7 Construction Organization Design

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7 Construction Organization Design

7.1 Construction Condition

7.1.1 Site Access

7.1.1.1 Highway

Pak Lay Hydropower Project is located at Stake No. 1829km of the main river of Mekong River in Pak Lay, Sayabuary, Laos. There are three national trunk highways near the project area: the first one is 11# highway from Vientiane (the capital of Laos) to Pak Lay; the second one is 4# highway from Luang Prabang to Loewi (in Thailand), and 11# highway intersects with 4# highway in Pak Lay; the third one is 13# highway from Vientiane to Jinghong (in China), and 13# highway intersects with 4# highway in Luang Prabang. The dam site is about 251km away from the (downstream) Vientiane (the capital of Laos), about 31km away from the downstream Pak Lay on the right bank, and about 6km away from the lower side river mouth of Namphoun. There is no road from the right bank downstream the dam site to the river mouth of Namphoun, and a new highway about 6km shall be built. On the right bank of the river mouth of Namphoun, there is a village road to 4# highway, and the road is mostly an earth road and about 8km long.

Transportation from Vientiane to Pak Lay is mainly through 11# highway. The highway extends upward along the left bank of Mekong River, while crossing about 20 bridges and culverts set for various gullies and small rivers, and after going through Mekong River ferry in the lower reach of Pak Lay, it turns to the right bank to Pak Lay. The mileage of 11# highway is about 220km and the pavement width is about 6m. Except that the sections in the main villages and towns are of asphalt concrete pavements, the other sections are earth roads. A cross-river bridge is being built about 200m downstream the ferry, and the bridge length is 370m.

7.1.1.2 Railway

There is no railway in Laos and the railway in Thailand can only reach the border between Thailand and Laos.

7.1.1.3 Waterway

The flow path of Mekong River in Indo-China Peninsula can be divided into the upper reach, middle reach, lower reach and delta. The upper reach starts from the border of China, Burma and Laos and ends at Vientiane, with a length of 1053km.In the area which the upstream Mekong River flows through, the altitude is 200m~1500m. The area characterizes ragged topography, with mountain ranges blocking the river. The river course bends for several times and the width of river valleys is constantly changing (sometimes wide and sometimes narrow). The river bed slope is relatively steep, with lots of torrents and shoals.

After dredging of the upstream Mekong River Basin and canalization of channels, the 71km channel from Jinghong Port to No. 243 boundary monument between China and Burma ranks Class V, and the navigation capacity of a single ship reaches 300t~500t. The 331km channel from No. 243 boundary monument between China and Burma to Houayxay (in Laos) has the navigation capacity of 200t~300t ships throughout the year and the annual navigation period is 10~11 months.The channel from Houayxay to Luang Prabang is an original river course for the navigation of 150t ships. The navigation channel on the lower side of Luang Prabang has relatively poor navigation capacity.

Sanakham (in Laos) is about 110km (river course distance) downstream the dam site of the Project. On the opposite side of the river is Chiang Khan (in Loewi, Thailand), where wharfs were set for collecting and distributing of shipped materials.

According to the above-mentioned actual traffic condition, the external transportation of the Project is mainly through the combination of water transportation and road transportation. The materials purchased nearby shall be transported to the construction site through highway; the foreign materials can be transported to Houayxay or Chiang Khan Port Wharf through waterway and then transported to the construction site through highway.

7.1.2 Layout Characteristics of Hydraulic Structures

It is recommended to adopt the layout scheme of upper dam site, lower dam line and

left-bank powerhouse (right-bank ship lock) for the hydraulic structures layout of Pak Lay Hydropower Project. The hydraulic structures are composed of flood discharge and energy dissipation (sand flushing) structure, water retaining structure, powerhouse, ship lock and fishway. From left to right, it is left-bank non-overflow section, river-bed powerhouse monolith, sand flushing bottom outlet section, crest overflowing orifice and deep discharge orifice section, crest overflowing orifice and shallow discharge orifice section (11 orifices in total, with left five holes adopt energy dissipation by hydraulic jump), ship lock section and right-bank non-overflow section.

The entire dam axis is 942.75m long. The crest elevation is 245.00m and the maximum height is 51.00m.In which, the left-bank non-overflow section is 67.25m long in total; river-bed powerhouse monolith is 301.00m long; sand flushing bottom outlet section is 47.00m long; crest overflowing orifice and deep discharge orifice section is 65.00m; flood discharge section for left 5 crest overflowing orifices and shallow discharge orifices is 100.50m long; flood discharge section for right 6 crest overflowing orifices and shallow discharge orifices is 121.50m long; ship lock section is 42.00m; right-bank non-overflow section is 198.50m long. The main work quantities of hydraulic structures are shown in Table 7.1.2-1.

Table 7.1.2-1 Quantity of Main Works of Hydraulic Structures

Item		Unit	**Dam**	**Powerhouse**	**Navigation**	**Fishway**	**Total**
Earth excavation		10,000 m^3	**28.72**	**26.86**	**17.43**	**3.20**	**76.21**
Rock excavation		10,000 m^3	**258.45**	**64.82**	**51.16**	**7.47**	**381.90**
Tunnel excavation		10,000 m^3	**0.17**				**0.17**
Concrete		10,000 m^3	**59.26**	**75.61**	**26.59**	**0.90**	**162.36**
Rebar		10,000 t	**1.52**	**4.52**	**0.81**	**0.11**	**6.95**
Steel products		t	**50.00**		**210.00**		**260.00**
Curtain Grouting	Length in bedrock	10,000 m	1.94				1.94
	Length in concrete	10,000 m	0.23				0.23
Consolidation Grouting	Length in bedrock	10,000 m	4.39	1.55	0.18		6.11

	Length in concrete	10,000 m	1.99				1.99
Joint grouting		m^2	4362.00	5630.00			9992.00
Drain hole (diameter: 110mm)	Length in bedrock	10,000 m	1.40				1.40
	Length in concrete	10,000 m	0.22				0.22
Drain hole (diameter: 76mm)	Length in bedrock	10,000 m	2.69				2.69
	Length in concrete	10,000 m	1.01				1.01
Drain hole (diameter: 56mm)	Length in bedrock	10,000 m	3.00		1.50	0.54	5.04
Anchor bar (ψ36, l=9m)		Pcs.	8366.00			1600.00	9966.00
Anchor bar (ψ32, l=6m)		Pcs.	2872.00				2872.00
Anchor bar (ψ32, l=8m)		Pcs.	6451.00				6451.00
Anchor bar (ψ28, l=6m)		Pcs.			3820.00		3820.00
Anchor bar (ψ25, l=6m)		Pcs.	16328	2078.00			18406
C25 shotcrete with wire mesh (thickness: 12cm)		10,000m^2	3.02		1.20	1.04	5.26
C25 plain shotcrete (thickness: 8cm)		10,000m^2	1.29				1.29
Copper water seal		m	9411.00	2560.00	817.62		12788.62
Rubber water seal		m	3905.00	2560.00	793.02	2592.00	9850.02
Prestressed main anchor cable (T=3000kN, L=25m)		Pcs.	516.00				516.00
Prestressed secondary anchor cable (T=1000kN, L=10m)		Pcs.	220.00				220.00
Rock ballast backfill		10,000 m^3		0.75	1.28	0.26	2.28
Steel grid roof and roof truss of main powerhouse		10,000m^2		1.12			1.12
Building area		m^2	900.00		400.00	100.00	1400.00
Masonry retaining wall		10,000 m^3				0.58	0.58

7.1.3 Layout Condition of Construction Site

The river course at the dam site is in the low mountain-hill area, and the rivercourse is with a U-shaped insequent valley. The topography on both banks is not symmetrical, and the topography on the left bank of the c is relatively steep. At present, there is no highway to the dam site and the layout condition of construction site is relatively poor. The right-bank slope of the dam site is relatively gentle, and there are platforms both in the upper reach and lower reach for construction site layout. The external highway is

connected to 4# highway near Namphoun Village, and enters the construction site along Namphoun River and the right-bank lower reach of Mekong River. Centralized layout of construction site is suitable, and after simple leveling, the layout condition of construction site can be met.

7.1.4 Requirements of Navigation and Water Supply

The river course upstream Luang Prabang in Mekong River Basin in Laos has a navigation capacity of 150t ships throughout the year. The channel downstream Luang Prabang has a relatively poor navigation capacity, but the upper reach and lower reach of the dam site 250km downstream Luang Prabang still have the navigation demand all year round and the ships for navigation are mainly passenger ships and small and medium cargo ships.

Mekong River is the main water source of production and living for residents on both banks. During construction of Pak Lay Hydropower Project, the phase diversion method shall be adopted without cutting off water flow. While the downstream water supply is not considered, it takes about 10d~15d for impounding after the gate is closed. During impounding, the production and domestic water for the downstream residents will be affected to a certain extent, so the downstream water supply demand shall be considered during impounding after the gate is closed.

7.1.5 Main Construction Materials and Water and Electricity Supply Conditions

The total amount of concrete for the Project is 1,697,600 m^3, and the demand for concrete aggregate is about 3,740,000 t; the total demand for cementitious material is about 496,300 t; the consumption of rebar steel is about 71,200 t; the consumption of timber is about 65,500 t.

According to the site survey, no available natural gravel yard has been found on the dam site and in its neighborhood. The river sand on the river shoal is mostly silty fine sand with large silt content, and it is not suitable to be used directly as concrete aggregate. All concrete aggregate for the Project shall be rolled manually.

Dajiang Quarry is on the left bank 2km in the upper reach of dam site, the yard

elevation is 300.000m~650.000m and the yard area is about 150,000 m^2. The reserve in the available layer is more than 8,000,000 m^3. The lithology is gray micrite. After sampling and testing, no alkaline reaction is discovered. The available reserve in the yard and the material quality both meet the engineering demand. The topography around the yard is flat with good conditions for exploitation, processing and transportation.

The clay demand for the Project is about 209,900 m^3. Rice fields and dry lands are distributed in stripes in the downstream direction on the right-bank Class I platform in the upper reach of the dam site. Except that the surface layer is the planting soil layer, the lower portion (within the scope of 4m) is all yellow and grayish yellow silty clay with rich reserve, and the clay can be used as impermeable soil.

The foreign materials during construction of the Project mainly consist of cement, fly ash, steel, electromechanical equipment, timber, oil, hot work materials, etc.

Cement: Lao cement plants are all disputed in the south of Laos. The annual cement output of the cement plant newly established in Laos by Sinohydro Resources Ltd. is 2 million t, but the haul distance is relatively far and about 200km from the construction site. As the Project is near Chiang Khan, Thailand and the haul distance of the highway is about 70km, it is proposed to import cement from Thailand.

Laos is lacking in fly ash, rebar, steel, etc. which are proposed to be purchased from Thailand.

Timber, oil, hot work materials and other materials: they can be purchased locally.

Construction electricity: after calculation according to the construction peak intensity, the electrical load during the peak construction period is 18.19MW. For power supply during construction, the self-provided diesel generator units can be adopted, or a 10kV power transmission line can be erected from Pak Lay to the dam site.

Water for construction: the water from Mekong River shall be adopted as the domestic and production water for people along the banks of Mekong River. The river water is not corrosive to concrete and harmless to the human body. The production

and domestic water for the Project can be pumped and purified from Mekong River through a self-built pump station.

7.1.6 Influence of Upstream and Downstream Cascade Stations

In 2008, Lao Government (Electricity Department of Ministry of Energy and Mines) entrusted the French company CNR to conduct an optimization study on the cascade water level for 5 hydropower stations on Mekong River in Laos. In September 2009, CNR submitted the final report on cascade water level optimization study. After coordination by several parties, Lao Government determined the final water level linking scheme, which is detailed as follows:

a) For Pak Beng, the normal pool level shall be selected under the precondition that the reservoir backwater does not go beyond the border between Laos and Thailand;

b) The normal pool level of Luang Prabang Reservoir shall not exceed 310.000m;

c) The normal pool level of Sayabuary Reservoir shall not exceed 275.000m;

d) The normal pool level of Pak Lay Reservoir shall not exceed 240.000m;

e) The normal pool level of Sanakham Reservoir shall not exceed 220.000m;

According to the determined cascade development scheme, Pak Lay Hydropower Project is a Cascade IV station for hydroelectric development of the main river of Mekong River, with the upper cascade station as Sayabuary Hydropower Project and the next cascade station as Sanakham Hydropower Project. At present, the upstream cascade Sayabuary Hydropower Project of Pak Lay Hydropower Project has started while the downstream cascade is still under the feasibility study design. The synchronous construction conditions for upstream and downstream cascades have been taken into consideration for the main works design of Pak Lay Hydropower Project. The impacts of the upstream and downstream cascades are not considered tentatively during construction period, and the main works is designed according to the water flowing condition in the natural way.

7.1.7 Natural Conditions

7.1.7.1 Topographical and Geological Conditions

The dam site is in the low mountain-hill area, and the river course is with a U-shaped longitudinal valley. The river accumulation terrace develops continuously on the right bank of river bed with the elevation of 227.00m~237.00m and the width of 50.00m~130.00m. The gullies on both banks are moderately developed. The river bed slope is gentle, the river valley is open and broad, the slope of both banks is about 30°~35°, and the left bank is a little steep than the right bank. The flow direction of the main river course on the dam site is S65°W.When the water level is 217.80m, the water surface is about 230m wide; at the normal pool level of 240.00m, the water surface is about 788.00m wide. The main river channel is on the left side of the river course.

The exposed stratum is the Permian dark gray and grayish green mica quartz schist and dark gray and grayish white palimpsest fine sandstone. The Quaternary is mainly river bed alluvial silty fine sand, and a small amount of gravel and eluvial silty clay are piled up on both banks. Except there is partial bedrock exposed on the reef flat of river bed, and there is a small amount of bedrock exposed on the left bank of river bed, the rest earth's surface is covered with the Quaternary river alluvium, slope wash and a small amount of eluvium.

The dam site is a longitudinal valley. There is no significantly large scale of fault development on the exposed rock mass and the stratum exposed after drilling, but the attitude of bed and schistosity is slightly in disorder. The schistosity and joint fissure surface on the rock stratum surface and in schist are well developed, and the low-angle dip joint is developed. The course extrusion and crumpling of partial schist is severe, and the attitude of bed is getting gentle partially.

Except for the exposed partial bedrock at the river bed and left-bank on the dam site, the rest bedrock is covered by the Quaternary river alluvium and eluvial-slope wash. The river bedrock mass is weakly weathered, the lower limit of burying depth for medium weathering is less than 10.0m, and the stratum under the overburden in most area is exposed through drilling and the weakly weathered rock mass will be drilled afterwards. The bedrock on both bank slopes is strongly weathered, the lower limit of burying depth

for strong weathering is 15.0m~25.0m and the lower limit of burying depth for medium weathering is 25.0m~50.0m.The surfaces of both banks are covered by the Quaternary eluvial clay, slope deposit clay and silty clay mixed with a small amount of broken stone and rubble. The mountain slope is about 30°~35°, the ground vegetation is flourishing and the forest is vast. Under natural conditions, the side slope relatively stable.

The water permeability of the dam site rock varies largely with vertical zoning, and the water permeability decreases with the increase of depth. With the water permeability of rock mass q≤3Lu as the standard, after drilling, it suggests that the burying depth of the relative impervious bed top plate on both banks is 37.00m~50.00m, the burying depth in the river bed is 35.00m~56.00m and the burying depth in the deep river channel area is 50.00m~56.00m (with the elevation of 150.00m~155.00m).

7.1.7.2 Hydrological and Meteorological Conditions

Laos has a tropical monsoon climate with relatively high temperature. There are two seasons throughout the year—dry season and rainy season. The rainy season is from May to October with the average temperature of 24.2°C and abundant rainfall due to the southwest monsoon. The dry season is from November to April of the next year with the average temperature of 27.3°C, and due to the dry and cool northeast monsoon, there is nearly no rainfall and droughts are frequent in the plain area. The annual average temperature of Laos is about 25°C, and the hottest month is April with the monthly average temperature of 29°C; the coolest month is December with monthly average temperature of 24°C, and the minimum temperature is 18°C. The annual average temperature of Sayabuary (where Pak Lay Hydropower Project is located) is 25.3°C; the hottest month is April with the extreme maximum temperature of 40.5°C; from December to February, the temperature in mountainous areas is the lowest with extreme minimum temperature of 1.3°C. The annual average rainfall is 1298.1mm, the number of annual average rainfall days is 115d, and the rainfall from April to October accounts for 90% of the annual rainfall. The maximum measured wind speed is 25m/s. The annual average flow on the dam site is 4170m^3/s.

The flood in Mekong River Basin is caused by torrential rain. The flood and torrential rain appear almost in the same period of the year. Generally, the flood period is from June to October, and the maximum peak discharge appears mainly from July to September. After analysis on the maximum annual flow data of Chiang Khan Hydrologic Station, the probability of the maximum annual flow occurring in August is 60%, and the probability of the maximum annual flow occurring in July and September is respectively 6% and 34%. The characteristics of flood near Pak Lay dam site are: large flood discharge, relatively small flood peak and relatively fat process shape. According to the statistical data of Chiang Khan Hydrologic Station, the maximum flood discharge for 1d accounts for about 34% of the maximum flood discharge for 3d, the maximum flood discharge for 3d accounts for about 64% of the maximum flood discharge for 7d, the maximum flood discharge for 7d accounts for about 71%~77% of the maximum flood discharge for 15d, the measured annual average maximum peak discharge is 16300m^3/s, and the maximum peak discharge is 26000m^3/s.

The dam site flood discharge at various frequencies is shown in Tables 7.1.7-1~7.1.7-4; the dam site water level ~ flow relation curve is shown in Table 7.1.7-5.The reservoir capacity curve is shown in Figure 7.1.7-1.

Table 7.1.7-1 Maximum Annual Flood Design Result of Dam site at Various Frequencies

Unit: m^3/s

p(%)	0.5	1	2	3.33	5	10	20	50
Design value	29000	27200	25500	24000	23000	21100	19000	16200

Table 7.1.7-2 Maximum Flood Result of Dam site at Various Frequencies in Various Periods

Unit: m^3/s

Item	Frequency P (%)				
	3.33	5	10	20	50
From November 1 to April 30 of the next year	10100	9410	8160	6900	5200
From November 1 to May 31 of the next year	10200	9430	8170	6910	5210

From December 1 to April 30 of the next year	6320	5790	4900	4020	2940
From December 1 to May 31 of the next year	6870	6290	5320	4370	3200

Table 7.1.7-3 Maximum Flow of Dam Site in Each Month at Various Frequencies Unit: m^3/s

Item	Frequency P (%)				
	3.33	5	10	20	50
Jan.	3710	3480	3080	2670	2100
Feb.	2470	2340	2100	1850	1500
Mar.	2350	2190	1910	1620	1250
Apr.	2490	2340	2070	1780	1360
May	6250	5710	4770	3810	2480
Nov.	10100	9330	8090	6840	5160
Dec.	5990	5520	4710	3920	2910

Table 7.1.7-4 Average Flow of Dam Site in Each Month at Various Frequencies Unit: m^3/s

Item	Frequency P (%)					
	5	10	20	50	75	85
Jan.	2380	2210	2010	1690	1490	1390
Feb.	1760	1640	1510	1290	1130	1060
Mar.	1450	1360	1260	1090	960	898
Apr.	1470	1380	1290	1120	994	933
May	2660	2380	2080	1600	1310	1190
Jun.	5130	4590	3990	3050	2460	2200
Jul.	10700	9530	8270	6260	5010	4470
Aug.	15300	13900	12400	9940	8320	7570
Sept.	13600	12400	11000	8900	7580	7010
Oct.	7810	7290	6710	5750	5110	4820
Nov.	5880	5240	4560	3570	3030	2820
Dec.	3530	3190	2840	2320	2030	1920

Table 7.1.7-5 Water Level ~ Flow Relation Curve at Dam Site

Water Level m	Flow m^3/s	Water Level m	Flow m^3/s	Water Level m	Flow m^3/s
214.87	685	222.5	4230	230.5	18900
215.27	772	223	4760	231	20200
215.67	853	223.5	5350	231.5	21600
216.07	950	224	5990	232	23000
216.5	1060	224.5	6680	232.5	24500
217	1200	225	7420	233	26000
217.5	1340	225.5	8220	233.5	27600
218	1500	226	9070	234	29200
218.5	1680	226.5	9960	234.5	30800
219	1870	227	10900	235	32600
219.5	2100	227.5	11900	235.5	34300
220	2360	228	12900	236	36200
220.5	2650	228.5	14000	236.5	38000
221	2980	229	15200	237	40000
221.5	3350	229.5	16400		

222	3760	230	17600		

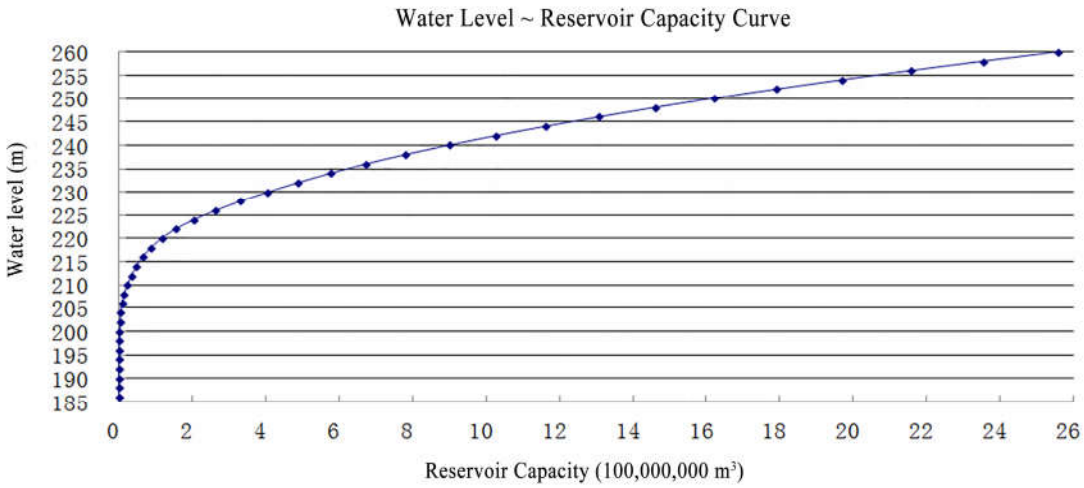

Figure 7.1.7-1 Water Level ~ Reservoir Capacity Curve

7.2 Construction Diversion

7.2.1 Diversion Method

At the dam site of Pak Lay Hydropower Project, the river valley is wide, and the riverway is U-shaped longitudinal valley in general. The left bank is deep riverway while the right side is beach. When the water level is 217.80m, the water surface is about 230m wide; at the normal pool level of 240.00m, the water surface is about 788.00m wide. The recommended hydraulic structures layout (from left to right) for the Project is: left-bank non-overflow section + river-bed powerhouse monolith + overflow section + ship lock section + right-bank non-overflow section. According to the hydraulic structures layout characteristics and the upstream and downstream topographical and geological conditions of the dam site, it is recommended to adopt phase diversion method. In the first phase, the right-bank beach, construction ship lock, flood discharge gate and right-bank non-overflow section shall be fenced; in the second phase, the left-bank deep riverway, 14 units for construction and left-bank non-overflow section shall be fenced.

7.2.2 Diversion Standard and Flow

7.2.2.1 Class of Diversion Structures

The total reservoir capacity of Pak Lay Hydropower Project is 904 million m^3, and

the installed capacity of the Project is 770MW. The main structures, such as the water retaining dam, powerhouse, ship lock, etc., are Grade 2 structures, and the secondary structures are Grade 3 structures. According to the provisions in DL/T 5397-2007 *Specification for Construction Planning of Hydropower Engineering*, the diversion structures are Grade 4 structures.

7.2.2.2 Diversion Standard and Flow Selection

a) Diversion Standard and Flow in First Phase

According to the provisions in Specification for Construction Planning of Hydropower Engineering, for a Grade 4 diversion structure, when the earth-rock cofferdam is adopted, the design return period of flood is 20~10 years; when the concrete cofferdam is adopted, the design return period of flood is 10~5 years. According to the construction characteristics of hydraulic structures layout and master construction schedule, in the first phase of the Project, the construction scheme with the earth-rock cofferdam for water retaining throughout the year shall be adopted. As the water level before cofferdam of the 20-year return flood retaining standard is only about 0.90m higher than that of the 10-year return flood retaining standard, the cofferdam scale of both standards is basically the same, and compared with the 10-year return flood retaining standard, the 20-year return flood retaining standard is improved a lot. Therefore, the upper limit of the diversion standard in the first phase shall be adopted, and the 20-year return flood shall be adopted with the peak discharge of 23,000m^3/s.

b) Diversion Standard and Flow in Second Phase

The construction in the second phase is mainly in the powerhouse with 14 units on the left main river course, and the construction is relatively simple. According to the construction characteristics of hydraulic structures layout and master construction schedule, in the second phase of the Project, the construction scheme with the earth-rock cofferdam for water retaining throughout the year shall be adopted. As the water level before cofferdam of the 20-year return flood retaining standard is only about 1.00m higher than that of the 10-year return flood retaining standard, the diversion standard is the same with

that for the first phase. The upper limit of the diversion standard shall be adopted, that is, the 20-year return flood shall be adopted with the peak discharge of 23,000m^3/s. During installation of units, water intake and tailrace gate will be adopted for retaining the water during the flood season. The flood control standard is for flood appearing once 100 years during the whole year and the peak discharge is 27,200 m^3/s.

c) Other Diversion Design Standards and Flow

① Final gap-closing design standard of right-side beach in the first phase: according to the master construction schedule, the dry season in the first phase will be in February of the 2nd year, and the 10-year return flood in February shall be adopted as the final gap-closing standard with the average monthly discharge of 1890m^3/s.

② Final closure design standard of left-side main river bed in the second phase: according to the master construction schedule, the closure in the second phase will be in December of the 3rd year, and the 10-year return flood in December shall be adopted as the closure standard with the average monthly discharge of 3190m^3/s.

③ Design standard of gate closing and impounding: According to the master construction schedule, gate closing and impounding of the Project is proposed to be in March of the 4th year. The 10-year return flood in March shall be adopted as the design standard of gate closing with the monthly average discharge of 1360m^3/s.

