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The Three Gorges Project

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1. Introduction to the project

The Three Gorges Project is a key backbone project for the management and development of the Yangtze River. Its dam site is located in the middle section of the Xiling Gorge at the main stream of the Yangtze River, in Sandouping Town, Yichang City, Hubei Province, with a control basin area of about 1×10^6 km^2, an average annual flow of 14 300 $m^3 \cdot s^{-1}$, an average annual runoff of 4.51×10^{11} m^3, a normal water level at an elevation (EL) of 175 m, and a corresponding reservoir capacity of 3.93×10^{10} m^3. The Three Gorges Project consists of a water conservancy and hydropower project, a power transmission and transformation project, and a resettlement project; the water conservancy and hydropower project includes a dam, a dam-toe power station, an underground power station, a ship lock, a vertical ship lift, and the Maopingxi protective dam. A panorama of the project is shown in Fig. 1.

The Three Gorges Project officially began on 14 December 1994. River closure was achieved on 8 November 1997 and the project's power-generation and shipping benefits began to be exerted in June 2003. The reservoir began to fill in 2003 and was successfully impounded to reach a water level at an EL of 175 m for the first time in October 2010. The overall completion acceptance of the project was met in November 2020. As of 2021, the impounding target of 175 m EL has been successfully achieved for 12 consecutive years.

The scale and comprehensive benefits of the Three Gorges Project are huge, and its engineering technology is complex. Its characteristics and design complexities include [1]:

(1) **The handling of an enormous flood discharge.** The maximum design flood is 10% greater than a 10 000-year flood, and the corresponding peak flow and discharge flow are 124 300 and 102 500 $m^3 \cdot s^{-1}$, respectively. It was also necessary to take into account the requirements of float age drainage, sediment removal and construction diversion, river closure, and so forth.

Fig. 1. Panorama of the Three Gorges Project.

(2) **The huge scale of the power station.** The total installed capacity of the power station is 22 500 MW; a number of 32 turbine generator units with a single-unit capacity of 700 MW are installed, with a water-level fluctuation of up to 40 m.

(3) **The large scale of the navigation and high functional requirements.** The ship lock has a planned annual one-way freight volume of 5.0×10^7 t and a fleet of 10 000 tonnage to allow navigation through the dam. It was necessary to adapt to the complex water, sediment, and river terrain conditions at the dam site, as well as the requirements of the phased operation of the project.

By focusing on the above technical challenges, the Three Gorges Project has put forward and applied new theories and methods in the process of design, research, construction, and operation, and has made a series of significant technological achievements.

2. Technological achievements of the project

2.1. General layout

In the design of the general layout of the Three Gorges Project, due to the need to handle flood discharge on a huge scale, a wide leading edge would have been required for the discharge sections if a conventional layout of the flood-discharge orifices had been adopted. Due to the large installed capacity of the power station and the large number of installed units, it was necessary for the length of the flood-discharge dam sections to be as short as possible while still meeting the requirements of energy dissipation and anti-scouring [2]; moreover, the construction diversion and navigation needed to be taken into account.

After studying a variety of different layout schemes and structure types, flood-discharge dam sections with deep outlets combined with surface orifices were finally arranged in the main river trough. The dam-toe power plants were arranged on the flood plain on both sides of the riverbed, and the navigation structures were arranged on the left bank, considering the navigable water flow conditions and sediment accumulation obstruction at the outlets of the upstream and downstream approach channels. A phased diversion method was adopted to meet the navigation

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requirements during the construction period. A longitudinal cofferdam was arranged on the Zhongbaodao eyot in the riverbed of the dam site, and a diversion channel was arranged on the right natural river branch of the Yangtze River, as shown in Fig. 2. This design successfully solved a series of technical difficulties such as handling the large flood discharge of the project, incorporating a large number of installed units and the large-capacity power station, and meeting the high requirements for the passing capacity of the navigation structures.

