# Hangzhou Regional Center (Asia-Pacific) for Small Hydro Power

**Newsletter — December 2007**

## SHP Worldwide



## SHP in China



## HRC News



## Technology Exchange

# SHP Worldwide

### *International Seminar on Small Hydro Power Was Held in India*

"International Seminar on Small Hydro Power" was held in Trivandrum, Kerala, India on 12-14 December 2007. It is Organized by Government of Kerala, UNIDO Regional Centre for Small Hydro Power and Energy Management Centre Kerala. This conference is supported by UNIDO, Ministry of New & Renewable Energy Sources of India, International Network on Small Hydro Power (IN-SHP), Agency for Non-Conventional Energy and Rural Technology (ANERT), Indian Renewable Energy Agency (IREDA) & Kerala State Electricity Board. Main Objectives of the Conference are:

- To exchange views on small hydro power development in the region and its potential for the meeting the current and future rural electrification needs;
- To study, through case histories, the various models of small hydro power development in the region;
- To examine the potential for development of Pico, Micro, Mini and Small hydropower development in the countries of the region;
- To take note of the financing options and policies for small hydro power development in the region;
- To explore the opportunities for local user participation from concept to completion of small hydro projects;
- To identify Action Programs in each of the participating countries and develop a strategy for accelerated development of small hydro power as a means of sustainable development with the involvement of UNIDO, UNDP and bilateral or multilateral agencies

Source: UNIDO

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### *The 3rd Hydro Power for Today Forum was Held in Hangzhou, China*

Co-sponsored by IN-SHP, IEA, UNIDO, the 3rd Hydropower for Today forum was held on 12th, June, 2007, in Hangzhou, and was successfully concluded on 13th, June, 2007. The focus of this forum was on SHP in Africa and Asia. The Forum had 188 delegates: 66 from 26 countries abroad and 122 from China.

During the period of 2 days, an extensive array of presentations were made. The Forum after discussing various problems faced by most of the developing countries for the speedy development of the most urgent SHP development, looking at various approaches to their solutions form Asia, Africa, Latin America and the Europe and exchanging views on how best the needy regions in Asia and Africa could be best served by the most appropriate small hydro power solutions.

The Forum had the benefit of 27 learned presentations from researchers and practitioners of SHP from all over the world in 7 technical sessions, chaired by an International Presidium for each session.

The delegates were given insights into some interesting new technology developments like the further improvements in the updraft free exit flow turbine, giving hope of giving a weight reduction to one third of the normal turbines, cost reduction of 30-60% over conventional axial

flow turbines and making it environmentally and fish friendly, avoiding the costly draft tube too. We have, of course, to wait for its commercialization in the near future. The other technological innovation reported was the studies conducted simultaneously in China and Finland on performance prediction of Bulb turbines by flow simulation and bringing prediction and reality to closer distance.

The "Light-up Rural Africa" Programme has been officially kicked off at this Forum. And all the countries, the People's Republic of China and IN-SHP all declared their intention to actively participate in this programme to promote SHP development in African rural areas.

Source: IN-SHP

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### *ESHA and the WFD*

ESHA attended two meetings on the Water Framework Directive (WFD) that took place in Brussels. The first meeting, concerned with the Drafting Group on Environmental Objectives and Exemptions, took place on 10 September 2007 where the second draft version of the paper "Exemptions to the Environmental Objectives under the WFD, Article 4.4 - 4.6" was discussed.

The meeting of the Working Group 2A on Ecological Status (ECOSTAT) took place from 8-9 October 2007 where inter-calibration exercises, amongst others, were discussed.

The latest documentation regarding the WFD implementation can be summarized as follows:

- Key conclusions in June 2007 CIS Workshop "WFD & Hydropower". In June 2007, the hydro-morphology group met to discuss the different aspects of the WFD and Hydropower.
- Floods Directive adopted. The Directive on the assessment and management of Floods was adopted on 18 September 2007 and will enter into force 20 days after its publication in the Official Journal.
- Study on costs and benefits of the WFD The study on "Costs and benefits related to the implementation of the WFD" has been finalised.
- ECOSTAT – Documents on samples and tests to be performed on inter-calibration exercises for rivers have now been documented.

Source: ESHA

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### *Two New Studies from the World Energy Council*

The WEC has published two studies on Energy and Climate Change this year.

The study, entitled "Energy and Climate Change", draws on the collective experience and resources of energy professionals worldwide. It has looked in detail at the impact of existing climate change measures and how effective they have been in promoting sustainable development, using the criteria of the three "As" – accessibility (to affordable energy); acceptability (of the energy sources used, particularly in environmental terms); and availability (how secure and reliable are those sources?).

The second publication, "2007 Global Energy Survey", focuses on the topic "Tackling the Three Ss: Sustainability, Security and Strategy" and is based on interviews with more than 50 senior executives from the world's leading energy companies and their strategic suppliers by

Korn/Ferry International.

For more details, see http://www.setatwork.eu/news/n017.htm

Source: T@W

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### *ESHA Present at ENERGAIA, 6-8 December, Montpellier, France*

ESHA represented during the ENERGAIA International Renewable Energies Exhibition held in France from 6-8 December 2007. ESHA will be taking part in the "Roundtable on Sustainable Hydropower – the way forward" which will take place on the afternoon of 7 December 2007. This roundtable is organised in the framework of the IEE SHERPA Project and will focus on issues such as ISO 14001 certification for SHP producers – an innovative approach, sustainability guides for SHP, public image of SHP, new approaches to environmental and social engineering, as well as spatial planning. Innovative products will also be presented. ESHA will also represent the Small Hydropower sector during the RESTMAC Roundtable held on 6 December 2007 entitled "Europe and Renewable Energies: EU Renewable Energy Policy & Market Development – The Renewable Energy Policy Roadmap and how to create a scale up effect" together with the other renewable energy sectors.

