Revision of the West Seti Dam Design in Nepal

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Abstract: Recent research on the effects of seismic activity on concrete faced rock-filled dams (CFRD) is examined in light of the potential CFRD-type West Seti Dam under consideration in Nepal. Revision of Nepal's West Seti Dam design is recommended.

Key words: Concrete faced rock-filled dams (CFRD), seismic activity, West Seti Dam, Nepal

The West Seti Dam site is very close to the Lesser Himalayas/Main Boundary Thrust (MBT) fault, which has the maximum earthquake potential. There is too great a risk to build one of the world's highest concrete faced rock-filled dams (CFRD) in a very dangerous earthquake zone in the foothills of the Himalayas. Some years back we sent a report from the Water and Energy Commission suggesting to the then Ministry of Water Resources that it would be risky to build the proposed West Seti CFRD dam. I had strongly recommended in the report sent to the Water Resources Ministry to constitute a panel of few leading dam experts of high standing in the international community of river engineering to seek their opinion. In September 2009, in the aftermath of last year's Wenchuan earthquake in China, the Committee on Seismic Aspect of the International Commission on Large Dams (ICOLD) published a study indicating that CFRD dams are vulnerable to strong ground shaking due to large in-plane forces (Wieland and Houqun 2009).

The Wenchuan Earthquake

The earthquake of 8 magnitude that struck Sichuan on May 12, 2008, in the district of Chengdu of southern China, resulted in destruction of many towns, and damage to public works. It is said that the 158 meters high Zipingpu (CFRD) dam was also on the verge of collapse.

World experts in dam engineering had gathered in Bulgaria in the wake of the Wenchuan earthquake to hear how the major dams in China's Wenchuan county performed during the earthquake. Initially fears were high, with widespread cracking immediately visible to the 158m high Zipingpu dam, which towers over the devastated town of Dujianyan.

The Wenchuan earthquake affected more dams than any other previous earthquakes. It is also the most important seismic event to have occurred in recent history. Therefore, plans for a joint mission were discussed with the Chinese delegates at the meeting of the International Commission on Large Dams (ICOLD) held in Sofia, Bulgaria, in early June 2008.

The ICOLD Mission

At the 80th Anniversary Meeting of ICOLD in Paris in November 2008, a date was finalized. The joint ICOLD-CHINCOLD mission was fixed to take place in March and April 2009, approximately 11 months after the earthquake.

Thirteen foreign dam and earthquake experts from Austria, Canada, Japan, Switzerland, the UK, and the USA participated in this mission, called the International Seminar on Earthquake and Dam Safety. Local arrangements were made by Jia Jinsheng (ICOLD President) and Chen Houqun on behalf of CHINCOLD. The program began with a one day seminar in Beijing where the participants were briefed on the Wenchuan earthquake, followed by a three day visit of dam and run-of-river power plants in Sichuan. It concluded with a final one day seminar in Chengdu where dam owners and designers presented specific dam projects affected by the earthquake and the following specific issues were discussed:

- personal experience gained from the mission,
- lessons learned,
- topics for possible cooperation of ICOLD with CHINCOLD, and
- a paper on reservoirs and the Wenchuan earthquake.

Conclusions of the Mission

Martin Wieland and Chen Houqun have published the final conclusions of the ICOLD-CHINCOLD Mission in the journal International Water Power and Dam Construction. Wieland, of Poyry Energy Ltd, is Chairman and Houqun is Vice Chairman, respectively, of the ICOLD Committee on Seismic Aspects of Dam Design. Houqun is also an academician with the China Academy of Engineering, China Institute of Water Resources and Hydropower Research, Beijing. Their final conclusions state that the concrete face of CFRD dams are vulnerable to strong ground shaking mainly due to large in-plane forces.

Severe Damage

The Wenchuan earthquake severely damaged the Zipingpu Dam. The following failures were recorded: • subsidence of the crown in the central part of the dam of the order of 50 cm in relation to the side survey control points, • deformation of the lower face of the dam, an area of approximately 1000 m2, • deviations and deformations

