

Dam Rehabilitation Decision-Making in China

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1 Dam Safety Situation in China

There are about 85000 reservoirs in China, of which there are 420 large-scale reservoirs, 2744 medium-sized reservoirs, which have played an important role in flood control, irrigation, water supply, water power, improvement of ecological environment etc.. These dam projects are of important parts of flood control and ensuring safety system and one of the most important infrastructures in the national economy in China. However, many dams constructed during the 1950s ~ 1970s, owing to restriction of economic-technological at that time, being of low flood control criteria, poor quality, imperfect maintenance management and project ageing, near 40% of the totality were deteriorated into deficient dam. These deficient dams not only have no normal role, but also have potential threat to people's lives and property downstreams in case of dam failure. Statistical data from 1954 to 2001 show that a total of 3462 reservoir dams have breached, and the average annual dam-breach rate is 8.79×10^{-4} , much more than the world average. Since 1980, China Government has improved dam safety management, the dam-breach rate greatly decreases and the average within 21 years is 5.54×10^{-4} , but still higher than the world average.

2 Planning of Deficient Dam Rehabilitation in China

China Government has always attached great importance to dam safety, and significant increased the investment in reinforcing the deficient dams especially after Banqiao and Shimantan reservoir dams breached during "75.8" Flood. From 1976 to 1985, the Centre Government has funded for reinforcing 65 large dams, strengthening reinforcement and rehabilitation of the deficient dams. In 1986 and 1992 the Ministry of Water Resources of China respectively took 81(2 lots in total) reservoir dams as the main deficient ones, of which reinforcement and rehabilitation done by the Centre Government funds. Engineering measures have been made to reinforce the deficient dams and non-engineering measures, that is degrading or decommissioning measures, have been also applied to the projects.

In March, 2000 the Ministry of Water Resources of China issued the "*Plan Exclusive on Reinforcement and Rehabilitation of Deficient Dams in China*" and set out the following objects: complete reinforcement and rehabilitation of the deficient dams(the first and second lots) before 2001, at the same time reinforcement of some dams which are in grave danger, located in important regions, and their initial design being approved, can be taken into account, and the total investment is 11.42 billion yuan; finish reinforcement and rehabilitation of the large and keynote medium-sized deficient dams as well as other dams(1346 in total) during 2002-2005, and the total budget is 23.76 billion yuan; complete reinforcement and rehabilitation of other deficient dams during 2006-2010, and the total budget is 15.18 billion yuan; and before 2015, various reservoirs should conform with the requirements of national flood control standards. The total budget of 50.36 billions yuan in reinforcement and rehabilitation respectively will be collected by the

Central Government, local governments and reservoir owners.

China Government has always attached great importance to stipulation of laws and regulations for dam safety and rehabilitation, and issued the “Regulations of Dam Safety Management” (1991), “Dam Registration Method ”and “Dam Safety Appraisal Method in China” (1996), “Guideline on Dam Safety Evaluation” (2001), “Regulations Regarding Dam Degrading or decommissioning Management” (2002). And the Country is working out the “Dam Degrading and Rejecting Criteria”.

3 Dam Rehabilitation Decision-Making

According to the “Dam Safety Appraisal Procedures in China” (1996), Dam safety authorities and other departments of water administration should appraise dams periodically, generally once each 6-10 years.

Dam safety appraisal should be graded. Large-scale dams and medium and small-sized dams of 70m height, which have influences on county’s safety, should be appraised by water authorities of provinces, autonomous regions and provincial cities; medium-sized dams and small dams of 50m height, which have influences on county’s safety, should be appraised by sub-provincial water administrations; small dams of 15m height or the storage capacity more than 1000000m³ should be appraised by county’s water administrations; and the dams run directly by the Ministry of Water Resources of China should be appraised by the Ministry itself or river-basin management agencies.

Dam safety appraisal generally includes dam safety analysis, assessments and field inspections. Such activities must be undertaken by the water authorities with qualifications. According to the “Guideline on Dam Safety Evaluation”, there are eight contents: project quality assessments; operation management assessments; checks of flood control standards; structure safety assessments; seepage safety assessments; seismic safety assessments; metal structure safety assessments; dam safety comprehensive assessments etc.

Dam safety appraisal activities include dam classifications according the following principles:

The category 1(good dams): Actual flood control ability conform to the requirements of “Flood Control Standards”(GB50201-94), dam operation under good conditions, no obvious quality problems and operation according to design criteria.

The category 2 (common dams): Actual flood control ability don’t conform to the requirements of the “Flood Control Standards”(GB50201-94), but fit in with the “Flood Control Standards for Reinforcement and Rehabilitation of Hydraulic Projects in Recent Stages”, dam normal operation, no significant quality problems and operation according to design criteria.