Source: ESHA

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### *Swedish SHP Owner Appeal to the European Court*

An owner of a SHP plant in Sweden has, supported by SERO Hydropower, appealed to the European Court to change a decision from the highest level of the Swedish justice system. The background is that in Sweden older licenses to produce hydropower since 1994 can be changed if there is an environmental reason or a public reason that is stronger than the value of lost power production as a result of the decision. Normally this means that a producer is obliged to accept a reserved flow corresponding to 5 percent of the gross income without compensation. The 5 percent income loss is normally translated to an annual loss of 5 percent of the energy production based on statistical figures.

However, in a recent case it was calculated from a theoretical value that took into account almost the whole flow volume of the year. Power plants of that kind have not yet been constructed and in this case there was an existing plant with more than 25 years of production statistics. A duration curve also showed the impossibility of the theoretical value.

As the various Swedish courts refused to take into account the obvious and basic facts in this case, the plant owner decided to bring it to the European Court by July 30, 2007.

Source: ESHA

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## SHP in China

### *South-South Cooperation Seminar Held at Hangzhou*

Seminar on aid to foreign countries in the new situation and South-South cooperation schemes was held in 4-5 Nov. at Hangzhou, sponsored by China International Center of Economic

& Technical Exchange. The topics of the seminar included regional cooperation, how to cooperate with ASEAN and African countries etc. Over 50 representatives from around 30 organizations in China were present. Several HRC's staff attended the seminar and made recommendations on ways of developing more international cooperation by means of South-South cooperation. (2007-11-06)

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### *National Foreign Aid Training Conference Held in Beijing*

National Foreign Aid Training Conference was held in Beijing on July 26. The conference intended to update foreign aid training according to the new situations and tasks. Altogether 260 representatives attended the conference, coming from various government ministries, including the Ministry of Commerce, Ministry of Foreign Affairs, Ministry of Finance, Ministry of Education, Ministry of Science and Technology, Ministry of Agriculture, and Ministry of Health, and local departments in charge of foreign aid affairs.

Minister Bo Xilai reviewed the achievements of foreign aid since the founding of new China. Up to 2006, China had hosted 2500 sessions of foreign aid training for 150 countries and regions, serving over 80,000 people and covering more than 150 majors in 20 training fields, such as economics, management, agriculture, health, justice, and education. Foreign aid training had helped us develop an excellent rapport with other developing countries and promote economic cooperation.

The “Foreign Aid Human Resources Coordination System”, which was established with the joint efforts of different government ministries, pooled in the best resources of every ministry for closer cooperation and brought foreign aid training to a higher level, Bo said.

Foreign aid training is more than a form of international exchange and cooperation, as Minister Bo expressed, it also assumes the role of spreading Chinese culture and promoting world harmony. It is our responsibility to improve the quality of training and make sure that the countries receiving the aid can really benefit from the training program.

Vice Minister of the Ministry of Foreign Affairs Zhang Yesui confirmed the significance of foreign aid training in terms of promoting international prestige and boosting economic cooperation. He urged the better coordination between different ministries and within each ministry, in order to improve the quality of foreign aid training.

Vice Minister of the International Department of the Central Committee of CPC Chen Fengxiang, Vice-Minister of the Ministry of Education Wu Qidi, Vice Minister of the Ministry of Land and Resources Zhang Ruisheng, Vice Governors of Shanxi, Jiangsu, Zhejiang Province, and Vice Mayors of Shanghai and Chongqing attended the conference.

Source: website of Ministry of Commerce

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## HRC News

### *Vice Minister Hu Siyi Inspected HRC*

On June 12, Vice Minister of Ministry of Water Resources (MWR) Mr. Hu Siyi inspected HRC, accompanied by Mr. Tian Zhongxing, Director of Bureau of Rural Electrification, MWR, Mr. Liu Zhiguang, Deputy Director of Department of International Cooperation, Science and Technology,

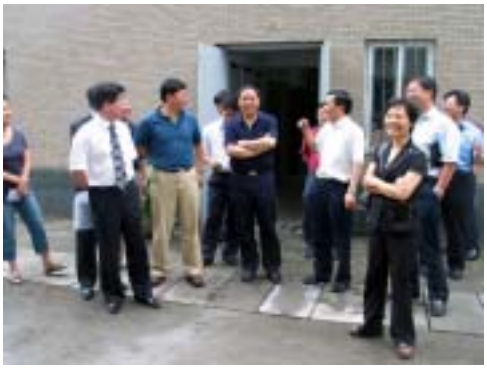
MWR, as well as the Division Chiefs Mr. Wu Hongwei, Mr. Jinhai and Mr. Zhu Shoufeng, etc.

Mr. Zhang Jianyun, President of Nangjing Hydrualic Research Institute, extended warm welcome to Vice Minister Hu and the other leaders from the MWR, and expressed high appreciation to MWR for the great concern and continuous support to HRC.

After listening to the Work Report delivered by Dr. Chen Shengshui, Director of HRC, Vice Minister Hu highly evaluated HRC's achievements, which had been scored under the correct leadership of NHRI and based on the great support of related departments and bureaus of MWR as well as the joint effort of HRC staff. Moreover, Vice Minister Hu made an important speech on HRC's major work of the next stage. He required that HRC should put emphasis on rural hydropower development, take full advantage of its own superiority to participate in the missions related to rural hydropower at the ministry and state level, such as the planning on rural hydropower development, the research on the relevant principles and policies, the issues on rural hydropower management and technology progress, and the establishment of technical standards concerned, etc. And great attention should be paid to the current restraining factors to rural hydropower development, inclusive of the relocation and ecological environment problems caused by hydropower exploitation. Having the long-term view in mind, we should think about the self-sustainable development for the institute in the "Post Hydropower Period". Vice Minister Hu also made clarifications in response to some issues concerned by HRC staff, and expressed that he would continuously pay attention to the construction of HRC's scientific research platform, and meanwhile, HRC was demanded to make full preparation and create condition actively.