2.2. Flood discharge, energy dissipation, and anti-slide stability of the high-gravity dam

2.2.1. A 3D staggered arrangement of orifices for a high waterhead and super-large flood discharge

A unique and complex 3D staggered layout scheme of large, three-layer orifices [3] were innovatively adopted in the design of the Three Gorges Dam flood-discharge structures, as shown in Fig. 3, in order to safely pass the super-large flood discharge and river diversion during the construction period. The deep flood-discharge outlets adopt a type of short pressure pipe and falling sill aeration, while the bottom diversion outlets adopt a layout scheme with long pressure pipes, joint crossing, and a control gate installed, in order to successfully solve the technical difficulties of cavitation, erosion, sediment abrasion, energy dissipation, and anti-scouring of the flood-discharge outlets under a high waterhead, large water-level amplitude, and complex operating conditions.

In the 3D staggered layout scheme of the three-layer flood-discharge orifices, the surface orifice, deep outlet, and river diversion bottom outlet are arranged in the same dam section. With a high opening rate of the dam body (33% plane, 32% facade, and 31% volume), large orifice size, high acting head (the design head of the deep outlet is 85 m), frequent operation, large water-level fluctuation, and complex structural type, problems such as large-orifice structure stress, multiple reinforcements, and difficult construction were extremely prominent. Based on an in-depth analysis of the structural characteristics of the multilayer large orifices, research on nonlinear finite-element crack analysis and nonlinear reinforcement design methods for reinforced concrete was carried out for the first time in China. The principles behind orifice reinforcement and the development of cracks around orifices were clarified, and a robust design was adopted. According to the formation mechanism of the orifice tensile stress, comprehensive measures such as an upstream transverse joint to stop water from moving backward and transverse joint grouting were adopted. Thus, the water pressure in the orifice is balanced by the external water pressure between the joints and the lateral stiffness of the dam is enhanced, so that the stress and deformation indicators of the flood-discharge outlets are all within the design control range. This effectively reduces the quantity of orifice reinforcement bars required, reducing the construction difficulty and saving project investment.

The flood-discharge facilities of the Three Gorges Dam have been operating for more than ten years, since 2003; during this period, they withstood a maximum flood peak flow of 71 200 $m^3 \cdot s^{-1}$ in 2012 (about the equivalent of a 20-year return period flood), and the operation and scheduling of the flood-discharge structures were found to be normal.

2.2.2. Deep anti-slide stabilization technology of the No. 1 to No. 5 plant dam sections on the left bank

Downstream of the No. 1 to No. 5 plant dam sections on the left bank of the Three Gorges Dam, a dam-toe plant is arranged; as a result, the downstream of the dam bedrock faces the air, forming a high and steep slope with a slope angle of about 54°, a temporary slope height of 67.8 m, and a permanent slope height of 39 m (as shown in Fig. 4). At the top of the slope, a gravity dam nearly 100 m height is located. Furthermore, there are many long and low-angle downstream dip cracks in the dam foundation. Among them, the potential slide surface connectivity rate of the No. 3 dam section foundation is as high as 82.9%, and the shear strength is low, which is very unfavorable for the dam foundation deep anti-slide stability. Therefore, the deep anti-slide stability of the gravity dam was one of the major technological challenges of the Three Gorges Project.

Through systematic and fine geological exploration, the exact location, orientation, trait, spread range, and combination relationship of each long and low-angle dip structure surface in the dam foundation were ascertained. The study proposed a comprehensive analysis theory of the deep anti-slide stability of the gravity dam foundation. The analysis theory took the sliding along the long and low-angle dip structural surface identified by the exploration as the basic slide mode; it also considered two more extreme slide modes, and comprehensively used safety factor methods such as