7.2.3 Diversion Procedure

According to the master construction schedule, the project construction is divided into two phases, and the diversion procedure is as follows:

a) Construction in First Phase

1) Excavation of the right-bank slope will be started from July of the 1st year, and filling of Phase I longitudinal concrete cofferdam and the upstream and downstream earth-rock cofferdam shall be started from December. By the end of February in the 2nd year, the flow on right-bank beach will be cut off, and the left-bank main river bed is for overflowing and navigation.

2) From December of the 1st year to November of the 3rd year, Phase I

upstream and downstream cofferdams and longitudinal cofferdam shall be used for water retaining, the left-bank main river bed shall be used for diversion and temporary navigation during construction. During the period (from December of the 1st year to November of the 3rd year), the right-bank ship lock, 14 flood discharge gates, two-bottom-orifice section, Phase II longitudinal cofferdam, etc. shall be constructed.

3) By the end of November in the 3rd year, the metal structures of ship lock shall be installed and the normal navigation conditions shall be met. The 14 flood discharge radial gates and bottom outlet gate shall be installed, and the conditions for reservoir impoundment shall be met.

b) Construction in Second Phase

1) In November of the 3rd year, Phase I upstream and downstream cofferdams and the longitudinal cofferdam section in the powerhouse section shall be dismantled; filling of Phase II upstream and downstream cofferdams will be started from December, and the Project will enter the second phase of construction. In the middle ten days of December, closure of the left-bank main river bed shall be conducted, the right-bank 14 flood discharge gates shall be used for overflowing, and the right-bank permanent ship lock shall be used for temporary navigation.

2) From December of the 3rd year to May of the 5th year, Phase II upstream and downstream cofferdams and longitudinal cofferdam shall be used for water retaining, the right-bank 14 flood discharge gates shall be used for discharging, and the permanent ship lock shall be used for temporary navigation. During the period, the left-bank powerhouse section with 14 units and left-bank non-overflow section shall be conducted.

3) In March of the 4th year, Phase II upstream and downstream cofferdam anti-seepage treatment shall be completed, and the impounding and water retaining conditions of the cofferdam shall be met.

4) At the end of March in the 4th year, the right-bank flood discharge gate will be closed for impounding. After impoundment has been conducted for 17d, the water level will be above the temporary navigation water level of 236.50m, and

the water amount and water level will both meet the conditions for temporary navigation during construction. By gate adjustment in later period, the conditions for first unit debugging and power generation can be met after the water lever is above 239.00m.

5) By the end of May in the 5th year, Phase II upstream and downstream cofferdams and part of longitudinal cofferdam shall be dismantled to the specified elevation. The units shall be installed and debugged under the condition of water retaining with powerhouse water intake and tailrace gate. At the end of June in the 6th year, the first-batch unit (2 sets) will have the conditions for power generation. At the end of March in the 8th year, the last-batch unit (2 sets) will have the conditions for power generation. The power generation construction period of the first batch (2 sets) is 5 years and the total construction period is 6 years and 9 months.

The construction diversion procedure and hydraulic element list is shown in Table 7.2.3-1. After the preliminary diversion model test, the calculation results of diversion hydraulics indicators for each phase are quite close to the hydraulic model test. The table for the Phase is still prepared as per the calculation results and it will be revised after the final model results come out.

Table 7.2.3-1 Construction Diversion Procedure and Hydraulic Element List

Phase of Diversion	Phase I Diversion		Phase II Diversion		
	Phase I Final Gap-closing	Cofferdam water retaining	Phase II River Closure	Cofferdam water retaining	Dam body water retaining
	February in the 2nd year	December 1 in the 1st year ~ November 30 in the 3rd year	December in the 3rd year	December 1 in the 3rd year ~ May 31 in the 5th year	June 1 in the 5th year ~ March 31 in the 8th year
Diversion Standard	10 years (monthly average)	20 years	10 years (monthly average)	20 years	100 years
Peak discharge (m^3/s)	1890	23000	3190	23000	27200
Water retaining structures	Phase I upstream and downstream cofferdams + longitudinal cofferdam		Closure dike	Phase II upstream and downstream cofferdams + longitudinal cofferdam	Water intake and tailrace gate of dam body
Flow discharge structures	Left-side main river bed		14 flood discharge gates on the right bank		
Discharge flow (m^3/s)	1890	23000	3190	23000	27200
Upstream water level (m)	219.102	233.509	222.319	236.500	236.586
Downstream water level (m)	219.043	232.000	221.284	232.000	233.375
Elevation of upstream cofferdam crest (m)	-	235.500	-	238.500	-
Elevation of downstream cofferdam crest (m)	-	234.000	-	234.000	-

Notes: 1. Numbers in the parentheses of the table above is the model test results. 2. The water retaining level at the upstream of Phase II cofferdam is the navigation water level.

7.2.4 Design of Diversion Structures

a) Phase I Diversion Structures

1) Geological Conditions

Phase I diversion and water retaining structures mainly consist of the upstream and downstream transverse earth-rock cofferdams, Phase I longitudinal cofferdam, etc.

Except that a small part of Phase I transverse cofferdam is out of the right-bank terrace, a large part is located on the right reef flat. The topography is relatively flat except for the right-bank terrace with the fluctuation difference less than 3.0m.The thickness of river bed alluvium at reef flat is generally less than 3.0m and the biggest thickness is about 6.0m. The bedrock is exposed in partial areas of the alluvium and the bedrock is strongly weathered schist mixed with palimpsest fine sandstone or the schist and sand stone are interbedded with each other, with diabase wall in partial areas. The composition of river bed alluvium on the reef flat is silty and fine sand. At the position near the terrace, the content of silt and clay increases with strong water permeability, and anti-seepage treatment is needed or the alluvium will be excavated; at the Grade I terrace on the right bank, the terrace deposits mainly consists of silty clay and sandy clay with the thickness of 10.0m~142.0m and medium water permeability; at the mountain slope on the right of cofferdam, the thickness of slope wash is generally less than 10.0m with medium water permeability. The burying depth of the top plate line (≤10Lu) of relative impervious bed of the cofferdam foundation is 10.0m~20.0m. Necessary anti-seepage treatment shall be carried out for the cofferdam foundation.

The longitudinal cofferdam is located on reef flat and along the river bed, with relatively flat topography and the fluctuation difference less than 3.0m.The thickness of river bed alluvium at reef flat is generally less than 2.0m, and the biggest thickness is about 3.0m. The composition of the alluvium is silty and fine sand, with exposed bedrock in partial areas, and the bedrock is strongly weathered dark gray schist mixed with grayish white palimpsest fine sandstone or the schist and sandstone are interbedded with each other. The alluvium is strongly permeable, and anti-seepage treatment is needed or the

alluvium needs to be excavated; the burying depth of the top plate line (≤10Lu) of relative impervious layer is 24.0m~28.0m.

2) Cofferdam Design

Phase I upstream and downstream transverse cofferdams are respectively located about 120m upstream and 240 downstream from the dam axis, and are impervious earth-rock cofferdams. The full length of the cofferdam axes is respectively 509.295m and 394.920m, the crest elevation is respectively 235.50m and 234.00m, the crest width is 10.00m, and the maximum cofferdam height is respectively 16.5m and 15.00m. The cofferdam body is mainly filled with rubble, rock ballast mixture, clay, etc. The side slopes of upstream face and downstream face are 1:1.65 and 1:1.50 respectively. The clay core wall is adopted for seepage-proofing of cofferdam body, and curtain grouting is adopted for seepage-proofing of cofferdam foundation. The 1.0m-thick boulder shall be adopted for scour prevention of the upstream face side slope of the cofferdam.

Phase I longitudinal cofferdam is located on the edge of the right beach of main river bed. It is an impervious concrete cofferdam. The full length of the axis is 527.756m and the crest elevation is 234.00m~235.50m. In consideration that Phase II longitudinal cofferdam is the heightened and lengthened version of Phase I longitudinal cofferdam, the design crest width of Phase I cofferdam is 3.00m and the maximum cofferdam height is 22m. The crest width of the common cofferdam body in the first and second phases is 3.00m, the side slope of upstream face and downstream face is 1:0.4, the crest width of uncombined cofferdam body is 3.00m. The upstream face slope is vertical and the downstream face slope is 1:0.7. Curtain grouting is adopted for seepage-proofing of rock foundation.

b) Phase II Diversion Structures

1) Geological Conditions

Phase II diversion structures mainly consist of the upstream and downstream transverse earth-rock cofferdams and Phase II longitudinal cofferdam.

Phase II transverse cofferdam is located at the deep groove of river bed. The upstream and downstream cofferdams are both earth-rock cofferdams. The river surface at the

upstream cofferdam is about 203m wide, and the river surface at the downstream cofferdam is about 212m wide. The left side of cofferdam is a bank slope and the right side is reef flat with the average elevation of about 220.00m.The topography is steep on the left and gentle on the right. The deep groove of river bed is in the middle. At the normal water level (217.80m), the maximum water depth is about 12.7m.

The thickness of eluvial-slope wash on the left side of cofferdam is less than 8.0m, and its composition is mainly silty clay mixed with a small amount of weathered broken stone and rubble. The burying depth of the top plate line (≤10Lu) of the relative impervious bed is 15.0m~28.0m.

The alluvium distributed in the main river channel mainly consists of medium and coarse sand, with pebble and gravel in the lower portion, and the thickness is 5.0m~20.0m. The overburden of the deep groove in the upstream cofferdam is slightly thicker than the overburden of the deep groove in the downstream cofferdam. The bedrock is mainly the interbedding of grayish white palimpsest fine sandstone and dark gray schist. The schist is thin with schistosity development. The palimpsest fine sandstone is medium-thick. Part of the schist contains a lot of quartz vein and calcite vein with veined silication. Some veins are enteroid and bend significantly, with slight wrinkles. Quartz veins and calcite veins are filled in arborization or crumby structure. Generally, they are not continuous and do not stretch long. The overburden of main river channel is strongly permeable, and the underlying bedrock is mostly medium-weathered. With permeability q≤10Lu as the standard, the burying depth of the top plate of the relative impervious bed in this section is generally 15.0m~25.0m.

At the right reef flat, the thickness of river bed alluvium is generally less than 3.0m. Part of the bedrock is exposed and is the interbedding of strongly weathered gray ~ grayish white palimpsest fine sandstone and dark gray schist. Part of the schist is with veined silication.

2) Cofferdam Design

Phase II upstream and downstream transverse cofferdams are respectively located

about 220m upstream and 200m downstream from the dam axis, and are impervious earth-rock cofferdams. The full length of the cofferdam axes is respectively 321.195m and 296.635m, the crest elevation is respectively 238.500m and 234.000m, the crest width of cofferdam is 10.00m, and the maximum cofferdam height is respectively 35.00m and 29.00m. The cofferdam body mainly consists of rubble, rock ballast mixture, weathered rock ballast, etc. One berm shall be set on the upstream side and downstream side each. Above the berm elevation, the slope of upstream face and downstream face is 1:1.65, and clay core wall is adopted for seepage-proofing of the cofferdam body. Below the berm elevation, the slope of upstream face and downstream face is respectively 1:1.65 and 1:1.50. High pressure jet grouting is adopted for seepage-proofing of the cofferdam body and overburden foundation, and curtain grouting is adopted for the rock foundation. The 1.0m-thick boulder shall be adopted for scour prevention of the upstream face side slope of the cofferdam.

The 10-year return flood standard during construction shall be adopted as the water retaining standard of seepage-proofing construction platforms of the upstream and downstream cofferdams. The seepage-proofing construction schedule of the cofferdam is arranged during January ~ March. The water retaining standard of construction platform is the 10-year return flood during January ~ March with the peak discharge of 3080m^3/s. The corresponding upstream and downstream water level is respectively 222.193m and 221.135m.

Phase II longitudinal cofferdam is the heightened and lengthened version of Phase I longitudinal cofferdam, and is divided into two parts in the plane: upstream section of Phase II longitudinal cofferdam and downstream section of Phase II longitudinal cofferdam. The full length of the upstream section axis is 274.931m, the crest elevation is 238.500m, and the length of the common section in the first and second phases is 167.095m. The cofferdam crest width is 3.00m, the side slopes of the upstream face and downstream face are both 1:0.4, and the maximum cofferdam height is 20.00m; the extended section is 110.836m long, the cofferdam crest width is 3.00m, the upstream face slope is vertical, and

the side slope of downstream face is 1:0.7.The maximum cofferdam height is 33.50m.The full length of the upstream section axis is 165.209m, the crest elevation is 234.000m, and the length of the common section in the first and second phases is 133.026m. The cross section structure is the same with that of Phase II. The extended section is 32.183m long, the cofferdam crest width is 3.00m, the upstream face slope is vertical, the side slope of downstream face is 1:0.7, and the maximum cofferdam height is 30.00m. Curtain grouting is adopted for seepage-proofing of rock foundation.

3) Cofferdam stability calculation

1) Upstream and downstream earth-rock transversal cofferdams

Slope stability of earth-rock cofferdams is analyzed and calculated using arc slide face, simple Bishop Method. See Table 7.2.4-1 for the analysis and calculation results of slope stability for the cofferdams.

Table 7.2.4-1 Safety Coefficient for the Stability of Earth-rock Cofferdam

Working conditions for calculation	Min. safety factor				Min. safety coefficient allowed in related standard	Stability Assessment
	Phase I upstream transversal cofferdam	Phase I upstream transversal cofferdam	Phase II upstream transversal cofferdam	Phase II upstream transversal cofferdam		
Normal operating condition (design flood level)	1.300	1.302	1.241	1.295	1.15	meeting the requirement on anti-sliding stability
Normal operating condition 1 (construction period)	1.385	1.380	1.257	1.385	1.05	
Normal operating condition 2 (reservoir water recession)	1.151	1.066	1.168	1.187	1.05	
Occasional condition 3 (earthquake)	1.153	1.156	1.103	1.149	1.05	

The calculation results show that the proposed structure type of earth-rock cofferdam in the design meets the requirements in related standard.

2) Concrete longitudinal cofferdam

See Table 7.2.4-2 for the calculation results of stability and stress during the water

retaining period of concrete longitudinal cofferdam.

Table 7.2.4-2 Stability and Stress Calculation Results of Concrete Longitudinal Cofferdam

Description		R(·) N	S(·) N	R(·)÷S(·)	Stress at cofferdam's heel σ_1 MPa	Stress at cofferdam's toe σ_2 MPa
Phase I Water Retaining	Phase I upstream cofferdam incorporated into Phase II cofferdam	7023506	1281157	5.482	0.156	0.202
	Phase I downstream cofferdam incorporated into Phase II cofferdam	6989215	1539818	4.539	0.178	0.173
	Phase I cofferdam not incorporated into Phase II cofferdam	5413981	1281157	4.226	-0.025	0.282
Phase II Water Retaining	Phase II upstream cofferdam incorporated with Phase I cofferdam	6960444	1806106	3.854	0.206	0.140
	Phase II downstream cofferdam incorporated with Phase I cofferdam	6989215	1539818	4.539	0.178	0.173
	Upstream connection section between Phase I and Phase II cofferdams	6732814	1806106	3.728	0.014	0.295
	Downstream connection section between Phase I and Phase II cofferdams	5854921	1195517	4.897	-0.042	0.326

Note: "-" in the table indicates tensile stress and the allowed tensile stress shall be no higher than 0.1MPa and the compressive stress of C15 concrete shall be no higher than 3.7MPa.

The calculation results show that the stresses at both the heel and toe of the concrete longitudinal cofferdam are small and this structural type meets the stability requirement.

7.2.5 Diversion Works Construction

7.2.5.1 Transverse Cofferdam Construction in First and Second Phases

The upstream and downstream transverse cofferdams in the first and second phases

are earth-rock cofferdams. The main work quantity is: 1,586,900 m^3 earth-rock filling, 27,827m high-pressure jet grouting and 11,849m curtain grouting. According to the master construction schedule, Phase I upstream and downstream earth-rock cofferdams will be constructed from November of the 1st year to May of the 2nd year. Phase II upstream and downstream earth-rock cofferdams will be constructed from November of the 3rd year to May of the 4th year.

Cofferdam filling: in the first phase, the excavated material from ship lock and bank slope and the exploited material from the borrow area shall be used as Phase I filling material and directly used for the cofferdam; the excavated material from the borrow area and bank slope shall be used as filling material for Phase II cofferdam directly. As to cofferdam filling, a 3m^3 hydraulic excavator shall be adopted for excavation and loading, a 132kW bulldozer shall be used for aggregating of excavated material, and a 20t dump truck shall be used for transporting the material to the cofferdam. A 132kW bulldozer shall be used for aggregating of excavated material on the cofferdam, and an 18t vibrating roller shall be used for rolling.

Curtain grouting: the orifice-closed grouting method shall be adopted for foundation curtain grouting. Drilling and grouting shall be conducted in segments from top to bottom without washing or waiting for setting and with in-orifice circulation. The grouting shall be conducted in 2 orifices according to the principle of sequence encryption. SGZ-I geological drilling rig shall be adopted for drilling, and BW200 grouting pump shall be adopted for grouting.

High-pressure jet grouting: a geological drilling rig shall be adopted for drilling, slurry shall be used for wall stabilization, and a high-pressure jet trolley shall be adopted for grouting. The final hole depth into the bedrock is 1.0m. After the jet pipe is lowered to the design depth, the water, gas and slurry which meet the requirements shall be fed. Grouting shall be conducted at the hole bottom for 3min. After the grouted slurry emerges on the ground, the slurry shall be jetted, rotated and lifted simultaneously from bottom to top according to the predetermined lifting speed and rotating speed, until the design height is reached.

7.2.5.2 Transverse Cofferdam Removal in First and Second Phases

According to the master construction schedule, Phase I upstream and downstream cofferdams will be removed by the end of November in the 3rd year, and the earth-rock removal quantity is 461,500m^3; Phase II downstream cofferdam will be removed by the end of May in the 5th year, and the earth-rock removal quantity is 474,700m^3. As to cofferdam removal, a 2m^3 hydraulic backhoe shall be adopted for excavation and loading, a 132kW bulldozer shall be used for aggregating of excavated material, and a 20t dump truck shall be used for transporting the material to the sand-retaining sill filling site and waste disposal areas on left and right banks of Phase II.

7.2.5.3 Longitudinal Cofferdam Construction and Removal in First and Second Phases

Longitudinal cofferdams in the first and second phases are concrete cofferdams, and the main work quantity is: 116,600m^3 C15 concrete pouring, 92,600m^3 concrete removal and 11,678m curtain grouting. According to the master construction schedule, Phase I longitudinal cofferdam will be constructed during January ~ May of the 2nd year, and Phase II longitudinal cofferdam will be constructed during January ~ June of the 3rd year.Removal of the concrete cofferdam will be completed by the end of May in the 5th year. The foundation surface of some of Phase I cofferdam sections is lower than the river level, and the underwater concrete pouring method can be adopted. In consideration of the concrete construction quality, schedule and safety, it is recommended to adopt the construction scheme of temporary bracing of small foundation pit, namely that the clay straw bags can be used for filling, so as to form a small foundation pit. With the clay straw bags functioning as the water retaining objects, pouring for the concrete cofferdam can be conducted.

The longitudinal cofferdam shall be heightened and lengthened in January ~ May of the 3rd year. The concrete shall be transported to the reception point by a 10t~20t dump truck through ③ highway and the road in the foundation pit, and hoisted into the silo with a W200A crawler crane. Handheld electrical vibrator is used for spreading and vibrating, assisted with hand fit, after the concrete is delivered into bunker.

Curtain grouting: the orifice-closed grouting method shall be adopted for foundation curtain grouting. Drilling and grouting shall be conducted in segments from top to bottom without washing or waiting for setting and with in-orifice circulation. The grouting shall be conducted in 2 orifices according to the principle of sequence encryption. SGZ-I geological drilling rig shall be adopted for drilling, and BW200 grouting pump shall be adopted for grouting.

7.2.6 River Closure

7.2.6.1 Phase I Final Gap-closing

According to the master construction schedule, Phase I final gap-closing of river will be conducted in January and February of the 2nd year. According to the hydraulic structures layout characteristics, topographical and geological conditions of right-bank beach and hydrological and meteorological conditions, Phase I upstream and downstream transverse cofferdam and part of the longitudinal cofferdam shall be constructed under the reef flat dry land conditions, and only part of the longitudinal cofferdam needs to be constructed underwater. Therefore, there is no specific c process in the first phase of the Project, and after the sub cofferdam will be filled to reach the elevation above the water surface, final gap-closing of Phase I foundation pit is completed.

In consideration that Phase I cofferdam will be constructed throughout the year, in order to conduct leakage stopping of cofferdam foundation pit as soon as possible, the longitudinal sub cofferdam will be filled to reach the elevation above the water surface in February (during the dry season). The corresponding final gap-closing standard shall be the 10-year return flood in February with the monthly average discharge of 1890m^3/s, and the initially estimated water level is 219.102m.When the longitudinal sub cofferdam is poured to reach the elevation 220.00m above water surface, Phase I final gap-closing will be conducted. After final gap-closing, flow will be discharged from the left main river bed.

7.2.6.2 Phase II River Closure

According to the master construction schedule, Phase II closure will be conducted in December of the 3rd year. Phase II closure design standard shall be the 10-year return flood in December with the monthly average discharge of 3190m^3/s.

According to the hydraulic structures layout characteristics and the topographical and geological conditions of river bed, and based on the layout of charge make-up area and construction roads, end-dump closure shall be adopted for Phase II closure of the Project, and the one-way advancing from the left bank to right bank shall be conducted. During closure, the right-bank 14 flood discharge gates and closure gap shall be jointly used for flow discharge. After final gap-closing, only the right-bank 14 flood discharge gates shall be used for flow discharge.

After closure hydraulic calculation, when the discharge reaches the average discharge of the 10-year return flood in December, after final gap-closing of the dike, the upstream water level is 222.319m, the maximum closure drop is 1.035m, the maximum unit discharge is 43.06m^3/(s·m), the maximum unit stream power is 2.91t·m/(s·m), and the average maximum flow rate is 3.08m/s. The crest elevation of closure dike is 225.000m, the dike crest width is 25m, and the side slopes of upstream and downstream sides are both 1:1.5.The Phase-II river closure material preparing area is 333,500m^3 in total.

7.2.7 Foundation Pit Dewatering

Foundation pit dewatering mainly contains 2 parts: namely initial dewatering and regular dewatering.

After final gap-closing and leakage stopping of the cofferdam, in order to ensure that the main works are constructed on dry land, the water collected in foundation pit and water seeping in the cofferdam body and cofferdam foundation shall be discharged, namely initial dewatering. According to the foundation pit dewatering calculation, the total amount of initial dewatering of Phase I foundation pit is about 160,000 m^3, the planned dewatering time is 5d, then the dewatering intensity is about 1609m^3/h, and two 20SA-14 water pumps shall be selected (1 pump as standby). Regular dewatering is mainly the discharge of water seeping in the cofferdam and cofferdam foundation, surplus water released from construction site and rainfall catchment, in which rainfall catchment shall be calculated

according to the maximum daily rainfall intensity during the period when the maximum permeable head, and rainfall catchment is required to be emptied on the same day of rainfall. After calculation, the total amount of regular dewatering is about 1,570,000 m^3, the maximum dewatering intensity is 1586 m^3/h, and two 20SA-14 water pumps (1 pump as standby) shall be selected.

Phase I foundation pit pumping equipment is placed at the left and right bank slope toes of the downstream cofferdam, and water shall be pumped out of the downstream cofferdam.

The total amount of initial dewatering of Phase II foundation pit is 1,300,000 m^3, the planned dewatering time is 15d, then the dewatering intensity is about 6638m^3/h, and five 20SA-14 water pumps shall be selected (1 pump as standby). The total amount of regular dewatering is about 940,000 m^3, the maximum dewatering intensity is 1277 m^3/h, and two 20SA-14 water pumps (1 pump as standby) shall be selected.

Phase II foundation pit pumping equipment is placed at the left bank slope toe of the downstream cofferdam, and water shall be pumped to the downstream cofferdam.

7.2.8 Reservoir Impoundment and Downstream Water Supply

According to the master construction schedule, the first unit will be qualified for power generation by the end of June in the 6th year, so by the end of June, the reservoir water level shall reach the power generation water level of 239.000m. In consideration of using the permanent ship lock to meet the temporary navigation demand during construction, according to the construction progress of Phase II cofferdam, reservoir impoundment of the Project is initially determined at the end of March in the 4th year. The water level of reservoir impoundment in the early period reaches the temporary navigation water level of 236.500m, and then gets to the power generation water level of 239.000m by gate adjustment before unit debugging.

Considering the downstream water flow in early impoundment period of this phase to be 500 m^3/s temporarily, and calculating the monthly average flow as per the assurance rate of 75%, it will take 17d to reach to the temporary navigation water level.

The gates of 14 crest orifices shall be used for impoundment of the Project. The gates shall be closed at the end of March. In the middle ten days of April, the reservoir water level can reach the temporary navigation water level. During the reservoir impoundment period, the opening of crest orifice gates shall be controlled to supply water to the lower reach.

7.2.9 Temporary Navigation During Construction

According to survey, passenger ships, the channel sections near the upper and lower reaches of the dam site are mainly for navigation of cargo ships and other middle and small ships throughout the year. Therefore, the temporary navigation scheme during construction or other schemes for passengers and freights to pass the dam shall be studied. The temporary navigation scheme during construction of the Project is: in the first phase, the ship lock, 14 flood discharge gates and 2-bottom-orifice section on the right beach will be constructed, and the left main river bed will be used for overflowing and navigation; in the second phase, the powerhouse with 14 units in the left main river bed will be constructed, before Phase II closure, the navigation conditions of the right-bank permanent ship lock shall be met, during Phase II construction, the permanent ship lock will be used for temporary navigation.

According to the present navigation state in the upper and lower reach basins of Mekong River dam site, and according to the practice experience of some navigation river courses in China, the navigation parameters of the river course are determined as: when the average flow rate of river cross section is less than 2.0m/s, the ship shall be self-propelled; when the average flow rate of river cross section is 2.0m/s~3.5m/s, the Employer shall organize tug boats to assist navigation; when the average flow rate of river cross section is more than 3.5m/s, navigation in the river shall be suspended. After Phase I cofferdams of the Project is constructed, the width of the left river course is about 240m, and the water depth in the dry season is 3m~12m.After hydraulic calculation and according to the demonstration of model tests, the minimum navigation discharge at Phase I is 810m^3/s, the maximum navigation discharge is 10000m^3/s, the annual average number of navigation days is 332d, and the navigation assurance rate is 91%. Therefore, Phase I project has relatively small influence on navigation of the natural river course.