On behalf of Bureau of Rural Electrification and Department of International Cooperation, Science and Technology, Director Tian and Director Liu respectively put forward the concrete requirements on HRC's future development.

The meeting was presided by President Zhang Jianyuan, with the attendance of the HRC leaders, division chiefs, senior engineers and some retired leaders.(2007-06-21)



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## *The United Nations Asian and Pacific Center for Agricultural Engineering and Machinery (APCAEM) Visited HRC*

On June 21, Dr. Joong-Wan CHO (Head / Senior Economic Affairs Officer) and Mr. Ping CHANG (Senior Expert) from the United Nations Asian and Pacific Center for Agricultural Engineering and Machinery (APCAEM) paid a visit to HRC, and Ms. Cheng Xialei, Deputy Director of HRC was present to welcome. Both sides exchanged information and ideas about respective business, technology, advantage and prospective target, as well as future cooperative chance.

The United Nations Asian and Pacific Center for Agricultural Engineering and Machinery (APCAEM) is a subsidiary body/regional institution of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), which was based in Beijing, China in 2004. It is committed to enhancing environmentally sustainable agricultural and food production, applying green and modern agro-technology for the well being of producers and consumers of the agricultural/food products. (2007-06-27)

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### *French Officials Visited HRC*

On July 11 afternoon, a 4-person group headed by Mr Fornage from French Development Agency (AFD) paid a visit to HRC. In the meeting, both sides introduced their own background and business scope, and explored the potential of mutual cooperation especially in the fields of SHP environment impact study, construction project appraisal, technical training etc. in earnest.

Deputy Director Mrs. Cheng Xialei, two section-chiefs respectively from International Cooperation and Science & Technology Division and Foreign Affairs & Training Division were present at the meeting. (2007-07-13)

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### *HRC Research Project "SHP Sustainable Development in China" Has Been Accepted by MWR*

The project "research on sustainable development of small hydropower in China" implemented by HRC has fulfilled the acceptance by Ministry of Water Resources on 24th October, 2007. The content of this research project includes five parts: technical development strategy of SHP in China, market competitiveness of SHP in China, environment impact of SHP in China, investment and financing of SHP in China, macro economy policy of SHP in China.

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### *HRC Research Project "Collection and Analysis of International SHP Standards" Accepted by MWR*

HRC research project "Collection and Analysis of International Technical Standards for SHP" has been accepted by MWR on Sep.23rd, 2007. In the project, a large number of relevant international technical standards were collected and being compared with the Chinese corresponding ones. Measures for improving Chinese SHP standard system were also proposed.

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### *Verified by HRC, Shuanglongdong SHP Station Got Its First VER*

Shuanglongdong SHP station got its first VER from April 2006 to April 2007, which is verified by HRC as third party. This SHP station was renovated by HRC with the new containerized equipment. With the help of HRC, the owner signed VER selling contract with foreign buyer for 4 years.

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## *HRC Project" Key Technique of Containerized SHP Station" Has Passed the Examination*

"948" Project"key technique of containerized SHP station" has been accepted by "948" Project Administration Office of Ministry of Water Resources on 15th March, 2007.

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## *2007 Training on Qualification of Hydropower Safety Supervisor Concluded*

On 23rd Nov, still a warm day though already in winter, 2007 training workshop on qualification of hydropower safety supervisors was successfully concluded at the scenic city of Hangzhou. Sponsored by Bureau of Rural Hydro & Electrification, Ministry of Water Resources, the Workshop has been implemented by National Research Institute for Rural Electrification (HRC).

200 trainees across the country attended the training workshop which has been divided into two phases with a duration of 5 days each. The unified teaching material <Rural Hydropower Safety Supervisor> compiled by Bureau of Rural Hydro & Electrification, Ministry of Water Resources was adopted for the first time. Based on the teaching material, the training organizer set out the training objectives, worked out the outlines, scheduled the training arrangement and conducted a closed-book examination.

Through the training, participants had better understanding that safety dominates everything. Meanwhile, the qualification, requirement, duty and task of safety supervision are further clarified. The participants recognized further the targets, procedures and content of safety supervision. They have learnt more measures and techniques for accident prevention. The trainees returned home with bump harvest.

The questionnaires by the trainees show that the training effect is salient and they placed high evaluation of the training workshop. (2007-12-03)

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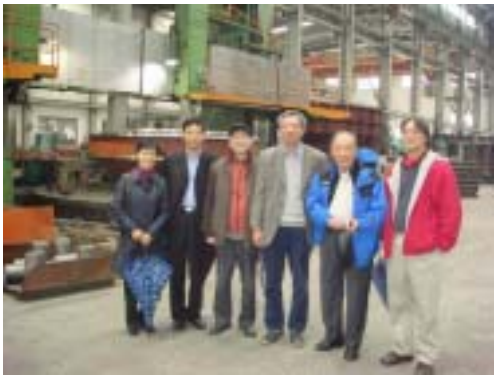
## *Cooperative Agreements Reached Between HRC & ORENCO, U.S.A.*



In 15-20 Nov 2007, Dr Tseng president of ORENCO in U.S.A together with his assistant Mr. Eddie Shiang visited HRC and discussed the cooperative projects of refurbishing Xihu Hydropower Station in Jinhua and building a SHP station at Fox River in U.S.A.