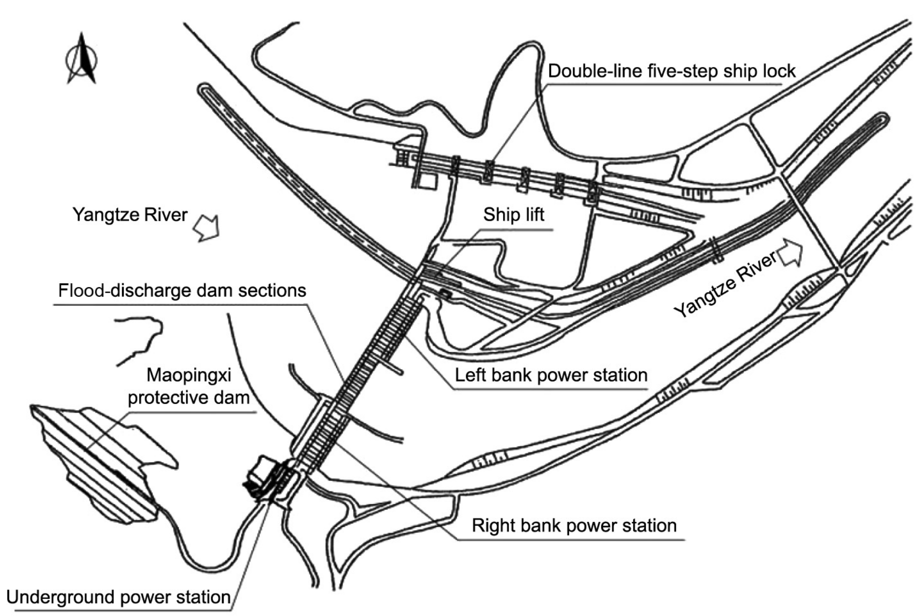

Fig. 2. General layout of the Three Gorges Project.

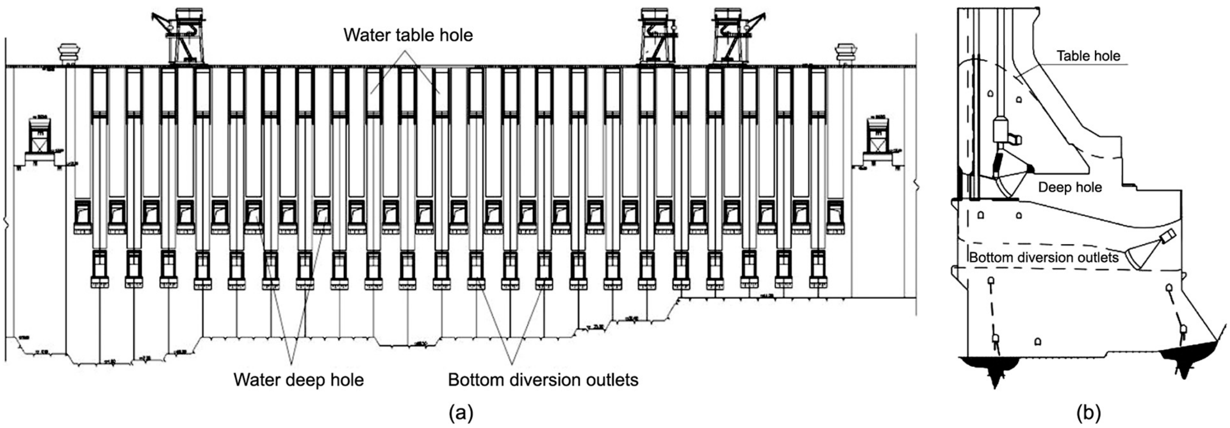

Fig. 3. Layout of three-layer orifices in the flood-discharge passing dam section of the Three Gorges Dam. (a) Upstream of the discharge dam section; (b) cross-section of the discharge dam section.

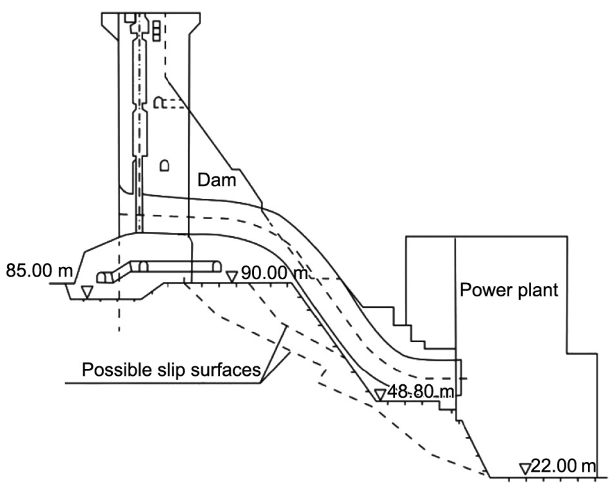

Fig. 4. Schematic diagram of the typical slide surface with deep anti-slide stability in the No. 1 to No. 5 plant dam sections on the left bank.

the rigid body limit equilibrium method, linear and nonlinear finite-element analysis, and geomechanical model tests to carry out systematic demonstrations. The following stability-control criteria were established: The anti-slide stability safety factor of the deterministic basic slide mode must be greater than 3.0, and the anti-slide stability safety factor of the extreme slide mode must be greater than 2.3–2.5. Based on the analysis results, comprehensive reinforcement measures were adopted, such as cogging the dam heel, moving the curtain grouting forward, incorporating deep drainage tunnels, establishing the joint action of the plant and dam, and including prestressed anchors.

