Dam. Combining the practice teaching characteristics of hydraulic instrument observation and drawing on the actual monitoring experience of Baozhusi Hydropower Station and Gongzui Hydropower Station, the content of the monitoring training is mainly divided into three parts: field inspection, instrument monitoring, and the collation, compilation and analysis of monitoring data. Combined with the three simulated dams that have been built in Qingfengling Teaching Power Plant, the training of hydraulic instrument observers mainly includes external observation and internal observation, which covers deformation monitoring, seepage observation, stress and strain and temperature monitoring.

Key Word: Qingfengling; small hydropower; monitoring; training; construction.

1. The necessity and importance of dam safety monitoring

The importance of dam safety is manifested in two aspects:

One is the loss or partial loss of investment and the sufficient achievement of benefits (flood control, power generation, water supply and shipping).

The other is the catastrophic consequences brought by dam safety problems or dam crashes.

There are many reasons for the dam accidents, but every accident goes through a process from quantitative change to qualitative change, and thus they can be discovered early by monitoring.

A dam has a huge operating range, complex structure, difficult construction and harsh operating environment; moreover, it is precisely because the design, construction and management require not only theory but also experience that there is no absolute guarantee that a dam will be safe forever, and thus a corresponding safety monitoring system must be established for it [1].
2. The concept and function of dam safety monitoring

Dam safety monitoring is the instrument monitoring and field inspection of the dam body, dam foundation, dam abutment, and the near-shore slopes and other buildings and equipment that have direct impacts on dam safety, and it also includes data collation, compilation and analysis as well as safety evaluation on this basis.

The Meishan Arch Dam in Anhui Province is composed of 15 piers and 16 arches. In October 1962, abnormal deformation of the dam piers was observed through the vertical line, and cracks and a large amount of water leakage occurred in the rock of the dam foundation between the 13th pier and the 16th pier; it was found that the dam foundation was unstable and that the problem was serious [2]. Due to the structural characteristics of the multiple arch dam, the collapse of a pier and arch would cause the dam to collapse, and thus emergency measures were taken. The reservoir was emptied and reinforced, avoiding a crisis. This crisis was caused by deficiencies in the survey and design work.

Zhexi Datou Dam in Hunan Province and Shanxi Hengshan Arch Dam are all powerful examples of timely discovering hidden safety hazards of dams through safety monitoring or data analysis [3].

Dam safety monitoring is a must-have project in water conservancy and hydropower construction at home and abroad, accounting for a certain percentage of project funding. It is stipulated in Switzerland that monitoring equipment and installation costs should account for 1 to 2% of the project cost. According to the stipulations by The US Bureau of Reclamation, the cost of effective observation facilities should account for about 1% of the total project cost, and it can reach 2--3% of the total project cost in special cases. China related departments also attach great importance to the construction of dams and require that monitoring facilities should be included in the budget estimates during the feasibility and design stages. When preparing budgets for monitoring facilities, the need for modern management must also be taken into account. What needs to be included in the budget should include not only basic instruments and equipment, but also the hardware and software as well as installation and commissioning required for data acquisition and data processing automation [4-5].

3. Significance of the construction of Qingfengling Small Hydropower Monitoring Training Base

Qingfengling Small Hydropower Monitoring Training Base is a base under planning and construction of Sichuan Electric Power Company. With the steady progress of China's power construction and the continuous deepening of power reforms, an unprecedented situation has been achieved in the past 10 years in power supply construction, especially in hydropower station construction. As a sustainable renewable energy source, the construction of small hydropower stations meets the requirements of environmental protection and is supported by national policies. According to the latest national development plan of China, the Sichuan Electric Power Company has received a large number of small hydropower stations. Due to the complex composition of each small hydropower station, there are various differences in the company in terms of electrical equipment, hydraulic monitoring equipment and operation management equipment. At the same time, the quality of personnel is uneven and many of them are not equipped with corresponding professional qualifications. In order to facilitate the company's unified management, scheduling and operation, it is necessary to provide relevant employees with training related to the management of small hydropower operation. Relying on its comprehensive training qualifications and highly-qualified teachers, the Sichuan Electric Power Company Skills Training Center (Sichuan Electric Power Vocational and Technical College) can successfully complete the construction of Qingfengling Small Hydropower Monitoring Training Base.

4. Construction goals of Qingfengling Small Hydropower Monitoring Training Base

4.1. The construction goal of institutional mechanism

Focusing on the installation, repair and maintenance of various instruments and equipment of small hydropower and following the principles of joint construction, management and sharing by schools and
enterprises, the goal is to build the base into a base featured by “industry-education-training integration”, with the functions of skill training, skill appraisal and teaching.

4.2. The construction goal of hardware environment
According to the needs of the cultivation of high-skilled talents, it aims to strengthen the construction of internship training bases and equipment facilities, so as to provide theoretical and practical integrated teaching and productive training for 50 trainees in this professional field. Newly built training buildings will meet the requirements of the training 200 people at the same period. A vocational skill appraisal institute will be established to be qualified for the advanced skill appraisal of corresponding work types and the certification of other industrial training.