Early this year, ORENCO under support of HRC, applied for the renewable energy award from California Energy Commission for refurbishing Xihu Hydropower Station in Jinhua, which has been approved recently. Dr Tseng came to Hangzhou to make further investigation of the power station and prepare for the next phase of cooperation. Earlier, Xihu Hydropower station in Jinhua was set as the pilot hydropower station of containerized type for indigenous production developed by HRC.

Currently, the design scheme has been finished and the equipment is being manufactured. It is expected to put into commissioning next year. During the visit, Dr Tseng went to the site of Xihu Hydropower Station in Jinhua, accompanied by HRC Deputy Director Ms Cheng and HRC Honorary Director Prof. Zhu. After the visit to Jinhua Turbine Factory and a local hydropower station, Dr Tseng appreciated highly China's domestic SHP equipment and its automation technique.

During his visit, Dr Tseng introduced the SHP development in USA and discussed the technical schemes of setting up a low-head SHP station at Fox River in USA. HRC would try to participate in the project in EPC form.

HRC explored with Dr Tseng in other cooperative issues and signed agreements. Dr Tseng expressed his willingness to disseminate SHP technology and products developed by HRC in the U.S.A and South American countries. (2007-12-03)

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## *The 1st CDM Capacity-building Training Course for SHP Successfully Concluded*

On 26 October 2007, the 1st CDM capacity-building training course for SHP (small hydropower) sponsored by Rural Hydropower & Electrification Development Bureau, Ministry of Water Resources, and organized by the National Research Institute for Rural Electrification (NRIRE), Ministry of Water Resources in Hangzhou was successfully concluded. During this training, great attention has been paid from Rural Hydropower & Electrification Development Bureau, with the leaders present on the training. Our institute, NRIRE, made every effort to prepare and compile the teaching materials on "CDM Project Development Document (PDD) for SHP". The training period was short, however, with pretty substantial and practical content the training course achieved the expectation.

The 4-day training suitcases 8 special subjects, such as concept of CDM, CDM project flow-chart & SHP market, SHP CDM methodology, international carbon market development analysis, opportunity & risk in the international cooperation for SHP CDM, etc., which combined case studies and exchanges to make participants understand the significance of CDM implementation in hydropower sector.

All the participants expressed their appreciations for everything organized during the training. On the evaluating questionnaires, participants fully affirmed the achievements of this training course and gave a score of 92.58 (the total is 100). Cherishing the profound friendship among staffs working in the hydropower industry, participants earnestly hoped that our institute could explore more chances for them to exchange the experience and promote the mutual progress. At the same time, these participants made valuable suggestions for our work, which no doubt would be helpful to us in future.(2007-11-06)

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## *Customers from Turkey Visited HRC*

From October 16th to 19th, a 3-person group from RC Corporation in Turkey paid a visit to HRC, which is a visit after our initial visit to them. In the meeting both sides interchanged opinions in depth on the key issues of equipment selection and technical proposal for two hydropower-projects about to cooperate. We also arranged the visits to the manufactories and the hydropower stations designed by HRC, which was satisfactory to the guests. They expressed in

earnest that the equipment-supply scope could be confirmed and the agreement could be signed as soon as possible.(2007-10-31)

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### *HRC Participant Attended "Management of Hydropower Development 2007"*

Spnsored by Swedish International Development Agency (SIDA), HRC participant, Mr.Pan Daqing attended the "Management of Hydropower Development 2007" —an advanced international training programme held in Stockholm, Sweden from Sept. 2 to Sept. 28.

The course was one of the global training programmes on hydropower development under the sponsorship of SIDA, aiming at enhancing managerial and technical skills and covering subjects of strategic importance to sustainable economic and social development. Entrusted by Sida, Vattenfall, a leading European energy company, conducted the training programme, attended by 22 delegates from 11 countries, with 4 particpants from China.

A very useful lecture was the introduction to methodology, a logical framework approach (LFA) by Kari. The topic was important and interesting so that participants were extremely earnest to do the group work. The method is appropriate and applicable not only to projects of hydropower development, but also applicable virtually for all other fields.

The non-technical presentation on Hiv/Aids and infrastructure development by Lise Munck was impressive. Whether you are working in the hydropower sector or not, the topic was important to all. The significance the lecturer exposed that prevention plays a key role especially at the initial stage. If neglected, you will have to pay much higher price than expected and sometimes it could go far beyond control. The lecture started with a quiz, attracting much of the attention in a new way. The three countries Thailand, Egypt and South Africa taken as examples vividly illustrate how important it is to prevent something at the very initial stage.

The visit on the date of 17th Sept. to Stornorrfors Hydropower Station built at Ume River is beneficial. The station was firstly built in the 1950's with 3 units at that time. In 1985 one more unit was added, thus with the total installed capacity reaching 600 MW. Though the station was put up some 50 years ago, it is still operating in sound condition. The noise from the units is quite low. The operators for the whole station account for only 12 persons. At the central controlling room, 3 staffs are seen on duty at the day time. At night, no one is on duty there, but the operators work and control at home, as we were told. According to the introduction by Vattenfall engineers, the annual output amounts to as high as around 2500 GWh. (2007-10-9)

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### *New Contracts Awarded for SHP Equipment Export*

Hangzhou Yatai Hydro Equipment Completing Co., Ltd., a sub company of HRC, just won two orders for delivering SHP equipment (1×250kW and 2×4500kW) to two respective IPPs (independent power producer) in Turkey. (2007-07-31)

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### *HRC's Training Workshop for Mongolia Taishir SHP Opened*

On 10th of July, the Training Workshop on Operation & Maintenance for Mongolian Taishir Power Plant was opened and 12 operators from Mongolia attended the 4-week training at HRC.