According to the monitoring results of the operation period, the measured uplift pressures on the slide surfaces of the two deterministic basic slide modes are only 40%–56% of the design value, and the corresponding safety factors of the deep anti-slide stability are 3.37 and 4.20, respectively. These values meet the design control criteria, indicating that the comprehensive technical measures adopted are effective and the dam operation is safe and reliable.

2.3. Shallowly buried large underground power station in thin mountain

2.3.1. The single-cavern layout technology of the main cavern of the large underground power station

Restricted by the project's general layout and the topographic and geological conditions, the underground power station of the Three Gorges Project is located in the Baiyanjian Mountain on the right bank. The maximum inflow of a single unit is 991.8 $m^3 \cdot s^{-1}$, the rated water head is 85 m, and the water flow inertia time (T_w) of the waterway system is long, with a T_w value of 4.7–5.4 s. According to the traditional design method, a large-scale downstream surge chamber (with a single-chamber stable area of about 1200 m^2) is needed at the tailrace. As the Baiyanjian Mountain is thin and its blocks are developed, a high hollowing rate on the cracked rocks will lead to a major stability problem of the surrounding rock of the cavern group. For this reason, the relationships between the setting EL of the turbine, the length of the pressure section of the tail water, and the downstream water level were thoroughly studied by means of theoretical analysis, numerical simulation, model testing, and so forth, in order to break through the traditional design theories for a power station tailrace tunnel (including a pressure tunnel or non-pressure tunnel). Due to this innovative approach, a new type of tailrace tunnel with a mixed and alternating free surface and pressurized flows—that is, a tailrace tunnel with a sloping roof—was proposed, and the corresponding design theory and design method were established. As shown in Fig. 5, a tailrace tunnel with a sloping roof was adopted and the tailrace surge chamber was cancelled; thus, the arrangement of the underground cavern group was simplified [4], resulting in single-cavern layout technology for the large underground power station.

At the same time, a new technology with an ultra-long, ultra-high-voltage large-current phase-isolated enclosed busbar was adopted to realize the transfer of the main transformer to the ground surface and to cancel the main transformer cavern. Thus, the traditional layout technology for a large underground power station of the three-caverns type (i.e., the main powerhouse cavern, the main transformer cavern, and the tail water surge chamber) was changed to a single-cavern type (i.e., only the main powerhouse cavern). This innovative approach reduced the scale of the cavern group; hence, the hollowing rate of the mountain body and disturbance to the rock mass, the engineering technology risk, and the engineering investment were minimized significantly. Thus, the overall stability problem of the large underground power station cavern group in the thin mountain body was solved.

2.3.2. Stable arch design theory for the shallowly buried large underground powerhouse

The span of the main powerhouse of the Three Gorges Underground Power Station is 31 m, with a span of 32.6 m above the crane beam, and the maximum height of the powerhouse is about 87.3 m. The thinnest part of the rock mass overlying the cavern is

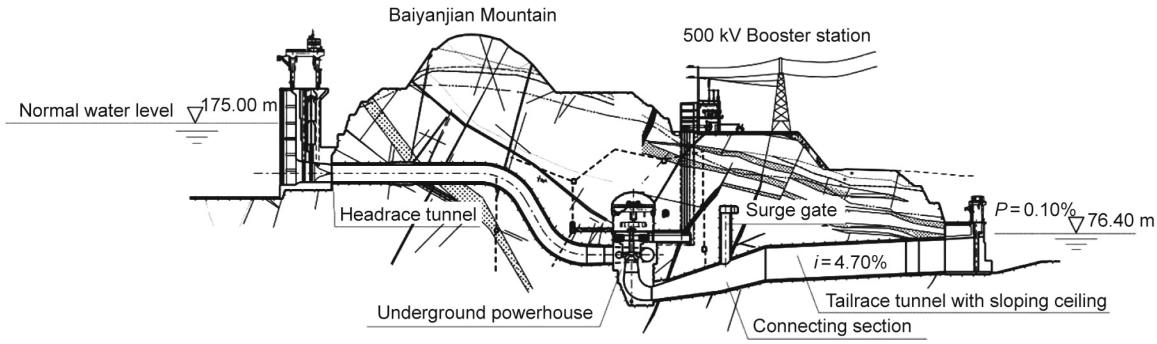

Fig. 5. Longitudinal section along the waterway system of the Three Gorges Underground Power Station. *P*: flood frequency; *i*: slope ratio.