The category 3(the deficient dams): Actual flood control ability don’t conform to the requirements of the “Flood Control Standards for Reinforcement and Rehabilitation of Hydraulic Projects in Recent Stages”, significant quality problems which may constitute a real danger to dam safety and anomalous operation.

Major efforts must be underway to rehabilitate the deficient dams in proper ways according to the “Regulations of Dam Safety Management” as soon as dams are appraised as the category 3(the deficient dams). Emergency measures for dam safety should be prepared by dam management agencies before rehabilitation.

Three methods can be chosen for dam rehabilitation: the first is engineering measures (reinforcement); the second is non-engineering measures (degrading or decommissioning); the

third is combination of the engineering with non-engineering measures.

Before determination of concrete dam rehabilitation alternatives, corresponding analysis should be done as follows:

- (1) Quantitative evaluation of flood prevention and calamity mitigation of dams.
- (2) Qualitative evaluation of social benefits in waster resources protection and eco-environmental improvement of reservoirs and dams.
- (3) Quantitative evaluation of economic benefits in water power, irrigation, water supply, aquiculture and tourism of reservoirs and dams.
- (4) Quantitative evaluation of indirect benefits in promotion of the local national economy of reservoirs and dams.
- (5) Risk assessments of dam failure include quantitative evaluation of losses of people's lives and properties, public facilities; quantitative evaluation of indirect losses ,such as traffic block and unemployments; qualitative evaluation of impact on social-economic development and ecologic environment.
- (6) Investment evaluations should be done for dam reinforcement and rehabilitation alternatives

As shown above, a deficient dam should be reinforced in engineering measures when it has significant social-economic benefits and the measures are reliable in technology and reasonable in economy; If there is no significant social-economic benefits and the measures are not reliable in technology and reasonable in economy, degrading or decommissioning with proper reinforcement can be made; When a dam is more dangerous and reinforcement measures are not reliable in technology and reasonable in economy, and degrading can't ensure the safety of the dam, it must be abandoned.

At present, owing to shortage of water resources, uneven temporal and spatial distribution, frequent floods and draughts in China, reservoirs are required to play greater role in flood regulations. Therefore, for most of the deficient dams especially large-scale and medium-sized deficient dams.

4 Project Inceptions of Dam Reinforcement and Rehabilitation

Deficient dam reinforcement and rehabilitation need vast investments and financial supports from governments at all levels. In recent years, the Chinese Central Government has strengthened dam reinforcement and rehabilitation of the deficient reservoirs. According to "*Plan Exclusive on Reinforcement and Rehabilitation of Deficient Dams in China*", project inceptions must obey the following procedures:

- (1) Review of appraisal report of "the category 3 dams (the deficient dams)". Dam Safety Appraisal Organization Unit should report appraisal materials to the Dam Safety Management Center of the National Ministry of Water Resources, and the Center is in charge of review and verification of the appraisal results of "the category 3 dams".
- (2) Examination and approval of feasibility study reports and preliminary design of dam reinforcement and rehabilitation. Large reservoirs are examined and approved by their river-basin management agencies; medium-sized and small reservoirs by the provincial Planning Committees, if the investment surpasses certain scale, it should be approved by the corresponding river-basin management agencies.
- (3) Dam Safety Appraisal Organization Unit should report the following material to the

National Ministry of Water Resources: dam safety appraisal reports as well as the appraisal results of “the category 3 dams reviewed and verified by the Dam Safety Management Center”, approved documents of preliminary design and written promises of corresponding capital given by local administrations.

(4) Relative documents approved by the National Ministry of Water Resources are reported to the National Planning Committee for approval of project inception and arrangement of investment plans.

5 Implementation of Dam Reinforcement and Rehabilitation

As regards the dam reinforcement and rehabilitation, “project juridical person responsibility system, construction supervising and project bidding system” is executed so as to guarantee project quality. The Ministry of Water Resources is responsible of audit the implementation of projects. After the completion of the dam reinforcement and rehabilitation, audit and acceptance of the project should be conducted, and if necessary, a safety review before impoundment should be conducted.

6 Case of Dam Reinforcement and Rehabilitation

Shaheji Reservoir Dam is located 18km away from Chuzhou City of Anhui Province, and it belongs to the Yangtse River water system. Its catchment area is 300 km², and its total capacity is 1.85×10⁸m³. It is a large reservoir (Ⅱ-type) mainly for flood control and irrigation, water supply and fishery, including hydraulic structures such as a dam, culverts, spillways, etc. The dam is a rolled homogeneous earth dam with the crest of 720m long, and the maximum height is 26.4 m. The dam was constructed in 1958, and completed in 1974 after 5-stage constructions.