The electric-mechanic equipment of the Plant has been designed by HRC's design institute

and the controling equipment of the Plant will be supplied by HRC's R+D center. The plant will be put into commissioning by the end of this year. (2007-07-13)

→CONTENT

### *French Officials Visit HRC*

On July 11 afternoon, a 4-person group headed by Mr Fornage from French Development Agency (AFD) paid a visit to HRC. In the meeting, both sides introduced their own background and business scope, and explored the potential of mutual cooperation especially in the fields of SHP environment impact study, construction project appraisal, technical training etc. in earnest.

Deputy Director Mrs. Cheng Xialei, two section-chiefs respectively from International Cooperation and Science & Technology Division and Foreign Affairs & Training Division were present at the meeting. (2007-07-13)

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### *HRC's CDM Project Successfully Registered*

The Diaoluohe SHP Station in Hainan province for which HRC has particpated in the application was successfully registered by the CDM Executive Council as another new CDM project on 22 June 2007. It has become the 90th CDM project in China and an annual reduction of 22,705 ton $CO_2$ is expected, thanks to the implementation of the projects. (2007-07-09)

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### *2007 Training Workshop on Small Hydropower Successfully Concluded*

On June 25, the 40-day 2007 Training Workshop on Small Hydropower was successfully concluded in HRC. In total, 31 officials and engineers from 18 countries all over the world attended this rewarding event with fruitful results achieved.

At the closing ceremony, HRC leaders delivered warm speeches respectively, congratulated the participants on their good fulfillment of training plan and the achievement of remarkable progress. A piece of wisdom "Live and Learn" was presented for mutual encouragement. It was also highly appreciated that the participants were active and responsive in the class, and very cooperative during the training period. Finally, the leader addressed --- "The door of HRC will open to you forever" ---- fully expressed the sincerity and kindness of HRC to all the participants.

In succession, the participants also spoke one after another, with their heartfelt thankfulness respectively going to the Chinese government, the Ministry of Commerce (MOFCOM) and HRC, for the great aid, the organization of the program and the professional management on the training course. All the participants expressed truly that in future they would like to try their best to promote the substantial cooperation between China and their own countries, to strengthen the long-term friendship and together to make further contribution to the global SHP development.

Based on the hard-working and joint efforts over one month, and through the various lectures, on-site study and close technical exchange, each participant has scored a satisfactory result and obtained a certificate issued by the Chinese Ministry of Commerce.

The pen-drivers, copied with all the HRC's presentations, participants' country papers, photos of the whole training period as well as some pieces of Chinese traditional music, were distributed to all the participants, which aimed at enabling them to enjoy the wonderful experience and happy time forever …… (2007-06-26)

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### *International Trainees Enable the Export of Equipment*

During the international training workshop (from May 17 to June 25), our participant from Fiji helped his company to purchase a 400kW generator from HRC. Now this equipment is being fabricated and the follow-up cooperation continues.

Besides, other participants (from Micronesia and Mozambique etc.) have also expressed their intentions for cooperating with HRC in SHP development in their respective countries (2007-06-27)

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# Technology Exchange

## Case Study on the Construction of Double-curvature Concrete Arch Dam

*By Li Zhiwu, Hangzhou Regional Center (Asia & Pacific) for Small Hydro Power*

**Abstract:** the double-curvature concrete arch dam is commonly used for medium & small-sized hydropower projects. Through analyzing the construction technology, approach, technics and quality control etc. for the double-curvature concrete arch dam of Furong reservoir, this article illustrates characteristics and experience, such as saving the cost and facilitating the construction process & management of dam-base treatment, plane & vertical transport of concrete, shuttering, pouring and temperature control etc. for the construction of a concrete arch dam, which can be taken as reference for similar projects.

**Keyword:** double-curvature arch dam; concrete; construction technology; case study

The dam of Furong reservoir is located in Changshan County, Zhejiang Province, which is one of the key projects in Zhejiang. It controls a catchment of 126km$^2$, with a total reservoir capacity up to 95.8 million m$^3$. The dam adopts a parabola double-curvature arch type of concrete C15W6F50, and the maximum height is 66m. 3 sluice orifices are made on the dam-crest surface, with each of 6m in the net width, and arc steel gates are applied there.

### I General Layout of Construction

1. Wind-supply system

There are 2 wind-supply plants, one is at about 120m downstream of the dam in which one 10m$^3$ air-compressor is used to supply wind for the excavation of right bank and riverbed, and the

other is located at about 80m downstream of the left abutment inside which another 10m$^3$ air-compressor is erected as to provide wind for the excavation of left bank and temporary works. For the sake of small partial excavation in early stage and drilling for consolidation grouting, there are also equipped two sets of 3m$^3$ electrically mobile air-compressors.

2. Water-supply system

Water supply adopts one 100D16 grade-8 centrifugal pump with a high lift head, thereby supplying water to ponds through a pipe of 4 inches in its diameter. Water ponds are placed at inner side of the road crossing the dam, about 100m upstream of the dam, and there are 4 cylindric steel water ponds with each capacity of 27m$^3$. The cooling water for dam is directly from the water pipe of 4 inches in a diameter near the pumping house.

3. Power-supply system

Two substations are erected, one is placed at the upstream of dam on which one 400kVA transformer is installed to provide electric power to the dam site, and the other is located at the quarry where one 80kVA transformer adopted to supply electric power for aggregate production and living purpose.