In the second phase, the completed permanent ship lock will be used for navigation. The minimum navigation water level in the upper and lower reaches of the ship lock is respectively 236.50m and 217.00m. Before Phase II closure, all civil works and metal

structure installation works for the ship lock shall be completed, and the operating conditions shall be met after debugging. During Phase II cofferdam fill and river course closure, the hydraulic conditions are difficult. To ensure navigation safety, and in consideration of the 165d break period of navigation, the permanent ship lock can be used for temporary navigation when the reservoir water level meets the minimum navigation water level requirement. During the break period of navigation in the river course, expense compensation shall be conducted. The compensation expense for break of navigation in the whole construction period is about USD 2.43 million.

7.2.10 Construction Diversion Model Test

To test and verify such hydraulic calculation results as upstream and downstream water level, flow velocity and flow regime, following related standard, 1:100-scale overall construction diversion model test has been studied. The test result shows that, the layout schemes of Phase I and II construction diversion for this project are feasible and the detailed conclusions are shown as follows:

a) Phase I construction diversion

1) Test conditions

Table 7.2.10-1 Working Conditions of Phase I Construction Diversion Model Test

Condition	Total discharge m^3/s	Downstream water level m	Test operation mode	Remarks
1-1	4000	221.87	Flow passing through the left side of the river course	Mainly focusing on the navigation conditions of the river course
1-2	6000	223.61		
1-3	8500	223.27		
1-4	14500	228.32		
1-5	19000	230.14		Mainly focusing on the surrounding environment of cofferdams and the flow regime, flow velocity and flow profile etc. of the river course
1-6	21100	230.92		
1-7	23000	231.60		

Note: the downstream water level in the table above refers to the water level at Stake No. 0+900m

2) Discharging capacity

The discharge capacity of the left narrowed river course is smaller compared with the

design value yet it basically meets the requirement on Phase I diversion design. When discharging a 20-year flood (Q=23000m^3/s), the water levels in front of the upstream and downstream earth-rock cofferdams are 234.025m and 232.265m respectively, lower than the crest elevations of upstream and downstream earth-rock cofferdams, which are 1.475m and 1.735m.

3) Flow regime

The flow regime having considerable impact on the diversion structures has not been detected under various working conditions.

Water flows smoothly in front of the upstream and downstream earth-rock cofferdams under various discharges.

Bypass flow is detected at the pier head upstream of the concrete longitudinal cofferdam, and its scope and strength increase with the increase in the discharging volume. An around 120m-wide scope of area is impacted when the discharge reaches 6000m^3/s or above.

The main river flow in the narrowed river channel goes forward in the middle of the channel and slightly to the left. As the flow goes forward, it spreads to the right; the water area next to the longitudinal concrete cofferdam becomes a backflow area.

After the narrowed river course, the main river flow still goes forward to the left-bank side, all the way spreading to the right. The flow distribution becomes even gradually and the fluctuation of the water surface is small.

4) Flow profile and water table fluctuation

Water surface fluctuations of different parts under various working conditions are all not big. The measured max. water surface fluctuations in front of of upstream and downstream transversal cofferdams and longitudinal cofferdam are 0.61m, 0.55m and 1.37m respectively. The max. water surface fluctuation value measured at both banks is 1.25m.

Due to the narrowing of the river course, affected by the bypass flow at the upstream pier head of the longitudinal cofferdam and the compression caused by its backflow,

conspicuous water drop is detected at the upstream side of the narrowed river reaches (Stake No. Dam 0-300～0-150m section).

5) Flow velocity

The flow velocities near the upstream and downstream earth-rock cofferdams are comparatively small and the max. flow velocity measured at the upstream cofferdam is 0.69m/s and that at the downstream cofferdam is 0.20m/s.

The flow velocity at the upstream pier head of the longitudinal concrete cofferdam and that between Stake No. dam 0±0m and Stake No. dam 0-200m on the left side of the cofferdam are relatively big and the rest is below 2.2m/s. When discharging a 20-year flood, the flow velocity at the upstream pier head of the longitudinal concrete cofferdam and that between Stake No. dam 0±0m and Stake No. dam 0-200m on the left side of the cofferdam are 5.97m/s and 4m/s.

Affected by the narrowing of the river course and the bypass flow, the flow velocity near the bottom of the riverbed on the left side of the narrowed river course is high, especially that at the swelling part in the river, with a measured max. flow velocity of 7m/s under various working conditions, 7.21m/s being the biggest.

The flow velocity between Stake No. dam 0-400m to Stake No. dam 0+800m on the left bank is mostly above 2m/s, with a max. measured value of 4.93m/s; that on the right bank is all below 1.6m/s/

6) Navigation conditions

When the incoming flow is 4000m^3/s and below, the surface flow velocity is smaller than 2.0m/s and ships can pass through the narrowed river section; when the incoming flow is 6000m^3/s and below, the surface flow velocity is smaller than 2.0m/s and the discharge is lower than 10,000m^3/s, the surface flow velocity is smaller than 3.5m/s, taking the flow velocity of 3.5m/s as the critical point of navigation suspension, then ship could pass through the narrowed section with the help of aid-to-navigation when the flow velocity is 4000m^3/s~10000m^3/s and the navigation gets suspended when the flow velocity exceeds 10000m^3/s.

7) Suggestions

A distinctive swelling body is found in the river channel between Stake No. dam 0~150m to Stake No. 0+150m. It is considered to remove the swelling body beforehand to enhance the flow passing capacity and improve the navigation condition.

b) Phase II construction diversion

1) Test condition

Table 7.2.10-2 Test Conditions of Phase II Construction Diversion Model

Test condition	Total discharge m^3/s	Upstream water level m	Downstream Water level m	Test Running Mode	Remarks
2-1	16700	236.5	229.23	All surface outlets ①②③ are opened by 14m+ All surface outlets ④⑤⑥⑦⑧ are opened by 10m+ All surface outlets ⑨⑩⑪⑫⑬⑭are opened by 2m	Mainly to know navigation conditions at the gate area of the upstream and downstream approach channels
2-2	19000	—	230.14	Gates of all the 14 surface outlets are fully opened	Mainly to focus on the flow regime, flow velocity and flow profile of the surrounding of cofferdam and river course
2-3	21100	—	230.92		
2-4	23000	—	231.6		
2-5	25500	—	232.44		

Note: 1. The downstream water level in the table above refers to the water level at Stake No. dam 0+900m.

2. The numbering of the outlets ①～⑭ is in a left-to-right sequence.

2) Discharging capacity

For the 14 outlets (11 shallow outlets and 3 deep outlets), the discharging capacity of them when fully opened could meet the design requirement of Phase II diversion. When discharging a 20-year flood (Q=23000m^3/s), the water levels in front of the upstream and downstream earth-rock cofferdams are 234.551m and 231.899m respectively, 3.949m and 2.101m higher than the crest elevation of the two cofferdams.

3) Flow regime

Water surface near each of the cofferdam is smooth and steady and consipicous

unfavorable flow regime is not detected.

When the Phase I upstream earth-rock cofferdam is demolished to an elevation of 218m, in case of a 4300m^3/s discharge, the water surface above the cofferdam that is yet to be demolished will have comparatively big fluctuation. Except for that, there is no unfavorable flow regime.

The inflow of the upper reservoir area is smooth and steady; a weak bypassing flow is detected at the pier head of the upstream navigation well and the pier head of the upstream section of Phase II longitudinal concrete cofferdam.

Behind the gate orifices at the flood discharging dam section, the flow regime is symmetrical and steady and is smoothly connected with the downstream river flow.

4) Flow profile and water surface fluctuation

Jointly affected by the flow volume and the gate opening pattern, the water surface fluctuation is not considerable under each working condition, with a 2.5m fluctuation being the biggest.

The measured max. water surface fluctuation in front of the upstream and downstream earth-rock cofferdams are 0.67m and 0.73m respectively.

When all the gates are opened, the water surface fluctuations near the upstream and downstream longitudinal concrete cofferdams are both below 1.2m; when the gates are partially opened (working condition 2-1, Q= 16819m^3/s), water surface fluctuation around the downstream longitudinal concrete cofferdam is considerably bigger than that under other working conditions (all above 1.5m) and the measured max. water surface fluctuation is 2.5m.

Water surface fluctuation at downstream bank side is below 1.5m.

5) Flow velocity

Except for the water releasing structures that have higher flow velocity, the rest structures are featured by a flow velocity lower than 4m/s.

The measured max. flow velocity around the upstream cofferdam is 0.96m/s and that around the downstream cofferdam is 0.92m/s.

For the upstream longitudinal concrete cofferdam, except for the pier head and measuring point 9# where the flow velocities are comparatively high (with a measured max. flow velocity of 3.35m/s), flow velocities of other measuring points are all below 2m/s. For the flow velocity at downstream longitudinal concrete cofferdam, except for when the gates are partially opened (working condition 2-1, Q=16819m^3/s), leading to a comparatively higher velocity (measured max. flow velocity of 3.69m/s), flow velocities under other working conditions are all below 2.2m/s.

When all the gates of the 14 surface outlets are fully opened, the flow velocity at the end of the apron at each flood releasing section generally goes up with the increase in the discharging volume and the flow velocity reaching the bottom will go up to more than 4.5m/s, with a max. velocity of 6.66m/s. When discharging a 20-year flood, the velocity of the flow reaching the bottom of the apron will reach around 6m/s.

Flow velocity at downstream bank side is small and the measured max. velocity is below 1.64m/s.

6) Downstream scouring

Whether an apron of a water releasing structure is subject to scouring depends more on the scheduling pattern of the gates. In the test, considerable scouring is detected when the upstream water level is 236.5m and the gates are partially opened (working condition 2-1, Q= 16819m^3/s). The scouring pit behind the deep channel area is 194.14m a.s.l at its lowest point (scouring depth of 9.86m), the scouring pit of the stilling basin is 213.04m a.s.l at its lowest point (scouring depth of 5.96m) and the scouring pit behind surface outlets ⑨~⑭ is 215.81m a.s.l at its lowest point (scouring depth of 3.19m).

7) Navigation condition: when reaching the max. navigable discharge 16700m^3/s, the gate areas of the upstream and downstream approach channels could basically meet the navigation requirement.

7.2.11 Summary of Construction Diversion Work Quantities

The summary of main work quantities of diversion in each phase is shown in Table 7.2.11-1.

Table 7.2.11-1 Summary of Main Work Quantities of Construction Diversion

Item	Unit	Phase I Diversion				Phase II Diversion				Total
		Phase I longitudinal concrete cofferdam	Upstream transverse cofferdam	Downstream transverse cofferdam	Subtotal	Phase II longitudinal concrete cofferdam	Upstream transverse cofferdam	Downstream transverse cofferdam	Subtotal	
Clay fill	10,000 m^3		5.89	5.21	11.10		2.54	1.50	4.03	15.13
Clay straw bag	10,000 m^3	5.85			5.85				0.00	5.85
Fill of weathered fine slag	10,000 m^3				0.00		18.26	14.69	32.96	32.96
Crushed rock revetment fill	10,000 m^3		1.51	1.29	2.80		2.02	1.62	3.64	6.44
Reinforced gabion slope protection	10,000 m^3				0.00		7.84		7.84	7.84
Fill of rock ballast mixture	10,000 m^3		15.00	12.67	27.67		45.95	20.31	66.25	93.92
High-pressure jet grouting	m				0.00		16016	11811	27827	27827
Curtain Grouting	m	7194	2732	4271	14197	4484	2467	2379	9330	23527
Filter material	10,000 m^3		1.45	1.24	2.69		1.01	0.68	1.69	4.38
Foundation clearing and excavation	10,000 m^3	1.70	2.01	1.93	5.64	0.17			0.17	5.81
Earth-rock removal	10,000 m^3	5.85	21.81	18.49	46.15		8.67	38.80	47.47	93.61
C15 concrete pouring	10,000 m^3	8.59			8.59	3.07			3.07	11.66
Water and grout stop plate (1.2mm thick red copper sheet)	m	361			361	282			282	643
Concrete removal	10,000 m^3	3.55			3.55	5.71			5.71	9.26

Navigation channel dredging	10,000 m^3				7.50					7.50

7.3 Material Source Selection and Exploitation

7.3.1 Material Source Selection for Concrete Aggregate

7.3.1.1 Demand for Concrete Aggregate

Demand for concrete aggregate: the total amount of concrete for the Project is about 1,697,600 m^3. The demand for finished sandstone is 3,740,000 t, in which, there are 1,300,000 t fine aggregate and 2,440,000 t coarse aggregate.

Due to lack of test materials, except masonry for the Project and other fragmentary temporary concrete works in this phase, excavated material from the structures shall not be used. In consideration of the loss coefficients of rock exploitation, transportation and processing, concrete pouring, etc., the total design demand for rock is 2,080,000 m^3 (bank measure).

7.3.1.2 Material Source Selection

After prospecting, no natural sandstone near the project dam site is suitable to be used as concrete aggregate, and artificial aggregate shall be used.

Dajiang Quarry is located on the left bank (near the river) in the upper reach of Mekong River and about 2km away from the dam site. It is accessible through a tractor road. The elevation of the quarry is 300.00m~650.00m, and its area is about 150,000 m^2.

The ground surface is mainly bedrock outcrop, and the overburden thickness on the mountain top is less than 2.0m. The lithology is grey micrite with overall uniformity. The bedrock outcrop is generally strongly weathered ~ mediumly weathered, with grained structure and massive structure. The rock is hard and relatively intact, and the stripping amount of unavailable layer is small. After calculation according to the parallel section method, the reserve of available layer is more than 8 million **m^3.** The total design demand for rock is 2,080,000 m^3 (bank measure). In consideration of the reserve factor of 1.4 times, the planned demand for rock is 2,920,000 m^3, and the reserve in the quarry can meet the aggregate demand of the Project.

The test results suggest that the dry density of fresh rock is 2.69g/cm^3~2.71g/cm^3 with the average value of 2.7 g/cm^3; the saturated compressive strength is 48.5MPa

~64.1MPa with an average value of 53.9MPa. The physical and mechanical property test results of rock in quarry are shown in Table 7.3.1-1.

Table 7.3.1-1 Physical and Mechanical Property Test Results of Rock in Quarry

Sampling No.	Sampling Position	Index Property	Grain Density ρ_p	Dry Density ρ_d	Saturated Density ρ_s	Saturated Water Absorptivity ωs	Porosity n	Saturated Compressive Strength R_s	Dry Compressive Strength R_d	Remarks
			g/cm^3	g/cm^3	g/cm^3	%	%	MPa	MPa	-
PD4-A	PD4 left tunnel depth: 25m	Range value	2.72	2.69~2.70	2.70~2.71	0.29~0.25	-	71.2~48.8	115~79.7	Grayish white
		Mean value	2.72	2.70	2.70	0.26	0.74	56.6	94	
PD4-B	PD4 right tunnel depth: 25m	Range value	2.72	2.70	2.71	0.27~0.23	-	77.4~39.4	110~83.1	Grayish white
		Mean value	2.72	2.70	2.71	0.25	0.74	56.5	98	
PD4-C	PD4 left tunnel depth: 5m	Range value	2.71	2.69	2.70	0.29~0.25	-	83.9~44.0	100.0~49.8	Grayish white
		Mean value	2.71	2.69	2.70	0.27	0.74	64.1	78.5	
PD4-D	PD4 right tunnel depth: 15m	Range value	2.71~2.73	2.68~2.71	2.69~2.71	0.18~0.38	-	33.4~57.1	69.8~102	Grayish white, with white spots
		Mean value	2.72	2.70	2.71	0.26	0.74	48.7	87.2	
PD4-E	PD4 right tunnel depth: 5m	Range value	2.71	2.69~2.70	2.70	0.19~0.24	-	46.1~61.6	78.9~101	Grayish white with light yellow, and with relatively developed white dike and block mass
		Mean value	2.71	2.70	2.70	0.22	0.37	52.7	89.7	
PD4-G	PD4 left tunnel bottom	Range value	2.72	2.70~2.71	2.71	0.16~0.28	-	26.1~59.3	65.4~91.8	Grayish white with light yellow, and with yellowish brown linear materials in partial area
		Mean value	2.72	2.71	2.71	0.19	0.74	48.5	78.4	
PD4-H	PD4 right tunnel bottom	Range value	2.71	2.69~2.70	2.70	0.20~0.28	-	42.5~64	70.4~83	Light gray with white pisolitic spots
		Mean value	2.71	2.70	2.70	0.23	0.37	49.9	76.9	

The alkaline reaction test results of aggregate all suggest: the tested rock samples from the quarry are non-alkaline-reactive aggregate.

In conclusion, the reserve and quality of rock in Dajiang Quarry meet the requirement of artificial concrete aggregate of the Project.

7.3.2 Filling Material Source Selection

The earth-rock filling work quantity of the Project is about 1,610,000 m^3, which is mainly cofferdam filling, and excavated material shall be directly used or material exploited from the waste disposal area shall be used for cofferdam filling. The total excavation work quantity in the first and second phases is about 4,640,000 m^3, and the quality and reserve both meet the requirement.

The cofferdam filling work quantity in the first phase is about 500,000 m^3, in which, the filling quantity before river closure and final gap closing is about 120,000 m^3. The filling material is mainly exploited from the excavated material of Phase I dam and ship lock, or the excavated material can be directly transported to the cofferdam. Phase I excavation work quantity is about 2,460,000 m^3, in which, the excavation quantity before river closure is about 600,000 m^3, and the reserve meets the requirement of cofferdam filling material. Phase II cofferdam filling quantity is about 1,090,000 m^3, in which, the filling quantity before river closure and final gap closing is about 300,000 m^3. The filling material is mainly exploited from the excavated material and stock of Phase II dam and powerhouse, or the excavated material and stock can be directly transported to the cofferdam. Phase II excavation quantity is about 2,180,000 m^3, in which, the excavation quantity before river closure is about 780,000 m^3, and the reserve meets the requirement of cofferdam filling material.

7.3.3 Earth Material Source Selection

The borrow area is located on the Grade I terrace on the right bank of the dam site, and it is distributed in a strip along the downstream direction. The terrain of the borrow area is flat, with paddy field, dry land and a small amount of shrubwood at present; the borrow area is 40m~90m wide and about 2000m long, its distribution elevation is

230.00m~237.00m and its area is about 152,100 m^2; after planar geological surveying and mapping and drilling, the earth material is mainly the terrace deposit, the 0.2m~0.3m surface layer is soil for cultivation, below which is yellow and grayish yellow silty clay, and the content of silty soil and silty sand is increased near the river bank. In the borrow area, the water content in the upper soil layer 4m below the top increases obviously, and is in plastic ~ soft plastic state.

The average thickness of the soil layer in the borrow area is more than 10.0m. In consideration of the water content, the thickness of available layer shall be determined as 3.5m. The average thickness method shall be adopted for calculation, the thickness of the stripping layer is about 0.3m and the total reserve is about 533,000 m^3. The soil in the borrow area is mostly low liquid limit clay. The range value of maximum dry density is 1.60g/cm^3~1.74g/cm^3 with the average value of 1.68g/cm^3, the average optimum moisture content is 20.7%, and the average natural moisture content is 16.77%; the penetration test suggests that most of the clay is extremely slightly permeable and only a small amount of the clay is slightly permeable. Each test index basically meets the soil quality index requirement of impervious body.

The clay demand of the Project is about 209,800 m^3. The physico-mechanical indices and reserve of the soil in the borrow area distributed along the Grade I terrace on the right bank in the upper reach of dam site meet the demand of the Project.

7.3.4 Borrow Area and Quarry Exploitation Planning

7.3.4.1 Borrow Area Exploitation

Before earth excavation in the borrow area, vegetation clearing and topsoil excavation shall be conducted at first, then a 132kW bulldozer with a ripper shall be used for soil loosening, a 3m^3 hydraulic excavator shall be used for loading, and a 10t~20t dump truck shall be used for transporting the earth to the dam.

7.3.4.2 Quarry Exploitation

a) Principles of Quarry Exploitation Planning

1) The effective rock reserve within the exploitation area shall meet the demand

for planned exploitation amount.

2) To control the lumpiness and grading of excavated material, the bench blasting exploitation scheme shall be considered at first.

3) The exploitation working face and discharge operation line shall be determined according to the supply intensity requirement.

4) During exploitation in the quarry, the side slope shall be neat, safe and stable.

b) Selection of Main Layout Parameters of Quarry Exploitation

1) Bench Height

The bench height in quarry exploitation is related to geological conditions, drilling and blasting method, loading equipment performances, etc. The concrete and filling work quantities of Pak Lay Hydropower Project are large, and high exploitation intensity is required. The $2m^3$~$3m^3$ excavators are proposed as the excavating and loading equipment, and the bench height is determined as 8m~12m.

2) Final Slope Angle

The final slope angle shall be determined according to the rock properties, geological structure, maximum slope height, slope stability and other factors. The highest slope in the quarry has an elevation of 400.000m~530.000m and a height of 130m. Based on the domestic and overseas exploitation practice experience, the final slope angle is determined within 65°.

3) Slope Support in Quarry

The planned artificial slope height of the quarry is about 130m. During excavation, the quarry slope of the overburden, strongly weathered stratum and weakly weathered stratum shall be respectively 1:1.0, 1:0.75 and 1:0.3 according to geological data. A 3.0m-wide berm shall be set for every 20m. In order to ensure the slope stability and construction safety of the quarry, a complete drainage system shall be set. The drainage system includes the peripheral intercepting ditches and drainage ditches in the quarry, and the system shall be completed synchronously with the elevation drop of excavated bench. Before slope excavation, intercepting ditches shall be set along the slope top of the exploitation boundary. A drainage

ditch shall be set at the slope toe for each berm. Free drainage shall be adopted in the working face. With the elevation drop and formation of slope surface, the intercepting ditches and drainage ditches within the exploitation scope shall be completed in the same period.

According to the present geological data on the quarry area, the main supporting measures for the slope are:

The 10cm~20cm shotcreting shall be conducted on the whole slope surface, and bar-mat reinforcement shall be adopted for the strongly weathered stratum and above; system anchor bolts shall be set for the strongly weathered stratum and above, the anchor bolt has a diameter of 25mm, a length of 6m and a spacing and a row spacing of 3m×3m, the system drain hole has a diameter of 56mm, a depth of 5m and a spacing and a row spacing of 3m×3m. Random anchor bolts and random drain holes shall be set for the weakly and strongly weathered strata and below.

c) Quarry Transportation Road Layout

Dajiang Quarry has a steep terrain, which makes it difficult to arrange roads. It is proposed to adopt the combined method of vertical transportation and horizontal transportation, to arrange a transportation road and 1 draw shaft. The quarry transportation road shall be a branch led from ⑥ highway with a length of about 1.60km. Its starting point elevation is 290.00m, final point elevation is 400.00m, pavement width is 7.0m and the subgrade width is 8.5m. The top elevation of draw shaft is 520.00m, the shaft diameter is 6m, and the height is about 90m. The diameter of the storage silo in the lower portion of the draw shaft is 12m and its height is 30m. A mucking adit shall be arranged in the lower portion of the draw shaft, the elevation at the adit bottom is 400.00m, the adit is about 70m, and the section size is 7.5m×6.5m (width × height), and the quarry transportation road shall be connected. The construction equipment (bulldozers, excavators and dump trucks) shall be transported to the place with an elevation of 400.00m through the quarry transportation road, and transported to the mountain top through a construction access road.

d) Quarry Overburden Stripping

The surface of the exploitation boundary in the quarry is mainly the bedrock outcrop. The thickness of the overburden on the mountain top is less than 2.0m. The stripping amount of the unavailable layer is small. The 132kW bulldozer and $2m^3$~$3m^3$ hydraulic excavator shall be used for excavation, and the excavated material shall be transported by a 15t dump truck and unloaded into the draw shaft. The vibrating rock feeder at the lower opening of the draw shaft shall be used for rock feeding. A 20t dump truck shall be used for transporting the material to the waste disposal yard through the temporary construction road.

e) Quarry Exploitation

According to the master construction schedule, the peak period for concrete pouring in the Project is from April of the 2nd year to April of the 3rd year, lasting for 12 months. The average intensity of concrete pouring during the peak period is $80,800m^3$/month, so that the average exploitation intensity in the quarry during the peak period is determined as $98,600m^3$/month (bank measure).

Vertical excavation and segmented horizontal exploitation shall be adopted for the quarry. After major blasting and shaping and the excavation platform is formed, the Deep hole millisecond compression blasting from top to bottom and segmented exploitation shall be conducted, and the bench height is 10m.

The YQ-100 down-hole drill shall be used for drilling. A 132kW bulldozer and a $2m^3$~$3m^3$ hydraulic excavator shall be used to unload the material into the draw shaft. The vibrating rock feeder at the lower portion of the draw shaft shall be used for rocking feeding, and a 15t dump truck shall be used for transporting rock to the sandstone processing system.

In consideration of overburden stripping and available material exploitation in the quarry, and based on the requirements of deep hole blasting, bench exploitation and raw material transportation, the exploitation and transportation machineries which meet the exploitation intensity requirement shall be adopted. The demand for drilling, excavating and transportation machineries and other machineries in the quarry is shown in Table

7.3.4-1.

Table 7.3.4-1 List of Construction Mechanical Equipment in Quarry

S/N	Name	Spec. & Model	Unit	Qty.	Remarks
1	Hydraulic down-hole drill	YQ-100	Set	2	
2	Breaker hammer		Set	6	
3	Air compressor	$16m^3$/min	Set	2	
4	Hydraulic excavator	$2m^3$	Set	2	
5	Hydraulic excavator	$3m^3$	Set	2	
6	Bulldozer	132kW	Set	2	
7	Dump truck	15t	Set	8	

7.4 Construction of Main Works

7.4.1 Earth-rock Excavation

7.4.1.1 Construction Characteristics

Earth-rock excavation of the main works includes excavation of the concrete dam foundation, side slopes, powerhouse foundation, ship lock foundation, sand trap, fishway, etc. The total excavation amount is about 4,640,000 m^3. According to the construction diversion method and master schedule, the earth-rock excavation shall be conducted in two phases.