4.3. The construction goal of faculty
Focusing on the construction of faculty composed of “double-position teachers”, it aims to build a relatively stable team composed of internship instructors and trainers with sufficient quantity and good quality, and the student-teacher ratio will be within 5:1. Practical training instructors and training management systems in line with the modern vocational education management system will also be formulated. The internship training instructor will be held by those who have both corporate work experience and intermediate or higher professional skills or senior professional qualifications. The technical staff hired from the enterprise will be 5 or more, and the external technical staff will have intermediate technical positions or senior professional qualification certificates. More than 5 senior lecturers will be cultivated.

4.4. The construction goal of practical teaching system
It intends to form systematic and scientific teaching modules, teaching plans, links, methods, assessment standards and evaluation mechanism; an efficient and pragmatic practical teaching organization and management mechanism will also be developed.

The network platform with rich practical teaching resources will be used to form perfect teaching and vocational standards, develop corresponding teaching materials, courseware and software, which will fully open to the other organizations to achieve school-school and school-enterprise sharing. An online interactive platform will be developed to initially fulfill the needs of online question answering and learners' independent learning.

5. The construction scheme of Qingfengling Small Hydropower Monitoring Training Base
According to the relevant requirements of Technical Specification for Concrete Dam Safety Monitoring (DL/T5178-2003), Technical Specification for Earth-Rockfill Dam Safety Monitoring (SL 551-2011) and Technical Specification for Dam Safety Monitoring Automation (DL/T5211-2005) as well as the guidance of some laws and regulations such as Detailed Rules for Dam Safety Inspection of Hydropower Station and Regulations on the Safety Management of Reservoir and Dam, the main items monitored are deformation, seepage, pressure, stress-strain, hydraulics and environmental quantities. Deformation monitoring items include surface deformation, internal deformation, dam foundation deformation, cracks and joints, concrete panel deformation, bank slope displacement, etc. Seepage monitoring items cover the seepage of dam body, seepage of dam foundation, seepage and flow around the dam, etc. Pressure monitoring items include pore-water pressure, uplift pressure, soil pressure and earth pressure on interface, etc. Stress monitoring items covers concrete stress, strain, anchor rod (anchorage cable) stress, steel bar stress, steel plate stress, bedrock strain and temperature field, etc. The hydraulic monitoring items includes the observation of discharge pressure, discharge flow rate and water surface line. Earthquake monitoring includes strong-motion earthquake observation and dynamic pore-water pressure observations. Environmental monitoring items include the dam water levels of the upstream and downstream, rainfall, temperature, etc.

Combining the practice teaching characteristics of hydraulic instrument observation and drawing on the actual operation monitoring experience of Baozhusi Hydropower Station and Gongzui Hydropower
Station, the content of the monitoring training is mainly divided into three parts: patrol inspection, instrument monitoring, and the collation, compilation and analysis of monitoring.

Combined with the three simulated dams that have been built in Qingfengling Teaching Power Plant, the training of hydraulic instrument observers mainly includes external observation and internal observation, which covers deformation monitoring, seepage observation, stress and strain and temperature monitoring.

5.1. Deformation monitoring

5.1.1. Rock mass monitoring near dam. It is planned to set four sets of bimetallic pipe labels on both ends of the gravity dam and arch dam to measure the vertical displacement of the dam body; 12 permanent monitoring piers will be set in the dam area to monitor the horizontal displacement of the two dams. (Refer to the layout for the location of specific monitoring points)

5.1.2. Dam deformation observation. It is planned to set up 4 permanent observation piers on the gravity dam to monitor its horizontal displacement with the sight line. At the same time, a set of tension wire alignment will be set to determine the horizontal displacement of the dam. Two measurement methods will be used for the same target body, and the related data will be compared. Then, at the permanent joints of gravity dams and arch dams, 5 sets of 3-direction joint meters are planned to monitor the opening degree of the dam body. In addition, hydraulic overflow settlement gauges and movable inclinometers will be buried in earth-rock dams respectively to measure the settlement and inclination of the dam body.

A laser collimation system will be purchased to monitor the horizontal displacement of the gravity dam. Due to that the external temperature, humidity and other conditions have great influences on the accuracy of the laser collimation method, the laser collimation system is expected to be placed in the training building. In addition, a direct plumb line and an inverted plumb line will be installed in the training building, so as to simulate the monitoring of the dam immunity with the vertical coordinate instrument; a set of hydrostatic level gauge will be employed to simulate observing the gradient of the dam -- only setting 4 gauging points.

5.2. Seepage observation

(1) Uplift pressure monitoring

Twelve single-tube deep-hole piezometers will be buried at both ends and middle of three dams respectively to measure the base uplift pressure of the dam.

(2) Seepage flow monitoring

A small ditch will be set on the side of the earth-rock dam, and a right-angled triangular weir will be installed to simulate and measure the seepage flow. The measuring cup, measuring cylinder, bucket and needle-type water level gauge will be used in the training building to monitor the seepage flow.