4. Aggregate producing system

The concrete aggregate adopts natural sand and rock, and the sand & rock producing system is situated about 1.5km upstream of the dam, including a screening device. The maximum daily production of the system amounts to about 600m$^3$, which can meet the requirement of max. concrete pouring per month, i.e. 11000m$^3$. In order to balance the production of the sand & rock materials and the concrete，a storage of about 3000m$^3$ for finished materials shall be placed near the quarry. Furthermore, to coordinate the production of the aggregate and the quarry material, and also mitigate the impact of flood on the aggregate generation, another storage of 30000m$^3$ for the quarry materials shall be located upstream of the processing workshop.

The sand & rock producing system is composed of a 1m$^3$ backacter, a ZL50 loader, a mesh screen, a SZ1300×6300 shaking screen, 3 sets of 4-6 inch submersible pumps, 4 sets of 5t dump trucks and 2 sets of 13.5t dump trucks.

5. The concrete mixing system

The concrete mixing system is situated on a slope within a 100m-range of the upstream left bank, including material storing & batching part, feeding part and mixing part. The material storing & batching system is located in 60-100m upstream of the dam, with a gallery bunker applied at the bank slope. Based on the actual topographic and geologic conditions, the bunker is shaped in a 40m×15m rectangle, and its stacking height is 12m and the finished material of 1800m$^3$ can be stored. The feeding elevation of bucker is 280m, and the discharging elevation is 265m. According to the concrete grading requirement, the bucker is divided into 5 compartments, among which the concrete (3m–thick for the lower part) and the brick wall (upper part) are applied for separation. Each compartment is equipped with 2 blanking holes, and each kind of graded aggregate enters the weigh bucket through the blanking hole, and after weighing, it is discharged on a belt conveyer with a width of 800mm, and finally sent into the feed hopper of mixing plant.

Cement shall be manually unpacked inside the cement storehouse, and hereafter conveyed to the feed hopper through a Φ450mm hard PVC pipeline.

The mixing plant is made of steel structure, with a height up to 11m. There are 3 layers, top floor is for feeding with a height of 3m, on middle floor is installed a control board and the mixing

machines (3.1m high), and bottom floor is for concrete discharging with a height of 5m. The material-feeding elevation of mixing plant is 265m, and the discharging elevation is 255m. 2 sets of $1m^3$ mixing machines are symmetrically arranged inside the mixing plant, and the producing capability is $240m^3$ concrete/machine/shift, and the maximum monthly generating capacity is $12000m^3$.

6. The concrete conveying system

The horizontal transport of concrete from the mixing plant to the lifting point of a telfer is carried out by 2 flatcars along with $4m^3$ buckets, on 762-type light rails driven by a 3t windlass. In order to improve the efficiency and speed up the concrete pouring, 2 buckets shall be adopted alternatively.

The vertical and horizontal transport of concrete from the lifting point to the concrete pouring surface of the dam shall be undertaken by the fixed cable crane.

The lifting capacity of cable crane is rated at 15t, with a span of 280m, the maximum lifting height up to 107m and the deflection 15m. The ends of cable crane are fixed on slopes of both banks by means of ground anchoring piles, and the anchor is 331m in elevation, and the height difference between the anchor and the dam crest is 52m. The bucket is horizontally dragged by a 5t-windlass on an auxiliary cable between upstream and downstream, and the maximum horizontal dragging distance can extend about 20m. Except dam section 1, 2 and 11 where concrete cannot be directly supplied above an elevation of 260m, others can be poured with concrete directly by cable crane. In case concrete cannot directly reach the pouring spot, an access needs to be put up, so cable crane shall lift concrete to an adjacent dam section, then a double-rubber-tyre cart is used to convey the concrete to the spot for pouring.

7. The storehouse for cement and flyash

The cement warehouse is placed at the external side of road crossing the dam, above the mixing plant, with an elevation of 280m, and its storage totals about 450t that can meet the peak demand for 7 days.

The flyash storehouse is placed at the external side of road crossing the dam, downstream of the left bank, with a capacity of about 280t.

## II Excavation of Dam Foundation

1. Excavation of soil, sand and gravel

Vegetation and superficial soil shall be cleaned up manually, and sand, gravel and road spoil be excavated mechanically. A hoe shovel of $1m^3$ and a self-loading truck of 5t capacity are applied for excavation and transportation.

2. Rock excavation

(1) Excavation procedure

Rock excavation at both banks shall be carried out simultaneously from upwards to downwards. Spoil at left abutment shall be excavated by mechanical means. At the right abutment, manual excavation is applied for the place above 250m in elevation, and below that, mechanical means shall be used, with a hoe shovel of $1m^3$ capacity. The excavation of both banks shall be followed with rock excavation for the foundation pit. All the rock excavation shall be based on the process of firstly excavating the common rock, and then the protective layer.

(2) Excavating method

The excavation of common rock shall adopt a method combining the use of down-the-hole

drill and pneumatic drill. For the common rock excavation of over 6m deep, the down-the-hole drill shall be applied for making pores, and then electric detonator and blasting fuse be used for ladder-shaped extrusion blasting if possible. If the down-the-hole drill is not suitable to make pores for common rock excavation, the pneumatic drill can be applied to make pores for blasting the common rock. Rock excavation on the protective layer of dam foundation shall apply the smooth blasting technology, with blasting layer thickness of 80-100cm and pore distance of 60-80cm. The explosive is interruptedly filled inside the pores, and the pores are linked with blasting fuses.

**III Treatment of Foundation**

The foundation treatment is mainly composed of consolidation grouting, curtain grouting, drain hole and contact grouting.

