

Questions to be responded to by the firm submitting the application

Why do you think this project should receive an award? How does it demonstrate:

- innovation, quality, and professional excellence
- transparency and integrity in the management and project implementation
- sustainability and respect for the environment

Longkaikou Hydropower Project, with a total installed capacity of 1800MW, mean annual energy output of 7.396 billion kW.h, total reservoir capacity of 55,800 m³, and flood control storage of 126 million m³, is developed mainly for power generation and also for irrigation, water supply and flood control. The design of the project was awarded 2 national awards, 16 provincial and ministry level awards, and 25 patents including 5 invention patents.

1. Research on key technologies and technological innovations

(1) Innovations in dam seismic analysis method and trapezoidal key groove technology to improve overall dam aseismic performance

The damsite is located in an area of high seismic intensity, the design and check seismic intensity of the dam are Magnitude IX and X respectively, and the peak ground motion horizontal acceleration is 0.394g and 0.471g. The dam aseismic problem is prominent and constitutes the difficulty in key technical issue of the Project. The main innovations are detailed as follows:

① In-depth study was made on the impacts of dam transverse joint state and 3-D seismic wave on dam seismic response with the analysis method of 3-D finite element nonlinear seismic wave response of whole dam section for the first time in China. The trapezoidal key groove first substituted for grouting of transverse joints to improve the dam overall aseismic performance, thus facilitating rapid construction of dam roller compacted concrete and reducing project investment of about 20 million yuan, so it is worthwhile popularizing.

② The analytical method and the supporting judgment standard for dam check earthquake and ultimate seismic capacity were put forward to provide important reference for revision of aseismic code and similar projects.

(2) Innovation in technical solution to complex geological defects to reach international leading level

There are complex topographical and geological conditions at the damsite. Large deformable bodies of 7.6 million m³ exist above the right abutment, and a deep trench, 20m ~ 43m wide, 20 ~ 36m deep, was found in the flood release dam section at the main riverbed, affecting the project safety and

construction progress. Combining production with study and research with application, the Designer effectively solved the major technical problems arisen in the project construction. Main innovations include the following:

① In the light of the slope with large deformable body and the deep and thick highly weathered rocks at the right abutment, the abutment joint technology by means of anti-slide pile was innovated and in combination with drainage inside and outside the slope and surface treatment measures, deep excavation of abutment was avoided, the engineering quantities and construction duration were reduced, and the slope stability was ensured. As compared with the conventional excavation scheme, the abutment joint technology by means of anti-slide pile resulted in reduction of project investment of 48.27 million yuan.

② The scale of deep trench at the main riverbed is gigantic, which renders extremely complex topographical conditions arisen in the global hydropower projects. The Designer innovated in the scheme of upstream anti-seepage support-retaining structure and excavating the overburden under the reinforced concrete slab and replacing with concrete. Upper dam concreting and lower excavation and concrete backfill were conducted synchronously, and the real-time monitoring technology was employed to ensure the construction safety. As compared with the conventional scheme, the scheme enabled the project to supply the power about 10 months ahead of schedule, resulting in economic benefits of 1.79 billion yuan and ensuring the project safety and construction progress. The deep trench treatment scheme opened up a new thought for geological defect treatment of dam foundation. "*Research and Application Achievement of the Complex Geological Defects Treatment of Longkaikou Hydropower Project*" was highly evaluated by Mr. Ma Hongqi, a senior academician from China Society for Hydropower Engineering, that is, "**This achievement has overallly reached the international leading level.**"

(3) Innovation in analysis and research method of dam foundation surface optimization to reduce project investment

The dam foundation is mainly composed of Upper Permian basalt, and orthophyre intrusions are filled in the basalt bedding fissures, causing considerable impacts on dam foundation deformation and stability against sliding. The Designer conducted advanced acoustic detection and pre-evaluation of foundation surface by taking the favorable opportunity. According to rock mass information obtained during dam foundation excavation and anti-sliding stability analysis results, the 3-D design platform was used to distinguish the proportion of various rock mass by layers and corresponding modulus of deformation, predict the foundation surface position and adjust dynamically.