The first phase will be started from August of the 1st year to January of the 3rd year, involving the flood discharge gate foundation, side slopes, Phase I powerhouse foundation, ship lock foundation, etc. The excavation amount is 2,530,000 m^3. Before closure in February of the 2nd year, the portion above the normal water level will be excavated. After closure, the portion below the normal water level will be excavated. The monthly peak excavation intensity is 274,200 m^3.

The second phase will start from January of the 3rd year to June of the 4th year, involving the dam foundation, side slopes, Phase II powerhouse foundation, access highway, fishway, etc. The total excavation amount is 2,130,000 m^3, and the monthly peak

excavation intensity is 196,100 m^3.

7.4.1.2 Waste Disposal Area Planning

Waste disposal areas shall be set on both the left and right banks. The right-bank waste disposal area is located in the gully which is about 0.7km downstream the right bank of the dam site, and the capacity of the waste disposal area is about 3,850,000 m^3; the left-bank waste disposal area is located in the gully which is about 0.8m upstream and the left bank of the dam site, and the total capacity of the waste disposal area is about 1,750,000 m^3.

7.4.1.3 Layout of Main Mucking Roads

According to the topographical conditions, waste disposal area planning and the elevation of excavation platform, the corresponding mucking roads shall be arranged respectively.

a) Right-bank Road Layout

Three onsite main roads shall be arranged on the right bank. ⑤ highway is the road connecting the right dam abutment to right-bank waste disposal area, and is mainly used for mucking during excavation of the right-bank slope of the dam; ⑦ highway is the road of the lower foundation pit in the upper reach of the right bank, and several branches shall be led to connect the excavation area; ① highway is the right-bank access road to the dam.

b) Left-bank Road Layout

Three onsite main roads shall be arranged on the left bank. ② highway is the access road to the dam; ⑧ highway is the road of the lower foundation pit in the upper reach of the left bank, and several branches are led and connected to the excavation area; ④ highway is the road of the lower foundation pit in the lower reach of the left bank, and branches are led and connected to the excavation area; ⑥ highway is the road connecting the left bank and sandstone processing system.

c) Cross-river Transportation

There is no bridge crossing the Mekong River within dam site area. The banks are

connected by the Mekong River Ferry downstream Pak Lay as the major river crossing transportation facility, which cannot satisfy the transport demand between left and right banks during construction of Pak Lay Hydropower Project. Therefore, it is required to build a bridge over Mekong River about 1,000m downstream the dam site to connect the left and right banks.

7.4.1.4 Excavation Procedure and Method

a) Phase I Excavation

In the first phase, excavation shall be conducted first for the bank slope and then the river bed, and conducted in layers from top to bottom.

The excavation elevation of right-bank slope is about 246.000m~297.000m, and the excavation height is 51m. Excavation shall be conducted in 6 layers, and the excavation height of each layer is about 8m~10m. Excavation of the left-bank slope is above the normal water level and can be conducted on dry land throughout the year. As to earth excavation, a 132kW bulldozer with a ripper shall be used for soil loosening, a 3m^3 hydraulic excavator shall be used for loading, and a 20t dump truck shall be used for transporting the excavated soil. As to rock excavation, a hydraulic drill and a YQ-100 down-hole drill shall be used for drilling, bench blasting shall be adopted, and the bench height is 8m~10m. At the bottom, a 2m-thick protective layer shall be reserved, and the layer shall be drilled with a breaker hammer, and shallow blasting shall be adopted. Presplitting blasting shall be adopted for the peripheral walls. A 235kW bulldozer shall be used for aggregating of the excavated rock ballast. A 3 m^3 excavator and 20t dump truck shall be used for transporting the rock ballast away. Before closure, the excavated waste material shall be transported to the right-bank waste disposal area; after closure, the excavated waste material shall be transported to the filling area of the cofferdam.

The elevation of the right-bank terrace is 210.000m~246.000m and the excavation height is 36m. Excavation shall be conducted in 4 layers, and the excavation height of each layer is 8m~10m. Before closure, the portion above the normal water level shall be excavated; after closure, the rest portion shall be excavated when water level of foundation

pit drops. As to earth excavation, a 132kW bulldozer with a ripper shall be used for soil loosening, a 3m^3 hydraulic excavator shall be used for loading, and a 20t dump truck shall be used for transporting the excavated soil. As to rock excavation, a YQ-100 down-hole drill shall be used for drilling (assisted with a breaker hammer). Presplitting blasting shall be adopted for the peripheral area, and bench blasting shall be adopted for rock with a bench height of 8m~10m. The protective layer reserved at the bottom is 2m thick. A breaker hammer shall be used for drilling of the protective layer, and shallow hole blasting shall be adopted. After blasting, a 3m^3 hydraulic excavator and a 20t dump truck shall be used for transporting the excavated material, and a 132kW bulldozer shall be used to assist collection of the excavated material. Before closure, the excavated waste material shall be transported to the right-bank waste disposal area; after closure, the excavated waste material shall be transported to the filling area of the cofferdam.

b) Phase II Excavation

Phase II excavation is mainly the excavation of Phase II dam and powerhouse foundation.

The excavation elevation of the portion above the normal water level on the left bank slope is about 220.000m~320.000m, and the maximum excavation height is 100m. Excavation shall be conducted in 12 layers, and the excavation height of each layer is 8m~10m. Excavation shall be conducted before closure. After closure, excavation of the rest portion shall be excavated when the water level of foundation pit drops.

As to earth excavation, a 132kW bulldozer with a ripper shall be used for soil loosening, a 3m^3 hydraulic excavator shall be used for loading, and a 20t dump truck shall be used for transporting the excavated soil. The excavated waste material shall be transported to the right-bank waste disposal area or directly transported to the cofferdam.

Foundation excavation of the deep groove portion of the river bed shall be conducted after closure. The excavation depth of the overburden is 10m~15m, a 132kW bulldozer with a ripper shall be used for soil loosening, a 3m^3 hydraulic excavator shall be used for loading, and a 20t dump truck shall be used for transportation; the excavation

depth of the bedrock is generally about 3m~10m (over 20m for partial bedrock), a YQ-100 down-hole drill shall be used for drilling, bench blasting shall be conducted, a breaker hammer shall be used for drilling if the depth is less than 4m, shallow hole blasting shall be adopted, the protective layer reserved at the bottom is 2m thick, a breaker hammer shall be used for drilling of the protective layer, and shallow hole blasting shall be conducted. A $3m^3$ hydraulic excavator and a 20t dump truck shall be used for transporting the excavated material, and a 132kW bulldozer shall be used for aggregating of the excavated material. The excavated waste material shall be transported to the right-bank waste disposal area or directly transported to the cofferdam.

7.4.2 Foundation Treatment

7.4.2.1 Consolidation Grouting

Total quantity of consolidation grouting for rock foundation of the dam is 81,000m. Grouting holes are arranged in quincunx pattern. KQ-100 rig is adopted for drilling and SGB-I grout pump for grouting. Grouting for holes less than 8m deep is done in one time and for holes more than 8m deep is done in sections from bottom to top.

7.4.2.2 Curtain Grouting

Curtain grouting of the dam, with total quantity of 44,400m, is performed with cement grout. Drilling and grouting for holes of odd numbers and even numbers are conducted respectively and in sequence. Drilling and grouting is conducted for holes of odd numbers first and then for holes of even numbers. SGZ-IA geological rig is adopted for drilling and SGB-I grout pump for grouting. Drilling and grouting are done in sections from the top to the bottom with the hole opening sealed.

7.4.3 Concrete Construction

7.4.3.1 Construction Characteristics

The hydraulic concrete structures consist of non-overflow section, overflow section, bottom outlet section, powerhouse section and ship lock section. The entire dam axis is 942.75m long. The crest elevation is 245.00m and the maximum height is 51m. For the non-overflow section on the right bank, the maximum bottom width (both upstream and downstream directions) is 31m, the length along dam axis direction is 198.50m, and the maximum dam height is 38m; for ship lock section, the length along dam axis direction is 42m, and the maximum dam height is 38m; for the overflow section, the maximum bottom width (both upstream and downstream directions) is 54m, the length along dam axis direction is 287m, and the maximum dam height is 48m; for the bottom outlet section, the maximum bottom width (both upstream and downstream directions) is 85m, the length along dam axis direction is 47m, and the maximum dam height is 51m; for the powerhouse section, the maximum bottom width (both upstream and downstream directions) is 84m, the length along dam axis direction is 301m, and the maximum dam height is 47m; for the non-overflow section on the left bank of powerhouse, the maximum bottom width of (both upstream and downstream directions) is 30m, the length along dam axis direction is 67.25m, and the maximum dam height is 47m.

Total concrete quantity of hydraulic structure is 1,624,000m^3, in which the quantity of dam is 592,600m^3, the powerhouse is 756,100m^3, the ship lock is 265,900m^3 and the fishway is 9,000m^3.

Based on the stage diversion arrangement and construction schedule, concrete dam on the right bank and ship lock foundation are constructed in the first phase which will last for 15 months, from April of the 2nd year to June of the 3rd year. When construction of the first phase is done, the entire dam would reach the crest elevation. The average pouring intensity of peak months is 81,100m^3. Concrete dam on the left bank, powerhouse and fishway are constructed in the second phase which will last for 21 months, from January of the 4th year to September of the 5th year, according to the construction schedule. The average pouring intensity of peak months is 81,200m^3.

7.4.3.2 Proposed Concrete Pouring Scheme

a) Basic Design Principles

1) Concrete transportation and pouring scheme must be fit for the layout pattern, terrain and stage diversion manner of hydraulic structures and the construction layout conditions. It shall also meet the requirements of construction schedule;

2) For dam body, the capacity of concrete transportation and pouring shall not only satisfy the requirements of concrete pouring intensity, but also give consideration to auxiliary lifting works, such as transportation of rebar, frame and other equipment and materials.

b) Proposed Concrete Transportation Scheme

Based on the hydraulic structures layout and construction characteristics, consideration is given to the relatively broad terrain of dam site where cable crane is not proper for construction. It is proposed to use portal crane and dump truck for transportation of normal concrete in this stage: for horizontal transportation, dump truck picks up materials at concrete batching and mixing plant and delivers the materials to the lifting range of portal crane; for vertical transportation, portal crane and crawling crane are used to lift and send horizontal bucket of 3m^3 to 6m^3 into the bunker directly.

c) Construction Layout of Concrete Pouring Scheme

Concrete production system for the first construction stage locates at downstream on the right bank, about 300m away from the dam axis. Elevation of discharging platform is 230.000m. Concrete production system for the second construction stage locates at

upstream on the left bank, about 1,000m away from the dam axis. Elevation of discharging platform is 270.000m.

Roller compacted concrete for non-overflow section on the right bank is delivered into the bunker directly by 10t to 20t dump truck trough Road ①, Road ⑦, upstream cofferdam of the first stage and internal road of foundation pit;

Concrete for ship lock section is delivered to feeding site of portal crane by 10t to 20t dump truck trough Road ③, downstream cofferdam of the first stage and internal road of foundation pit, and then sent into the bunker directly in $3m^3$ to $6m^3$ horizontal bucket by 3 MQ600 portal cranes. The crane rail is arranged along the central line of ship lock;

Concrete for overflow section is delivered to feeding site of portal crane by 10t to 20t dump truck trough Road ①, Road ⑦, upstream cofferdam of first stage and internal road of foundation pit, and then sent into bunker directly in $6m^3$ horizontal bucket by 5 MQ1000 portal cranes. The MQ1000 portal cranes are located on the upstream rail of this section and the crane rail is parallel to the dam axis, with central stake mark of 0-018.00m. Elevation of rail surface is 212.500m.

Concrete for Phase I bottom outlet section and powerhouse section guide wall is delivered into bunker with $6m^3$ horizontal bucket by 4 MQ1000 portal cranes, in which 2 of the MQ1000 portal cranes are located on the upstream trestle of this section and the other 2 MQ1000 portal cranes are located on the downstream trestle of this section. Rails of the former two cranes are parallel to dam axis, with central stake mark of 0-038.00m and the elevation of rail surface is 203.000m. Rails of the latter two cranes are parallel to dam axis too, with central stake mark of 0+064.00m and the elevation of rail surface is 206.000m. Concrete for upstream section is delivered to feeding site of portal crane by 10t to 20t dump truck trough Road ①, Road ⑦, upstream cofferdam of the first stage and internal road of foundation pit. Concrete for downstream section is delivered to feeding site of portal crane by 10t to 20t dump truck trough Road ③, downstream cofferdam of first stage and internal road in foundation pit.

For the parts beyond the coverage of portal crane, such as apron and guide wall, the

concrete is delivered by 10t dump truck and lifted into the bunker by W200A crawling crane;

Concrete for Phase II powerhouse section and non-overflow section on left bank is delivered into bunker with $6m^3$ horizontal bucket by 8 MQ1000 portal cranes, in which 4 of the MQ1000 portal cranes are located on the upstream trestle of this section and the other 4 MQ1000 portal cranes are located on the downstream trestle of this section. Rails of the former four cranes are parallel to dam axis, with central stake mark of 0-038.00 m and the elevation of rail surface is 203.000m. Rails of the latter four cranes are parallel to dam axis too, with central stake mark of 0+064.00m and the elevation of rail surface is 206.000m. Another 2 W200A crawling cranes are provided to deliver the concrete for the parts beyond the coverage of portal cranes into the bunker. Concrete for upstream section is delivered to feeding site of portal crane by 10t to 20t dump truck trough Road ⑥, Road ⑧, upstream cofferdam of the second stage and internal road of foundation pit. Concrete for downstream section is delivered to feeding site of portal crane by 10t to 20t dump truck trough Road ⑥, Road ②, Road ④, downstream cofferdam of the second stage and internal road in foundation pit.

Roller compacted concrete for non-overflow section on left bank of the second stage is delivered into the bunker directly by 10t to 20t dump truck trough Road ⑥, Road ⑧, upstream cofferdam of the second stage and internal road of foundation pit.

Refer to *Schematic Drawing of Concrete Pouring Method* for the details of construction layout of concrete pouring scheme.

7.4.3.3 Concrete Pouring Method

Concrete pouring is performed with the portal crane lifting of $3m^3$ to $6m^3$ horizontal bucket into bunker as the primary means and the W200A crawling crane lifting of $3m^3$ horizontal bucket into bunker as the secondary means. Handheld electrical vibrator is used for spreading and vibrating, assisted with hand fit, after the concrete is delivered into bunker.

Dam body roller compacted concrete construction is performed through RCC process,

in which the bunker surface keeps raising with thin spreading layers of 0.34m and compacted layers of 0.3m.

a) Analysis on Pouring Intensity of Portal Crane

1) Productivity Calculation of MQ1000 Portal Crane

The computational formula is Formula 7-4-9 in Volume III of *Construction Organization Design Manual for Water Conservancy and Hydropower Project*.

It is: $Q=Q_j mnK_1K_2K_3 K_4$

Where: Q refers to monthly production capacity of one portal crane, in m^3/month;

K_1 refers to utilization factor of construction condition, which is 0.4 to 0.8;

K_2 refers to utilization factor of time, which is 0.8;

K_3 refers to utilization factor of productivity, which is related to bunker surface condition and is valued as 0.8 upon analysis;

K_4 refers to simultaneous operating factor when more than one portal crane run at the same time, which is related to bunker surface condition and is valued as 0.9;

m and n refers to working days per month (25d) and working hours per day (20h);

Q_j refers to technical productivity and Q_j = nq. As the number of buckets lifted in one hour is 9 to 11 and the volume of each bucket is $6m^3$, the technical productivity is 54 to $66m^3$/h.

According to the parameters above, the practical productivity is $9332m^3$ to $13207m^3$/month. Based on the utilization condition of the crane in actual construction, monthly pouring intensity of MQ1000 crane is adopted as the stable productivity of mass concrete pouring can reach $10,000m^3$/month and the stable productivity of structural concrete pouring can reach $7,500m^3$/month: The productivity is valued as $10,000m^3$/month for overflow section and $7,500m^3$/month for powerhouse section for intensity analysis.

2) Productivity Calculation of MQ600 Portal Crane For technical productivity of DMQ540 portal crane, Q_j=nq. As the number of buckets lifted in one hour is 12 to 15

and the volume of each bucket is $3m^3$, the technical productivity is $36m^3/h$ to $45m^3/h$. The practical productivity is $6220m^3$ to $9072m^3$/month and the monthly pouring intensity of MQ600 portal crane, $6500m^3$/month, is adopted for intensity analysis.

b) Pouring Intensity Analysis

The maximum pouring intensity for non-overflow section on right bank is about $5600m^3$/month which can be achieved with 1 MQ600 portal crane. The pouring intensity can reach $6500m^3$/month. The equipment configuration capacity can satisfy the requirement of concrete pouring intensity of dam body.

The maximum pouring intensity for ship lock section is about $18,900m^3$/month and the pouring intensity of 3 MQ600 portal cranes can reach $19,500m^3$/month. The equipment configuration capacity can satisfy the requirement of concrete pouring intensity of dam body.

The maximum pouring intensity for overflow section is about $46,700m^3$/month and the pouring intensity of 5 MQ1000 portal cranes can reach $50,000m^3$/month; additionally, the maximum pouring intensity for parts of overflow section, like stilling pool, is about $20,600m^3$/month, for which 6 W200A crawling cranes are provided with monthly pouring intensity of $5,000m^3$ for each. The equipment configuration capacity can satisfy the requirement of concrete pouring intensity of dam body.

The maximum pouring intensity for concrete of Phase-I bottom outlet section and powerhouse dam section guide wall is about $22,000m^3$/month and pouring intensity of 4 MQ1000 portal cranes can reach $30,000m^3$/month. The equipment configuration capacity can satisfy the requirement of concrete pouring intensity of dam body.

The maximum pouring intensity for Phase II powerhouse section and non-overflow section on left bank is about $69,400m^3$/month and pouring intensity of 8 MQ1000 portal cranes can reach $60,000m^3$/month. Another 2 W200A crawling cranes are provided therefore with monthly pouring intensity of $5000m^3$ for each. The equipment configuration capacity can satisfy the requirement of concrete pouring intensity of dam body.

c) Joints and Bunkers of Dam Body

The minimum foundation surface elevation of overflow section is 197.000m and the

crest elevation is 245.000m. The maximum dam height is 48.00m. The interval between transverse joints is 24.50m and the maximum bottom width of transverse joint is about 35m. The pouring is performed monolithically without longitudinal joint.

The powerhouse section is of complicated structure. Concrete pouring of the lower part is conducted in 1-joint 2-bunker manner with the 1 construction joint along the water direction.

7.4.3.4 Analysis on Construction Progress

The maximum dam height of non-overflow section on right bank is 38m and the quantity of concrete pouring is about 43,800m^3. The monthly peak pouring intensity is about 5,600m^3. The pouring course of this section is proposed to be conducted from June of the 2nd year to January of the 3rd year according to the schedule. The mean ascending velocity of dam body is 4.8m per month and the monthly peak ascending velocity can reach 6m in consideration of the influence of construction unevenness. Pouring of this section is done monolithically in thin layers. Mean area of bunker surface is 410m^2 and the thickness of each pouring layer is 1.5m to 3m. The interval between pouring of layers shall be 5d to 7d. The ascending velocity of dam body is 6m to 9m, which can satisfy the requirement of construction progress.

The maximum dam height of overflow section is 48m and the quantity of concrete pouring is about 337,100m^3. The peak pouring intensity of a month is about 46,700m^3. Concrete pouring of this section is proposed to be conducted to the crest elevation from April of the 2nd year to the end of December according to the schedule. The monthly average ascending velocity of overflow weir is 5.40m. Pouring of this section is done monolithically in thin layers. Mean area of bunker surface is 700m^2 and the thickness of each pouring layer is 1.5m to 3m. The interval between pouring of layers shall be 5d to 7d. The ascending velocity of dam body is 6m to 9m, which can satisfy the requirement of construction progress. Monthly mean ascending velocity of gate pier is 6.50m and the monthly peak can reach 8m in consideration of the influence of construction unevenness. Pouring of this section is done monolithically in thin layers. Mean area of bunker surface is 240m^2 and the thickness of each pouring layer is 2m to 3m. The interval between pouring

of layers shall be 5d to 7d. The ascending velocity of dam body is 8m to 12m, which can satisfy the requirement of construction progress.

The maximum dam height of Phase II powerhouse section is 47.0m and the quantity of concrete pouring is about 756,100m^3. The monthly peak pouring intensity is about 81,200m^3. Concrete pouring of this section will be conducted to the crest elevation from June of the 4th year to March of the 5th year. The monthly average ascending velocity is 4.70m and the peak velocity can reach 6.8m considering the influence of construction unevenness. Pouring of this section is done monolithically in thin layers. Mean area of bunker surface is 150m^2 and the thickness of each pouring layer is 2m to 3m. The interval between pouring of layers shall be 5d to 7d. The ascending velocity of dam body is 8m to 12m, which can satisfy the requirement of construction progress.

7.4.3.5 Temperature Control

a) Basic Data

These data is from the collection of SAYABUARY meteorological station near the construction site. Refer to Table 7.4.3-1 for temperature data and refer to Table 7.4.3-2 for other meteorological data.

Table 7.4.3-1 Temperature Data Unit: °C

Month	1	2	3	4	5	6	7	8	9	10	11	12	Entire Year
Mean lowest temperature of years	14.2	14.9	18.0	21.6	23.5	24.4	24.1	23.9	23.3	21.6	18.4	14.6	20.2
Mean highest temperature of years	27.8	30.6	33.2	33.8	32.4	31.5	30.7	30.2	30.6	29.8	28.2	26.6	30.5
Mean extremely lowest temperature of years	1.3	7.0	7.0	13.5	19.0	18.0	15.6	20.8	17.8	11.2	7.0	2.5	1.3
Mean extremely highest temperature of years	34.5	37.0	39.5	40.5	39.7	37.0	38.5	35.7	35.0	36.7	34.5	34.6	40.5
Mean temperature of years	21.0	22.8	25.6	27.7	27.9	28.0	27.4	27.1	26.9	25.7	23.3	20.6	25.3

Table 7.4.3-2 Other Meteorological Data

Month	1	2	3	4	5	6	7	8	9	10	11	12	Entire Year
Mean humidity of years (%)	71	69	66	70	75	78	80	81	80	78	76	73	75
Mean evaporation of years (mm)	60.0	78.4	104.6	88.2	62.3	57.8	51.3	42.6	44.2	48.9	49.4	50.4	737.9
Mean wind speed of years (m/s)	1.2	1.4	1.6	1.4	1.3	1.4	1.3	1.2	1.2	1.2	1.4	1.3	1.3

b) Stable Temperature Field

As the base plate and side wall of powerhouse, gate dam and ship lock are quite thin, there is no stable temperature field due to influence from periodic variation of air temperature at the top and both sides. There is only quasi stable temperature. The lowest mean temperature of base plate and side wall concrete construction period subject to sinusoidal variation related to annual variation period of exposed semi-infinite body suffering from external temperature on its surface. According to analysis on meteorological data, the temperature of December is the lowest and the lowest mean temperature of concrete would exist in January in consideration of the temperature delay of concrete. The quasi stable temperature is valued as 21°C.

c) Temperature Control Standard

1) Basic Temperature Difference

As the overflow section is of the largest bottom width of 35m, for the structure, concrete pouring of this section shall be done monolithically in thin layers, which is helpful to accelerate the construction. Based on the computational analysis of temperature and thermal creep stress of concrete block and the reference of practical experience and normative standards of established hydropower project in China, the ultimate tension of the foundation concrete used in construction at the 28d is not less than 0.85×10^{-4}. The concrete ascends continuously with pouring thickness of 1m to 1.5m per layer and with time interval of 5d to 7d between pouring of layers.

The powerhouse section is of complicated structure. Concrete pouring of the lower part is conducted in 1-joint 2-bunker manner with the 1 construction joint along the water

direction. The concrete for this part is of high strength grade and the ultimate tension at the 28d is not less than 0.85×10^{-4}.

Refer to Table 7.4.3-3 for basic allowable temperature difference of concrete.

Table 7.4.3-3 Basic Allowable Temperature Difference ΔT Unit: °C

Part and Basic Confining Range		Basic Temperature Difference	Quasi Stable Temperature	Allowable Maximum Temperature
Dam	(0~0.2L)	18	21	39
	(0.2~0.4L)	20		41
Powerhouse	Base plate of tailrace pipe	16		37
	Area above base plate of tailrace pipe	19		40

Note: L refers to the maximum side length of concrete block.

2) Temperature Difference between Upper and Lower Lifts

When the upper lifts of concrete block grows evenly for more than 0.4L during the short interval, the allowable temperature difference between upper and lower lifts is 17°C to 19°C; when the side surface of concrete block subjects to long term exposure, the allowable temperature difference between upper and lower layers shall not be more than 17°C.

3) Allowable Temperature Difference between Inside and Outside

According to relative standards and actual engineering experience, the control of temperature difference between inside and outside shall be imposed on the parts out of the confining area and the standard temperature difference is determined as 20°C provisionally. For the convenience of construction management, it is required that the allowable highest temperature of upper part concrete of dam body (dam height over 0.4L), which is out of confining area, shall not be more than 44°C, so as to ensure the highest temperature of controlled concrete would not exceed allowable value.

4) Abrupt Temperature Drop of Concrete Surface

If the daily mean temperature drops for 6°C or more within 2 to 4 continuous days, early surface protection shall be provided for the basic parts like base plate of structures

and the exposed concrete surface of 3d to 28d, especially foundation block, upstream surface, gallery tunnels and other important parts.

d) Temperature Control Indicators and Anti-cracking Measures

1) Main Temperature Control Indicators of Concrete Pouring

Refer to Table 7.4.3-4 for major temperature control indicators of concrete pouring.