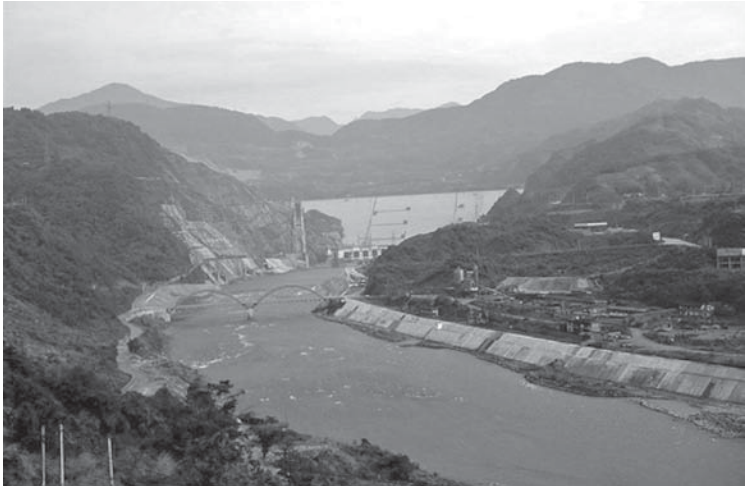

Figure 1. China's Zipingpu CFRD Dam in China which was Damaged in the 2008 Earthquake.

of the construction elements throughout the face of the dam, • widening of the construction joints (approximately 15 cm on the upper face), • extended massive landslides throughout the reservoir, and • landslides on both left and right abutments of the dam causing further damages to secondary constructions. Fortunately the dam was made safe by quickly lowering the water level.

Complete Collapse

In an article published in the journal New Scientist Fred Pearce (2008) writes that the Zipingpu Dam would have collapsed had the reservoir been full. At the time of earthquake there was only 300 million cubic meters of water in the reservoir out of its 1,120 million cubic meters full capacity. The Chinese government's action was swift in the aftermath of the earthquake. The bottom outlets were hastily opened to empty the reservoir to prevent further damages. Immediately 2,000 soldiers were pressed into service to quickly carry out the most urgent repair works.

Unreliability of CFRD

The reservoir of the 132 meters high RCC (roller compacted concrete) Shapai Arch Dam located not too far away from the epicenter was full at the time of Sichuan earthquake. The dam remained intact even though this type of dams is not regarded as best suited to accommodate the seismically induced foundation displacements. But the Zipingpu (CFRD) Dam, located 18 km away from the epicenter, was severely damaged and it was on the verge of collapse though its reservoir was virtually empty. This implies that CFRD dams are not resistant to high seismic loads.

The CFRD is very sensitive to settlement and deformation of the rock-fill supporting the upstream face. The deformations of rock-fill produce movements of the concrete slab joints by opening them, and if the movements exceed certain limits then the resulting leakage is difficult to control. This type of dam can be built at competitive prices in shorter construction period. Despite such advantages many dam experts have serious reservations about the reliability of very high CFRD dams. Even the reputed proponent of the CFRD, J. Barry Cooke has recognized in an article published in Hydropower & Dams (Cooke 1997) that the CFRD is of empirical design and based on precedent design and experience. Unfortunately there are hardly any dams close to 200 meters in height already in operation over a reasonable length of time.

Our Own Past Experience

The West Seti type CFRD dam has also been considered as one of the alternatives in course of the Kankai Project feasibility study. The French expert called in by German Government to advise on Kankai Dam dissuaded the German study team from considering the CFRD as a viable option, although the height of the Kankai High Dam is only 85 meters. As a result, an embankment type dam with asphaltic concrete face was selected.

The possibility of adopting concrete-faced embankment dam was also considered in course of feasibility study of the Karnali Project carried out with the World Bank assistance. It is explained in the feasibility study report that this alternative was rejected because of the fear that serious damage to the plinth and the concrete face could result from seismically induced foundation displacements.

Revision of Design

The potential impact of the West Seti Dam failure would be huge, as the surge of water resulting from such failure would have terrible consequences for the people living downstream. At present, the Nepal government is eager to build the 195 meters high West Seti (CFRD) Dam turning a blind eye to the dam failure risks. We must be concerned about the fate of millions of peoples living in Nepal and India if the West Seti dam failed.

It has been clearly explained in the detailed feasibility study report of the Karnali Chisapani High Dam that in the 200 meter height class, the only type of embankment dam with demonstrated satisfactory performance is a rock-fill or gravel-fill dam with an impervious core of earth