Shaheji Dam is of great importance. It protects not only 3 downstream cities: Chuzhou, Shaheji and Wuyi with a population of over 300 000 and agricultural land of 20 000 ha., but also the most important Chinese traffic arteries--Beijing-Shanghai railway (about 800m away from its downstream) and Chinese national highway No. 104 (less than 4km away from the dam site).

After a short impoundment, disperse immerse occurred in its downstream slope, and during its operation, the dam body often subsided and cracked, the culvert cracked and leaked, and the spillways collapsed, and so on. Therefore, its impoundment was always restricted and it greatly threatened its downstream and had a serious influence on full play of comprehensive benefits of the Reservoir.

Thus, in Nov. 1994, the reservoir authority invited many experts and held “Dam Safety Workshop of Shaheji Dam”. An expert group for the dam safety appraisal of Shaheji Dam was founded and inspected the site, and it was thought the dam in of dangerous situation. After the workshop, Nanjing Hydraulic Research Institute, Water Resources Research Institute of Anhui Province and Water Resources Planning and Design of Chuzhou City etc. were consigned to conduct analysis and evaluation of dam safety situations.

In Jan. 1996, the Water Resources Department of Anhui Province held “Dam Safety Appraisal Meeting of Shaheji Dam”, examined dam safety evaluation report and discussed and put forward safety appraisal results. The appraisal results show that Shaheji Dam is of large defects and cannot operate safely and should be classified as “the category 3 dams”. Owing to its important geographical location, it should belong to one of nationwide key deficient reservoirs and suggested to take engineering measures as soon as possible.

Soon afterwards, the Water Resources Department of Anhui Province submitted the appraisal materials and reports to Dam Safety Management Center of Chinese Ministry of Water Resources. The Center organized relative experts to review the documents and agreed with the appraisal results of “the category 3 dams” were in agreement with the actual situations.

In April 1997, the Water Resources Department of Anhui Province submitted “Feasibility study report of the dam reinforcement and rehabilitation of Shaheji Dam” to the Yangste River Water Conservancy Committee and asked for approval.

In April 1998, the Yangste River Water Conservancy Committee examined and checked the feasibility study report and preliminarily determined a total investment of 46.5195 million yuan for the dam reinforcement and rehabilitation. Thus it entered into the preliminary design period of the dam reinforcement and rehabilitation. According to “the category 3 dams” and suggestions of Chinese Ministry of Water Resources, the Planning Committee of Anhui Province approved the preliminary design.

In Aug. 1998, the Planning Committee and the Water Resources Department of Anhui Province promised the local corresponding capital to the Chinese National Planning Committee and Ministry of Water Resources.

In Aug. 1998, “Preliminary design report of the dam reinforcement and rehabilitation of Shaheji Dam” was completed and reported to the Planning Committee of Anhui Province for approval.

In March, 1999, the Planning Committee of Anhui Province examined and checked the preliminary design report, and the approved dam reinforcement and rehabilitation projects included: dam foundation high-pressured injection grouting; seepage control for the dam clay core; downstream slope earth exchange and protection; upstream slope repaving with blocks; establishment of dam safety monitoring automation system; spillway improvement; rebar concrete liner improvement in culverts etc.. The approved investment was 419.54 2 million yuan.

In March 1999, The Water Resources Department of Anhui Province reported relative documents of project inception to the National Ministry of Water Resources, including dam safety appraisal report, results of the category 3 dams, approved documents of preliminary design, and reports of local corresponding capital. After approved by the Chinese Ministry of Water Resources, they were reported to the Chinese National Planning Committee.

In Nov., 1999, the Chinese National Planning Committee approved project inception of the dam reinforcement and rehabilitation of Shajeji Dam, and arranged investment plans, of which the Central Government allocated subsidiary of 30 million yuan in 2 years, and the other was supported by the local government.

In Feb. 2000, Chuzhou City Government determined Shaheji Reservoir Administration as the project juridical person and responsibility entity of the dam reinforcement and rehabilitation project. And the dam reinforcement and rehabilitation entered into the implementation stage.

In March 2000, Water Resources Office of Chuzhou City began call for bids on the dam reinforcement and rehabilitation.

In April 2000, Water Project Quality Supervise Station of Chuzhou City issued “Assignment of Quality Supervising” of the dam reinforcement and rehabilitation project. The project juridical person issued construction contracts with bidder units and consignment supervising contracts with supervising units. The dam reinforcement and rehabilitation began to be in action.

In Aug. 2002, the dam reinforcement and rehabilitation project was completed. In Oct. the

project was successfully examined.

7 Concluding Remarks

In China, the dam reinforcement and rehabilitation of the deficient dams is a long-term and an arduous task. The Chinese government is strengthening relative scientific researches ,studies on new methods and practical techniques and establishment of laws and regulations for non-engineering reinforcement and rehabilitation measures. At the same time, risk analysis and management techniques are introduced so as to improve scientific dam reinforcement and rehabilitation decision-making.