Table 7.4.3-4 Concrete Temperature Control Indicators Unit: °C

Position	Distance to Foundation Surface	Temperature Control Indicators and Relative Measures	Month		
			1, 2, 12	3~10	11
Dam	0~0.2L	[Tp]°C	23		
		[Tmax]°C	39		
	0.2~0.4L	[Tp]°C	25		
		[Tmax]°C	41		
	More than 0.4L	[Tp]°C	Sent in bunker naturally	27	25
		[Tmax]°C	42	44	42
Powerhouse	Base plate of tailrace pipe	[Tp]°C	21		
		[Tmax]°C	37		
	Area above base plate of tailrace pipe	[Tp]°C	24 24 22		
		[Tmax]°C	40 42 40		

Note: [Tmax] and [Tp] in Table ① refer to allowable highest temperature and allowable pouring temperature inside the pouring block;

2) Measures of Concrete Temperature Control

(1) Reduce temperature rise caused by hydration heat of concrete

Reducing the temperature rise caused by hydration heat of concrete would lessen the temperature stress caused by uneven temperature difference. The temperature rise caused by hydration heat of concrete may be reduced through various measures such as optimization of mix design, utilization of moderate heat Portland cement of calorific value at important parts like foundation, and using of Fly ash as much as possible; under the precondition of ensuring the concrete quality meet the design and construction

requirements, the cement consumption per unit shall be minimized; concrete pouring shall be conducted continuously in thin layers so as to make full use of the layer surface for heat dissipation. In seasons of high temperature, running water cooling shall be provided on concrete surface so as to accelerate the heat dissipation of surface.

(2) Lower temperature of concrete pouring

The following measures are used to improve the construction process, to lower the concrete pouring temperature and to reduce the temperature stress caused by uneven temperature difference:

- Aggregate pile height in finished aggregate yard shall not be less than 6m. Pergola shall be built and water spraying shall be conducted to lower the ambient temperature. It is practical to obtain materials through ridges.
- Simple measures such as cold water spraying and air cooling shall be used for coarse aggregate when necessary. Dewatering measures shall be provided if cold water is used, so as to ensure stable water content of aggregate.
- Flake ice and low-temperature water are used for concrete mixing in seasons of high temperature.
- Cooling water pipe shall be buried in advance to control the temperature rise caused by hydration heat.
- Water spraying and ventilating of mixing plant shall be performed so as to lower the ambient temperature.
- The concrete transportation time shall be reduced and the concrete shall be sent into bunker and be covered as quickly as possible, so as to minimize the time of exposure to sunshine.
- Concrete pouring shall be arranged in morning, evening and night, avoiding construction in the period of high temperature as much as possible. Concrete of foundation parts shall be poured in seasons of low temperature as much as possible.

(3) The foundation excavation of structures is required to be flat so as to avoid stress concentration on structures.

(4) Long intervals shall be avoided when concrete pouring is performed by thin layers.

The pouring layers shall grow continuously and evenly and the interval between pouring shall be not more than 14d. The height difference between adjacent blocks shall not be more than 10m to 12m.

(5) Surface protection shall be well performed. If the daily mean temperature drops for more than 6°C within 2 to 4 continuous days, thermal insulation material shall be applied on the new concrete surface over 3 days until the bunker of upper concrete layer is open. The equivalent heat emission coefficient is required to be not more than 12.56kJ/m.h.°C; for surfaces of pier, wall and foundation concrete, which subject to long term exposure, it is required to use thermal insulation material for heat preservation, of which the equivalent heat emission coefficient is required to be not more than 12.56kJ/m.h.°C; for poured base plate, apron and other thin plate structures, the heat preservation of top surface shall last until the water discharging; time of frame removal shall be determined according to the existing strength of concrete. Besides that, it shall be avoid removing the frame at night or in period during which the temperature drops abruptly. The frame removal shall be delayed if it is expected that the temperature drop of concrete surface may exceed 6°C to 9°C after template removal. If frame removal must be done, thermal insulation material shall be applied immediately after template removal and the equivalent heat emission coefficient is required to be not more than 16.75kJ/m.h.°C.

7.4.4 Installation of Metal Structures and Electromechanical Equipment

7.4.4.1 Quantity and Characteristics of Installation Work

Metal structure, hoisting equipment and electromechanical device to be installed in this project is of total quantity of 45,000t and there are 14 sets of hydro generator to be installed.

The major parts to be installed are headrace and generation system, flood gate system and ship lock system. There are 65 sets of gate, with total weight of 14,141t; 38 sets of intake trash rack, with total weight of 1,540t; 4 sets of trash raft, with total weight of 1200t; 29 sets of hoisting equipment; 2 sets of portal crane; and water turbines, generators and transformers, with total weight of 17654t; there are also water-turbine generator set and related pipelines, auxiliary equipment and electrical devices.

Refer to Table 7.4.4-1 for installation quantity of metal structure and hoisting equipment; refer to Table 7.4.4-2 for technical parameters of gate and hoisting equipment; and refer to Table 7.4.4-3 for main electrical devices of unit.

Table 7.4.4-1 Installation Quantity of Metal Structures and Hoisting Equipment

Unit: t

Item	Flood gate system	Headrace and generation system	Ship lock system	Fishway	Total
Gate	7365	6138	621	17	14141
Trash rack	0	1540	0	0	1540
Trash raft	0	1200	0	0	1200
Embedded parts	1439	2116	443	8	4006
Hoisting equipment/portal crane	2020	680	180	5	2885
Total	10824	11674	1244	30	23772

Table 7.4.4-2 Technical Parameters of Gate and Hoisting Equipment

S/N	Name	Capacity	Specification	Qty.	Unit	Unit Weight (t)	Subtotal (t)	Remarks
1. Flood discharge system							10824	
1.01	Bulkhead gate (I) at upstream of flood gate	Plane stoplog sliding gate	16.0m×29.0m-28.000m	1	Set	500	500	
1.02	Embedded part of bulkhead gate (I) at upstream of flood gate			3	Pc.	30	90	
1.03	Bulkhead gate (II) at upstream of flood gate	Plane stoplog sliding gate	16.0m×20.3m-20.00m	1	Set	350	350	
1.04	Embedded part of bulkhead gate (II) at upstream of flood gate			11	Pc.	23	253	
1.05	Bulkhead gate hoist at upstream of flood gate	Two-way portal crane	2×800kN/2×630kN	1	Set	650	650	
1.06	Rail of portal crane at dam crest of flood gate		QU120	1	Set	105	105	Single piece is about 285m long; double piece
1.07	Service gate of flood discharge gate deep orifice	Radial gate	16.0m×28.50m-28.000m	3	Set	550	1650	

1.08	Embedded part of service gate of flood discharge gate deep orifice			3	Pc.	40	120	
1.09	Service gate hoist of flood discharge gate deep orifice	Hydraulic hoist	2×6500kN	3	Set	110	330	
1.10	Service gate of flood discharge gate shallow orifice	Radial gate	16.0m×20.5m-20.000m	11	Set	330	3630	
1.11	Embedded part of service gate of flood discharge gate shallow orifice			11	Pc.	29	319	
1.12	Service gate hoist of flood discharge gate shallow orifice	Hydraulic hoist	2×3800kN	11	Set	70	770	
1.13	Bulkhead gate at downstream of flood gate	Plane stoplog sliding gate	16.0m×20.40m-20.14m	2	Set	320	640	
1.14	Embedded part (I) of bulkhead gate at downstream of flood gate			3	Pc.	29	87	
1.15	Embedded part (II) of bulkhead gate at downstream of flood gate			5	Pc.	23	115	
1.16	Embedded part (III) of bulkhead gate at downstream of flood gate			6	Pc.	15	90	
1.17	Bulkhead gate hoist at downstream of flood gate	Two-way portal crane						Common portal crane on dam crest
1.18	Emergency bulkhead gate of sand flushing bottom outlet	Plane fixed wheel gate	10.0m×12.1m-35.0m	1	Set	165	165	
1.19	Embedded part of emergency bulkhead gate of sand flushing bottom outlet			2	Pc.	50	100	
1.20	Emergency bulkhead gate hoist of sand flushing bottom outlet	Trolley	2500kN	1	Set	110	110	Including the rail
1.21	Service gate of sand flushing bottom outlet	Plane fixed wheel gate	10.0m×12.0m-35.0m	2	Set	160	320	
1.22	Embedded part of service gate of sand flushing bottom outlet			2	Pc.	50	100	
1.23	Service gate hoist of sand flushing bottom outlet	Fixed winch hoist	3200kN	2	Set	80	160	
1.24	Bulkhead gate of sand flushing bottom outlet	Plane sliding gate	10.0m×10.0m-30.55m	1	Set	110	110	
1.25	Embedded part of bulkhead gate of sand flushing bottom outlet			2	Pc.	30	60	
1.26	Bulkhead gate hoist of sand flushing bottom outlet	Single-way portal crane						Common tailrace portal crane
2. Diversion generation system							11674	
2.01	Intake trash rack	Plane perpendicular trash rack	6.65m×28.0m-4.0m	28	Set	55	1540	
2.02	Embedded parts of intake trash rack and guide slot			28	Pc.	25	700	

2.03	Intake bulkhead gate	Plane stoplog sliding gate	15.1m×16.3m-38.98m	14	Set	260	3640	Include 10 sets of temporary water retaining gate
2.04	Intake bulkhead gate embedded part			14	Pc.	33	462	
2.05	Embedded part of intake bulkhead gate chamber			14	Pc.	5	70	
2.06	Portal crane at dam crest of intake	Two-way portal crane	2×1000kN/2×400kN	1	Set	360	360	Include trash removing devices
2.07	Portal crane rail of intake		QU100	1	Set	100	100	Single piece is about 345m long; double piece
2.08	Tailrace emergency gate	Plane fixed wheel gate	13.6m×10.88m-32.44m	5	Set	190	950	Maximum water head difference of lower gate is 20m
2.09	Tailrace temporary water retaining gate	Plane sliding gate	13.6m×10.88m-32.44m	9	Set	172	1548	
2.1	Embedded part of tailrace emergency gate			14	Pc.	41	574	
2.11	Tailrace portal crane	Single-way portal crane	2×1600kN	1	Set	320	320	
2.12	Rail of tailrace portal crane		QU120	1	Set	130	130	Single piece is about 345m long; double piece
2.13	Intake trash raft			4	Set	300	1200	
2.14	Intake trash raft guide slot			4	Set	20	80	
3. Ship lock system							1244.0	
3.01	Emergency bulkhead gate of upstream lock head	Plane sliding gate	12.0m×5.73m-5.23m	1	Set	42	42	
3.02	Embedded part and chamber of emergency bulkhead gate of upstream lock head			1	Pc.	15	15	
3.03	Hoist equipment of emergency bulkhead gate of upstream lock head	Bridge crane	2×500kN	1	Set	80	80	
3.04	Upstream lock head bridge crane rail		QU80	1	Set	12	12	Single piece is about 44m long; double piece

3.05	Service gate of upstream lock head	Herringbone gate	12.0m×7.0m-5.0m	1	Set	70	70	
3.06	Embedded part of service gate of upstream lock head			1	Pc.	8	8	
3.07	Service gate hoist of upstream lock head	Hydraulic hoist	2×320kN	1	Set	8	8	
3.08	Service gate of downstream lock head	Herringbone gate	12.0m×27.0m-21.0m	1	Set	290	290	
3.09	Embedded part of service gate of downstream lock head			1	Pc.	25	25	
3.1	Service gate hoist of downstream lock head	Hydraulic hoist	2×1250kN	1	Set	25	25	
3.11	Bulkhead gate of downstream lock head	Plane sliding gate	12.0m×9.64m-9.14m	1	Set	58	58	
3.12	Embedded part of bulkhead gate of downstream lock head			1	Pc.	20	20	
3.13	Bulkhead gate hoist of downstream lock head	Fixed winch hoist	2×630kN	1	Set	25	25	
3.14	Floating mooring ring			12	Set	2.5	30	
3.15	Embedded part of floating mooring ring			12	Pc.	6.5	78	
3.16	Service gate of water delivery gallery of upstream and downstream lock head	Reversed radial gate	2.2m×2.6m-30.53m	4	Set	32	128	
3.17	Service gate embedded part of water delivery gallery of head and downstream lock head			4	Pc.	50	200	
3.18	Service gate hoist of water delivery gallery of head and downstream lock head	Hydraulic hoist	630kN	4	Set	8	32	
3.19	Bulkhead gate of water delivery gallery of upstream lock head	Plane sliding gate	2.2m×3.3m-12.53m	2	Set	8	16	
3.2	Bulkhead gate embedded part of water delivery gallery of upstream lock head			2	Pc.	6	12	
3.21	Bulkhead gate of water delivery gallery of downstream lock head	Plane sliding gate	2.2m×3.3m-14.44m	2	Set	8.5	17	
3.22	Bulkhead gate embedded part of water delivery gallery of downstream lock head			2	Pc.	9	18	
3.23	Bulkhead gate hoist of water delivery gallery of downstream lock head	Fixed winch hoist	250kN	2	Set	5	10	
3.24	Intake trash rack and embedded part of water delivery gallery of upstream lock head	Fixed type	2.3m×3.3m-5.0m	10	Set	2.5	25	
4. Fish pass system							30	
4.01	Upstream flood control service gate	Plane sliding gate	6.0m×3.0m-2.99m	1	Set	6	6	
4.02	Embedded part of upstream flood control service gate			1	Set	4	4	
4.03	Hoist of upstream flood control service gate	Fixed winch hoist	2×100kN	1	Pc.	5	5	
4.04	Downstream flood control gate	Plane sliding gate	6.0m×3.0m-3.36m	1	Set	6	6	
4.05	Embedded part of downstream flood control gate			1	Pc.	4	4	

4.06	Downstream flood control gate hoist	Fixed winch hoist	2×100kN	1	Set	5	5	
5. Total							23772	

Table 7.4.4-3 Installation Quantity of Generator Unit and Main Electrical Equipment

Category	Equipment	Unit	Installation Quantity	Remarks
Generator Unit	55MW water turbine	Set/t	14/756	
	55MW generator	Set/t	14/395	
	Bridge crane	t	2×165 1×42	
Main electrical equipment	Main transformer	Set	5	Transportation weight 110t
	GIS	t	36×8	

7.4.4.2 Installation Site Planning

Based on the installation scale of metal structures and electromechanical devices of this project, it is proposed to arrange metal structure installation site at the right end of Mekong River Bridge, which is about 1200m downstream the dam site. The site elevation is 240.00m.

7.4.4.3 Metal Structure Installation

To guarantee the installation quality of metal structure and to avoid work concentration of metal structure installation in the later period of construction, it is proper to arrange civil construction and hand over installation working surface by stages and in groups as early as possible, so as to prepare for installation in advance.

1) Installation of Embedded Part

Gate embedded parts are stacked on installation site of metal structures. They are delivered to the orifice by 10t truck through the road to dam and lifted to right position by lifting equipment for concrete construction. Concrete backfilling of the second stage is performed after the inspection and acceptance of embedded part installation.

2) Installation of Radial Gate Leaf

Installation of radial gate includes the assembling and welding of trunnion, radial arm and gate leaf, as well as the water seal installation. Components of radial gate are stacked on installation site of metal structures.

The gate is installed after the crest bridge construction is completed. The components are delivered to the orifice by 15t to 40t truck through road to dam and lifted to right position for installation in blocks by lifting equipment for concrete construction and other auxiliary facilities.

3) Installation of Portal Crane on Dam Crest

Powerhouse, spillway gate and ship lock are provided with 3 sets of portal cranes for each (in which: 1 set is located at the water inlet of dam crest; 1 set is provided for tailrace; and 1 set is located at the dam crest of flood gate). The portal cranes mainly consist of main and auxiliary trolley, cart running mechanism, portal and other components. Components of portal crane are delivered to installation position by 30t trailer and lifted by 90t truck crane in the sequence of cart running mechanism, landing leg, main beam and lifting trolley.

4) Metal structures of navigation structure are lifted for installation by lifting equipment for concrete construction.

7.4.4.4 Installation of Electromechanical Equipment

a) Transportation of Turbogenerator Unit

It is primarily proposed to transport the heavy and large components of turbogenerator unit to Port Bangkok of Thailand by sea and then to the construction site through highway. Part of the components can be delivered to the construction site by water transportation directly.

The permanent access road of this project is leading to the powerhouse through the left bank. The unit equipment is transported into the site as per the conventional construction procedures.

b) Installation of Bridge Crane

Two sets of 165t bridge cranes are arranged in powerhouse of the Project. Installation of bridge cranes must be completed before unit installation. Best effort shall be made to install the bridge crane before powerhouse capping, with the portal crane for concrete pouring, or the special crane.

c) Unit Installation

Spiral case of water turbine is lifted by bridge crane in powerhouse. The case tiles are spliced and welded in the foundation pit. Pump-in test is performed for the tiles. Generator stator is piled up on site for installation.

7.4.4.5 Installation Schedule

a) Gate Installation Schedule

Installation of radial gate of door: Flood gate installation is arranged from February to November of the 3rd year, with a period of 10 months.

Installation of headrace and tailrace gates: Headrace gate installation of the first stage is arranged from April to May of the 5th year, with a period of 2 months; tailrace gate installation is arranged from February to March of the 5th year, with a period of 2 months.

b) Installation Schedule of Ship Lifting Equipment

According to general construction schedule, the ship lifting equipment is proposed to be installed from June to November of the 3rd year, with a period of 6 months.

c) Installation Schedule of Electromechanical Equipment

The electromechanical equipment will be installed after the concrete pouring of powerhouse structures is completed. The first-batch unit (2 sets) will be installed from September of the 5th year to June of the 6th year, with a period of 10 months. The other batches of units are installed every 3-4 months for each batch (2 units) and the installation is completed at the end of March in the 8th year.

7.5 Transport for Construction

7.5.1 Site Access

7.5.1.1 Existing Site Access Conditions

Pak Lay Hydropower Station is located on the main stream of Mekong River in Laos, where the 1829km stake mark is. The project site (downstream) is about 251km away from the Vientiane Highway, 31km away from the town-level Pak Lay Highway and about 6km away from the mouth of Namphoun River. There is no national main line or provincial highway leading to the dam site area on either bank. The only connection between the dam site to the external world is only country road.

There is no railway in Laos and the railway in Thailand can only reach the border between Thailand and Laos.

For water transportation of Mekong River, the channel from Luang Prabang to Vientiane is of poor shipping condition, which provides only low shipping capacity and even lower capacity in dry seasons due to flow and riffle.

a) Highway

There are three national trunk highways near the project area: the first one is 11# highway from Vientiane (the capital of Laos) to Pak Lay; the second one is 4# highway from Luang Prabang to Loewi (in Thailand), and 11# highway intersects with 4# highway in Pak Lay; the third one is 13# highway from Vientiane to Jinghong (in China), and 13# highway intersects with 4# highway in Luang Prabang. In Pak Lay, there is a highway, the 4# highway, leading to mouth of Namphoun downstream the dam site, of which the section between Pak Lay and Namphoun Village is about 17km; Namphoun Village is connected to mouth of Namphoun River by a 8km long country road which is to be upgraded; mouth of Namphoun River is about 5km away from the right end of the proposed Mekong River Bridge downstream the dam site. There is no highway in this section. New access road is required to be built and standards of the newly built highway are improved: Class III highway, subgrade width of 8.5m, pavement width of 7.0m and concrete pavement. The access road crosses the Namphoun River at the mouth, where a bridge of 140m long is required to be built.

Transportation from Vientiane to Pak Lay is mainly through 11# highway. The highway extends upward along the left bank of Mekong River, while crossing about 20 bridges and culverts set for various gullies and small rivers, and after going through Mekong River ferry in the lower reach of Pak Lay, it turns to the right bank to Pak Lay. The mileage of 11# highway is about 220km and the pavement width is about 6m. Except that the sections in the main villages and towns are of asphalt concrete pavements, the other sections are earth roads. There is no bridge crossing the Mekong River within dam site area. The banks are connected by the Mekong River Ferry downstream Pak Lay as the

major river crossing transportation facility. A cross-river bridge is being built about 200m downstream the ferry, and the bridge length is 370m.

At present, the transportation routes leading to dam site area are:

1) Friendship Bridge of Nong khay in Thailand → Vientiane → 13# Highway → Xiang Ngeun → 4# Highway → Pak Lay;

2) Friendship Bridge of Nong khay in Thailand → Vientiane → 11# Highway → Pak Lay;

3) Loewi in Thailand → Namheung → 4# Highway → Pak Lay;

4) Mohan in China → 13# Highway → Xiang Ngeun → 4# Highway → Pak Lay;

b) Waterway

The flow path of Mekong River in Indo-China Peninsula can be divided into the upper reach, middle reach, lower reach and delta. The upper reach starts from the border of China, Burma and Laos and ends at Vientiane, with a length of 1053km. The altitude of the area in which the upstream Mekong River flows through is 200m~1500m. The area subjects to ragged topography, with mountain ranges blocking the river. The river course bends for several times and the width of river valley is constantly changing (sometimes wide and sometimes narrow). The river bed slope is relatively steep, with lots of torrents and shoals.

After the dredging of the upstream Mekong River and the canalization of channels, the 71km long channel from the Jinghong Port to the No. 243 boundary monument between China and Burma ranks Class V, and the navigation capacity of a single ship reaches 300t ~ 500t. The 331km long channel from the No. 243 boundary monument between China and Burma to Houayxay (in Laos) has the navigation capacity of 200t~300t ships throughout the year and the annual navigation period is 10~11 months. The channel from Houayxay to Luang Prabang is a 300km long original river course for 150t ships. The navigation channel downstream Luang Prabang has relatively poor navigation capacity.

There are 3 major transportation routes leading to construction site through waterway or combination of waterway and highway:

1) The first one goes along Mekong River and enters Laos at Houayxay or Luang Prabang, and then gets to dam site area through waterway with small-tonnage ships along Mekong River or highway.

2) The second one goes to Port Bangkok in Thailand and enters Laos at Kenthao after passing Loewi in Thailand through internal highway. It then gets to dam site area through highway. It is also practical to leave Laos at Nong khay through the internal railway of Thailand and enter Laos again at Vientiane through highway, and then get to dam site area.

3) Sanakham (in Laos) is about 110km (river course distance) downstream the dam site. Chiang Khan (in Loewi, Thailand) is on the opposite side of the river. Wharfs are established in Chiang Khan for collecting and distributing of shipped materials, from which the cement, steel products and other materials imported from Thailand are delivered to dam site area through water transportation.

According to the actual traffic condition aforementioned, the external transportation of the Project is mainly the combination of water transportation and road transportation. The materials purchased nearby are transported to the construction site through highway; the foreign materials from Jinghong, China can be shipped to Houayxay by water transportation and then to the construction site by road transportation; foreign materials from Thailand can be shipped to Chiang Khan Port Wharf through waterway and then transported to the construction site through highway.

7.5.1.2 Transportation of Foreign Materials

a) Total quantity of foreign materials transportation and quantities of each year

Refer to Table 7.5.1-1 for each year's quantity of external material transportation in this project, which is listed upon calculation.

Table 7.5.1-1 Freight Quantity of Each Year Unit: t

Item	Freight Quantity								
	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	Total
Cement	1650	151200	70610	98620	86350	4800	300	100	413630
Timber	100	23940	11180	15610	13670	760	190	40	65490
Rebar and steel products	459	24378	13545	16598	14777	1011	329	135	71232
Fly ash	330	30240	14122	19724	17270	960	60	20	82726
Construction machinery	26	7371	3445	4810	4212	234	65	13	20176
Permanent electromechanical equipment	0	0	0	2890	3935	5915	5175	0	17915
Explosive material	364	1056	480	430	350	25	12	12	2729
Coal	117	26208	12233	17095	14963	832	208	39	71695
Oil	996	21775	10175	14205	12430	2691	569	436	63277
Building materials	11165	39690	18540	25890	22665	1260	315		119525
Living materials	180	42525	19860	27735	24285	1350	345	75	116355
Others	180	43470	20310	28350	24840	1380	360	60	118950
Total	15567	511853	194500	271957	239747	21218	7928	930	1163700

According to the Table above, the total quantity of external material transportation is 1,163,700t and the peak quantity exists in the 2nd year, with annual quantity of 411,800t.

b) Transportation Intensity of Foreign Materials

According to calculation on freight quantity of each year, the peak annual intensity is 411,800t and the peak monthly intensity is 51,400t. The peak daily intensity is 2,400t.

c) Major Destination of Foreign Materials

According to actual condition of this project, the cement is proposed to be imported from Thailand and delivered to construction site through road or water transportation; Fly ash is imported from Thailand and delivered to construction site through road or water transportation; rebar and steel products are also imported from Thailand and delivered to construction site through road or water transportation; most materials such as oil, explosive

materials, timber, building materials and living materials are purchased locally and delivered to construction site through road or water transportation.

7.5.1.3 Transportation of Heavy and Large Equipment

Heavy and large equipment mainly includes main transformer, generator rotor, turbine runner and bridge crane crossbeam, etc. The main transformer and generator rotor are the key equipment for transportation control. Refer to Table 7.5.1-2 for transportation characteristics of such equipment.

Table 7.5.1-2 Transportation Characteristics of Heavy and Large Equipment

Name of Heavy and Large Equipment	Unit	Qty.	Transport Dimension m×m×m	Unit Weight t
Turbine	Set	14		756
Turbine hub	Set	14	φ3.0×5.0	65
Generator	Set	14		395
Rotor support	Set	14	5.2×5.2×2.2	40
Cross beam of bridge crane	Pc.	4	22.0×3.0×3.0	60
Main transformer	Set	5	6.5×4×6.8	110

According to site access condition of this project, the heavy and large components of electromechanical equipment are primarily proposed to be shipped to Port Bangkok by sea (superheavy components can be shipped in divided parts), and then to dam site area through road transportation after passing Loewi in Thailand and entering Kenthao in Laos through internal highway of Thailand.

7.5.2 On-site Access

a) Principle of On-site Access Layout

1) Construction road layout must be accessible and reliable, and shall form the mutual standby construction path of left and right bank, upstream and downstream;

2) Transport networks of various elevations are arranged according to the construction schedule and the water level, initial filling of years, so as to ensure the smooth traffic at different construction periods;

3) On-site access layout within construction area is coordinated with layout of construction site to minimize the distance of material transportation;

4) The connection between high and low traffic paths is determined according to excavated road layout of dam abutment;

5) Combination of permanent and temporary roads within the construction site shall be taken into consideration.

b) Planning of Main Transport Lines in Site

There is no bridge crossing the Mekong River within dam site area. The banks are connected by the Mekong River Ferry downstream Pak Lay as the major river crossing transportation facility, which cannot satisfy the transport demand between left and right bank during the construction period of Pak Lay Hydropower Station. Therefore, it is required to build a bridge over Mekong River about 1.0km downstream the dam site to connect the left and right bank. The bridge is proposed to be 530m long, 9.5m wide and with load grade of Class I highway.