5.3. Monitoring of stress-strain and temperature

Strain meters, steel rebar meters, plate strain meters, compressive stress meters, joint meters, thermometers, crack meters, earth pressure meters, non-stress meters and rock mass displacement meters will be embedded in the dam body to monitor changes within the dam body, 2 pieces for each kind of meter. The above sensors will be connected into an automatic monitoring system, which is controlled by the dam safety monitoring and control system software.

5.4. Selection of gauging points

The selection of gauging points is featured by relatively large initiative, which requires designers has rich experience. It is generally believed that the arrangement of gauging points should meet the requirements of “few but precise”.

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Large and medium-sized projects or small projects where dam safety is particularly important should take into account the needs of modern management, and thus it is needed to realize the automation of major monitoring projects. According to the specific situation of the three simulated dams that have been built in Qingfengling Teaching Power Plant, it is planned to implant the deformation monitoring equipment into the dam by drilling; appearance equipment is monitored and measured in the form of fixed and active stations on the dam. And most of the electronic monitoring instruments are required to be connected to our central computer, with the purpose to realize the automation of main monitoring projects and real-time data analysis.

6. Conclusion

According to the construction requirements, the above-mentioned monitoring items are divided into several practical training areas, as shown in Table 1, Table 2, Table 3 and Table 4 for details.

Table 1. Training Function and Construction Plan of the Hydraulic Forecasting Training Area

| Function description | Training Objects | Training objectives | Main equipment and expenses | Site for construction |
|----------------------|------------------|--------------------|-----------------------------|----------------------|
| It is mainly to train the operation and management personnel of hydropower stations to make scientific predictions on the future hydrological conditions, especially on catastrophic hydrological phenomena. | Management personnel involved in the operation of small hydropower, hydrological forecasters, hydrological data processors, etc. | Flow judgment, flow velocity measurement, uplift pressure measurement, data analysis, data calculation, handling of specific situations, etc. | Triangular weir, electronic flow-meter and electric fluvigraph, 1 set of each; data analysis and processing system, 2 sets | Simulation model area of suction intank canal of the power plant |

Table 2. Training Functions and Construction Plan of Hydraulic measurement operation area

| Function description | Training Objects | Training objectives | Main equipment and expenses | Site for construction |
|----------------------|------------------|--------------------|-----------------------------|----------------------|
| It is mainly to train the observers of hydropower stations to master the principle of external observation, the arrangement of gauging points, the operation of instruments and equipment, data recording, analysis and processing, etc. | Management personnel involved in the operation of small hydropower, hydraulic observers, hydraulic monitors, data processors, etc. | Arrangement of gauging points, operation of instruments and equipment, and data recording, analysis, processing | Total station, theodolite, level gauge, supporting system for data collection and processing, auxiliary equipment, etc. | Simulation model area of suction intank canal of the power plant |

Table 3. Training Functions and Construction Plan of the Hydraulic Monitoring Practice Training Area

| Function description | Training Objects | Training objectives | Main equipment and expenses | Site for construction |
|----------------------|------------------|--------------------|-----------------------------|----------------------|
| It is mainly aimed at the training of hydropower station operators to monitor the external deformation and settlement of hydraulic structures and monitor the operation status of the buildings. | Management personnel involved in the operation of small hydropower, hydraulic observers, hydraulic monitors, data processors, etc. | Horizontal displacement measurement, vertical displacement measurement, deformation degree, uplift pressure measurement, and data recording, analysis and processing | Data acquisition and processing system used in conjunction with hydrostatic level gauge, bimetal tube standard, tension wire alignment, direct plumb line and an inverted plumb line, other related auxiliary equipment, etc. | Simulation model area of suction intank canal of the power plant |
Table 4. Training Functions and Construction Plan of the Hydraulic Observation Training Area

| Function description | It is mainly to train the operators of hydropower stations to observe the internal deformation and settlement of hydraulic structures. |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Training Objects     | Management personnel involved in the operation of small hydropower, hydraulic observers, hydraulic monitors, data processors, etc. |
| Training objectives  | Selection of observation methods, use of observation instruments, collection and processing of observed data, sorting and analysis of data such as water level, temperature, penetration observation, deformation observation, and observation automation |
| Main equipment and expenses | One laser collimator and supporting observation data analysis system and related auxiliary equipment |
| Site for construction | Training building |

After a construction period of three to five years, Qingfengling Small Hydropower Monitoring Training Base will surely become a standardized training and appraisal base capable of various technical skills, including the observation of hydraulic instruments, engineering measurement, hydraulic operation, maintenance and management of small hydropower stations and hydrological test. On the one hand, this base will meet the training needs of employees in various positions of the company's small hydropower stations, and become a training and evaluation base for mid-to-high-level small hydropower operation and management professionals. On the other hand, it will also be a training base for small hydropower operation management and certification in Sichuan Province. Then it will gradually develop into a first-class and distinctive skilled talent training center with various functions about small hydropower operation and management, including training, vocational skills appraisal, teaching, and so on.

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