The analysis and research method adopted for the optimization of foundation

surface of Longkaikou Hydropower Project put the entire design and construction in dynamic control. Remarkable effects were achieved at the aspects of ensuring the rock quality of foundation surface, reducing the engineering quantities, shortening the construction duration, etc., and the project investment was reduced by 194 million yuan, resulting in remarkable economic and comprehensive benefits.

(4) New construction diversion method in wide valley to accelerate construction progress.

The river diversion method by the open channel on the left bank and the technology of double-layer discharging of the bottom outlets and gaps were adopted during the construction. The diversion channel is characterized by large flow, high head, complex operating conditions, resulting in great comprehensive technical difficulties. The main innovations include the following:

- ① The diversion open channel structure was arranged in combination with the water retaining dam section on the left bank, thus solving well the Stage-2 and Stage-3 diversion and the plugging issues of gaps and bottom outlets, and creating good conditions for accelerating the project progress.
- ② Double-layer discharging technology was applied in the diversion channel of large-scale projects for the first time. During dry seasons, the inflow is discharged through the bottom outlets, while during flood seasons, the inflow is discharged jointly through the bottom outlets and the gaps above. The design unit discharge of the open channel and the bottom outlet is 270m³/s and 380m³/s respectively. The successful application of double-layer discharging technology has gathered engineering experience for construction diversion of large-scale hydropower projects.

List of invention patents of Longkaikou Hydropower Project

S.N.	Patent	Type	Patent No.
1	A connecting structure between gate piers of hydraulic structures in an area of high seismic intensity and its construction method	Invention patent	ZI201110326934.0
2	Design method of shallow-buried flexible anti-slide pile for support of slope with thick overburden	Invention patent	ZL201010221237.4
3	A key groove type joint-cutting structure for roller compacted concrete gravity dam and its construction method	Invention patent	ZL200910098392.9
4	A kind of design of structure joints by use of external water pressure and its construction technology	Invention patent	ZL200810122129.4
5	A structure connecting gravity dam and bank slope with adverse geological conditions and its construction method	Invention patent	ZL200910098395.2

Note: in addition to 5 invention patents listed in the table above, 20 patents for utility model were awarded for the project.

2. Application of outstanding technologies

(1) Initial application of 3-D co-design in hydropower industry to improve design quality

In China's hydropower sector, Longkaikou Hydropower Project is the first project for which 3-D co-design was applied. The 3-D co-design covers the project design of all stages and all specialties, and 3-D model was used for comparison of the project layouts, analysis and treatment of slopes, analysis of complex structures, design optimization, construction safety monitoring and coordination between the specialties, production of design drawings, technical explanation for design and its result presentation, etc. The 3-D co-design upgraded the design level and quality, and solved the common "mistake, missing, mutual interference, lack" problems existing in previous design process.

The digital design and application of Longkaikou Hydropower Project won the first prize of the first digital design contest of China electric power projects.

(2) Industrial innovation to apply dolomite aggregate to main structures

The native rock required by concrete aggregate for main structure of the Project totaled 5,850,000 m³. In view of this, the quality and reserves requirements can only be met by the Yan Zhiya Dolomite Quarry in the range of 20km upstream and downstream of the damsite can meet the quality and reserves requirements. But the dolomite aggregate had been applied only to small hydropower projects in China and abroad and there was lack of application experience in large-scale hydropower projects.

The systematic tests and studies including comprehensive and in-depth experimental analysis, project analogy and site detection were carried out for the performance of dolomite aggregate and concrete to systematically demonstrate the technical feasibility of dolomite as aggregate material for large-scale hydropower projects. Longkaikou Hydropower Project became the first large-scale project in China and abroad in which dolomite was successfully used as artificial aggregate in main structures, filling the blank in the use of crushed dolomite artificial aggregate in China's large-scale hydropower projects and providing valuable design and operation experience.

(3) Technical research and application of aggregate processing system with super elevation difference and belt conveyor for long-distance and stepped aggregate transportation

The quarry has high and steep terrains, and forms a vertical height difference of 700m with the aggregate processing system, but the horizontal distance is only 1000m. From the quarry to semi-finished aggregate processing plant, the combination pattern of "3-level jumps" by setting 3 vertical shafts and 3 adits

was adopted to solve successfully the problem of small and narrow site and large vertical height difference.