only one times the span of the powerhouse, which is far less than the design requirement of greater than two times, as specified in the design code. For the shallowly buried large-span underground cavern with a high side wall, no mature theories or methods were available to follow for the design of the top arch of the thin surrounding rock. Based on traditional arch theory, the arch effect and the stability of the rock mass of the shallowly buried underground cavern were thoroughly studied, and the load-bearing mechanical mechanism of the top arch of the surrounding rock of the underground cavern was revealed. The studies showed that the stability of the top arch of the shallowly buried underground cavern depended on whether a stable arch-bearing area could be formed in the rock body of the top arch, which is defined as a stable arch of surrounding rock. By studying the influence of different burial depths on the stable arch of the surrounding rock of the cavern, and according to whether a stable principal compressive stress arch ring could be formed in the surrounding rock of the cavern roof arch, criteria for determining the minimum thickness of the overlying rock mass of the cavern roof arch were established. On this basis, a design method was proposed to determine the minimum buried depth of a large underground cavern according to the stability of the arch of surrounding rock [5].

Applying the theory of a stable arch of surrounding rock and the practice of finely controlled blasting construction, the minimum burial depth of the surrounding rock of the Three Gorges Underground Powerhouse on the right bank that was required to form a stable arch was found to be about 2/3 times the cavern span, and the surrounding rock of the top arch possessed the necessary requirements for the burial depth and *in situ* stress to form a stable arch. This development broke through the restriction that the thickness of the overlying rock mass of a main cavern must not be less than two times the width of the cavern, as specified in the design code. Thus, a large-scale shallowly buried underground powerhouse was built with the largest excavation section size in the world during the same period and a burial depth of only one times the span.

2.4. A large double-line five-step ship lock with a high waterhead

The main structure of the Three Gorges Ship Lock is 1.6 km long and is arranged in a double-line rock groove formed by vertical excavation of the rock mass and anchor rod reinforcement. The maximum slope height of the side slope is 170 m, and the depth of the vertical lock groove at the bottom of the slope is 70 m. The total waterhead of the lock is 113 m, and the head of the interstep is 45.2 m. It is the largest inland ship lock in the world, with the highest total waterhead, the greatest number of continuous steps, and the most complex technical conditions [6].

Based on the geological conditions of the Three Gorges Ship Lock, a new type of fully lined ship lock was studied and proposed. The lock head walls, lock chamber walls, and main water-conveyance galleries are all made of a reinforced-concrete thin-lining structure, as shown in Fig. 6. A joint force-bearing body between the lining body and the rock mass is formed through tensile–shear high-strength bolts to jointly bear the loads of the miter gates, water pressure, ships, and so forth. Compared with traditional gravity structures, the rock excavation was reduced by 8.4×10^6 m^3, 6.0×10^6 m^3 of concrete was saved, and the construction period was shortened by nine months.

The comprehensive hydraulic index of the Three Gorges Ship Lock ranks as the highest in the world, with a design water-conveyance time of 12 min and a one-time water-conveyance volume of up to 237 000 m^3. How to ensure the berthing conditions of the lock chambers and the safe operation of the water-conveyance galleries and valve equipment while meeting the water-conveyance time requirements was a key technical problem that needed to be solved in the hydraulic design. The main water-conveyance galleries are arranged symmetrically on both sides of the lock chamber, and the bottom of the lock chamber adopts a type of constant-inertia dispersed water outlet plus cover-plate energy dissipation with four sections and eight branch galleries. Its excellent dynamic balance characteristics ensure the fast and stable water conveyance of the lock chambers. In order to prevent cavitation erosion and acoustic vibration of the valve section gallery and valve, a comprehensive anti-cavitation technology involving a water-conveyance gallery with a high cavitation number, quick-opening valves, a bottom-expanded gallery shape, and lintel natural ventilation was proposed [7,8].