1. Consolidation grouting

Since reinforced meshwork is laid and the process needs to be accelerated, a pipe-pulling method is thus adopted at the riverbed section, that is, holes are made before concrete pouring and then the 2-inch steel pipe is pre-embedded. The outside of steel pipe shall be painted with mould oil, and it is rotated as concrete pouring, and the pre-embedded pipe shall be pulled out after concrete consolidating finally. When the intensity of covered concrete reaches 50%, the depth of hole shall be rechecked, and in case of any blocking inside, pneumatic drill shall be used to make it through. After the depth meets design requirement, grouting shall be made. The 01-30 type of pneumatic drill is applied for making pores with a depth of 6m into the base rock, and the diameter of 38mm. The consolidation holes shall be arranged as cinquefoil shape, and hole-distance and row-distance are both 3m, and this construction consists of 2 procedures. At the faultage and cranny places, reinforcing holes shall be accordingly increased, and drilled holes shall be washed by means of wind and water until the water returning back becomes clear. The grouting shall be undertaken by purely pressing in one time for the whole hole, with the grouting pressure of 0.5MPa, and the water-cement ratio is 3:1. The slurry change and the finishing standard etc. shall all be based on the specifications.

2. Curtain grouting

On the dam foundation, a row of waterproof curtain holes shall be arranged, and both dam ends shall be respectively extended for 15m and 18m long by means of grouting adits. The grouting-hole distance is 2.5m, and grouting shall be undertaken through separate process. The construction inside gallery is divided into three processes, and two construction processes be applied for other places. The curtain grouting needs to be started after consolidation grouting and contact grouting at the related dam sections, with a 150-hydraulic type of geological borer applied for making holes of 56mm in the diameter, and the hole depth shall be 8-10m under the relative aquiclude ($q \leq 1Lu$) beside no less than the design depth.

Before grouting, pressurized water shall be used for a wash, and the washing pressure is 0.8 times of the grouting pressure and it shall be no more than 1MPa, and washing ends after the returned water is clean. At first, the guide hole shall be tested with pressurized water section by section from upwards to downwards, called a single-point method, and a simple water-pressing test shall be applied for each grouting section of every sequential grouting hole. The grouting is undertaken by section from upwards to downwards, and the sectioned length is generally 1.5m for the contact part, and 5m for each part below. The circulating grouting method shall be used for

the inside hole, with grouting pressure of 1.0-2.0MPa. Hole enclosing shall adopt a sealing method of section pressure grouting. The slurry change and the finishing standard etc. shall meet the specifications.

3. Drain hole

A group of drain holes shall be arranged downstream of the curtain grouting on the dam foundation, with hole distance of 3m and diameter of 110mm. The depth of drain hole into the base rock is 0.6 times of the curtain depth there and it shall be no less than 10m, and the drain holes inside the gallery incline towards the downstream by an angle of $3^o$, and those on the bank slope lean to the upstream with an angle of $3^o$.

Drain holes of bank slope shall be drilled on the concrete sidesteps after the dam, and the construction of drain holes shall be commenced after the related curtain grouting is completed and accepted by testing, and holes shall be made by a 150-hydraulic type of geological borer equipped with a bort bit.

4. Contact grouting

The contact grouting covers the whole dam foundation of right bank, and the holes for consolidation grouting can be still adopted, that is to use the pneumatic drill to clean the holes from their openings until 1m beneath the base-rock surface. Before pouring the concrete, a galvanized iron pipe of 1 inch shall be embedded to extend toward the downstream dam surface. The grouting pressure is 0.5Mpa, and the grouting construction shall be undertaken according to two processes.

## IV Concrete Pouring for Dam

The concrete pouring for dam body shall apply a successively & meanly ascending mode by thin layers.

1. Measuring and lofting

Before starting concrete works for the dam, the measurement team has already intensified the control network of dam area, and construction lofting for the dam shall adopt the intensified Grade-4 control network, and a ND3000S infrared range finder used to determine gage-station sites on dam. Then a wild$T_2$ electronic theodolite shall be applied to loft the shuttering points through the polar-coordinate method, and the lofting intensity is one point for each 1.5m. After lofting, the measurer will check the size with a steel rule, and in case of any questionable part, recheck shall be carried out as to confirm there is no error before shuttering made by woodworkers.

2. Treatment for foundation surface or concrete construction joint

The loose rock on base-rock surface shall be cleaned up by manpower.

The plane construction-joint shall be washed by highly pressurized water, as to get rid of concrete burrs. After consolidation, the superficial concrete skin shall be eradicated by highly pressurized water until fresh dinas exposes. Before concrete pouring, dirt and water on base rock or concrete shall be removed, and the surface be made wet with water, then a 2-3cm-thick mortar with the same grade shall be placed at the mean time.

3. Scaffold

The scaffold for upstream & downstream sides of dam body adopts the tripod which is made of ∠65×65 angle iron for construction, and on the scaffold are erected plates, and the safety net shall be put up for the suspending part. The scaffold is only used for the shuttering purpose.

4. Erection of water & grout stops

The water and grout stops shall be oxygen welded at both sides, and after finalized in the machining shop, it shall be welded and erected on site.

5. Shuttering

Formwork is mainly made of steel, and side angles with abnormal shape shall be amended by a wooden formwork. The formwork shall be fixed by a ϕ10mm lacing wire, supported with prefabricated concrete column. Before concrete pouring, check shall be made, and during the pouring, a woodworker shall watch on, as to make adjustment timely in case of any loose. Besides the technics commonly applied, shuttering shall adopt a kind of construction measures with sleeve screws fixed to the lacing wire, so as to improve its profile quality, that is, the machined sleeve screw is rotated on the lacing wire for fixing the formwork, and the head of sleeve screw shall be placed inside the dam body by 2-3cm. After removing the formwork, a spanner is used to move the sleeve screw away, and the same mortar shall be adopted to envelop the screw hole left. So from the outside, the actual effect is very good, and it seems that there is no construction impact of the lacing wire on the dam body, and its surface is smooth and even.