According to the needs of construction layout and main work construction, the new main lines to be built in project area are:

Right bank:

1) Road to dam on right bank (Road ①), which starts at right end of Mekong River Bridge (terminal point of access road), with elevation of 240.000m and ends at right dam abutment, with elevation of 245.00m; it is 1.4km long. Design standard: Class III highway, with subgrade width of 8.5m and concrete pavement of 7.0m wide; it is a permanent road.

2) Road to the downstream cofferdam of right river bed and the foundation pit (Road ③), which starts at Road ①, with elevation of 240.00m and ends at foundation pit of right river bed, with elevation of 203.00m; it is about 0.5km long. Design standard: Class III highway, with subgrade width of 8.5m and clay bound macadam pavement of 7.0m wide; it is a temporary road.

3) Road to borrow pit (Road ⑤), which starts at the right jetty head, with

elevation of 245.00m and ends at waste disposal area on right bank, with elevation of 235.00m; it is about 1.0km long. Design standard: Class III highway, with subgrade width of 8.5m and clay bound macadam pavement of 7.0m wide; it is a temporary road.

4) Road to the upstream cofferdam of right river bed and the foundation pit (Road ⑦), which starts at Road ⑤, with elevation of 240.00m and ends at foundation pit of right river bed, with elevation of 225.00m; it is about 0.8km long. Design standard: Class III highway, with subgrade width of 8.5m and clay bound macadam pavement of 7.0m wide; it is a temporary road.

5) Road to the waste disposal area on left bank and the explosive materials warehouse (Road ⑨), which starts at Road ①, with elevation of 242.00m and ends at explosive materials warehouse, with elevation of 277.00m; it is about 1.0km long. Design standard: Class III highway, with subgrade width of 8.5m and clay bound macadam pavement of 7.0m wide; it is a temporary road.

Left bank:

1) Road to dam on left bank (Road ②), which starts at left end of Mekong River Bridge, with elevation of 240.00m and ends at left dam abutment, with elevation of 245.00m; it is 1.4km long. Design standard: Class III highway, with subgrade width of 8.5m and concrete pavement of 7.0m wide; it is a permanent road.

2) Road to the downstream cofferdam of left river bed and the foundation pit (Road ④), which starts at Road ②, with elevation of 242.00m and ends at foundation pit of left river bed, with elevation of 225.00m; it is about 0.9km long. Design standard: Class III highway, with subgrade width of 8.5m and clay bound macadam pavement of 7.0m wide; it is a temporary road.

3) Road to Dajiang Quarry Area (Road ⑥), which starts at the left abutment, with elevation of 245.00m and ends at Dajiang Quarry Area, with elevation of 310.00m; it is about 3.0km long and is slightly higher than design water level. Design standard: Class III highway, with subgrade width of 8.5m and concrete pavement of 7.0m wide; it is a temporary road.

4) Road to the upstream cofferdam of left river bed and the foundation pit (Road ⑧), which starts at Road ⑥, with elevation of 247.00m and ends at foundation pit of left river bed, with elevation of 203.00m; it is about 0.8km long. Design standard: Class III highway, with subgrade width of 8.5m and clay bound macadam pavement of 7.0m wide; it is a temporary road.

5) Road to waste disposal area on left bank (Road ⑩), which starts at Road ⑥, with elevation of 275.00m and ends at waste disposal area on left bank, with elevation of 315.00m; it is about 0.4km long. Design standard: Class III highway, with subgrade width of 8.5m and clay bound macadam pavement of 7.0m wide; it is a temporary road.

6) Road to Dajiang Quarry Area (Road ⑫), which starts at Road ⑥, with elevation of 290.00m and ends at exploiting platform of Dajiang Quarry Area, with elevation of 400.00m; it is about 1.60km long and is significantly higher than design water level. Design standard: Class III highway, with subgrade width of 8.5m and concrete pavement of 7.0m wide; it is a temporary road.

Refer to Table 7.5.2-1 for characteristics of roads in site.

Table 7.5.2-1 Characteristics of Construction Roads and Bridges in Site

Location	No.	Starting and Ending Point	Highway Class	Highway Mileage km	Subgrade Width m	Pavement Width m	Pavement Type	Remarks
Right bank	①	Road to dam on right bank	III	1.4	8.5	7	Concrete	Permanent road
	③	Road to the downstream cofferdam of right river bed and the foundation pit	III	0.5	8.5	7	Clay bound macadam	Temporary road
	⑤	Road to borrow pit	III	1.0	8.5	7	Clay bound macadam	Temporary road
	⑦	Road to the upstream cofferdam of right river bed and the foundation pit	III	0.8	8.5	7	Clay bound macadam	Temporary road
	⑨	Road to the waste disposal area on right bank and the	III	1.0	8.5	7	Clay bound	Temporary road

		explosive material warehouse					macadam	
Left bank	②	Road to dam on left bank	III	1.4	8.5	7	Concrete	Permanent road
	④	Road to the downstream cofferdam of left river bed and the foundation pit	III	0.9	8.5	7	Clay bound macadam	Temporary road
	⑥	Road to Dajiang Quarry Area, which is slightly higher than design water level	III	3.0	8.5	7	Concrete	Temporary road
	⑧	Road to the upstream cofferdam of left river bed and the foundation pit	III	0.8	8.5	7	Clay bound macadam	Temporary road
	⑩	Road to waste disposal area on left bank	III	0.4	8.5	7	Clay bound macadam	Temporary road
	⑫	Road to Dajiang Quarry Area, which is significantly higher than design water level	III	3.0	8.5	7	Concrete	Temporary road
Other roads			III	5.4	7	6	Clay bound macadam	Temporary road
Total of roads in site				18.2				
Mekong River Bridge			Load grade: Class I road of 530m long and 9.5m wide					

7.6 Construction Processing Facility

7.6.1 Aggregate processing system

a) Overall Planning

Total concrete amount of the Project is 1,697,600m^3, and total demand for concrete aggregate is about 3,740,000t, in which, coarse aggregate is 2,430,000t and fine aggregate is 1,310,000t.

According to overall planning and general layout of construction, an aggregate processing system is proposed to be set 2.0km (straight-line distance) upstream the dam site on left bank. This system is about 400m southeast to Dajiang Quarry Area. During main work construction, the aggregate processing system use rock from Dajiang Quarry Area to product concrete aggregates for the two concrete production

systems on left and right bank of dam area. Concrete production system on right bank is about 400m downstream the dam axis and the system on left bank is located about 900m upstream the dam axis.

b) Scale of production

According to general construction schedule, the peak period of concrete pouring exists from June of the 2nd year to March of the 3rd year, during which the concrete pouring quantity is about 625,600m^3. The mean monthly pouring intensity of the peak period is 69,300m^3/month. With the monthly unbalance factor valued as 1.25, the mean monthly pouring intensity is determined as 86,000m^3/month. The production scale of aggregate processing system is determined, based on a double shift plan, as handling capacity of 750t/h and production capacity of 600t/h. The produced concrete aggregates mainly supply the main works of the first and second stage, as well as the diversion works.

c) Process Flow and Equipment Type Selection

In consideration of the large amount and high production intensity of aggregates for this project, as well as the significantly different concrete pouring intensity of different construction periods, coarse aggregate is produced by combining open-circuit coarse crushing & secondary crushing with closed-circuit fine crushing & screening, and artificial sand is produced through closed-circuit fine crushing, superfine crushing (by using a vertical shaft impact crusher) and screening according to the process flow design. Rod mill is also provided for sand manufacturing as an auxiliary. This process flow, with relatively low circulation load rate, makes sand by crushing instead of grinding. It can adjust the grading of aggregates flexibly.

As the raw material is grey micrite, there may be a few karst caves developed in the stock yard based on preliminary geological judgment. There may be silt in the rock formation. Thus, the special washing process is under consideration, so as to control the silt content of finished aggregate.

Refer to *Process Flow Chart of Aggregate Processing System* for details.

d) Process Layout

Based on the site terrain, geological conditions and quarry location, as well as the principle of proximity, the aggregate processing system is intensively located near Dajiang Quarry Area on the left bank about 2.0km (straight-line distance) upstream the dam site, with an elevation of 300.000m to 330.000m. The system consists of coarse crushing workshop, semi-finished product stock yard, screening and washing workshop, size screening workshop, fine crushing workshop, super fine crushing workshop (sand-making by crushing), check screening workshop, rod milling workshop, mountain flour recycle workshop, finished product stock yard and power supply, water supply and drainage facilities, etc.

The workshops distribute along the slopes on both sides of the existing highway within the gully beneath the Dajiang Quarry Area, in a step like pattern from top to the bottom. As the north side of gully is close to the quarry area, most of the workshops are located on the south side of gully for the safety. Rock ballast is used for backfilling of gully bottom to create a platform as the stock yard of finished product. The waste water treatment facility of the system is located near the highway with lower elevation, so as to reduce the excavation quantity. The overall layout elevation of the system exceeds the water level of a 20-year return flood.

Raw material from quarry area is delivered to coarse crushing workshop of the aggregate processing system by dump truck. The combination of chute and adit can be adopted for exploitation delivery. The finished aggregate materials are transported to the two concrete production systems within dam area by dump trucks.

Water & power supply and waste water treatment: The total water demand of the aggregate processing system is about 1000 m^3/h and the water for processing is taken from Mekong River; the peak power consumption is about 4,760kW and the power is all supplied by diesel generating set; the designed capacity of waste water treatment is 850m^3/h. The waste water generated during aggregate processing flows to the waste water treatment facility through escape canal and is recycled and reused after treatment.

Refer to Table 7.6.1-1 ~ 2 for main technical indicators and equipment of aggregate processing system.

Refer to *Process Flow Chart of Aggregate Processing System* for the process flow of aggregate processing system.

Table 7.6.1-1 Main Technical Indicators of Sandstone Processing System

S/N	Item		Unit	Indicator	Remarks
1	Scale of production	Treatment capacity	t/h	750	
		Production capacity	t/h	600	
2	Working shift		shift/d	2	The total time for two shifts is 14h
3	Fixed member		Person	200	Excluding workers for exploitation and transportation in quarry area
4	Installed capacity		kW	6800	Including the standby capacity
5	Water demand		m^3/h	1000	
6	Capacity of semi-finished product stock yard		10,000 m^3	5	The dump capacity is 20,000m^3 and can meet the demand in 3d of peak period
7	Capacity of finished product stock yard	Sand	10,000 m^3	5	The dump capacity is 50,000m^3 and can meet the demand in 7d of peak period
		Broken stone	10,000 m^3	7.5	
8	Building area		m^2	1000	Excluding living and office occupancy
9	Floor area		10,000m^2	10	Including roads in system and excluding production and living camp

Table 7.6.1-2 Main Equipment of Sandstone Processing System

S/N	Name	Spec. & Model	Unit	Qty.	Power (kW)		Remarks
					Single Set	Total	
1	Jaw crusher	C125	Set	2	160	320	Coarse crushing workshop (imported)
2	Bar type vibrator feeder	SV1562	Set	2	44	88	Coarse crushing workshop (imported)
3	Cone crusher	GP300S	Set	2	250	500	Screening, washing and secondary crushing workshop (imported)
4	Cone crusher	HP400	Set	2	315	630	Fine crushing workshop (imported)
5	Vertical shaft impact crusher	PL9500	Set	2	2×220	880	Super fine crushing workshop (sand-making)

6	Screw washer	2WCD-1118	Set	2	2×30	120	Screening, washing and secondary crushing workshop
7	Rod mill	MBS-Z2136	Set	3	210	630	Rod milling workshop (including one standby mill)
8	Round vibrating screen	2YKR2460	Set	2	30	60	Screening, washing and secondary crushing workshop
9	Round vibrating screen	2YKR2460	Set	8	30	240	Size screening workshop
10	Round vibrating screen	3YKR2460	Set	4	45	180	Check screening workshop
11	Linear vibrating screen	ZKX1236	Set	11	7.5	82.5	Size screening, check screening and rod milling workshop (including one standby set)
12	Grit box	$5m^3$	Pc.	8			Size screening workshop and check screening workshop
13	Spiral classifier	FC-12	Set	8	11	88	Size screening workshop and check screening workshop
14	Spiral classifier	FC-15	Set	3	15	45	Rod milling workshop (including one standby mill)
15	Electric vibrator feeder	GZG130-4	Set	16	2×1.5	48	Semi-finished product stock yard (4 sets run at the same time)
16	Electric vibrator feeder	GZG100-4	Set	10	2×1.1	22	
17	Electric vibrator feeder	GZG80-4	Set	4	2×0.75	6	
18	Disk feeder	DB1600	Set	3	3	12	Rod milling workshop (2 sets run at the same time)
19	Hydraulic lithotripter	SDW60	Set	2	58.8	117.6	Screening of large rock block during raw material crushing
20	Sealing-tape machine	B=1000mm	m	1320		1000	18 pieces in total
21	Sealing-tape machine	B=800mm	m	870		368	26 pieces in total
22	Sealing-tape machine	B=650mm	m	202		45	3 pieces in total
23	Sealing-tape machine	B=500mm	m	195		24	6 pieces in total
24	Bulldozer	Yishan-80	Set	1			Finished product stock yard

25	Dump truck	20t	Set	20			Excluding standby
26	Wheel-type loader	$3m^3$	Set	3			It is used to transport finished aggregates and there shall be one standby dump truck.
27	Efficient waste water purifier	DH-SSQ-300	Set	3			Waste water treatment system
28	Efficient coagulation mixer	DH-HNQ-300	Set	3			
29	Sludge mixer	DH-HNQ-150	Set	4			
30	Coagulant aids stirring apparatus	7.5KW	Set	2	7.5	15	
31	Flocculating agent stirring apparatus	4KW	Set	2	4	8	
32	Regulating reservoir stirring apparatus	18.5KW	Set	2	18.5	37	
33	Sludge tank stirring apparatus	22KW	Set	1	22	22	
34	Combined vibrating screen	FMVS2030	Set	2	3.92	7.84	
35	Cyclone group	NZ-5 or NFN300	Set	2			
36	Belt conveyer	Width: 500mm; length: 45m	Pc.	1	11	11	
37	Waste water lift pump of purifier	150ZM-36	Set	3	75	225	
38	Waste water lift pump of vibrating screen	150ZM-30	Set	4	55	220	
39	Sludge pump	100ZM-60	Set	4	55	220	
40	Clean water recycling pump	SLW300-400	Set	3	110	330	
41	Plate-and-frame filter press		Set	4	8	32	

7.6.2 Concrete Production System

7.6.2.1 Overall Planning

Concrete production systems are located on both left and right bank of dam site, 1 for each, according to general construction schedule, transportation plan of concrete pouring

and overall layout. The concrete production system on right bank is located about 400m (straight-line distance) downstream the dam site. It produces 910,800m^3 concrete for the first stage construction, ship lock work, diversion and right bank work of Phase I powerhouse, etc.; concrete production system on left bank is located about 900m (straight-line distance) upstream the dam site. It produces 786,800m^3 concrete for left bank work of the second stage, diversion and left bank work of Phase II powerhouse, etc.

The finished aggregate for the two concrete production systems is supplied by the aggregates processing system 2.0km upstream the dam site on left bank. The aggregates are delivered to the truck receiver bin of the systems by dump truck.

The cement in bulk and Fly ash for the two concrete production systems are transported respectively from the cement plant by bulk tank truck through the downstream access road on right bank.

7.6.2.2 Concrete production system on right bank

Concrete production system on right bank is located 400m (straight-line distance) downstream the dam site, with the material discharging elevation of 230.00m. The concrete is discharged by dump truck and then delivered to the pouring bunker by portal (tower) crane.

a) Production Scale and Batching and Mixing Plant Configuration

According to construction schedule, the mean monthly pouring intensity during peak period of main work construction is 69,300m^3, which exists from June of the 2nd year to March of the 3rd year. In consideration of monthly unbalance factor, the peak monthly pouring intensity is 86,000m^3. Therefore, designed production capacity of concrete production system is determined as 260m^3/h. There is 1 HL320-2S4500L concrete batching and mixing plant provided.

b) Process Flow

Concrete production system consists of finished aggregate storage and delivery facility, cement and Fly ash storage and delivery facility, concrete precooling system, concrete mixing plant and other auxiliary facilities.

Finished aggregate is delivered by dump truck from the finished aggregates stock yard of aggregate processing system to the finished aggregate tank of concrete production system for storage. Coarse aggregate is delivered in aggregates tank to the concrete mixing plant for secondary screening and washing. Fine aggregate in finished aggregate tank is directly delivered to the concrete mixing plant by belt conveyer.

Cement and Fly ash are transported to the storage tank of system by bulk tank truck and then to the concrete mixing plant through pneumatic transmission.

According to temperature control requirement, the temperature of concrete at the outlet in season with high temperature is 17°C. The measures of "air cooling for coarse aggregate, mixing with flake ice and cold water" are adopted for concrete precooling.

c) Process Layout

Workshops and facilities are arranged within an elevation range of 230.00m to 240.00m based on concrete production process and the geological and topographic conditions of dam site area, as well as the construction load planning.

Storage and delivery facility of finished aggregate: truck receiver bin, finished aggregate tank, secondary screening and washing workshop, coarse aggregate adjusting bin and related belt conveyer, etc. There are 8 finished aggregate tanks provided for the system, which include 1 tank for large-sized rock, 2 for medium-sized rock, 2 for small-sized rock and 3 for sand. The total volume of the tanks is 10,000m^3, which satisfies the demand for aggregate in 1d; a screening, washing and dewatering workshop and a set of coarse aggregate adjusting bin are provided and the handling capacity of the workshop is 700t/h.

Storage and delivery facility of cement and Fly ash: cement tank, Fly ash tank and pneumatic transmission device, etc. There are 5 steel cement tanks (with storage volume of 1,000t per tank and total volume of 5,000t) provided for the system, which satisfies the demand for cement in 7d of peak period; there are 3 steel Fly ash tanks (with storage capacity of 600t per tank and total volume of 1800t) provided, which satisfies the demand for Fly ash in 8d of peak period. Cement and Fly ash are delivered respectively by 5 and 3

QPB-6.0 pneumatic injection pumps. The designed cement transmission capacity is 85t/h and the designed Fly ash transmission capacity is 25t/h.

Compressed air station: It supplies compressed air for the pneumatic transmission of cement and Fly ash and the mixing plant. The blast capacity of the concrete production system is 200m^3/min and there are 6 sets of 5L-40/8 air compressors provided (including one standby compressor).

Waste water treatment facility: The designed handling capacity is 80m^3/h. The waste water generated during the secondary screening and washing course can be recycled for use after treatment of the facility.

Refer to Table 7.6.2-1 ~ 2 for main technical indicators and equipment of concrete production system.

Refer to the *Process Flow Chart of Concrete Production System on Right Bank* and the *Layout Drawing of Construction Site* for process flow and location of the system.

7.6.2.3 Concrete Production System on Left Bank

Concrete production system on left bank is located 900m (straight-line distance) upstream the dam site, with the material discharging elevation of 270.00m. The concrete is discharged by dump truck and then delivered to the pouring bunker by portal (tower) crane.

a) Production Scale and Batching and Mixing Plant Configuration

According to construction schedule, the mean monthly pouring intensity during peak period of main work construction is 68,100m^3, which exists from August of the 4th year to March of the 5th year. In consideration of monthly unbalance factor, the peak monthly pouring intensity is 82,000m^3. Therefore, designed production capacity of concrete production system is determined as 260m^3/h. There is 1 HL320-2S4500L concrete batching and mixing plant provided.

b) Process Flow

The process flow of the concrete production is the same with that of the concrete production system on the right bank. See Item b) under Clause 7.6.2.

c) Process Layout

Workshops and facilities are arranged within an elevation range of 270.00m to 275.00m based on concrete production process and the geological and topographic conditions of dam site area, as well as the construction load planning.

Storage and delivery facility of finished aggregate: The facility is the same with that of concrete production system on the right bank.

Storage and delivery facility of cement and Fly ash: The facility is the same with that of concrete production system on the right bank.

Compressed air station: The facility is the same with that of concrete production system on the right bank.

Waste water treatment facility: The facility is the same with that of concrete production system on the right bank.

Refer to Table 7.6.3-1 ~ 2 for main technical indicators and equipment of concrete production system.

Refer to the *Process Flow Chart of Concrete Production System on Left Bank* and the *Layout Drawing of Construction Site* for process flow and location of the system.

7.6.3 Concrete Precooling System

Mekong River Basin has a tropical monsoon climate. The mean highest temperature of years on the dam site is 30.5°C and the mean lowest temperature of years is 20.2°C. The hottest month is June, with a mean temperature of 28°C. According to requirement of concrete temperature control, precooling system shall be provided for concrete production systems (hereinafter referred to as precooling system) on the left and right bank.

The precooling systems on the left and right bank are provided for concrete precooling of dam, powerhouse and other parts. The two precooling systems are of the same precooling process and the same facility configuration as the production scale and discharging temperature of concrete production systems are the same.

a) Production Scale and Batching and Mixing Plant Configuration

Precooling system is designed mainly for Level II and Level III precooling concrete (of which the discharging temperature would be 17°C in June). The production capacity of

precooling concrete is designed as 210m^3/h. One HL320-2S4500L concrete batching and mixing plant is provided and the installed precooling capacity is 5,520kW (4.75 million kca/h) under standard working condition.

b) Process Flow of Precooling

Precooling process: combination of "air cooling for coarse aggregate in stock bin of batching and mixing plant + mixing with flake ice and cold water".

Air cooling for coarse aggregate: Finished coarse aggregate after secondary screening and washing is delivered into coarse aggregate stock bin of mixing plant by belt conveyer for air cooling.

Flake ice production: Flake ice produced by machine is stored, dried and subcooled in Icehouse and then delivered to ice storage bin of mixing plant through pneumatic transmission. Then the ice would be sent into the blender by screw conveyer for concrete cooling.

Cold water production: The cold water of 5°C for ice-making and concrete mixing are all produced by screw chiller. The produced cold water flows into regulating reservoir and is delivered to the water consuming points.

c) Process Layout

Precooling system consists of facility for air cooling of coarse aggregate in stock bin of mixing plant, facility for ice-making, facility for cold water production and related refrigerating system. According to the process flow of concrete production and concrete precooling, the precooling systems are proposed to be set within the concrete production system according to construction site conditions.

Air cooler, fan and other air cooling devices are provided for coarse aggregate stock bin in mixing plant and refrigeration equipment for air cooling, ice-making and cold water production is set in the refrigeration plant.

Refer to Table 7.6.3-1 ~ 2 for main technical indicators and equipment of concrete precooling system.

Refer to *Layout Drawing of Construction Site* for location of concrete precooling

system.

Table 7.6.3-1 Main Technical Indicators of Concrete Production System for Left and Right Banks

S/N	Item		Unit	Indicator	Remarks
1	Scale of production	Design and production capacity	m^3/h	260	
		Design production capacity of precooling concrete	m^3/h	210	Concrete $D_{ischarging}$ = 17°C
2	Handling capacity of screening, washing and dewatering workshop		t/h	700	
3	Designed finished aggregate transmission capacity		t/h	1500	
4	Capacity of finished aggregate tank		10,000 m^3	1.0	Satisfy the demand of 1 d in peak period
5	Designed cement transmission capacity		t/h	85	
6	Cement reserves		t	5000	Satisfy the demand of 7 d in peak period
7	Designed Fly ash transmission capacity		t/h	25	
8	Fly ash reserves		t	1800	System on the left bank satisfies the demand of 10d in peak period and system on right bank satisfies the demand of 8d in peak period.
9	Demand for compressed air supply		m^3/min	200	
10	Water demand		m^3/h	430	
11	Flake ice production capacity		t/d	240	
12	5°C cold water production capacity		m^3/h	25	
13	Cold air circulation volume		10,000m^3/h	24	
14	Installed cooling capacity:		10,000kW	0.552	Standard working condition
			10,000kcal/h	475	Standard working condition
15	Installed capacity		kW	6400/6600	Left bank 6400kW; right bank 6600kW
16	Working system		shift/d	3	
17	Fixed member		Person	120	
18	Building area		10,000m^2	0.4	

19	Floor area	10,000m^2	4.5	

Table 7.6.3-2 Main Equipment of Concrete Production System for Left and Right Banks

S/N	Name	Spec. & Model	Unit	Qty.	Power of Single Set (kW)	Remarks
1	Concrete mixer station	HL320-2S4500L	Seat	1	510	
2	Injection pump	QPB6.0	Set	8	—	
3	Cement tank	1000t	Pc.	5	—	
4	Fly ash tank	600t	Pc.	3	—	Adopt 1,000t cement tank
5	Air compressor	5L-40/8	Set	6	250	1 for standby
6	Round vibrating screen	YKR3060	Set	1	55	
7	Round vibrating screen	2YKR3060	Set	2	55	
8	Spiral classifier	WCD-762	Set	1	11	
9	Vibrator feeder	GZG80-4	Set	16	1.5	
10	Radial gate	700×700	Set	10	—	
11	Dual-radial gate	1300×700	Set	6	—	
12	Spiral lobe refrigeration compressor	LG25 III A	Set	1/1	450/400	
13	Spiral lobe refrigeration compressor	LG20 III A	Set	3/1	250/200	
14	Spiral lobe refrigeration compressor	LG16 III A	Set	2	110	
15	Screw water chilling unit	LSLGF400	Set	1	100	
16	Flake ice machine	PBL-2×110	Set	8	4.65	
17	Icehouse	BK100	Seat	1	32	
18	Flake ice gas-moving device	QSB15	Set	1	45	
19	Air cooler	KL-2100	Set	1	—	
20	Air cooler	KL-1600	Set	1	—	
21	Air cooler	KL-1000	Set	2	—	
22	Fan	4-79-14E	Set	1	75	
23	Fan	4-79-12E	Set	1	55	
24	Fan	4-79-10E	Set	2	37	

25	Condenser	WN500	Set	1	—	
26	Condenser	WN450	Set	2	—	
27	Liquid reservoir	ZA8.0	Set	1	—	
28	Liquid reservoir	ZA6.5	Set	2	—	
29	LP circulating liquid reservoir	DX15.0	Set	4	—	
30	Cooling tower	LRCM-HS-300C3*2	Set	1	66	
31	Water pump	NPS250-280	Set	5	45	1 for standby respectively
32	Water pump	IS80-65-125	Set	2	5.5	1 for standby respectively
33	Metering pump	25F-41A	Set	2	1.0	
34	Dump truck	20t	Set	46	—	2 sets for standby at the left bank and 2 sets for standby at the right bank
35	Fully automatic electronic car weigher	100t	Set	1	—	
36	Belt conveyer	B=1000mm	m	855	270/310	6 pieces at the left bank and 7 pieces at the right bank
37	Belt conveyer	B=800mm	m	560	100/190	7 pieces at the left bank and 9 pieces at the right bank
38	Belt conveyer	B=650mm	m	580	155/165	11 pieces at each bank
39	Efficient (rotational flow) waste water purifier	DH-SSQ-300	Set	1	—	Waste water treatment system
40	Efficient coagulation mixer	DH-HNQ-300	Set	1	—	
41	Sludge mixer	DH-HNQ-150	Set	2	—	
42	Coagulant aids stirring apparatus	7.5kW	Set	1	7.5	
43	Flocculating agent stirring apparatus	4kW	Set	1	4	
44	Regulating reservoir stirring apparatus	18.5kW	Set	1	18.5	
45	Sludge tank stirring apparatus	22kW	Set	1	22	
46	Combined vibrating screen	FMVS2030	Set	1	4	
47	Cyclone group	NZ-5 or NFN300	Set	2		
48	Belt conveyer	Width: 500mm; Length: 45m	Pc.	1	11	
49	Waste water lift pump of purifier	150ZM-36	Set	2	75	

50	Waste water lift pump of vibrating screen	150ZM-30	Set	2	55	
51	Sludge pump	100ZM-60	Set	2	55	
52	Clean water recycling pump	SLW300-400	Set	1	110	
53	Plate-and-frame filter press	XMZ500/1500-U	Set	2	8	

7.6.4 Air, Water, Power and Communication

7.6.4.1 Air Supply for Construction

In this project, construction items powered by compressed air are: earth and rock excavation of diversion works, earth and rock excavation of foundation pit and side slope on left (right) bank of dam site, earth and rock excavation of powerhouse and ship lock work, earth and rock excavation of concrete production system and exploitation in quarry area. Earth and rock excavation, as well as quarrying mainly depends on hydraulic drilling rig (with self-equipped gas supply device). The air consuming points of other equipment are decentralized and not fixed, so that mobile compressed air station is provided for air supply. The air consuming points of concrete production system is kind of concentrated and fixed, so that fixed compressed air station is provided for air supply.