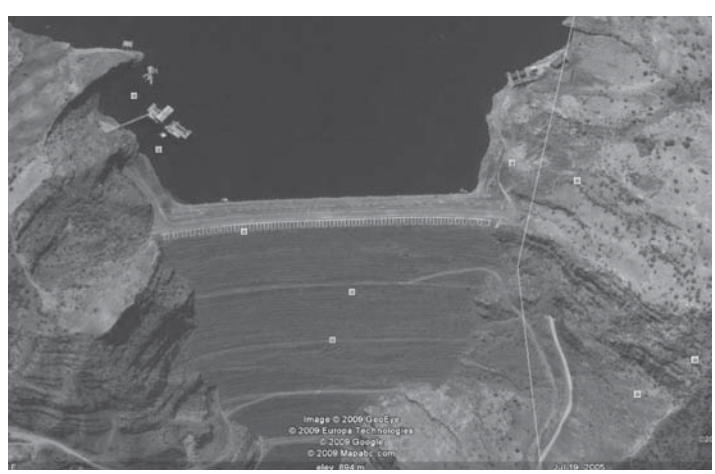

Figure 2. 300 Meter High Nurek Dam.

materials. Furthermore, this is the most satisfactory type of dam for accommodating seismically induced foundation displacements. This type of 300 m high Nurek Dam built in 1979/80 in the former Soviet Union in an area of very high seismicity has a good record of performance.

Nepal must not compromise on safety of the West Seti Dam. Thus the design of the West Seti dam must be revised to preclude the dam failure risks.

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References

Cooke, J. Barry, 1997, 'Development in High CFRDs', Hydropower & Dams v.4

Pearce, Fred, 2008, 'News review 08: China quakes, but the dams don't break', New Scientist n.2687 (28 December); URL: www.newscientist.com/article/mg20026872.100-news-review-2008-china-quakes-but-the-dams-dont-break.html.

Wieland, Martin and *Chen Houqun*, 2009, 'Lessons learnt from the Wenchuan earthquake', International Water Power and Dam Construction (11 September); URL: www.waterpowermagazine.com/story.asp?storyCode=2054099.◆

INTERNATIONAL NEWS

India and Bhutan planning hydro projects

India and Bhutan are preparing plans for several Bhutan hydro projects that could begin construction in 2012. The leaders of India and Bhutan signed agreements to prepare detailed project reports for four projects, ranging from 486 MW to 1800 MW in capacity. Power generated by the projects could be used in Bhutan, with surplus exported to India.

King Jigme Khesar Namgyel Wangchuck of Bhutan and Indian Prime Minister Manmohan Singh met recently and signed a number of agreements, including the ones related to the development of four new hydro projects, Indian media outlets reported.

(www.hydroworld .com)

Italy's Impregilo to lead construction of Sogamoso hydro project in Colombia

A consortium led by Italy's Impregilo was awarded the tender to build state-run Isagen's Sogamoso hydroelectric project in Colombia, Impregilo reported. The project, worth approximately US$500 million, involves the construction of a 190-meter-high dam that is 300 meters in length. Also, the project includes construction of an underground power station that will house a trio of turbines with a total generating capacity of 820 MW.

Colombian companies Conalvias and Tecnica Vial will work with Impregilo on the project. Impregilo is already carrying out preliminary work on the project, the company said. Recently, the Andean Development Corporation approved a US$140 million loan to assist with the Sogamoso hydroelectric project. The project's total cost is estimated at US$1.74 billion, and bond money will finance the first phase of construction. The Andean Development Corporation loan will help finance the second phase. Project completion is planned for 2014.

ICOLD president says environmental responsibility is a top priority

Months into a three-year term as president of the International Commission on Large Dams, Jia Jinsheng told HydroWorld that the evolving field of dam engineering must place environmental issues among the top of its priorities.

ICOLD, founded in 1928, is a non-governmental organization that provides a forum for the exchange of information and expertise pertaining to dam engineering and related topics. Some of the organization's goals are to ensure that dams are built safely and in an environmentally-friendly manner. The commission includes national committees from more than 80 countries.

"Looking to the future, we will have to be much more sensitive to environmental issues in order to be socially acceptable and environmentally friendly," said Jinsheng in a recent interview with HydroWorld. He noted that new ideas and practices regarding environmental issues are emerging in many aspects of the field.

Throughout the history of ICOLD, the organization's aim has shifted to include emerging areas of concern among subjects such as planning, construction, operations and design. Environmental concerns are among the most pressing of current issues, Jinsheng said.

Jinsheng emphasized that ICOLD was set up with one of life's necessities, water, at the forefront. With that in mind, the organization strives for safety and for dams that are built and operated in environmentally-safe ways, he said.

In some instances, environmentally-sound construction techniques come in the form of using local materials during construction, Jinsheng said.

"Especially in developing countries, you have new, local material dams," he said. "So, a lot of environmentally-friendly techniques have been (used) to build dams." ◆