6. Making & erection of reinforced steel

The reinforced steel shall be mainly made by manpower inside workshop, and poured and erected at the site. Steel number, specification, size and amount etc. of the reinforced steel shall be strictly based on design drawings, and it shall be erected according to the related standard.

7. Concrete pouring

The limited foundation area for concrete-pouring layer is controlled as 1.5m, and the non-limited area shall be controlled within 2-3m, on the basis of the dam structure and the temperature-controlling requirements. The concrete trimming shall be undertaken by means of an oscillator and a manually-pulled shovel, and during the trimming, the aggregate needs to be meanly placed, and ascends layer by layer. The thickness of each layer shall be within 50cm. The high-frequency inserting oscillator is applied, and at corners and small-sectional structures, an electric oscillator with flexible shaft is used, and during oscillation, attention shall be attached to strictly control the oscillating time and space for concrete, and its shaft shall be inserted into the lower concrete layer by 5cm, until concrete does not sink any more, there is no bubble, and bleeding begins.

8. Concrete conservation

Within 12-18h after concrete pouring, the concrete needs to be conserved, cooled and watered. Generally, water shall be sprinkled for conservation, and for overflow surface, dam crest and other special components, gunnysack shall be used for a cover and water is also sprinkled.

## V Joint Grouting

The joint grouting is divided into 5 layers in a total, with each elevation of ▽213, ▽223,▽237, ▽251, ▽265 and ▽279m respectively, and there are 44 pouring regions. The design temperature is $13.5^0$C.

The joint grouting shall adopt the pipe pulling-out method for its construction, that is, the air-filled plastic pipes shall be pre-embedded between the dam joints as to form some grouting loops, and the grouting shall be carried out in different sections.

Before grouting, the openness of horizontal joint shall be measured and recorded by using a

joint meter. In order to effectively control the openness increment of dam joint, the superficial joint meter shall be fixed downstream of the dam body before grouting. During the grouting process, any change on the superficial joint meter and the manometer shall be carefully watched on, and the pressure of vent pipe and the openness increment shall be strictly controlled, and meanwhile, water supply and pressure relief for the adjoining dam joint shall be prepared.

The joint grouting shall be undertaken layer by layer from downwards to upwards, and also extended from the dam middle to its both banks. The water-cement ratio adopts 3 grades such as 3:1, 1:1, 0.5:1, and grouting shall start from the ratio of 3:1, and after bleeding of the vent pipe, the 1:1 serosity shall be poured inside. When the bleeding concentration of vent pipe is close to 1:1 or when the pouring quantity of 1:1 serosity approximately equals to the joint dimension, the densest grade of 0.5:1 serosity shall be poured inside until the end. When finishing the pouring process, the sluice valve at the orifice shall be switched off firstly, and then the grouter is closed.

**VI Erection of Observation Facilities**

1. Installation of apparatus

Each apparatus which is to be embedded inside dam body, shall be acceptance-tested and stored strictly according to design requirements and other related standards, and each observation shall be made before, during and after the apparatus erection, and also the observed data shall be timely calculated and analyzed.

2. Construction of reversed hole

The reversed hole is very difficult to build and its construction needs to be highly accurate. Before and during the construction process, professionals shall be employed to offer instructions and inspect the construction accuracy at any moment, and in case of any deviation, it shall be rectified timely. The punching machinery shall adopt XU-300 oil-hydraulic geological borer. At the base-rock section, the drilling depth is 33.08m, thus meeting the requirement of 33m, and the effective hole-diameter is 153mm that also meet the requirement of 150mm. The pipe of reversed hole embedded inside dam shall be erected while the concrete pouring rises, and lofting shall be made for spot locating during its installation, and fixed with the turnbuckle drawing-pole. During pouring process, regular checks shall be undertaken, and in case of any deflexion, it need be adjusted timely as to ensure that the embedded accuracy meets the design requirement.

3. Construction of observation base-point

The installation & observation of observation base-point, check base-point and bench mark etc. inside dam body and outside dam shall all be undertaken in line with the requirements of design and standard, and the locations out of dam shall be reliable and stable, and try to be not affected by the stress inside dam area.

**VII. Construction Progress**

The construction is started from April 18, 2003 officially, and till to 26 August 2003, test on the excavation of dam foundation is accepted, which is one month earlier than the planned. The excavation of soil and rock adds up to 43800$m^3$, with a monthly average of 10350$m^3$ and the maximum up to 15000$m^3$ in one month.

The concrete pouring starts from Sept. 9, 2003 for the dam body and the first critical target has been achieved on Feb. 29, 2004 on schedule—the dam body hits an elevation of 251m for flood control, as to guarantee its safe construction during the flooding season. On 22 June 2004,

the second critical target is reached 3 days earlier than the plan—the dam body reaches the top elevation of overflow weir, 272m. On Sept. 16, 2004, the concrete pouring for dam body is completed half a month earlier, and that is to reach 279m, the elevation of dam crest. All the main works is finished on 22 October 2004. The concrete pouring amounts to 81000$m^3$, with an average of 6750$m^3$ per month and there are 6 months of pouring concrete over 7500$m^3$ successively, and the maximum is up to 11000$m^3$ in a month.

**VIII Conclusions**

During the construction of double-curvature concrete arch dam for Furong reservoir, its dam-foundation treatment, plane & vertical transport of concrete, shuttering, pouring and temperature control etc. are characterized in saving the cost, facilitating the construction management, improving the construction quality, shortening the construction term, and safeguarding the construction process, which can be taken as reference for similar projects.

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