According to overall layout planning of construction, this project is divided into 5 air supply areas and provided with 5 compressed air stations. Two of the stations are within the concrete production systems on the left and right bank. Refer to Table 7.6.4-1 for air supply capacity and compressor equipment of the other 3 stations.

Table 7.6.4-1 Air Supply Capacity and Compressor Equipment

S/N	Name of Compressed Air Station	Air Supply Capacity (m^3/min)	Spec. & Model	Qty.	Remarks
1	Compressed air station on the left bank of dam site	100	VY-12/7	10	1 for standby
2	Compressed air station on the right bank of dam site	150	VY-12/7	15	2 for standby
3	Compressed air station of quarry area	90	VY-12/7	9	1 for standby

Note: Self-equipped air supply device is not listed in the table.

7.6.4.2 Water Supply for Construction

There are plenty of water consuming points in this project, which are distributed within a wide range and with unbalance water consumptions. In order to reduce the investment on and the floor area of water supply system, production and living water are supplied by water plants established in different zones. Construction water supply is divided into 2 zones which refer to water supply for main work production (living) zone and water supply for Dajiang Quarry Area production (living) zone. The maximum water

consumption of water supply for main work production (living) is 2100m^3/h and the designed water supply capacity is 2100m^3/h (including capacity of 200m^3/h for living water supply); the maximum water consumption of water supply for Dajiang Quarry Area production (living) is 1300m^3/h and the designed water supply capacity is 1300m^3/h (including capacity of 100m^3/h for living water supply).

Mekong River is the water source of the Project, of which the water can only be used after treatment.

Process flow of living water treatment: water intaking – sand setting – dosing – mixing – reaction – sediment – production pool – positive delivery – pressure regulation pool at high position – users of each production item.

Living water is channeled to filter tank through branch pipe of settling pond and then transited to pressure regulation pool at high position through positive delivery after filtration, disinfection and secondary treatment, so as to provide water supply for users in living zones on the left and right bank, and the quarry area.

a) Water Supply System of Main Work Production (Living) Zone

Water supply system for main work provides water for the excavation of dam foundation and side slope, the concrete construction, curing, dabbing and washing of dam, powerhouse and ship lock and the production of workshops, as well as the domestic water for constructors works on the left and right bank. Water tank of 2 pressure level is adopted for production (living) water supply.

As the water level of Mekong River subjects to large increase amount, it is proposed to establish river bed siphon water intake pumping station by cooperative construction, which is located near the downstream of the right end of Mekong River bridge and with water intaking scale of 2,100m^3/h. According to the characteristics requirement, 3 horizontal centrifugal double suction pumps (2 for use and 1 for standby) are provided, with the flow of 1300m^3/h for single pump and the hydraulic head of 56m.

Water treatment plant is on the right bank of the dam site, which is about 1,000m upstream the dam axis. The layout elevation is 255.000m and the floor area is 12,000m^2.

b) Water Supply System of Dajiang Quarry Area Production (Living) Zone

Water supply system of Dajiang Quarry Area mainly provides water for the exploitation of quarry area, the operation of aggregate processing system and concrete production system on the left bank of the dam, as well as the domestic water for constructors. Water tank of 2 pressure levels is adopted for production (living) water supply.

As the water level of Mekong River subjects to large increase amount, it is proposed to establish river bed siphon water intake pumping station by cooperative construction, which is located at the left bank about 900m upstream the dam site (near the concrete system on the left bank) and with water intaking scale of 1,300m^3/h. According to the characteristics requirement, 2 horizontal centrifugal double suction pumps (1 for use and 1 for standby) are provided, with the flow of 1,800m^3/h for single pump and the hydraulic head of 70m.

Water treatment plant is located near the highway beside the concrete system on the left bank, with floor area of 9,000m^2.

Refer to Table 7.6.4-2 for main equipment of water supply systems of different zones.

Refer to *Layout Drawing of Construction Site* for location of water supply systems in different zones.

Table 7.6.4-2 Main Equipment of Water Supply Systems of Different Zones

S/N	Name	Spec. & Model	Qty. (Set)	Head (m)	Flow (m^3/h)	Power of Single Set (kW)	Remarks
Water Supply System of Main Work Production (Living) Zone							
1	Immersible pump	350QG1000-60-250	3	60	1100	250	2 for use and 1 for standby
2	Water pump	S350-75A	3	56	1300	280	2 for use and 1 for standby
3	Water pump	150S78	3	70	200	55	2 for use and 1 for standby
Water Supply System of Dajiang Quarry Area Production (Living) Zone							
1	Immersible pump	350QG1000-60-250	3	60	1100	250	2 for use and 1 for standby
2	Water pump	S350-75A	3	70	900	280	2 for use and 1 for standby
3	Water pump	S300-90A	3	78	750	280	2 for use and 1 for standby
4	Pontoon	16×5.2×1.2	1				Displacement: 80m^3

7.6.4.3 Power Supply for Construction

a) Power load for construction

According to overall planning layout of construction, the entire power supply area is divided into 2 zones which refer to dam site construction (living) power supply zone and Dajiang Quarry Area construction (living) power supply zone. The peak power consumption loads of the two zones during the construction period are 7,490kW and 8,585kW, and the total peak load during the construction period is 14,918kW.

Refer to Table 7.6.4-3 for the power consumption load during the construction of hydropower station.

Table 7.6.4-3 Construction Power Consumption Load

Zone	Item	Rated Capacity (kW)	Demand Coefficient	Active Power (kW)	Remarks
Dam site construction (living) power supply area	Concrete production system on right bank	6600	0.6	3960	The load for 380V voltage level is 2200kW and the load for 10kV voltage level is 1760kW.
	Water supply pump station	1170	0.75	877.5	The load for 380V voltage level is 450kW and the load for 10kV voltage level is 427.5kW.
	Regular dewatering of foundation pit	1400	0.35	490	The load for 380V voltage level is 154kW and the load for 10kV voltage level is 336kW.
	Construction equipment of dam, powerhouse and ship lock	3560	0.5	1780	The load for 380V voltage level is 20kW and the load for 10kV voltage level is 1760kW.
	Workshops	1500	0.6	900	380V voltage level
	Power consumption of office and living area	900	0.8	720	220V voltage level
	Illumination of construction site	300	0.8	240	220V voltage level
	Illumination of construction road	110	1	110	220V voltage level
	Subtotal	14540		9077.5	The load for 380V voltage level is 3724kW, the load for 10kV voltage level is 4283.5kW and the load of 220V voltage level is 1070kW.
	Power demand after considering various coefficients			7490	
Dajiang Quarry Area construction (living) zone	Aggregate processing system	6800	0.7	4760	380V voltage level
	Concrete production system on the left bank (which operates with different peak period with concrete	6400	0.6	3840	The load for 380V voltage level is 2100kW and the load for 10kV voltage level is 1760kW.

	system on the right bank)				
	Quarrying	150	0.7	105	380V voltage level
	Water supply pump station	1620	0.75	1215	10kV voltage level
	Power consumption of office and living area	150	0.8	120	220V voltage level
	Illumination of construction site	150	0.8	120	220V voltage level
	Illumination of construction road	80	1	80	220V voltage level
	Subtotal	14550		10240	The load for 380V voltage level is 7,355kW, the load for 10kV voltage level is 3,423kW and the load of 220V voltage level is 320kW.
	Power demand after considering various coefficients			8585	
Peak Load				14918	

b) Design Principle of Construction Power Supply

1) The construction power supply shall be safe and reliable, and shall meet the requirements of each construction stage;

2) Voltage level of construction power supply shall be determined based on the voltage of construction power consumption load;

3) The planning of construction power supply circuit shall be performed in accordance with the zones of construction;

4) Layout of construction substation shall be determined in accordance with the General Layout Drawing.

c) Source of Construction Power Supply

According to the actual conditions of the Laos's power grid and Thailand's power grid, it is known that the power grid of Laos is of small capacity and is unstable. It is difficult to rely on it for dependable construction power supply; the power grid of Thailand suffers from a kind of power shortage, so that there is no extra power for export as the construction power supply of the hydropower station. Therefore, diesel generator is proposed as the power supply of construction.

d) Construction Power Supply Voltage and Distribution of Diesel Generator Room and 10kV Substation

The voltage of construction power supply is determined as 10kV and 0.4kV.

According to the characteristic of power consumption load distribution, it is proposed to set a diesel generator room in dam site construction (living) zone and Dajiang Quarry Area construction (living) zone. The diesel generator room for main work construction zone is provided with 6 diesel generators (3 sets with capacity of 3400kW and the other 3 sets with capacity of 1000kW). Seven circuits of 10kV outgoing line are provided for each power consumption points of dam site (2 for standby). One 10kV substation is established in construction zone of dam area.

The diesel generator room for quarry area construction zone is provided with 5 diesel generators (3 sets with capacity of 3400kW and the other 2 sets with capacity of 1000kW). Four circuits of 10kV outgoing line are planned for each power consumption points of dam site (2 for standby). One 10kV substation is established in construction zone of quarry area.

e) Main Electrical Equipment for Construction Power Supply

Refer to Table 7.6.4-4 for main electrical equipment of construction power supply.

Table 7.6.4-4 Main Electrical Equipment of Construction Power Supply

S/N	Name	Spec. & Model	Unit	Qty.	Remarks
1	Diesel generator	10kV 3400kW	Set	6	
2	Diesel generator	10kV 1000kW	Set	5	
3	10kV high-voltage switch cubicle	XGN-12	Pc.	32	Just the number of switch cubicle in the diesel generator room
4	10kV cable	ZR-YJV22	km	15	
5	10kV circuit	LGJ-120/25	km	8	
6	10kV substation		Seat	1	With 2 transformers of 6300kVA
7	10kV substation		Seat	1	With 2 transformers of 6300kVA
8	10kV box-type substation		Seat	1	With 2 transformers of 1250kVA

7.6.5 Workshops

According to overall planning and general layout of construction, this project is divided into 2 main construction zones which refer to main work construction zone and quarry area construction zone. Workshops are only established in the main work construction zone.

Refer to Table 7.6.5-1 for main technical indicators of workshops.

Table 7.6.5-1 Main Technical Indicators of Workshops

S/N	Item	Machinery Repair Workshop	Vehicle Maintenance Station	Comprehensive Processing Workshop			Metal Structure Assembling Workshop
				Steel Bar Processing Workshop	Timber Processing Workshop	Concrete Prefabricating Workshop	
				Main Work Construction Zone	Main Work Construction Zone	Main Work Construction Zone	
1	Scale of production	25 (10,000 wh/y)	200 (Standard truck)	30 (t/shift)	20 (m^3/h)	12800 (m^3/year)	18 (t/shift)
2	Production shift (shi	1	2	2	2	1	2
3	Major equipment (set)	45	40	25	12	12	20
4	Fixed me (person/shift)	160	100	100	44	60	85
5	Installed capacity (kW)	437	360	250	100	100	600
6	Water consumption (m^3/h)	4	6	4	20	10	18
7	Building area (m^2)	3145	4300	1800	2400	1400	3285
8	Floor area (m^2)	16000	21000	12000	12000	21000	17500

7.7 General Layout of Construction

7.7.1 Conditions for Site Layout

Terrain at the right bank of the dam site of Balai Hydropower Station is wide and flat. The access road connects 4# Road near Nanpeng Village and leads to the site along the downstream right bank of Nanpeng River and Mekong River. Due to the convenience to get contact with the outside and good conditions for layout, it is suitable to locate the main construction site here.. Terrain at the left bank is comparatively steep and there has been no roads leading there currently. The terrace above the dam abutment and at the left end of the Mekong River Bridge can be used as a construction site, but the conditions for construction layout are relatively poor.

Dajiang Quarry Area is located on a hill which is at the left bank of and about 2.0km away from the upstream of the dam site. There is a piece of relatively broad hillside land where the aggregate processing system can be located. There is a comparatively large

gully at the left bank of and about 0.8km from the upstream of the dam site where a waste disposal area can be located. There is also a comparatively large gully at the right bank of and about 0.7km from the dam site where a waste disposal area can be located.

7.7.2 Principle of Layout

Based on the characteristics of the Project and in combination with the conditions for layout of the construction site, the general layout of construction shall be in accordance with the following principles:

a) Based on the terrain and landform of the project site and the characteristics of the Project, the general layout of construction shall be in accordance with the principle of being safe, reliable, economical, reasonable and convenient for production, living and management;

b) The general layout of construction shall be decided in combination with the condition of external traffic roads;

c) Considering the construction need of each works of the Project in advance and combining with the construction procedure and schedule, the temporary structures shall be arranged in a dispersed or concentrated manner reasonably as per the local circumstances;

d) Arrangement shall be reasonable and the land shall be used in a comprehensive way so as to maximize the land recycle rate and minimize the area of land to be used;

e) The traffic roads for construction shall be arranged in combination with the site layout so as to avoid re-shipment of materials as much as possible and the construction roads shall be arranged in an unblocked and reliable way;

f) Location of the dangerous goods warehouse shall be far away from construction sites, living area and official area;

g) Respect shall be shown to the local customs and the arrangement shall be made with consideration for the needs of local residents;

h) Construction areas below the dam axis are all arranged above the 20-year flood level of 232.00m a.s.l and construction areas above the dam axis are all arranged above the

normal pool level of 240.00m a.s.l.

7.7.3 Layout of Site

According to the construction need of Balai Hydropower Station Project, structures to be arranged at the construction site mainly include aggregate production and processing system, concrete mixing system, warehouse system, comprehensive processing workshop, equipment repair plant, vehicle parking lot, camps for construction, living and handling official businesses, camps for the Employer, the Design Representative and the Supervisor to live and handle official businesses, place to pile metal structures, processing workshop, etc. Generally, the construction site, according to the principles for construction arrangement and the conditions of the construction site, is divided into two parts: the place at the downstream and the left bank of the dam site which is relatively flat and where the major construction and living areas for construction of the Project as well as most construction facilities will be located; the place at the left bank where such facilities as the aggregate processing system, the left-bank concrete system, ②the camps for construction and living will be located. Layout of construction sites of each part is described below respectively:

a) Construction site at the right bank

Place to pile metal structures and the processing workshop: to be arranged on the terrace between Road① and Road③, about 100m away from the dam site, at an elevation of 235.00m~240.00m, with a floor area of approximately 28,000m^2. This site is also to be used as the Phase-I river closure material preparing area at the earlier stage.

The right-bank concrete system: to be arranged on the hillside land between Road① and Road⑨, about 400m from the dam site, at an elevation of 235.00m~240.00m, with a floor area of approximately 45,000m^2. It is to be used mainly to produce concrete for the Phase-I dam works, ship lock works, Phase-I diversion works and Phase-I powerhouse works.

Construction substation: to be arranged on the side hill at downstream of the starting

point of Road⑨, at an elevation of 240.00m, with a floor area of approximately 4,000m^2.

Material warehouse for hot work: to be arranged in the gully at the side of the waste disposal area at the right bank.

Gas station: to be arranged at the side of Road①, 300m away from the downstream of the right end of Mekong River Bridge.

Water plant at the right bank: to be arranged on the hill at the side of Road①, at an elevation of 260.00m, with a floor area of approximately 2,500m^2.

Camps for the Employer, the Design Representative and the Supervisor to live and handle official businesses: Be arranged on the right side of bridgehead of Mekong River Bridge, at an elevation of 240.00m~245.00m, with a floor area of approximately 45,000m^2 and a building area of approximately 12,000m^2.The elevation is higher than 236.70m, the water level for check flood of 10000-year return period. When the flood takes place (the design flood is of 2000-year return period with a peak discharge of 34700m^3/s, and corresponding downstream water level of 235.60m), it can enter the powerhouse area from the access or the Mekong River Bridge.

①Camps for living and handling official businesses during construction: Be arranged near the downstream of the camps for the Employer, the Design Representative and the Supervisor to live and handle official businesses, at an elevation of 238.00m~243.00m, with a floor area of approximately 48,000m^2 and a building area of approximately 15,000m^2.

Comprehensive processing workshop: Be arranged near the downstream of ①camps for living and handling official businesses during construction and the inner side of the access road, at an elevation of 235.00m~240.00m, with a floor area of approximately 45,000m^2. It is mainly used to build borer repair plant, processing plants of rebar, timber, formwork, etc.

Area to place construction equipment and the repair plant: Be arranged near the downstream of comprehensive processing workshop, at an elevation of 235.00m~240.00m, with a floor area of approximately 30,000m^2.

Comprehensive warehouse: Be arranged close to the downstream of the area to place construction equipment and the repair plant, at an elevation of 235.00m~240.00m, with a floor area of approximately 32,000m^2.

b) Construction site at the left bank

Electromechanical equipment warehouse: to be arranged at the terrace located at the downstream of the left end of Mekong River Bridge, about 1.6km from the dam site, at an elevation of 235.00m~240.00m, with a floor area of approximately 30,000m^2. This site is also to be used as the Phase-II river closure material preparing area at the earlier stage.

Camps for living and handling official businesses: to be arranged at the terrace located at the downstream of the left end of Mekong River Bridge, about 1.5km from the dam site, at an elevation of 235.00m~240.00m, with a floor area of approximately 49,000m^2 and a building area of approximately 16,000m^2.

Water plant at the left bank: to be arranged beside the left-bank concrete system, at an elevation of 280.00m, with a floor area of approximately 2,500m^2.

The left-bank concrete system: to be arranged at the terrace located about 1.0km from the upstream of the dam site, beside Road⑥, at an elevation of 270.00m, with a floor area of approximately 42,000m^2. It is to be used mainly to produce concrete for the Phase-II dam works, Phase-II diversion works and Phase-II powerhouse works.

Dajiang Quarry Area is located on the hill on the left bank of Mehong River which is about 2km from the upstream of the dam site. Farm tracks can reach the area. The aggregate processing system is located at a wasteland, at the southeast of and about 400m from Dajiang Quarry Area, at an elevation of 290.00m~300.00m and with a floor area of approximately 100,000m^2. This area has small gradient and it is convenient to utilize the naturally formed altitude difference to arrange the aggregate processing system, in which way area of land occupied will be reduced.

See *Layout Drawing of Construction Site* for details.

See Table 7.7.3-1 for features of production and living areas during major construction.

Table 7.7.3-1 Summary of Features of Production and Living Areas During Major Construction

Position	Name	Building area (m^2)	Floor area (10,000 m^2)	Remarks
Right bank Construction area	Place to pile metal structures and the processing workshop	5000	2.8	Also to be used as the Phase-I river closure material preparing area
	Right-bank concrete system	4500	4.5	Including storage yard of finished materials
	Construction substation	400	0.4	
	Material warehouse for hot work	1000	0.3	
	Gas station	400	0.2	
	Water plant at the right bank	300	0.25	
	Comprehensive processing workshop	5600	3.5	
	Camps for the Employer, the Design Representative and the Supervisor to live and handle official businesses	12000	4.5	
	①Camps for living and handling official businesses during construction	10000	4.8	
	Area to place construction equipment and the repair plant	7445	3.0	
	Comprehensive warehouse	8200	3.2	
	Subtotal	54845	27.45	
Left bank Construction area	Electromechanical equipment warehouse	3800	3.0	Also to be used as the Phase-II river closure material preparing area
	②Camps for living and handling official businesses during construction	11000	4.9	
	Water plant at the left bank	300	0.25	
	Left-bank concrete system	3600	4.2	
	Aggregate processing system	1000	10	Including storage yards for raw and finished materials
	Aggregate processing area and living area	1400	0.5	
	Subtotal	21100	22.85	
Others		3800	6.0	
Total		79745	56.3	

7.7.4 Earthwork Allocation and Waste disposal area Planning

Total excavation amount of the Project (the main works and the diversion works) is 4,639,200m^3 (bank measure). According to the preliminary balance computation of earthwork of the Project, amount of the excavated material of main works to be used to fill the cofferdam is about 1,208,200m^3 (bank measure); the amount of excavated waste is 3,431,000m^3, about 4,460,400m^3 when converted into loose measure. Quantities of cofferdam removal are 1,028,800m^3 (compacted measure), about 1,112,900m^3 when converted into loose measure. Total amount of waste of the Project is approximately 5,573,300m^3 (loose measure). Based on the principle of waste placed nearby, left and right banks balanced and minimum land occupied, it is planned to set up a waste disposal area at each bank the dam site respectively. The right-bank waste disposal area is located in the gully which is about 0.7km from downstream and the right bank of the dam site; the left-bank waste disposal area is located in the gully which is about 0.8km from the upstream and the left bank of the dam site.

Total amount to be excavated during the right-bank dam works, the ship lock works and the powerhouse section guide wall is about 2,509,500m^3 (bank measure), among which about 291,000m^3 (bank measure) will be used to fill the Phase-I cofferdam. The amount of waste is 2,218,500m^3, about 2,884,100m^3 when converted into loose measure. Quantities of Phase-I cofferdam removal are about 497,000m^3 (compacted measure), about 537,500m^3 when converted into loose measure. Total amount of waste at the right bank is approximately 3,421,600m^3 (loose measure) which will be dumped into the right-bank waste disposal area. Piling height of the right-bank waste disposal area is 277.000m. With a floor area of 144,000m^2, the yard has a total capacity of about 3,850,000m^3, so it is sufficient for waste dumping.

Total amount to be excavated during the Phase-II left-bank dam works and the ship lock works is about 2,129,700m^3 (bank measure), among which about 917,200m^3 (bank measure) will be used to fill the Phase-II cofferdam. The amount of waste is 1,212,500m^3 (bank measure), about 1,576,300m^3 when converted into loose measure. Quantities of

Phase-II cofferdam removal are about 531,800m^3 (compacted measure), about 575,400m^3 when converted into loose measure. Total amount of waste at the left bank is approximately 2,151,700m^3 (loose measure), in which 470,000 m^3 of Phase-II cofferdam removal will be dumped in front of the upstream cofferdam to form the sand-guide sill. The remaining 1,681,700m^3 will be dumped into the left-bank waste disposal area. Piling height of the left-bank waste disposal area is 315.00m. With a floor area of 116,000m^2, the yard has a total capacity of about 1,900,000m^3, so it is sufficient for waste dumping.

See Table 7.7.4-1 for features of waste disposal area.

Table 7.7.4-1 Summary of Features of Waste Disposal Area

Name	Volume (10,000 m^3)	Top height (m)	Floor area (10,000 m^2)	Amount of waste (loose measure) (10,000 m^3)	Remarks
Right-bank w aste disposal area	385	277.00	14.4	342.16	
Left-bank was te disposal area	190	315.00	11.6	168.17	
Sand-guide sill	47	225.00		47.00	
Total	622		26.0	557.33	

7.7.5 Construction Land

Construction land of the Project mainly includes main works, living areas, construction sites, waste disposal areas, charge make-up areas, on-site access roads, quarry yard, etc. According to the natures and characteristics of each area, the construction land is classified as permanently occupied land and temporarily occupied land.

According to the layout of the hydraulic structures and the general construction layout, total land used as the construction land for hydraulic structures is 2,121,000 m^2 among which 576,000m^2 are occupied permanently and 1,545,000m^2 are occupied temporarily.

7.8 Construction Schedule

7.8.1 Principle and Basis for Preparation

a) Once the Project is commenced, construction shall be organized in order so that the power station can start operation and create benefits as soon as possible.

b) Based on the construction diversion procedure and in combination with features of the terrain, the landform and the site access of the Project, construction procedures of key works during the power generation period shall be studied and controlled in an adequate manner. A reasonable power generation period shall be decided upon comparison.

c) During the design stage, actual construction conditions of the Project shall be considered adequately. Continuous improvement in respect of construction level shall be taken seriously with reference to domestic and abroad projects of the same type. Averagely advanced Construction Schedule indicators shall be adopted.

d) In order to meet the requirements of bidding and contracting out system, a preparation period shall be arranged properly before formal commencement of the Project. The Employer shall complete the necessary preparation works within the preparation period so that construction of main works can be carried out later on by the Contractor in a quicker and more efficient way. According to *Specifications for Construction Planning of Hydropower Stations* (DL/T5397-2007), the preparation period is not included in the total construction period.