An analysis of various monitoring data has shown that the deformation of the ship lock slope is stable. The seepage pressure of the slope groundwater and the wall back, the deformation of the lock head and the lock chamber walls, and the stress of the high-strength structure bolts are all within the design's allowable ranges. The overall performance of the water-conveyance system has been found to be satisfactory.

2.5. A large vertical ship lift with a high waterhead

The Three Gorges Ship Lift is the first whole balance gear rack climbing-type vertical ship lift in China, with a ship passing scale of up to 3000 tonnage, a total lifting weight of 15 500 t, and a lifting height of 113 m. Compared with other vertical ship lifts around the world, the Three Gorges Ship Lift not only has a large ship passing scale and a high lifting height but also is characterized by large fluctuation ranges of the upstream and downstream water levels, rapid change of the downstream water level, high-intensity earthquake fortification, and high safety standards for passenger ships. Therefore, it has the largest scale and is the most technologically difficult ship lift in the world.

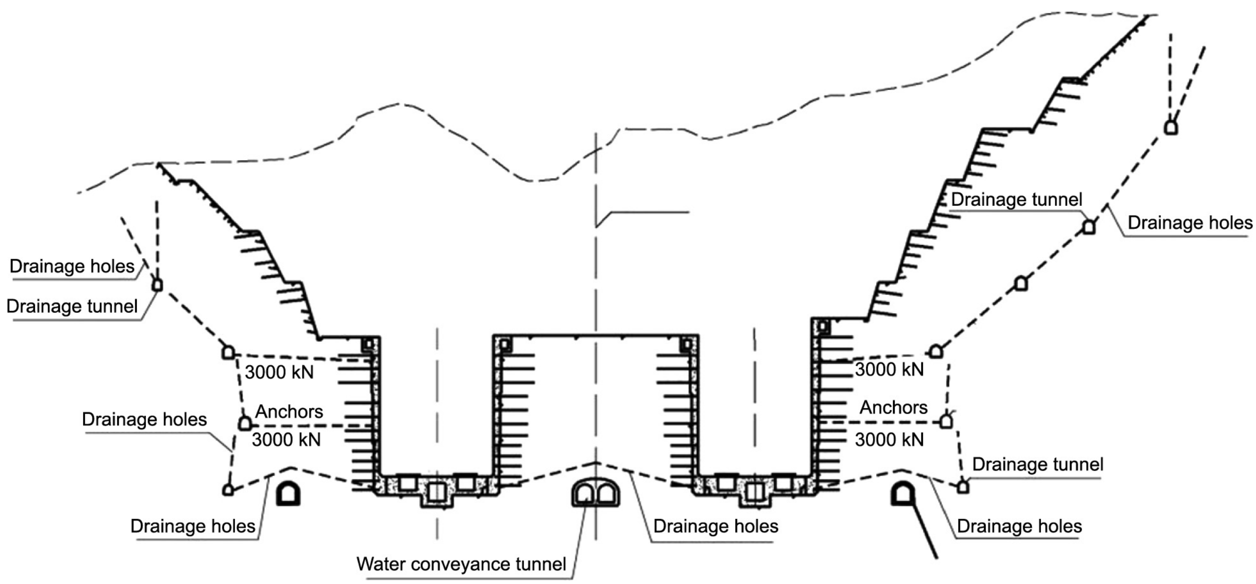

Fig. 6. A typical section of the fully lined ship lock chamber of the Three Gorges Project.

The design of the Three Gorges Ship Lift adopts a series of innovative technologies in order to: ① adapt to the complex and unfavorable natural conditions; ② overcome the design difficulties caused by unfavorable conditions such as a heavy load, high lift, and extreme working conditions; and ③ meet high-standard safe navigation requirements. A series of innovative technologies were adopted in the ship chamber section, in order to retain the basic configuration characteristics of the whole balance gear rack type climbing ship lift; these include a vertical support system for the ship chamber that integrates functions such as a lift drive, docking locking, and chamber-unbalance accident protection. The gear bracket mechanism can adapt to the multiple-degrees-of-freedom relative displacement between the tower column bearing structure and the ship chamber, and can maintain the high-precision meshing of the open gear and the rack of the driving mechanism. The electrical transmission control system of the driving mechanism can accurately ensure the level of the ship chamber during lifting and lowering operations and has the function of electrical synchronization. The horizontal support and steering system of the ship chamber can minimize the horizontal seismic load on the ship chamber structure and equipment, and has elastic cushioning and damping shock-absorption functions.