The straight-line distance from the aggregate processing plant to the site concrete batching system is about 7km with complex topography and geology along the route. The high speed belt conveyor is the S-shaped arranged transportation system with longest length and maximum capacity in China, and it was used in hydropower projects for the first time and the monthly concrete and aggregate delivery intensity was 250,000 m³. Its successful construction and use has guide significance for the application of long-distance belt conveyor and it takes the lead in China's hydropower industry.

3. A transparent and honest project

(1) The integrity contract was signed and the double contract management mechanism of "the investigation and design contract" and "the integrity contract" was implemented to prevent various corrupt practices during the execution of the contracts.

(2) The transparent, efficient and competitive bidding was adopted for the project consulting services. With the corporate spirit of "Responsibility, Efficiency and Excellence", Huadong Engineering Corporation Limited provided professional, objective, impartial services and recommendations to the Owner.

(3) The world first-class consulting and evaluation institutions such as Hydrochina Corporation and China International Engineering Consulting Corporation were invited to evaluate the technical results to realize technical transparency and openness.

(4) The quality system of investigation and design and the professional morality system of the consulting engineers were established, Based on the principle of technology first, reasonable proposals were offered to the Owner to maintain the Owner's benefits and laid foundation for high quality of the project.

4. A sustainable and environment-friendly project

(1) Superior project quality

The aseismic design of Longkaikou Hydropower Project is based on Magnitude IX so as to meet requirement of no dam break under the check seismic intensity of Magnitude X can be met, so the engineering structures are thus safe and reliable. The percent of pass of unit project acceptance is 100%, and the excellent rate is above 90%, indicating the project quality is superior. The dam has been in normal operation since reservoir impoundment in 2012, and the slope is stable without any abnormal deformation. The units have been in normal operation, and there is no hidden trouble affecting the

safe operation of the units.

(2) Environment-friendly Project

As compared with conventional concrete dam, the cement consumption of the RCC dam of the Project was decreased by about 30%, favorable for energy saving and environmental protection. On the premise of ensuring the safety and quality of the Project, the design was continuously optimized to significantly decrease the quantities of excavation and concrete works and the impacts on the natural environment. The concrete aggregate was transported based on the greening design and construction concept of “four saving and one environmental protection”, and the new technology of long distance belt conveyor with spatial stage turning was utilized to shorten the conveyor length and the tunnel is dominant along the route so as to decrease land acquisition and fulfill saving in energy, materials, land, and investment.

(3) Remarkable social, economic and environmental benefits

All the units of Longkaikou Hydropower Project were put into commercial operation in January 2014. As a backbone power source in the northwestern Yunnan, it has supported the economic development throughout the region, and has played a quite important role in promoting the regional economic development and strengthening the national unity.

The operation of Longkaikou Hydropower Project has resulted in significant benefits in energy saving and emission reduction. Based on its annual energy output, it can substitute for standard coal of 2.5 million tons consumed by coal-fired power stations, and reduce emission of carbon dioxide of 5.61 million tons and sulfur dioxide of 68.9 thousand tons.

In the design process, the factors of environmental protection, energy & land-saving, etc. were taken into full account, adequately reflecting the design concept of “Serve the projects and promote harmonious development between man and nature”.

For the project, the first fish proliferation and releasing station was built and successfully put into operation among the Chinese hydropower projects; and the research was first carried out on the technologies related to artificial simulated fish spawning sites and artificial fishing and releasing through the dam.

The discharge technology of ecological flow by partial opening of the large plain blocking gate was first applied to large-scale hydropower projects, thus providing good reference for ecological flow discharge of similar projects.

The ecological landscape design aimed at “greening and environmental protection”, broke the traditional idea of “damage first and protect later”, so that Longkaikou Hydropower Project could be built into an orderly developed,

beautiful, ecology-harmonious, and environment-friendly project. The ecological rehabilitation and cultural landscape construction of the project has become a model for the hydroelectric developments in China.

What services did the member firm provide to the project? Please describe briefly.

Huadong Engineering Corporation Limited undertook engineering investigation and design in all stages of pre-feasibility study, feasibility study, tendering design and construction drawing, corresponding scientific research, site technical services, and compilation of the design and completion data of the project. In the service process, the basic principles of “being feasible technically, reasonable economically, safe and reliable, and transparent and integrity” were carried out to make the project meet the safe, adaptable, economic, environment-friendly and aesthetic requirements.