7.8.2 Construction Schedule of Preparation Works

A preparation period of 2.5~3 years shall be arranged before formal commencement of the Project. Work to be done within this period mainly includes to rebuild or construct site access, to construct Mekong River Bridge and internal ② trunk roads, to erect power supply lines and communication lines to be used during construction, to participate in project bidding and to complete part of work of land expropriation and residents resettlement.

Preparation works refer to the work carried out in advance so that the contractor of the Project can start construction of main works as soon as entering the site. Construction

preparation shall be started in July of the first year and major work to be done during the first year is excavation, supporting and protection of bank slope of Phase-I non-overflow weir (at the right bank); major work to be done during the preparation period includes construction of internal trunk roads, ground leveling, erection of power supply lines and communication lines, and construction of aggregate processing system, concrete system as well as part of the temporary houses.

7.8.3 Construction Schedule of Diversion Works

7.8.3.1 Construction Schedule of Phase-I Diversion Works (at the right bank)

According to the layout of the hydraulic structures, stage diversion is adopted for the Project. During Phase I (20-year return flood design standard is adopted for the cofferdam), water flow and navigation for the non-overflow weir section at the right bank of the cofferdam, ship lock, the 14 water release gates and bottom outlet section will be realized via the left-bank main channel. From December of the 1st year, foundation excavation of both the upstream and the downstream Phase-I transverse earth-rock cofferdams shall be carried out and bank-off advancing will be conducted half a month later; meanwhile, foundation excavation for longitudinal concrete cofferdam shall be conducted; from January of the 2nd year, longitudinal cofferdam concrete pouring and longitudinal earth-rock cofferdam filling shall be carried out; by the end of February of the 2nd year, final gap-closing shall be completed for the sub cofferdam; by March of the 2nd year, curtain grouting and seepage-proofing work below 225.000m shall be completed and water pumping from the foundation pit shall be started. Cofferdam heightening shall be finished before the flood season. Before Phase-II river closure, i.e. during the period from the middle of November to the middle of December of the 3rd year, the upstream and downstream Phase-I earth-rock cofferdams and longitudinal concrete cofferdam at the non-junction part shall be removed.

7.8.3.2 Construction Schedule of Phase-II Diversion Works (at the left bank)

As for the 14-unit dam section and the non-overflow weir section of Phase-II cofferdam, water flow will be realized via the built 14 water release gates and navigation

via the permanent ship lock. Cofferdam of the whole year type will be adopted at both the upstream and the downstream. From November of the third year, bank-off advancing of both the upstream and the downstream Phase-II earth-rock cofferdams shall be carried out crosswise from the right to the left and in the middle of December, the Phase-II cofferdam will be fully completed. The cofferdam will be filled to the top of the grouting platform at an elevation of 225.00m at the end of January of the fourth year. Afterwards, seepage-proofing construction and water pumping from the foundation pit shall be started. By the end of March of the fourth year, seepage-proofing construction will be completed. In May of the fourth year, cofferdam heightening will be completed.

7.8.4 Construction Schedule of Main Works

7.8.4.1 Critical Path

According to the construction diversion procedure and the characteristics of the Project, upon analysis, critical path of the Project is: construction preparation→excavation and support of bank slope of dam during Phase I→Phase-I diversion→excavation of Phase-I foundation pit→concrete pouring of dam→installation of bridge and radial gate on top of the dam→Phase-II diversion→excavation of Phase-II foundation pit→concrete pouring on lower part of the machine hall of main powerhouse→concrete pouring on upper part and installation of bridge crane→installation of unit equiment. Total construction period of such critical path is 6 years and 9 months among which the power generation construction period of the first-batch unit (2 sets) is 5 years.

7.8.4.2 Construction Schedule of Dam Works

a) Construction Schedule of Phase-I Dam Works (at the right bank)

The elevation where the bank slope and the riverbed separate is 217.00m. Excavation of bank slope shall be completed before completion of Phase-I cofferdam. Construction is arranged from August to December of the 1st year with an excavation volume of about 217,300m^3 and an average monthly excavation volume of 54,300m^3. From March to June of the 2nd year, excavation at the riverbed shall be carried out with an excavation volume of about 615,000m^3 and an average monthly excavation volume of 188,700m^3. Upstream

and downstream dredging is arranged from December of the 2nd year to May of the 3rd year, and from December of the 3rd year to May of the 4th year. Excavation will be carried out in December of the 4th year to May of the 5th year, and the excavation quantities are 1,604,800m^3.

Given the fact that Phase-I foundation pit is relatively wide, concrete pouring and further excavation of the water release gate can be carried out simultaneously. From May to August of the second year, concrete pouring for the 14 water release gates shall be carried out, with concrete quantities of 128,400m^3, an average monthly pouring intensity of 32,100m^3 and an average monthly lifting height of 5m. As the foundation surface of non-overflow dam is relatively high, concrete pouring for it is arranged from June of the second year to the middle of January of the third year, with concrete quantities of 42,300m^3 and an average monthly pouring intensity of 5,600m^3. As the foundation surface of bottom outlet section is relatively low, concrete pouring cannot be carried out until the excavation is completed. It is arranged to start such concrete pouring from July of the second year and complete an elevation of 222.50m in December of the same year, with concrete quantities of about 82,000m^3 and an average monthly pouring intensity of 13,700m^3. In January of the third year, concrete pouring shall be carried on for the upstream gate pier and side wall of bottom outlet section, and for the right installation year in the upper part of bottom outlet section, which will be completed on April 15 and at the end of April of the third year respectively, with concrete quantities of about 33,000m^3 and an average monthly pouring intensity of 9,400m^3. From July of the second year to May of the third year, concrete pouring for the upstream section of powerhouse section guide wall can be carried out, with concrete quantities of about 4,100m^3 and an average monthly pouring intensity of 400m^3. Concrete pouring for the gate pier shall not be started until concrete pouring for the water release gate has reached the elevation for the starting point of the gate pier. Concrete pouring for gate pier is arranged from the middle of June to December of the second year, with concrete quantities of 95,200m^3, an average monthly pouring intensity of 11,400m^3 and an average monthly lifting height of 6.49m. In order to balance the concrete

pouring intensity, concrete pouring for stilling basin is arranged to be carried out from January to April of the third year, with concrete quantities of 82,200m^3 and an average monthly pouring intensity of 20,600m^3. From September of the second year to March of the third year, concrete pouring for the guide wall can be carried out, with concrete quantities of 62,200m^3 concrete and an average monthly pouring intensity of 8,900m^3. Portal crane track beam and highway bridge can be constructed from January to February of the third year. Arc doors of 14 water release gates can be installed from February to November of the third year. By this time, Phase-I dam works (at the right bank) will be fully completed.

b) Construction Schedule of Phase-II Dam Works (at the left bank)

Excavation of bank slope during Phase II (left bank) is arranged from March of the third year and to be completed before Phase-II river closure, with an excavation volume of about 415,400m^3 and an average monthly excavation intensity of 51,900m^3. Excavation at the riverbed is arranged from April of the fourth year with an excavation volume of 19,200m^3.

As only the non-overflow weir section of the bank slope and the fishway are involved, Phase-II (at the left bank) dam structures are relatively simple with simple construction procedures. Concrete pouring for the dam body is arranged from the middle of May of the fourth year to January of the fifth year with about 30,900m^3 concrete and an average monthly pouring intensity of 3,400m^3.

As the fishway is located at the bank slope dam section at the left bank, the foundation surface is relatively high. Foundation excavation is arranged from December of the third year to May of the fourth year with an excavation volume of 106,800m^3 and an average monthly excavation volume of 17,800m^3. Concrete pouring for the fishway is arranged from September of the fourth year to March of the fifth year with 9,000m^3 concrete and an average monthly pouring intensity of 1,300m^3.

7.8.4.3 Construction Schedule of Powerhouse Works

14 straight flow bulb-type units of the Project are installed in a centralized manner.

They are arranged in the main river channel. The Phase-I longitudinal concrete cofferdam passes through 12# unit section, which makes 13# and 14# units be enclosed in the foundation pit of Phase I. To reduce the construction disturbance and to benefit Phase-II construction, in the foundation pit of Phase I, only excavation of 14# unit and concrete pouring for bottom board at gate pier part of upstream water intake will be carried out. From June to August of the second year, excavation of 14# unit foundation can be carried out, with an excavation volume of 63,700m^3 and an average monthly excavation intensity of 21,200m^3. From September to October of the second year, concrete pouring can be carried out for the bottom board at upstream water intake gate pier, with concrete quantities of 4,100m^3 and an average monthly pouring intensity of 2,000m^3. As the upstream sand-guide sill is tied up by Phase-I upstream longitudinal concrete cofferdam, the sand-guide sill is constructed at the time of Phase-I concrete pouring from December of the first year to May of the second year, with an excavation volume of 4,600m^3 and concrete quantities of 4,700m^3.

As the access road is located at downstream of the installation yard at the left bank and the foundation surface is comparatively high, construction is free of affect due to flood, so perennial construction is practicable. Construction is arranged from January to June of the third year so as to meet the construction need of Phase-II (at the left bank) powerhouse area.

Foundation excavation for Phase-II (at the left bank) powerhouse area of 13 units (the excavation volume for14# unit has been completed in Phase I) is arranged from July of the third year to June of the fourth year, with an excavation volume of 829,500m^3 and an average monthly excavation intensity of 69,100m^3. Backfilling concrete pouring at the main powerhouse is carried out at the time of excavation from April to June of the fourth year, with concrete quantities of 39,100m^3 and an average monthly pouring intensity of 13,000m^3.

From July of the fourth year, concrete pouring for the upstream water intake gate pier of 14 units at the left bank, and for the lower part of the machine hall will be carried out.

By March of the fifth year, concrete pouring for the upstream water intake gate pier shall reach the top elevation; that for the machine hall shall reach 222.500m, the elevation of generator floor, with concrete quantities of 359,600m^3 and an average monthly pouring intensity of 39,900m^3. From April to May of the fifth year, lowering of the upstream intake gate will be carried out; from April to July of the fifth year, concrete pouring for plates, beams and pillars of the main powerhouse will be carried out; from August to September of the fifth year, the main powerhouse bridge crane track beam will be constructed. From August of the fourth year to January of the fifth year, concrete pouring for the tailrace pier will be carried out, with concrete quantities of 62,800m^3 and an average monthly pouring intensity of 10,500m^3. From February to March of the fifth year, lowering of tailrace gate will be carried out. The left installation yard is located behind the left-bank non-overflow section. As the foundation surface is relatively low, concrete pouring will be carried out after the foundation pit excavation is completed. The backfilling concrete pouring is arranged from July to December of the fourth year for the lower drainage sump and for the bottom of foundation, while the concrete pouring is arranged from January to April of the fifth year for the upper plates, beams and pillars, with concrete quantities of 19,300m^3 and 6,000m^3 respectively and an average monthly pouring intensity of 3,200m^3 and 1,500m^3 respectively. From May to June of the fifth year, bridge crane will be installed. The downstream auxiliary powerhouse is located at the passageway at the downstream of the machine hall. Concrete pouring for the downstream auxiliary powerhouse shall not be started until that for the machine hall reaches the elevation of foundation surface, so it is arranged from February to July of the fifth year, with concrete quantities of 178,900m^3 and an average monthly pouring intensity of 29,800m^3. As the central control building and the auxiliary powerhouse are located at the end of the left-bank access road, construction is relatively flexible, so concrete pouring is arranged from September of the fourth year to April of the fifth year, with concrete quantities of 24,300m^3 concrete and an average monthly pouring intensity of 3,000m^3. In September of the fifth year, unit installation will be carried out. By the end of June in the sixth year, the first-batch unit (2 sets) will be

operated for power generation; afterwards, 2 units will be put into operation every 4 months; after that, 2 units will be put into operation every 3 months. By the end of March in the eighth year, all 14 units will be put into operation for power generation. At this time, the whole plant works are completed.

7.8.4.4 Construction Schedule of Ship Lock Works

The ship lock works is located on the river beach at the right bank. Except for a minor part of the upstream and the downstream approach channels which is located within Phase-I cofferdam, the remaining major part of structures are all to be constructed in Phase-I foundation pit, so the construction is comparatively flexible. As to the construction period, based on the current construction techniques and compared with other completed lock works of the same level as that of the Project, it is predicted that the construction period for lock works of the Project will be about 2 years at least. Given the requirement that no interruption of navigation is allowed during the construction period, the construction schedule is arranged as: from December of the first year to March of the second year, construction of Phase-I upstream and downstream earth-rock cofferdams will be carried out with sections of the upstream navigation wall and the downstream navigation dike occupied by the cofferdams constructed at the same time; in order to solve the problem about source of materials to fill Phase-I cofferdam, from November of the first year to May of the second year, excavation of the upstream breasting dolphin and the downstream approach channel will be carried out with an excavation volume of 386,900m^3 and an average monthly excavation volume of 55,300m^3; afterwards, concrete pouring for breasting dolphin will be carried out and be completed in December of the second year with concrete quantities of 4,400m^3 and an average monthly pouring intensity of 600m^3; from June to September of the second year, excavation of upstream navigation wall and downstream navigation dike (outside of cofferdam) will be carried out with an excavation volume of 42,900m^3 and an average monthly excavation volume of 10,700m^3; afterwards, concrete pouring will be started and will be completed in June of the third year with concrete quantities of 58,700m^3 and an average monthly pouring intensity of 6,500m^3; essential to ship lock works, such major structures as the ship lock head

and the lock chamber shall be constructed as early as possible, so it is arranged to carry out foundation excavation from October of the first year to May of the second year with an excavation volume of 241,500m^3 and an average monthly excavation volume of 30,200m^3; from June of the second year to May of the third year, concrete pouring for such major structures will be carried out with concrete quantities of 169,000m^3 and an average monthly pouring intensity of 14,100m^3; at the same time of concrete pouring, it will be properly arranged to carry out installation of metal equipment which will be completed before Phase-II river closure. Navigation condition is mature as soon as all ship lock works are completed. Navigation is allowed when the water level of the reservoir meets the lowest upstream and downstream navigable water levels.

7.8.5 General Construction Progress

Power generation construction period of the Project from formal commencement to power generation of the first-batch unit (2 sets) is 5 years and the total construction period is 6 years and 9 months (not including preparation period). The largest number of workers during construction is about 2000. See Table 7.8.5-1 for indicators of construction intensity.

Table 7.8.5-1 Indicators of Construction Intensity

Item	Unit	Open excavation of earthwork and stonework	Concrete
Total volume (including diversion)	10,000 m^3	463.92	169.76
Completed quantities at peak year	10,000 m^3	159.89	63.00
Time of peak period	Year	3	2
Average monthly intensity during peak period	10,000 m^3	27.42	8.12
Time of peak period	Month, year	April to May of the second year	February to March of the second year

7.9 Major Technical Supply

7.9.1 Major Building Materials

Major construction materials include cement, rebar and steel products, timber, oil,

explosive material, etc. See Table 7.9.1-1 for estimated quantities of the major construction materials.

Table 7.9.1-1 Quantities of Major Materials

No.	Item	Unit	Qty.	
			Total amount	Annual peak consumption
①	Cement	10,000 t	41.36	15.12
②	Timber	10,000 t	6.55	2.39
③	Rebar and steel products	10,000 t	7.12	2.44
④	Fly ash	10,000 t	8.27	3.02
⑤	Explosive material	10,000 t	0.27	0.11
⑥	Oil	10,000 t	6.33	2.18

7.9.2 Major Construction Machinery

Construction machinery mainly includes equipment used for earth-rock excavation, foundation treatment, concrete pouring, aggregate processing, concrete production, water supply, power supply, etc. See Table 7.9.2-1 for major construction machinery of the Project. Types and quantities of machines listed in the table are decided via totalizing and balancing the calculated results based on the construction intensity and the construction methods.

Table 7.9.2-1 Major Machinery during Construction of Main Works

S/N	Name	Spec. & Model	Unit	Qty.	Power of Single Set (kW)	Remarks
I	Construction equipment for excavation, foundation treatment and concrete pouring					
1	Breaker hammer	QY-30	Set	30	/	
2	Down-hole drill	YQ-100	Set	13		
3	Vibratory roller	Tow-type (14~16t)	Set	4		
4	Vibratory roller	Self-propelled (10t)	Set	1	/	

5	Tamping roller	YT-25	Set	1	/	
6	Bulldozer	132kW	Set	6	/	
7	Dump truck	10t	Set	20	/	
8	Dump truck	20t	Set	50	/	
9	Dump truck	15t	Set	10		
10	Belt system		Set	1	/	
11	Gantry crane	MQ1000	Set	9	325	
12	Gantry crane	MQ600	Set	4	238	
13	Crawler crane	W200A	Set	8	/	
14	Vibrator	Φ80~Φ100	Set	15		
15	Concrete pump	HB30B	Set	2		
16	Concrete bucket	$3m^3$ horizontal bucket	Pc.	18		
17	Concrete bucket	$6m^3$ horizontal bucket	Pc.	12		
18	Sliding formwork		Set	2		
19	HP roughing machine		Set	8		
20	Mortar mixer	5kW	Set	4		
21	Grouting driller	300 type	Set	10		
22	Grouting driller	SGZ-IA	Set	20	5	
23	Grouting pump	SGB-1	Set	30	/	
24	Bucket dredger	$250m^3/h$	Set	3	/	
II	Equipment for aggregate processing and transportation					
1	Jaw crusher	C125	Set	2	160	
2	Bar type vibrator feeder	SV1562	Set	2	44	
3	Cone crusher	GP300S	Set	2	250	
4	Cone crusher	HP400	Set	2	315	
5	Vertical shaft impact crusher	PL9500	Set	2	2×220	
6	Screw washer	2WCD-1118	Set	2	2×30	
7	Rod mill	MBS-Z2136	Set	3	210	1 for standby
8	Round vibrating screen	2YKR2460	Set	2	30	
9	Round vibrating screen	2YKR2460	Set	8	30	

10	Round vibrating screen	3YKR2460	Set	4	45	
11	Linear vibrating screen	ZKX1236	Set	11	7.5	1 for standby
12	Grit box	$5m^3$	Pc.	8		
13	Spiral classifier	FC-12	Set	8	11	
14	Spiral classifier	FC-15	Set	3	15	1 for standby
15	Electric vibrator feeder	GZG130-4	Set	16	2×1.5	(4 sets run at the same time)
16	Electric vibrator feeder	GZG100-4	Set	10	2×1.1	
17	Electric vibrator feeder	GZG80-4	Set	4	2×0.75	
18	Disk feeder	DB1600	Set	3	3	(2 sets run at the same time)
19	Hydraulic lithotripter	SDW60	Set	2	58.8	
20	Sealing-tape machine	B=1000mm	m	1320		18 pieces in total
21	Sealing-tape machine	B=800mm	m	870		26 pieces in total
22	Sealing-tape machine	B=650mm	m	202		3 pieces in total
23	Sealing-tape machine	B=500mm	m	195		6 pieces in total
24	Bulldozer	Yishan-80	Set	1		
25	Dump truck	20t	Set	20		Excluding standby
26	Wheel-type loader	$3m^3$	Set	3		1 for standby
27	Efficient waste water purifier	DH-SSQ-300	Set	3		Waste water treatment system
28	Efficient coagulation mixer	DH-HNQ-300	Set	3		
29	Sludge mixer	DH-HNQ-150	Set	4		
30	Coagulant aids stirring apparatus	7.5kW	Set	2	7.5	
31	Flocculating agent stirring apparatus	4kW	Set	2	4	
32	Regulating reservoir stirring apparatus	18.5kW	Set	2	18.5	
33	Sludge tank stirring apparatus	22kW	Set	1	22	
34	Combined vibrating screen	FMVS2030	Set	2	3.92	
35	Cyclone group	NZ-5 or NFN300	Set	2		
36	Belt conveyer	Width: 500mm; Length: 45m	Pc.	1	11	
37	Waste water lift pump of purifier	150ZM-36	Set	3	75	
38	Waste water lift pump of vibrating screen	150ZM-30	Set	4	55	Waste water treatment system

39	Sludge pump	100ZM-60	Set	4	55	
40	Clean water recycling pump	SLW300-400	Set	3	110	
41	Plate-and-frame filter press		Set	4	8	
III	Equipment for concrete production					
1	Concrete mixer station	HL320-2S4500L	Seat	2	510	
2	Injection pump	QPB6.0	Set	8		
3	Injection pump	QPB4.0	Set	7		
4	Cement tank	1000t	Pc.	9		
5	Fly ash tank	600t	Pc.	6		Adopt 1,000t cement tank
6	Air compressor	5L-40/8	Set	10	250	1 for standby
7	Air compressor	4L-20/8	Set	2	130	1 for standby
8	Round vibrating screen	YKR3060	Set	1	55	
9	Round vibrating screen	2YKR3060	Set	2	55	
10	Round vibrating screen	YKR3060	Set	1	30	
11	Round vibrating screen	2YKR3060	Set	2	30	
12	Spiral classifier	WCD-762	Set	2	11	
13	Vibrator feeder	GZG80-4	Set	32	1.5	
14	Radial gate	700×700	Set	20		
15	Dual-radial gate	1300×700	Set	12		
16	Spiral lobe refrigeration compressor	LG25 III A	Set	2/2	450/400	
17	Spiral lobe refrigeration compressor	LG20 III A	Set	6/2	250/200	
18	Spiral lobe refrigeration compressor	LG16 III A	Set	2	110	
19	Screw water chilling unit	LSLGF400	Set	2	100	
20	Flake ice machine	PBL-2×110	Set	14	4.65	
21	Icehouse	BK100	Seat	2	32	
22	Flake ice gas-moving device	QSB15	Set	2	45	
23	Air cooler	KL-1800	Set	2	—	
24	Air cooler	KL-1400	Set	2	—	

25	Air cooler	KL-000	Set	4	—	
26	Fan	4-79-12E	Set	2	55	
27	Fan	4-79-10E	Set	6	37	
28	Condenser	WN750	Set	2	—	
29	Condenser	WN450	Set	2	—	
30	Liquid reservoir	ZA8.0	Set	2	—	
31	Liquid reservoir	ZA6.5	Set	4	—	
32	LP circulating liquid reservoir	DX15.0	Set	4	—	
33	LP circulating liquid reservoir	DX20.0	Set	4	—	
34	Cooling tower	LRCM-HS-300C3×2	Set	2	66	
35	Water pump	NPS250-280	Set	10	45	1 for standby respectively
36	Water pump	IS80-65-125	Set	4	5.5	1 for standby respectively
37	Metering pump	25F-41A	Set	4	1.0	
38	Dump truck	20t	Set	67		2 sets for standby at the left bank and 5 sets for standby at the right bank
39	Fully automatic electronic car weigher	100t	Set	2	—	
40	Belt conveyer	B=1000mm	m	1660	270/310	6 pieces at the left bank and 7 pieces at the right bank
41	Belt conveyer	B=800mm	m	1060	100/190	7 pieces at the left bank and 9 pieces at the right bank
42	Belt conveyer	B=650mm	m	1145	155/165	11 pieces at each bank
43	Efficient (rotational flow) waste water purifier	DH-SSQ-300	Set	2	510	Waste water treatment system
43	Efficient coagulation mixer	DH-HNQ-300	Set	2		
45	Sludge mixer	DH-HNQ-150	Set	4		
46	Coagulant aids stirring apparatus	7.5kW	Set	2		
47	Flocculating agent stirring apparatus	4kW	Set	2	7.5	
48	Regulating reservoir stirring apparatus	18.5kW	Set	2	4	
49	Sludge tank stirring apparatus	22kW	Set	2	18.5	
50	Combined vibrating screen	FMVS2030	Set	2	22	

Table 7.9.2-1 (Continued)

S/N	Name	Spec. & Model	Unit	Qty.	Power of Single Set (kW)	Remarks
51	Cyclone group	NZ-5 or NFN300	Set	4	4	Waste water treatment system
52	Belt conveyer	Width: 500mm; length: 45m	Pc.	2		
53	Waste water lift pump of purifier	150ZM-36	Set	4	11	
54	Waste water lift pump of vibrating screen	150ZM-30	Set	4	75	
55	Sludge pump	100ZM-60	Set	4	55	
56	Clean water recycling pump	SLW300-400	Set	2	55	
57	Plate-and-frame filter press	XMZ500/1500-U	Set	4	110	
IV	Equipment for air supply					
1	Air compressor	VY-12/7	Set	34		4 for standby
V	Equipment for water supply					
1	Immersible pump	350QG1000-60-250	Set	6	250	2 for standby
2	Water pump	S350-75A	Set	6	280	2 for standby
3	Water pump	150S78	Set	3	55	1 for standby
4	Water pump	S300-90A	Set	3	280	1 for standby
5	Pontoon	16×5.2×1.2		1		Displacement: $80m^3$
VI	Equipment for power supply					
1	Diesel generator	10kV 3400kW	Set	6		
2	Diesel generator	10kV 1000kW	Set	5		
3	10kV high-voltage switch cubicle	XGN-12	Pc.	32		Just the number of switch cubicle in the diesel generator room
4	10kV cable	ZR-YJV22	km	15		
5	10kV circuit	LGJ-120/25	km	8		
6	10kV substation		Seat	1		With 2 transformers of 6300kVA

Table 7.9.2-1 (Continued)

7	10kV substation		Seat	1		With 2 transformers of 6300kVA
8	10kV box-type substation		Seat	1		With 2 transformers of 1250kVA
VII	Equipment for drainage					
1	Water pump	20SA-14	Set	7	280	2 for standby
VIII	Equipment in workshops					
1	Machinery repair plant		Set	45		
2	Vehicle maintenance station		Set	40		
3	Metal structures installation yard		Set	20		
4	Steel bar processing workshop		Set	25		
5	Timber processing workshop		Set	12		
6	Concrete prefabricating powerhouse		Set	12		