In the upstream and downstream approach channel sections and the lock head sections, in order to meet the Three Gorges Project's operating conditions of a large-flow flood discharge, large-load peak regulation, and large water-level fluctuation, a new type of upstream partition dike was proposed. The dike has the following features: flow partitioning in the flood season and overtopping in the dry season; an extra-large new type of combination gate with a flap dock gate for ship passing, a bulkhead gate for connecting, and stop-log gate for positioning, which adapts to the large upstream water level amplitude; and an extra-large new type of double-leaf bulkhead gate that adapts to the downstream rapid water level change, with positioning under pressure, pressurized water stoppage, and step locking. Taken together, these features ensure the safety of ships when entering and exiting the ship lift [9].

As of the end of 2021, the Three Gorges Ship Lift has been running stably for six consecutive years, carrying more than 18 000 ships of various types, 490 000 passengers, and over 7.6×10^6 t freight. Thus, it has played an active role in improving the navigation quality of the Three Gorges Project.

2.6. River closure with large flow, a high drop, and deep water

The river closure of the Three Gorges Project had the greatest comprehensive difficulty in the world [10], with a maximum water depth of up to 60 m and a design flow of 14 000–19 400 $m^3{\cdot}s^{-1}$. The project was faced with technical problems such as an ultra-large water depth, large flow closure, and easy collapse of the dike head during the construction of the river closure. Therefore, based on a comprehensive analysis of the problems of deep-water dumping stability, navigation influence, and construction strength during the construction process, along with model tests and research on various schemes, a new and innovative technology was adopted involving horizontal dumping to raise the EL of the riverbed in deep water and single-embankment vertical-plugging closure. This innovative technology for the river closure construction of the Three Gorges Project created a world record in continuous filling at 194 000 $m^3{\cdot}d^{-1}$, and ensured the safe and smooth navigation of the Yangtze River during the river closure construction [11]. The river closure scenario of the Three Gorges Project is shown in Fig. 7.

During the diversion channel closure of the Three Gorges Project, the actual closure flow varied from 12 200 to 8 600 $m^3{\cdot}s^{-1}$, and the total design drop of the closure was 5.57 m. This was the first time in China that the technology of

Fig. 7. River closure of the Three Gorges Project.

vertical-plugging closure with the collaborative use of two embankments was successfully implemented.

2.7. High-strength construction and temperature control of the high dam mass concrete

The Three Gorges Dam is characterized by a large number of outlets, a complex structure, large dam blocks, strict requirements for concrete temperature control, and difficulty in temperature control and crack prevention. The traditional construction methods and techniques were considered to be inappropriate and difficult to meet the construction strength requirements due to: ① the large amount of work, with a concrete volume of the dam of up to $1.6 \times 10^7\ m^3$; ② the tight construction schedule; ③ the high construction strength; and ④ the long peak period of construction. Therefore, the traditional concrete construction technique was replaced, and a new technology was adopted that involved continuous-pouring concrete construction using a tower belt machine, which was supplemented by a portal tower crane and cable crane pouring. This was supported by the operation of five small machines for placing the concrete face: a placing face-leveling machine, vibrating machine, high-pressure water-jetting machine, placing face crane, and sprayer. In addition, computer monitoring was used throughout the whole process. In this way, a world record of an annual concrete-pouring volume of $5.48 \times 10^6\ m^3$ was achieved, and the safe, high-quality, and efficient construction of the concrete dam was realized.

At the same time, the designers independently developed and systematically innovated a complete set of temperature-control and crack-prevention technology for large-volume concrete, pioneered the production of 7 °C pre-cooled concrete from secondary air-cooled aggregates, and adopted the temperature-control and crack-prevention technologies of individualized water cooling and new thermal insulation materials. These remarkable innovations and the successful implementation of concreting in the Three Gorges Project raised China's hydraulic concrete temperature-control and anti-cracking technology to a world-leading level [12].

2.8. Comprehensive reservoir utilization operation

2.8.1. Multi-region collaborative flood-control regulation

In the detailed design of the Three Gorges Project, a flood-control compensation scheduling method for the Jingjiang reaches was studied and determined, in order to prevent upstream flooding. Multi-region collaborative flood-control regulation technology was innovatively proposed, represented by the coupling scheduling of a single reservoir to multiple flood-control objects and to medium and small flood decompression scheduling. The aim of this technology was: ① to increase the flood-control benefits of the Three Gorges Reservoir; ② to reduce the excess flood volume in the Chenglingji river section in the middle and lower reaches, and ③ to reduce the flood-control pressure when encountering small and medium floods. By applying this technology, while ensuring the safety of the Three Gorges Dam and not lowering the flood-control standards of the Jingjiang reaches, the water level of flood-control compensation scheduling for the Chenglingji river section can be controlled at 158.00 m, and the operation control water level to reduce the flood-control pressure in the middle reaches is controlled at 150.00 m. This not only reduces the excess flood volume in the middle and lower reaches of the river but also reduces the number of flood-control dike patrols, giving full play to the flood-control benefits of the Three Gorges Reservoir [13].

As the reservoirs in the upper reaches of the Yangtze River were gradually put into operation, a multi-region collaborative flood-control regulation model for the reservoirs in the upper reaches of the Yangtze River was studied and put forward. This model included the multidimensional attributes of time, space, quantity, sequence, and effect, with the Three Gorges Project as its core. The model optimized the operation timing, sequence, and size of the flood-control storage capacity of the reservoirs in the upper reaches of the Yangtze River, allowing them to effectively respond to the flood in the Yangtze River Basin in 2020 by retaining a flood volume of $2.54 \times 10^7\ m^3$ and avoiding the use of flood-storage and detention areas in the Jingjiang reaches near Chenglingji and Hukou. Thus, the model plays an important role in flood control and disaster mitigation.

2.8.2. Ecological scheduling to promote reproduction of the four major fish species

A scheduling index and a storage and discharge scheduling method for artificial flood peaks were proposed, in order to meet the natural reproduction requirements of the four major fish species in the middle reaches of the Yangtze River. The method was based on: ① considering the hydrology, water temperature, and hydraulic conditions needed for the reproduction of the four major fish species; ② identifying the ecological scheduling needs for the natural reproduction of the four major fish species; and ③ determining the key factors affecting the natural reproduction of fish, such as the continuous water rise time, initial water level, and daily water-level rise rate. This method also promoted the progress of ecological scheduling experiments.

According to an analysis of the monitoring data in the Shashi section, the annual runoff of fish eggs of the four major fish species has fluctuated and increased for more than ten years, reaching 6.680×10^8 in 2019 and 2.022×10^9 in 2020, respectively. The rising water process of ecological scheduling has had an obvious effect on promoting the reproduction of the four major fish species.

3. Conclusions and prospects

(1) Since the reservoir was impounded and put into operation, all of the structures of the Three Gorges Project have been operating normally, and the metal structural equipment of each part has been performing well. The power plant units and electromechanical equipment have been running well, and the power station has achieved 22 500 MW full-load continuous power generation many times. The double-line five-step ship lock and the ship lift are continuing to operate safely, efficiently, and stably.

(2) When faced with significant engineering issues in design and construction, the Three Gorges Project has always followed the path of scientific and technological innovation, adhered to original and collaborative innovation, and achieved world-leading scientific and technological innovations. The successful practice of the Three Gorges Project has greatly improved the overall technological level of water conservancy and hydropower development in China. Many of the innovative technologies developed in the Three Gorges Project have been widely applied in subsequent water conservancy and hydropower projects around the world.

(3) China's water-resource utilization and economic and social development are presenting new and higher requirements for the operation and management of the Three Gorges Project. It is necessary to strengthen research on the joint operation of the Yangtze River-controlled reservoir group with the Three Gorges Reservoir as the backbone. It is also necessary to integrate modern information technology and build a comprehensive regulation decision-making support system for the Yangtze River reservoir groups, with the Three Gorges Project as the core, in order to further improve their flood-control capability and ensure safe flood protection in the river basin. Other key considerations include:

adhering to ecological priorities; optimizing the energy structure of the Yangtze River Economic Belt; achieving green, circular, and low-carbon development; strengthening the optimal allocation of water resources; making efficient use of water resources; and ensuring safe water supply in central China.

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